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B. Cotta.

A

TREATISE ON ORE DEPOSITS,

BY

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TRANSLATED FROM THE SECOND GERMAN EDITION,

BY

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REVISED BY THE AUTHOR.

WITH NUMEROUS ILLUSTRATIONS.

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TRANSLATOR's PREFACE.

Several motives have induced me to undertake the labor of translating this work: first, that no work of a kindred nature has appeared, since the able one of Professor Whitney on the Metallic Wealth of the United States: next, the high personal respect I feel for Professor Von Cotta, and his kind encouragement to this undertaking: lastly, the desire of placing some of his valuable observations within the reach of students in my native country, who have not had the opportunity of hearing the Professor, or reading his works in German.

I shall feel more than compensated for the time spent, should it at some future day induce the production of a work of a similar character on the various mining districts of this country; and, with a view to that end, lead to the close observation of the peculiarities of each mining-district.

It has often been said, that the cause of the rapid progress of the moral and material development of this people has arisen from the personal character of the first settlers. Let us hope that the same intellectual energy may be applied to the scientific observations of our mineral products. In Europe such observations have been the growth of centuries. Whilst we acknowledge our debt for such patient labor, let us try in part to repay them by a careful study of our own resources.

The mineral wealth, moreover, that awaits our gathering, is enormous. We must not forget, that economy in its collections is a duty we owe to the bountiful Giver, as well as to those laborious men, who by their observations and researches have unlocked the treasures.

The importance of preserving the distinctive characteristics of Professor Von Cotta's work has, in a measure, necessitated the sacrifice of any attempt at style. My absence, while the book was in press, prevented a personal examination of the proof-sheets.

I have great pleasure in acknowledging the kind and continued assistance of the Rev. Rt. Wells Whitford, British and American Chaplain at Leipsic (grandson of Robert Wells, of Charleston, So. Carolina), during the progress of the impression.

I am much indebted to my friend, Professor Von Cotta, for the encouragement and attention he gave me, until he was obliged to be absent from Freiberg, in the Altai Mountains, in his official employment by the Russian Government.

FREDERICK PRIME, Jr.

26 Broad St. New-York,
February, 1869.

AUTHOR's PREFACE.

My former pupil, Mr. Frederick Prime Jr., a very enthusiastic student in this branch of geology, has received my full approval and permission to translate my book on Ore Deposits. I have suggested many alterations, and additions, which he will set forth in this translation; so that, as a whole, it may be considered as a new edition (the third one) of my work. From the attention I have given to it, as the translation progressed, I feel justified in approving it as a whole.

B. von COTTA.

Freiberg, January, 1869.

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GENERAL PART.

ORES AND METALLIFEROUS DEPOSITS.

§ 1. Under the general term ores are comprehended all minerals and mineral aggregates, which from their metallic contents attract the attention of the miner. Metalliferous deposits are therefore for us all local accumulations of minerals or mineral aggregates, which correspond to this demand.

The idea of the terms ores and metalliferous deposits, in mining parlance, cannot be well expressed in a more precise or scientific manner. There is not any particular class of minerals, or of rocks, corresponding to these terms. To them belong native metals, metallic oxides, metallic sulphides, and even metallic salts and their combinations; but on the other hand not all metalliferous species of the Mineral Kingdom, because many of these cannot, either from their nature, or the too small percentage of a metal they contain, proportionally to its worth, be worked with profit. No rock, for example, containing 5 per cent of oxide of iron can be considered as an ore; while on the other hand a vein of quartz, with but 1 per cent of gold, would be regarded as a very rich and valuable metallic deposit; so relative is the idea.

It is even possible, and has already occurred, that a mineral, which for a long time was useless to the miner, and on this account was not considered as an ore, has, by means of new discoveries, been included in the category of ores. Blende, for example, when it did not contain valuable metals, could hardly have been considered formerly as an ore, though commonly defined as such; but since a method has been discovered of extracting Zinc from it with profit, it may be ranked without doubt among the ores. Far more striking are the cases of Clay and

Cryolith from which Aluminum is produced; for these minerals, which formerly no one would have considered as such, belong now, when strictly defined, to the category of ores.

The expression 'metalliferous deposit' defines, as before mentioned, the local accumulation of any sorts of ores in any form. I divide all metalliferous deposits, according to their forms, into Regular and Irregular. The first are again divided into Beds and Veins: the last, into Segregations and Impregnations. These forms are general: that is, they are repeated with many modifications in very many localities of the Earth, and all known occurrences of ores can be classified under them.

These separate forms of metalliferous deposits are sometimes so typical, that there can be no doubt of their peculiar character; sometimes, however, undefined; and the forms passing, to a certain degree, into one another; so that it is by no means always easy to determine, to which class they belong; while these changes again have many modifications, which will be more specially treated of hereafter. I propose first to consider the Nature and Grouping of the ores, without noticing the particular form of the deposits in which they occur.

COMPOSITION OF METALLIFEROUS DEPOSITS.

§ 2. The metalliferous deposits, like the rocks, consist of minerals; only their composition is a much more complicated one, a much larger number of minerals taking an essential share in them, and being often much more irregularly distributed.

Some of these minerals are especially rich in metals: these are the ores; the rest of them form the 'gang' or 'vein-stone'. The ores, as well as the 'gang', consist frequently of other minerals, besides those which generally compose the widely extended rocks.

Many metalliferous deposits, like many of the rocks, consist essentially of only one ore; for example, Spathic Iron, Magnetite, Hematite, Limonite, and the like: others, on the contrary, in fact the greater part, consist of two or more ores combined with one another and with different kinds of gang; for example, argentiferous Galena, Blende, Copper Pyrites, Mispickel, Quartz, Heavy Spar, Fluor Spar, Calcite, etc. The metalliferous veins appear to be the most complicated in their composition, the stratified deposits the most simple; the reverse is however exceptionally the case.

MINERALS WHICH ESPECIALLY OCCUR AS ORES.

§ 3. The number of minerals occurring as ores is very large; of which many are very rare, or from other causes are, up to the present time, unimportant for practical purposes. It is impossible to draw a sharp line of demarcation between the important, and the unimportant ones; since the unimportant may, through the progress of science, become important. In the following list I have included most of the minerals that can be considered as ores, those which are at present unimportant being printed in smaller type. Those characteristics being added, which are of the most importance for the miner and smelter: viz. H, the hardness; G, the specific gravity, and the chemical composition; the last only in approximate numbers, which are the result of calculation, and are better adapted for the purpose of this book, than the special results of separate Analyses, which can never be generally adopted, and are only of value for the particular case where they occur. The most common constituents are considered; small decimals being left out and large ones considered as whole numbers. The list is arranged according to Dana's Mineralogy, 4th edition. Besides the abbreviations abovementioned, monomet. is used for monometric, dimet. for dimetric, trimet. for trimetric, hex. for hexagonal, monoclin. for monoclinic, triclin. for triclinic.

LIST OF MINERALS.

GOLD. Monomet. H=2·5—3. G=15—19. Generally alloyed with silver, frequently up to 40 per cent, also with copper and iron.

PLATINUM. Monomet. H=4—4·5. G=16—19. Nearly always alloyed with somewhat of iron and iridium, more rarely with rhodium, palladium and osmium, or even with copper and lead.

Platiniridium. H=6—7. G=16—23.

Palladium. Monomet. H=4·5—5. G=12. Palladium alloyed with a little platinum and iridium.

Quicksilver. G=13. Mercury with sometimes a little silver.

AMALGAM. Monomet. H=3—3·5. G=10—14. Ag 26—35, Hg 74—65.

Arquerite. Monomet. H=2—2·5. G=10. Ag 87, Hg 13.

Gold Amalgam. G=15. Hg 58—61, Au 38—42, Ag 0—5.

SILVER. Monomet. H=2·5—3. G=10—11. Silver frequently alloyed with other metals.

Bismuth Silver. Bi 27, Pb 33, Ag 15, Fe 4, Cu 1, S 16.

COPPER. Monomet. H=2·5 – 3. G=8. Pure copper often containing silver disseminated through it.

Iridosmine. Hex. H=6 – 7. G=19 – 21. Ir 20—73, Os 25—80, frequently with iron.

Tellurium. Hex. H=2—2·5. G=6. Tellurium with gold and iron.

BISMUTH. Hex. H=2 – 2·5. G=9. Pure bismuth with occasional traces of arsenic.

Tetradymite. Hex. H=1·5—2. G=7—8. Bismuth and tellurium in varying proportions with arsenic.

ANTIMONY. Hex. H=3—3·5. G=6. Antimony containing at times silver, iron, or arsenic.

ARSENIC. Hex. H=3·5. G=6. Arsenic often with traces of other metals.

Arsenical Antimony. Hex. H=3·5. G=6. As 65, Sb 35.

REALGAR. Monoclin. H=1·5—2. G=3. S 30, As 70.

ORPIMENT. Trimet. H=1·5 – 2. G=3. S 39, As 61.

Bismuthine. Trimet. H=2 – 2·5. G=3. S 18, Bi 82.

Stibnite. Trimet. H=2. G=4. S 27, Sb 73.

Discrasite. Trimet. H=3·5—4. G=9. Sb 23, Ag 77.

Domeykite. H=3—3·5. As 28, Cu 72.

SILVER GLANCE. Monomet. H=2 – 2·5. G=7. S 13, Ag 87.

ERUBESCITE. Monomet. H=3. G=4—5. S 28, Cu 56, Fe 16.

GALENA. Monomet. H=2·5 – 3. G=7. S 13, Pb 87.

Manganblende. Monomet. H=3·5—4. G=4. S 37, Abn 63.

Sulphuret of Iron and Nickel. Monomet. H=3·5—4. G=5. S 37, Fe 41, Ni. 22.

Clausthalite. Monomet. H=2·5 – 3. G=7 – 8. Se 28, Pb 72.

Naumannite. Monomet. H=2·5. G=8. Se 27, Ag 73.

Tiemannite. H=2·5. G=7. Se 25, Hg 75.

Lerbachite. G=8. Contains lead, mercury and selenium.

Berzelianite. Se 38, Cu 62.

Eucairite. Se 32, Cu 25, Ag 43.

Hessite. H=2—3·5. G=8. Te 37, Ag 63.

Altaite. Monomet. H=3—3·5. G=8. Te 38, Pb 62.

Grunauite. Monomet. H=4·5. G=5. S 32, Bi 10, Ni 22, Fe 6, Co 11, Cu 12, Pb 7.

BLENDE. Monomet. H=3·5—4. G=4. S 33, Zn 67, often with much iron.

COPPER GLANCE. Trimet. H=2·5 – 3. G=5. S 20, Cu 80.

Stromeyrite. Trimet. H=2·5—3. G=6. S 16, Ag 53, Cu 31.
CINNABAR. Hex. H=2—2·5. G=8. S 14, Hg 86.
Millerite. Hex. H=3—3·5. G=5. S 35, Ni 65.
PYRRHOTINE. Hex. H=3·5—4·5. G=4. S 59, Fe 41.
Greenockite. Hex. H=3—3·5. G=5. S 22, Cd 78.
Onofrite. H=2·5. G=7. Se 25, Hg 75.
COPPER NICKEL. Hex. H=5—5·5. G=7. As 56, Ni 44.
Breithauptite. Hex. H=5·5. G=7. Sb 69, Ni 31.
IRON PYRITES. Monomet. H=6—6·5. G=5. S 53, Fe 47.
SMALTINE. Monomet. H=5·5—6. G=7. As 72—92, Co 0—28, Ni 0—28, Fe 0—9.
CHLOANTHITE. Monomet. H=5·5. G=6. As 72, Ni 28.
COBALTINE. Monomet. H=5·5. G=6. S 19, As 45, Co 36.
Gersdorffite. Monomet. H=5·5. G=6. S 19, As 45, Ni 36.
Ullmannite. Monomet. H=5—5·5.
MARCASITE. Trimet. H=6—6·5. G=4. S 53, Fe 47.
Leucopyrite. Trimet. H=5—5·5. G=7. As 73, Fe 27.
MISPICKEL. Trimet. H=5·5—6. G=6. As 46, S 20, Fe 34.
Sylvanite. Trimet. H=1·5—2. G=5—8. Te 56, Au 28, Ag 16.
Nagyagite. Dimet. H=1—1·5. G=7. S 3—10, Te 13—32, Pb 51—61, Au 6—9.
Covelline. Hex. H=1·5—2. G=4. S 34, Cu 66.
MOLYBDENITE. Hex. H=1—1·5. G=4. S 41, Mo 59.
Skutterudite. Monomet. H=6. G=7. As 79, Co 21.
LINNAITE. Monomet. H=5·5. G=5. S 42, Co 58.
Cuban. Monomet. H=4. G=4. S 36, Cu 23, Fe 41.
CHALCOPYRITE (Copper Pyrites). Dimet. H=3·5—4. G=4. S 35, Cu 35, Fe 30.
Barnhardtite (Homichline). H=3·5. G=4. S 30—35, Cu 43—48, Fe 21—22.
Tin Pyrites. Dimet. H=4. G=4. S 30, Sn 27, Cu 30, Fe 13.
Sternbergite. Trimet. H=1—1·5. G=4. S 34, Ag 32, Fe 34.
Wolfsbergite. Trimet. H=3—4. G=4. S 25, Sb 50, Cu 25.
Berthierite. H=2—3. G=4. S 29, Sb 58, Fe 13.
Zinkenite. Trimet. H=3—3·5. G=5. S 22, Lb 34, Pb 44.
Miargyrite. Monoclin. H=2—2·5. G=5. S 21, Sb 43, Ag 36
Plagionite. Monoclin. H=2·5. G=5. S 21, Sb 38, Pb 41
Jamesonite. Trimet. H=2—2·5. G=5. S 20, Sb 36, Pb 44.
Heteromorphite. H=1—3. G=6. S 19, Sb 31, Pb 50.
Chiviatite. G=7. S 18, Bi 61, Pb 17, Cu 3, Fe 1.
Dufrenoysite. Monomet. H=2—3. G=5. S 30, As 31, Cu 39.

Binnite. Trimet. H=3. G=5. S 22, As 21, Pb 57.

PYRARGYRITE (Ruby Silver). Hex. H=2—2·5. G=6. S 18, Sb 23, Ag 59.

PROUSTITE (Ruby Silver). Hex. H=2—2·5. G=5. S 20, As 15, Ag 65.

Freieslebenite. Monoclin. H=2—2·5. G=6. S 19, Sb 27, Pb 30, Ag 24.

Bournonite. Trimet. H=2·5—3. G=6. S 20, Sb 25, Pb 42, Cu 13.

BOULANGERITE. H=2·5—3. G=6. S 18, Sb 24, Pb 58.

Aikinite. Trimet. H=2·5. G=6. S 17, Bi 36, Pb 36, Cu 11.

Wolchite. Trimet. H=3. G=6. S 20, Sb 25, Pb 42, Cu 13.

TETRAHEDRITE. Monomet. H=3—4·5. G=5. Contains sulphur, arsenic, antimony, silver, copper, iron, zinc, and mercury, in most varying proportions.

Tennantite. Monomet. H=3·5—4. G=4. S 28, As 19, Cu 49, Fe 4.

Geocronite. Trimet. H=2—3. G=6. S 16, Sb 17, Pb 67.

POLYBASITE. Hex. H=2—3. G=6. S 16, Sb 13, Ag 71.

STEPHANITE. Trimet. H=2—2·5. G=6. S 16, Sb 14, Ag 70.

ENARGITE. Trimet. H=3. G=4. S 33, As 19, Cu 48.

Xanthocone. Hex. H=2. G=5. S 21, As 15, Ag 64.

Fireblende. Monoclin. H=2. G=4. Contains sulphur, antimony, and silver up to 62 per cent.

Wittichite. Trimet (?). H=3·5. G=5. S 19, Bi 43, Cu 38.

Calomel. Dimet. H=1—2. G=6. Cl 15, Hg 85.

KERARGYRITE (Horn Silver). Monomet. H=1—1·5. G=5. Cl 25, Ag 75.

EMBOLITE. Monomet. H=1—1·5. G=5. Cl 13, Br 20, Ag 67.

Megabromite. Monomet. H=2·5—3. G=6. Cl 9, Br 27, Ag 64.

Mikrobromite. Monomet. H=2·5—3. G=5. Cl 18, Br 12, Ag 70.

Bromyrite (Bromic Silver). Monomet. H=1—2. G=6. Br 43, Ag 57.

Iodyrite (Iodic Silver). Hex. H=1—1·5. G=5. I 54, Ag 46

Coccinite (Iodic Mercury). I 56, Hg 44.

RED COPPER. Monomet. H=3·5—4. G=6. Cu 89, O 11.

Martite. Monomet. H=6. G=5. O 30, Fe 70.

Iserine. Monomet. H=6—6·5. G=5. TiO_2 55, FeO 29, Fe_2O_3 15.

Irite. Monomet. H=? G=6. Ir 55, Os 9, Fe 11, Cr 10, O 15.

MAGNETITE (Magnetic Iron Ore). Monomet. H=5·5—6. G=5. O 28, Fe 72.

FRANKLINITE. Monomet. H=5·5—6·5. G=5. O 25, Fe 45, Mn 9, Zn 21.
CHROMIC IRON. Monomet. H=5·5—6. G=4. Cr_2O_3 55, Al_2O_3 6, Fe_2O_3 12, FeO 18, MgO 9.
PITCH BLENDE. Monomet. H=5·5. G=6—8. O 15, U 85.
Melaconite. H=3. G=6. O 20, Cu 80.
Plumbic Ochre. G=8. O 7, Pb 93.
ZINCITE. Hex. H=4—4·5. G=5. O 20, Zn 80.
HEMATITE (Specular Iron). Hex. H=5·5—6·5. G=5. O 30, Fe 70.
ILMENITE. Hex. H=5—6. G=5. TiO_2 45, Fe_2O_3 15, FeO 40.
Braunite. Dimet. H=6—6·5. G=5. O 30, Mn 70.
Hausmannite. Dimet. H=5—5·5. G=5. O 28, Mn 72.
CASSITERITE (Tin Ore). Dimet. H=6—7. G=7. O 22, Sn 78.
PYROLUSITE. Trimet. H=2—2·5. G=5. O 37, Mn 63.
Minium. G=4. O 9, Pb 91.
Crednerite. Monoclin. H=4·5. G=5. O 26, Mn 39, Cu 35.
Voltzite. H=4·5. G=3. ZnS 83, ZnO 17.
Matlockite. Dimet. H=2·5—3. G=7. Cl 14, Pb 83, O 3.
Mendipite. Trimet. H=2·5—3. G=7. Cl 10, Pb 86, O 4.
Gothite. Trimet. H=5—5·5. G=4. Fe_2O_3 90, HO 10.
Manganite. Trimet. H=4. G=4. Mn_2O_3 89, HO 11.
Polianite. Trimet. H=6·5—7. G=5. MnO_2.
LIMONITE (Brown Hematite). H=5—5·5. G=4. Fe_2O_3 86, HO 14.
PSILOMELANE. H=5—6. G=4. Consists of peroxide of manganese and water with varying quantities of alkaline earths.
WAD. H=0·5—6. G=3. Essentially the same as the last.
ATACAMITE. Trimet. H=3—3·5. G=4. Cl 16, Cu 15, CuO 56, HO 13.
Sercarmontite. Monomet. H=2—2·5. G=5. Sb 84, O 16.
Valentinite. Trimet. H=2·5—3. G=5. Sb 84, O 16.
Bismuth Ochre. G=4. O 10, Bi 90.
Kermesite (Red Antimony). Monoclin. H=1—1·5. G=4. S 20, O 5, Sb 75.
Cervantite. G=4. O 20, Sb 80.
Ammiolite. Is an antimonite of mercury.
Molybdine. O 34, Mo 66.
Eulytine. Monomet. H=4·5. G=6. Silicate of bismuth.
Willemite. Hex. H=5·5. G=4. SiO_3 27, ZnO 73.
Dioptase. Hex. H=5. G=3. SiO_3 39, CuO 50, HO 11.
CHRYSOCOLLA. H=2—3. G=2. SiO_3 35, CuO 45, HO 20.

CALAMINE. Trimet. H=4·5—5. G=3. SiO_3 25, ZnO 67, HO 8.

Scheeletine (Tungstate of Lead). Dimet. H=2·5—3. G=8. WO_3 51, PbO 49.

Wulfenite (Molybdate of Lead). Dimet. H=2·5—3. G=6. MoO_3 39, PbO 61.

WOLFRAM. Trimet. H=5—5·5. G=7. WO_3 76, MnO 15, FeO 9.

Crocoisite. Monoclin. H=2·5—3. G=6. CrO_3 31, PbO 69.

Vauquelinite. Monoclin. H=2·5—3. G=5. CrO_3 28, PbO 61, CuO 11.

Melanochroite. Trimet. H=3—3·5. G=6. CrO_3 23, PbO 77.

Dechenite. H=4. G=6. VO_3 45, PbO 55.

Descloizite. Trimet. H=3·5. G=6. VO_3 29, PbO 71.

Vanadinite. Hex. H=2·5—3. G=7. Cl 2, VO_3 20, PbO 71, Pb 7.

Volborthite. Hex. H=3. G=3. VO_3 37, CuO 58, HO 5.

ANGLESITE. Trimet. H=2·5—3. G=6. SO_3 26, PbO 74.

Leadhillite. Trimet. H=2·5. G=6. PbO, SO_3 27, PbO, CO_2 73.

Caledonite. Trimet. H=2·5—3. G=6. PbO, SO_3 56, PbO, CO_2 33, CuO, CO_2 11.

Susannite. Hex. H=2·5. G=6. PbO, SO_3 27, PbO, CO_2 73.

Lanarkite. Monoclin. H=2—2·5. G=7. PbO, SO_3 53, PbO, CO 47.

Cyanosite (Sulphate of Copper). Triclin. H=2—2·5. G=2. SO_3 32, CuO 32, HO 36.

Voltaite. Monomet. A sulphate of the protoxide and peroxide of iron.

Goslarite. Trimet. H=2—2·5. G=2. SO_3 28, ZnO 28, HO 44.

COPPERAS (Sulphate of Iron). Monoclin. H=2. G=2. SO_3 29, FeO 26, HO 45.

Bieberite (Cobalt Vitriol). Monoclin. SO_3 28, CoO 26, HO 46.

Botryogen. Monoclin. H=2—2·5. G=2. Is a hydrated sulphate of iron, magnesia, and lime.

Copiopite. Is a sulphate of iron.

Coquimbite. Hex. H=2—2·5. G=2. Is a hydrated sulphate of the peroxide of iron.

Jarosite. Hex. H=3—4. G=3. Is a hydrated sulphate of potash and the peroxide of iron.

Linarite. Monoclin. H=2·5—3. G=5. PbO,SO_3 76, CuO 20, HO 4.

Brochantite Trimet. H=3·5—4. G=4. SO_3 18, CuO 70, HO 12.

Lettsomite. Is a hydrated sulphate of copper, alumina, and iron.

PYROMORPHITE. Hex. H=3·5—4. G=7. PO_5 16, Cl 2, PbO 74, Pb 8.

Mimetene. Hex. H=3·5. G=7. AsO_5 23, Cl 2, PbO 68, Pb 7.

Triphyline. Trimet. H=4—5. G=3. PO_5 45, FeO 40, MnO 6, LiO 7, MgO 2.

Triplite. Trimet. H=5—5·5. G=4. PO_5 33, MnO 33, FeO 34.

Thrombolite. H=3—4. G=3. PO_5 44, CuO 39, HO 17.

Vivianite. Monoclin. H=2. G=2. A hydrated phosphate of iron.

Erythrine (Cobalt Bloom). Monoclin. H=1·5—2·5. G=3. AsO_5 38, CoO 38, HO 24.

Annabergite. H=2—2·5. G=3. AsO_5 39, NiO 37, HO 24.

Köttigite. AsO_5 37, ZnO 31, CoO 7, NiO 2, HO 23.

Symplesite. Monoclin. H=2·5. G=2. A hydrated arsenate of iron.

Scorodite. Trimet. H=3·5—4. G=3. AsO_5 50, Fe_2O_3 34, HO 16.

Libethenite. Trimet. H=4. G=4. PO_5 30, CuO 66, HO 4.

Olivenite. Trimet. H=3. G=4. AsO_5 40, CuO 56, HO 4.

Conichalcite. Is a hydrated arsenate and phosphate of copper and lime.

Euchroite. Trimet. H=3·5—4. G=3. AsO_5 34, CuO 47, HO 19.

Arseniosiderite. H=1—2. G=4. AsO_5 38, Fe_2O_3 39, CoO 14, HO 9.

Erinite. H=4·5—5. G=4. AsO_5 35, CuO 60, HO 5.

Phosphocalcite (Lunnite). Monoclin. H=5. G=4. PO_5 21, CuO 71, HO 8.

Tyrolite. H=1·5—2. G=3. AsO_5 25, CuO 44, CoO,CO_2 11, HO 20.

Aphanesite (Abichite). Monoclin. H=2·5—3. G=4. AsO_5 30, CuO 63, HO 7.

Chalcophyllite. Hex. H=2. G=2. AsO_5 18, CuO 50, HO 32.

Liroconite. Monoclin. H=2—2·5. G=3. AsO_5 26, CuO 37, Al_2O_3 12, HO 25.

Uranite. Trimet. H=1—2. G=3. PO_5 15, CoO 6, U_2O_3 63, HO 16.

Chalcolith. Dimet. H=2—2·5. G=3. PO_5 15, CuO 9, U_2O_3 61, HO 15.

Plumbo-resinite (Bleigummi). H=4—4·5. G=6. PO_5 8, PbO 38, M_2O_3 35, HO 19.

CHALYBITE (Spathic Iron). Hex. H=3·5—4·5. G=4. CO_2 38, FeO 62.

SMITHSONITE. Hex. H=5. G=4. CO_2 36, ZnO 64.

CERUSITE. Trimet. H=3—3·5. G=6. CO_2 16, PbO 84.

MALACHITE. Monoclin. H=3·5—4. G=4. CO_2 20, CuO 72, HO 8.

AZURITE. Monoclin. H=3·5 —4. G=4. CO_2 26, CuO 69, HO 5.

Aurichalcite (Buratite). H=2. G=3. CO_2 16, CuO 29, ZnO 45, HO 10.

ZINC BLOOM. G=3·5. CO_2 14, ZnO 75, HO 11.

Emerald Nickel. H=3. G=2. CO_2 12, NiO 59, HO 29.

Bismuthite. H=4—4·5. G=7. BiO,CO_2+BiO,SO_3.

Cerasine. Dimet. H=2·5—3. G=6. PbCl 51, PbO,CO_2 49.

THE TEXTURE OF THE ORES AND VEIN-STONES.

§ 6. The metallic deposits are composed, like the common rocks, of minerals combined in the most heterogeneous manner.

The following varieties of texture may be especially distinguished.

1. Compact: when the individual mineral particles cannot be distinguished—compact dimonite, compact hematite.

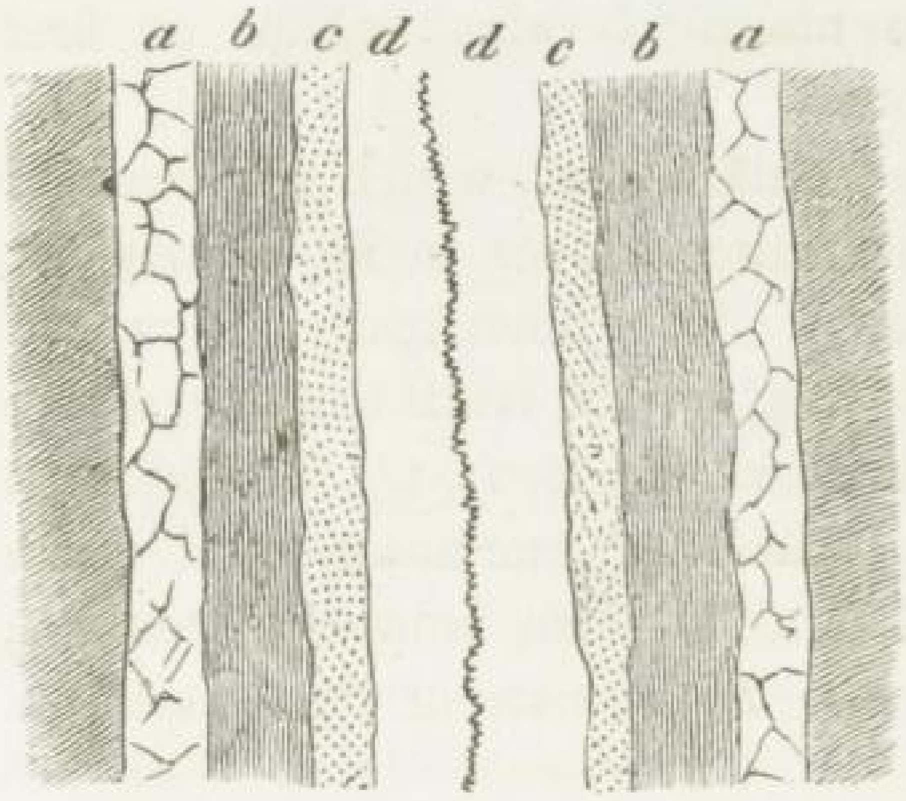
2. Granular: the separate particles form grains of about the same size—Granular Magnetite.

3. Irregular granular: by this name I mean the common modification in metallic deposits of the granular texture, in which the separate individual ingredients are of different sizes, unlike forms, and generally also unevenly distributed. This structure is very common in metallic veins and floors (*Stockwerke*).

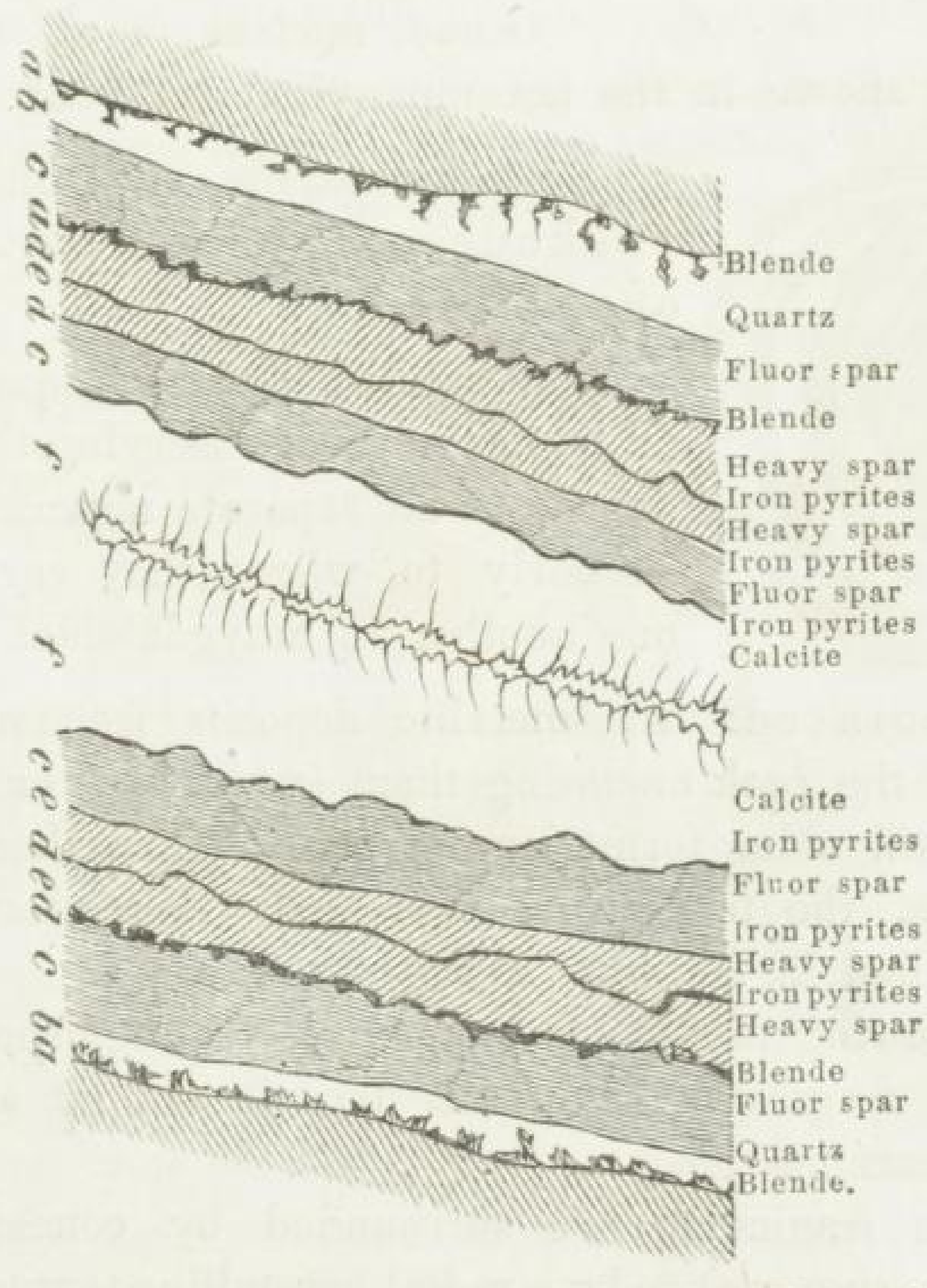
4. Disseminated: when the separate ores are distributed, in general unequally, as independent grains, lamins, or crystals, in a uniformly compact granular or schistose mass. If they form crystals, this texture completely coincides with the porphyritic structure in rocks. This texture is quite common in metallic deposits.

5. Combed or banded: the separate ingredients, or combinations of two or three of them, form layers of equal or unequal thickness.

This variety of texture is particularly common in metallic veins: the layers are then parallel to the fissure; the first or oldest comb (*a*) was deposited on both the sides of the cleft, on this the second (*b*), and so on (*c*, *d*), until the whole fissure was filled. In this manner the same, or at least very similar bands are symmetrically deposited from the sides to the middle.



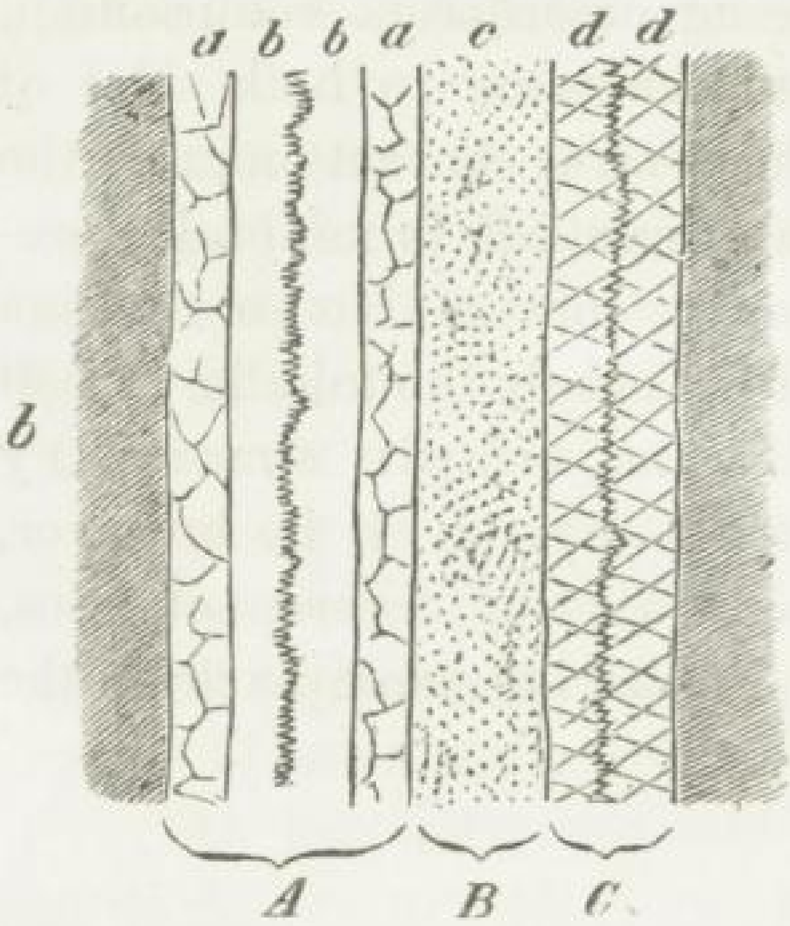
In the annexed ideal wood-cut, the separate layers or combs (*a*, *b*, *c*, *d*) are all represented as being of different composition, but the same on both sides of the centre; so that one and the same mineral, or mineral aggregation, occurs but once from either side to the middle. I call this the simple symmetry of the layers. It is, however, often the case that similar layers, separated by discrepant ones, are repeated several times; as in the following example from the Drei Prinzen vein near Freiberg.



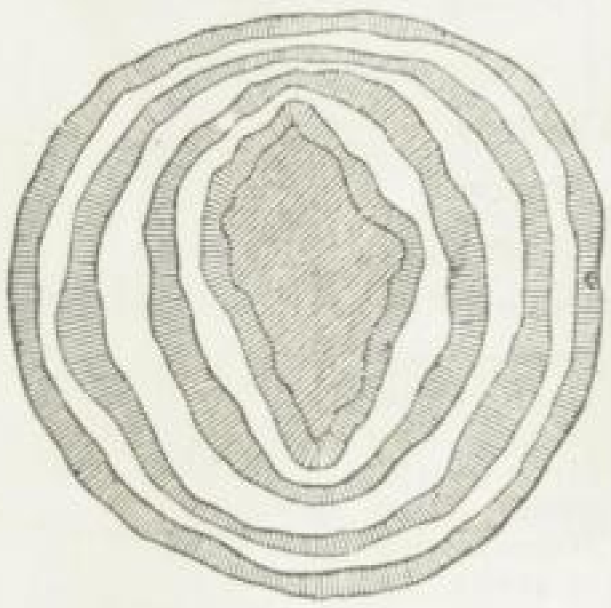
Drei Prinzen lode, from a drawing by Von Weissenbach.

I call this last case a symmetrical repetition (or self-repeating symmetry) of the layers. The symmetry of the combed texture appears to have been sometimes destroyed by later causes; as for example, through repeated re-opening of the same fissure, by which is formed a dislocation of the veins themselves, or double, or even manifold veins, which on first appearance seem to form but one.

The following wood-cut represents a vein, which appears, on the other hand, to be formed by seven unsymmetrically arranged combs, but in truth consists of the three veins (*A*, *B*, *C*,) formed next to and after one another, of which *A.* and *C.* also consist of combs, while *B.* consists of but one band.



The combed texture is not confined to veins alone, it also occurs in concentrical bands formed in Floors, so that the layers surround some nucleus, most commonly a fragment, as shown in the accompanying wood-cut.



Such formations are generally called cockade-ores (*Cocardenerze*) or ring-ores (*Ringerze*).

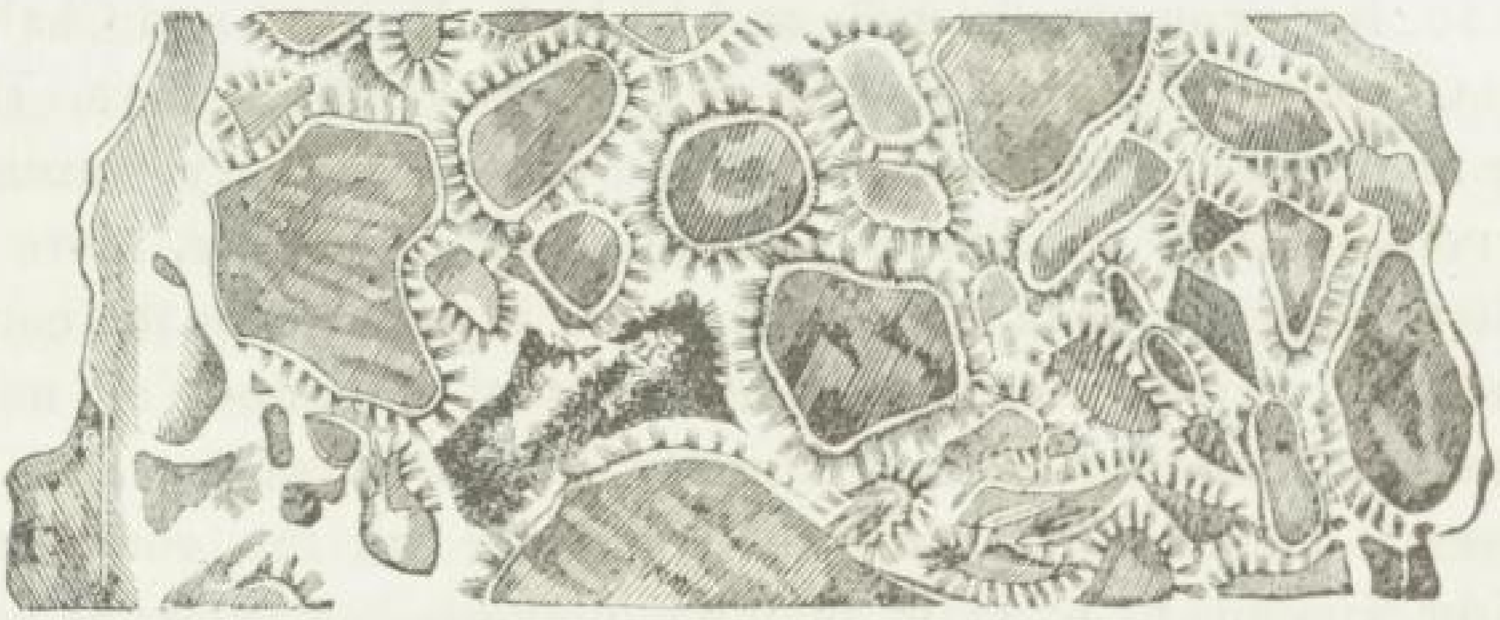
The banded texture frequently affords an opportunity of observing the successive deposit of the separate mineral substances, similarly to where they crystallize over one another in amygdaloidal cavities.

6. Brecciated: the metallic deposits frequently contain fragments of the rock enclosing them (wallrock), or those which come from still older formations of ore. When these fragments are numerous, the texture is brecciated; these formations are sometimes called in German *Brockengestein.*

The following modifications may be distinguished:

a. the fragments lie in the deposit without showing any peculiar appearance;

b. the fragments are surrounded by concentric layers (cockade ore, ring ore) or by a radial crystalline texture (*Sphärentextur*) in the manner shown in the following wood-cut;

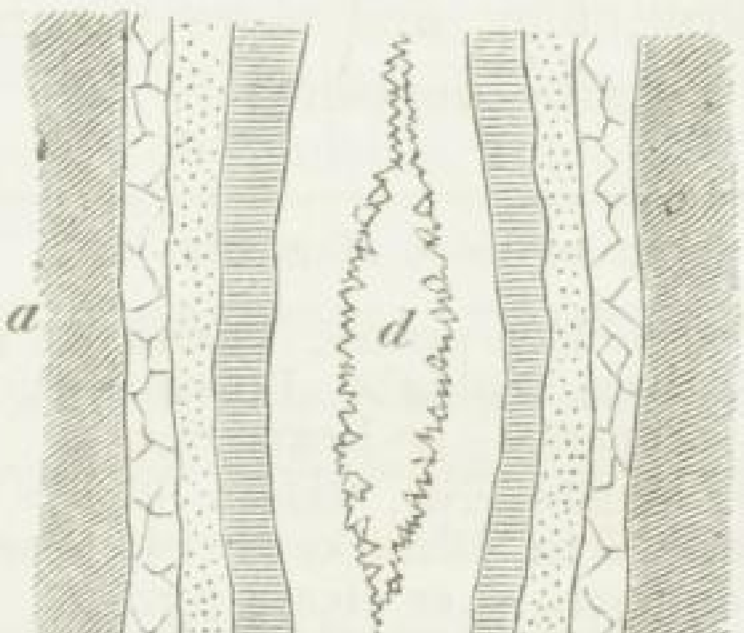


c. the fragments come entirely from the wallrock;

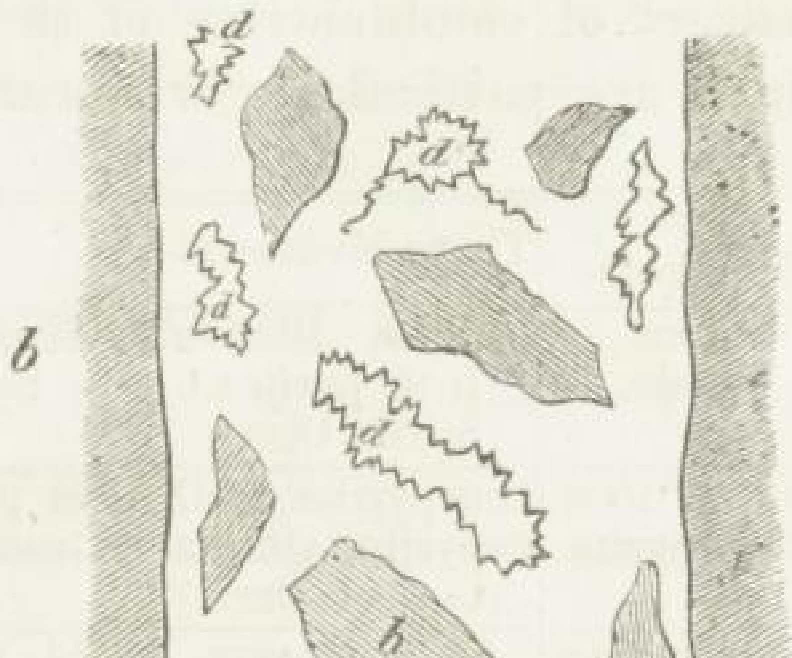
d. the fragments come from older metallic deposits; which is particularly striking when showing a banded texture; or

e. the fragments predominate; and are, in part, very large and flaky: this form passes into broken-up masses of rock traversed by numerous metallic threads.

7. Amygdaloidal: the metallic deposits are traversed by numerous irregular, generally angular or almond-shaped cavities, whose sides are lined with crystals. These cavities are a very common occurrence in metallic deposits, when more scattered; and generally take a central situation in combed veins, while they seem to occur everywhere between the fragments in brecciated metallic deposits. The two following wood-cuts attempt to represent this relation in an ideal manner.



Lode possessing (a) combed texture, with geode (*d*) in the middle.



Brecciated lode with fragments of the country rock (*b*) and geodes (*d*).

The outer limits of metalliferous deposits, especially of veins, are called selvages (*Salbänder*), when they have a marked line of demarcation between the deposits and the country rock.

GROUPING OF THE ORES AND VEIN-STONES.

§ 7. In metallic deposits, as well as in rocks, certain minerals appear to be, more frequently than others, combined or associated: so, for example, Blende and Galena, Pyrites and Chalcopyrite, Cobalt and Nickel ores, Tin and Wolfram ores, Heavy Spar and Fluor Spar. Quartz is but seldom entirely wanting in any combination. These combinations are, however, more complicated, and not always so constant as is the case in the common rocks: to which must be added, that the number of mineral species forming them is, generally, much greater. For these reasons it is hardly possible to enumerate all the combinations already known to exist in metallic deposits, or even, as in the case of rocks, to give them particular names. Such combinations of ores and vein-stones are sometimes called ore-formations, vein-formations, vein-types, etc., which will be more fully treated of hereafter.

The cause of the combination of certain minerals into groups, is probably a chemical and not a geological one, but yet differing from that of the combination of the elements forming the minerals. It consists, possibly, in the fact, that certain substances possess the ability to be dissolved, and to crystallize, under like conditions; and that they exist side by side in the same solution; while others on the contrary do not. In place of the list of combinations which here follow in the German edition, and which appear more suitably under the examples hereafter given; I here insert, according to the wish of the Author, a short tabular abstract of combinations of two, three, four, and more minerals, which are particularly frequent in metallic deposits.

Two Members.	Three Members.	Four or more Members.
Galena, Blende.	Galena, Blende, Iron pyrites. (Silver Ores.)	Galena, Blende, Iron pyrites, Quartz, — *and* Spathic Iron, Dialogite, Brown Spar, Calc. Spar, — *or* Heavy Spar.
Iron pyrites, Chalcopyrite.	Ironpyrites, Chalcopyrite, Quartz. (Copper Ores.)	Iron pyrites, Chalcopyrite, Galena, Blende, — *and* Spathic Iron, Dialogite, Brown Spar, Calc. Spar, — *or* Heavy Spar.
Gold, Quartz.	Gold, Quartz, Iron pyrites.	Gold, Quartz, Iron pyrites, Galena, Blende, — *and* Spathic Iron, Dialogite, Brown Spar, Calc. Spar, — *or* Heavy Spar.
Cobalt and Nickel Ores.	Cobalt and Nickel ores, Iron pyrites.	Cobalt and Nickel Ores, Iron pyrites, — *and* Galena, Blende, Quartz, Spathic Iron, Dialogite, Brown Spar, Calc. Spar, — *or* Heavy Spar.
Tin, Wolfram.	Tin, Wolfram, Quartz.	Tin, Wolfram, Quartz, Mica, Tourmaline, Topaz, etc.
Gold, Tellurium.	Gold, Tellurium, Tetrahedrite. (Various Tellurium ores.)	Gold, Tellurium, Tetrahedrite, Quartz, — *and* Brown Spar, — *or* Calc. Spar.

Two Members.	Three Members.	Four or more Members.
Cinnobar, Tetrahedrite.	Cinnobar, Tetrahedrite, Pyrites. (Various ores of Quicksilver.)	Cinnobar, Tetrahedrite, Pyrites, Quartz, — *and* Spathic Iron, Dialogite, Brown Spar, Calc. Spar, — *or* Heavy Spar.
Magnetite, Chlorite.	Magnetite, Chlorite, Garnet.	Magnetite, Chlorite, Garnet, Pyroxene, Hornblende, Pyrites, etc.

SUCCESSION OF MINERALS IN METALLIFEROUS VEINS AND GEODES.

§ 8. As the association (combination) of minerals in metalliferous deposits is not merely accidental, but is limited by certain laws of affinity, or conditions of origin; so is the succession of the individual minerals also, which manifests itself, either in the series of dissimilar combs, or in the successive crystallizations in geodes. Von Weissenbach, 30 years ago, observed the following succession of separate vein-stones from the sides (selvages) to the middle of the vein, in the system of lodes around Brand, near Freiberg:—

1. Quartz veins containing Iron pyrites, black Blende, Galena, and Mispickel affording a moderate percentage of silver.

2. Dialogite and Brown Spar (Rhomb Spar) with the above-mentioned ores, but richer in silver, and containing in certain portions Tetrahedrite, argentiferous Tetrahedrite, and such like rich silver ores.

3. Spathic Iron, Fluor Spar, and Heavy Spar, over which a more uncommon variety of Brown Spar (the *tautokliner Karbonspath* of Breithaupt) has sometimes formed. Ores the same as in 2, but less of them; the galena disseminated in the Heavy Spar generally contains but little silver.

4. Calcite, sometimes containing rich silver ores, but without the ores of 1.

Some of the so-called Formations, which have been discriminated in the system of veins around Freiberg, nearly correspond to these successions of combinations in a vein: viz. the so-called pyritic lead-formation (*kiesigen Bleiformation*), the noble lead-formation (*edlen Bleiformation*), and the barytic lead-formation (*barytischen Bleiformation*). These so-called Formations, besides occurring separately, are also found together in the same vein and succeeding one another. Where the barytic combination occurs alone, it frequently forms numerous combs of almost the same composition, which are often repeated, that is, a repeated alternation of Heavy Spar, Galena, and Blende, often with somewhat of Pyrites, Fluor Spar, Quartz, etc. The same process of Formation must have been periodically continued, in such cases, for a long period. More recently Breithaupt and Henwood have carefully examined the succession of minerals in veins and amygdaloidal cavities, whereby a certain conformity, even in parts of the earth most removed from one another, has been proved. While it was not possible to deduce any general law of succession from these series, still many accordant facts were discovered. In the first place, nearly all these series commence with Quartz. Very commonly the same minerals follow one another in the same order. It is sometimes possible to combine several series occurring in the same vein, and to complete them mutually; by which the series, apparently simple, become complex, and sometimes such as are repeated.

By the observation of such or similarly recurring mineral successions, in different districts, the question necessarily arises, as to what caused them. These causes, as well as those where the same combinations recur, appear to be chiefly of a chemical nature, and withal of great geological importance.

The worth of mineral combinations, and of mineral successions, is certainly misapprehended; if it be supposed, that they are characteristic of particular geological Periods; that their nature is dependent on the period of their origin; that in every period everywhere similar combinations or successions, in different periods dissimilar ones, were formed; and that it is possible, from the nature of these combinations or successions, to determine their geological age. In each separate portion of the earth they certainly appear to follow one another in nearly the same relative order as to age, in so far as they are the gradual result of similar geological events. But these events have taken place in the various regions of the earth at different periods, or have even been repeated at intervals; and it would, in this case, be equally incorrect to consider, that like combinations or successions were of the same age, as if the long since exploded idea were still maintained, that like rocks must all have been formed at the same time. It may however be correct, that like or similar combinations or successions were formed, in confined and geologically conformable districts, just as the similar rocks have been formed almost contemporaneously.

OCCURRENCE OF METALLIFEROUS DEPOSITS.

§ 9. Generally considered, it cannot be stated, that the occurrence of metalliferous deposits, joined to other determined geological phenomena, is always united with them, or is confined to particular rocks or formations. The most that can be asserted is, that they are more commonly found in mountainous regions than in plains, that they appear to be more frequent in the older rocks and formations than in the very recent ones, and that the new volcanic rocks, in particular, appear to contain but few of them.

But the case is entirely different, when particular forms or kinds of deposits are spoken of. It is immediately apparent, for example, that the metalliferous veins and floors occur principally near the limits of differently formed rocks; that they chiefly occur only between older rocks and formations, in consequence of which they are mostly found in mountainous regions; and that certain kinds or combinations of ores appear to be especially united with certain rocks; as for example, tin ores with greisen, granite, gneiss, mica schist, and quartz porphyry. I will return to these specialities hereafter, as also to the origin of metalliferous deposits.

We will now more closely examine the four principal forms, in which they occur.

ORE-BEDS.

WHAT ARE ORE-BEDS?

§ 10. Aggregations of ore, which lie parallel to the stratification or foliation of the rock enclosing them, consequently forming one or more subordinate layers between any stratified or foliated rock, are called ore-beds. To this class I consider to belong the superficial deposits, lying loose upon the surface, which were evidently formed by precipitation or denudation;

as Bog-Iron ore and auriferous sand. The first of these, I call parallel layers; the last, surface deposits. I must, however, somewhat modify the definition of parallel layers, by adding that they are only true beds or layers, when it is evident from the nature of their origin, that they were formed, in most cases, contemporaneously with the rocks in which they lie; that is, after the layers which originally lay under them, and before those covering them: as for example the Black-band in many coal formations.

Does any circumstance on the contrary prove, that they only correspond in their general form and extension to the parallel strata, and as having more recently filled a fissure, which has opened parallel to the stratification or foliation; they are then not true beds, but bedded veins, that is, veins having the form of beds. This distinction is sometimes easy, sometimes, on the contrary, very difficult; sometimes unimportant for the practical miner, sometimes of great importance; naturally, always a subject of interest to geologists.

In general there are no such sharp limits, between true beds and the enclosing rock, as in bedded veins. It is impossible for true beds to cause faults, they can never cut through a vein or other bed, they never send off veinlike branches in the original superstrata, nor can they contain fragments of these. But all these negative characteristics may naturally also occur in bedded veins. If the mass of the deposit is of such a different nature from the enclosing rock, that the same origin cannot be properly ascribed to both; it is already a reason to consider it a vein, or that at least subsequent metamorphic action or impregnation has taken place. If the bed, on the contrary, follow very constantly the flexures of the stratification or cleavage, or if many such are formed in one zone; by which I mean lenticular deposits lying separated from one another between two layers; there is then reason to think, that these are true beds. There are cases frequently occurring, in which the question can not be positively determined.

Some mining laws, without paying attention to the manner of their formation, distinguish beds and veins by the angle of their dip; the slightly inclined veins being called beds, the greatly inclined beds, veins. This is, self-evidently, a very unscientific method of classification; since a bed can as well have a dip of 90°, as a vein lie horizontally. From what has been said it is evident, that true ore-beds can only occur in stratified deposits, or in such as have a foliated texture; since a parallel stratification does not exist in massive rocks.

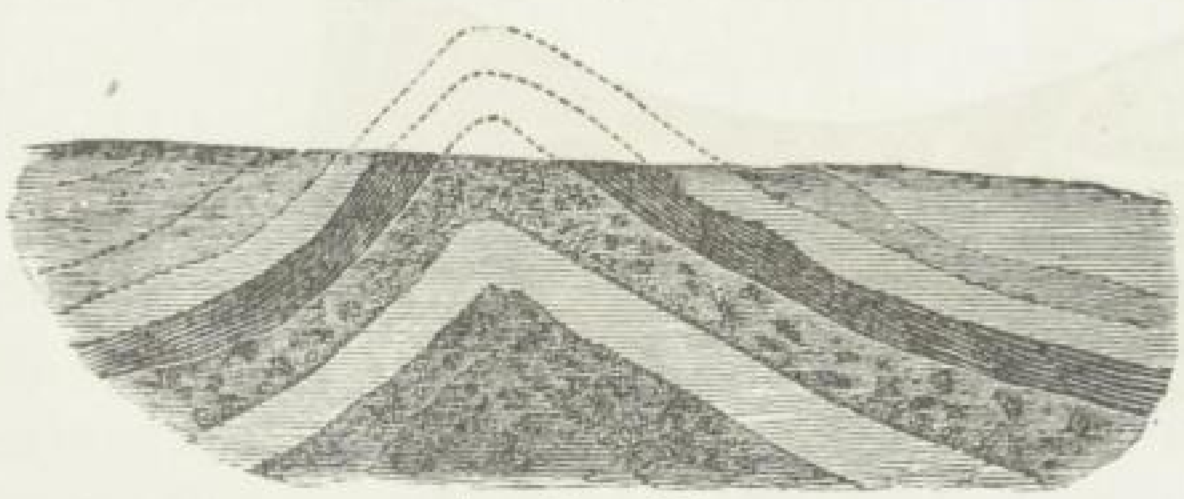
PECULIAR CONDITIONS OF ORE-BEDS.

§ 11. The extension of a bed in a horizontal line is called the *strike*; hence a horizontal line on the surface of the beds shows the *direction of the strike*. The slope of the layers, or the angle which the beds make with the plane of the horizon, is called the *dip*, which is consequently at right angles with the strike: the *direction of the dip* is the point of the compass towards which the beds slope. The direction of the strike and that of the dip, is determined by means of a pocket compass, while the angle of the dip is measured by an instrument called a clinometer.

When a bed is much folded, the general strike and dip must be determined, in addition to the strikes and dips of the different portions of the layer.

The layer immediately under the metalliferous bed is called the *floor* or *footwall:* that lying directly over it, the *roof* or *hanging wall.* The thickness of the beds must always be measured in a line perpendicular to the walls; it may be very variable in different portions of the same bed; and the bed, by thinning out, may entirely disappear. The *outcrop* is that portion of the bed appearing at the surface.

Ore-beds, like other strata, sometimes are much distorted, forming flexures, basins, saddles, and even air-saddles, when the upper portion is removed by denuding action.



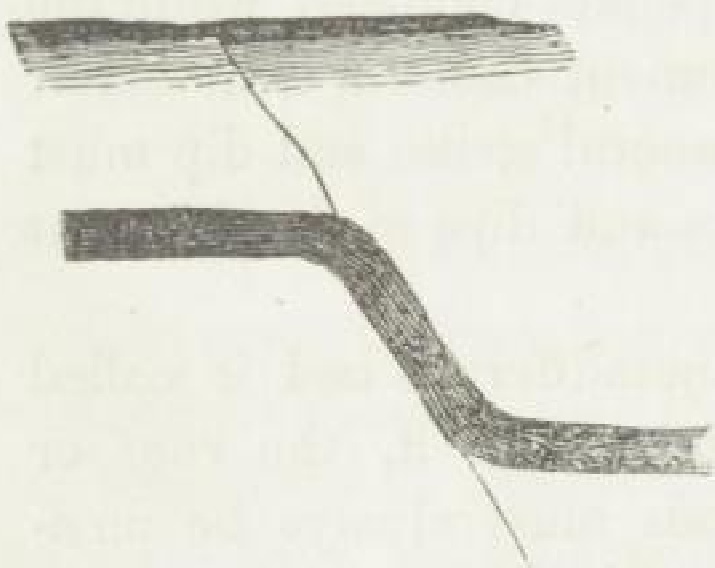
An air-saddle.

The beds are sometimes divided by intervening layers, so as to form two or more branches separating at a very acute angle. A disturbance of the strata is also frequently occasioned by *faults,* which will be more fully treated of under the head of veins. The mass of the bed is sometimes most curiously distorted and dislocated by such disturbing influences, as shown in the accompanying woodcuts.

1

2

3



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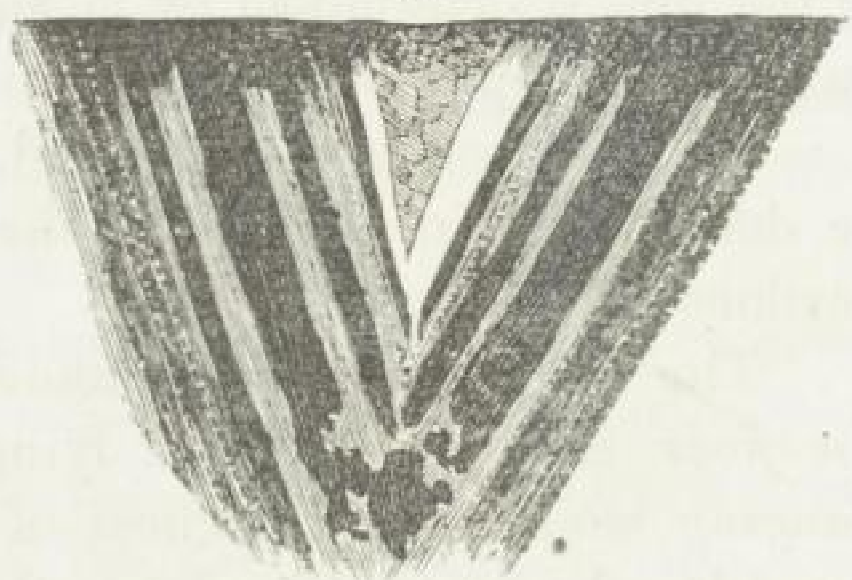

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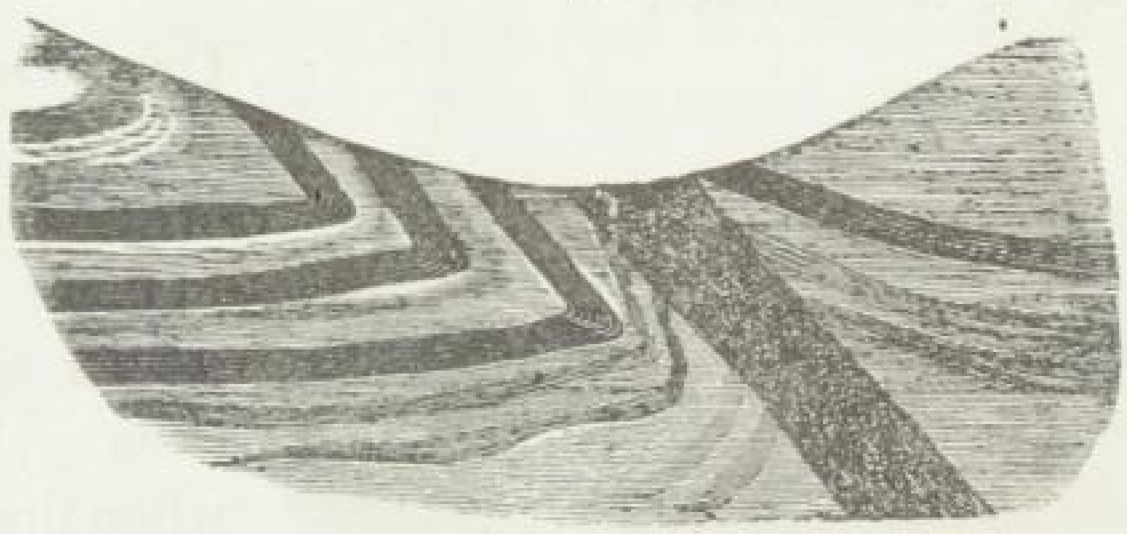


In the fifth figure the strata are *synclinal*; did they slope away from one another, they would be *anticlinal*.

The ore-beds do not possess so great a variety as the veins, segregations, and impregnations, in regard to their extent or composition; as a rule they are enclosed between two nearly parallel layers of rock, whose limits are not always apparent, since the bed frequently passes imperceptibly into the wallrock.

OCCURRENCE OF ORE-BEDS, AND DISTRIBUTION OF THE ORES IN THEM.

§ 12. True ore-beds can, from their nature, only occur in stratified or, at least, foliated rocks, or on the surface; they occur in rocks of all ages belonging to this class, the oldest as well as the most recent;—occurring, as a rule, more commonly and of a more complex nature in the older formations than in the more recent.

Of all ores, those of iron occur the most frequently in beds; in the case of other ores the distinction between true beds and zones of impregnation, recumbent segregations and bedded veins, is extremely difficult to determine.

Many beds consist of one or more layers of compact or granular ore, as limonite, hematite, magnetite, spathic iron, spherosiderite, and clay-ironstone. The ores in such cases naturally occur pretty evenly distributed, only depending in amount on the variations in thickness. Such deposits may possess sharp and well defined limits at the floor and roof, they may also pass imperceptibly into the enclosing rock.

In some metalliferous beds, especially those consisting of spherosiderite, the mass of ore forms one or more layers of nodules in a particular bed or zone of some stratified rock. These nodules may be so isolated as hardly to form a bed; in which case they may be regarded as scattered recumbent segregations or nodules. The texture of many iron ore-beds is oolithic, in which case the limits are more or less clearly defined.

Other ore-beds consist only of an aggregation of very small particles of ore in a distinct layer or stratum, as the copper slates *(Kupferschiefer)* of Thuringia, and the Fallbands in the crystalline schists of Scandinavia, which are probably more correctly impregnations. In this case the limits are generally not well defined, and the distribution of the ore is irregular: that is, the bed contains richer and poorer portions. The reason of this has not, up to the present time, been discovered; consequently, the ore can only be found by chance.

A true ore-bed can never possess a combed texture with symmetrical layers, this being only found in veins. A true bed can, also, hardly possess a real irregular granular texture, and the irregular distribution of ore so often combined with it.

The composition of ore-beds, in general, is a much more simple one than that of lodes.

Sometimes an ore-bed shows itself particularly rich in the neighbourhood of intersecting veins; this inequality, as a rule, is not original, but caused by impregnation from the veins. In placers the particles of ore are distributed according to purely mechanical laws, which will be more fully spoken of in § 15.

ORIGIN OF ORE-BEDS.

§ 13. There can be no doubt that all true ore-beds were originally formed by mechanical or chemical precipitation from water. Their condition may have been much changed afterwards; thus under certain conditions hematite may have been formed from limonite, etc.; but their origin remains a precipitation. However certain this may be, still the origin of the metalliferous portions of some of the beds remains unexplained.

Iron is a metal so widely distributed in its different forms, so common in all rocks, and held in solution in so many springs; that the origin of the strata, in which it predominates, appears by no means obscure. On this account deposits of iron-stone only require an explanation of their state of aggregation and manner of occurrence in each particular case. The case is different with most of the other metalliferous beds, such as those of chalcopyrite, and copper-slate; in these the origin of the metals is still somewhat obscure, and by no means so easy of explanation as in the case of iron-stone beds. The metals they contain must necessarily have come from the interior of the earth, whether in a state of vapor or dissolved in water; that is, they must have formed, in some other condition, a part of the earth's crust or interior; their concentration in a bed was always the result of secondary causes.

The presence of ore in fragmentary deposits and placers is easy to explain. They come from the mechanical destruction of metalliferous rocks by the action of water; a natural process of dressing has concentrated the heavier portions in particular layers or localities.

PROSPECTING FOR AND FOLLOWING OF ORE-BEDS.

§ 14. The prospecting for and following of an ore-bed is based on much simpler principles than those for the other metalliferous deposits. If it be supposed that a certain district contains a bed of ore, it is only necessary to examine the strata carefully, in the order in which they occur; any other method would be erroneous; the search can be made by means of adits, borings, trenches, or shafts. Only when traces of such a bed have been discovered, is it advisable to follow it in the direction of its strike and dip, in order to ascertain if it develops greater width or richness in any direction. Naturally, the inferior and superior layers forming the walls, must be chiefly observed; since the continuation of the bed can be looked for only between them; and as they are frequently, from their greater thickness or peculiar character, easier to recognise than the outcrop of the bed itself, they lighten the tracing. It is self-evident, that all disturbances of the original stratification, all foldings or faults, must be carefully observed.

Sometimes probable conclusions can be drawn *a priori* from the encreased or diminished thickness of the whole strata, or from the manner in which it was originally deposited in basins or saddles. All these conditions are unfortunately of such a nature, that no general rules can be deduced from them; much more depends on a sound and careful observation of the special case; and it is thus that geological education, observation, or knowledge of details, is proved.

SURFACE-DEPOSITS.

§ 15. It is well known that gold, platinum, tin ores, and many precious stones, are very frequently found in loose aggregates on the surface of the earth, in which undoubtedly they were not formed, but were brought there by the destruction of other deposits. These deposits have been called *surface deposits*, *placers*, or *washings*; this last, because the metallic particles or gems are obtained from the bed by various manners of washing; and also because a concentration takes place by means of a natural crushing and dressing.

All surface-deposits have been formed by the destruction of some other kind of deposit. During, or after the decomposition, the greater part of the enclosing rock, being specifically lighter or more easily dissolved, is, as a rule, carried away by the water. Only a portion of the same remained with the specifically heavier and less easily destructible metallic or ore particles, and has been again deposited with these. This is the reason why for the most part only gold, platinum, tin ores, or certain hard precious stones, magnetite, specular iron, and a few rare metals or metallic minerals, are found in surface-deposits. Precisely these minerals are, but slightly, or not at all, decomposed by the action of water and the atmosphere, and they, also, possess a greater specific gravity than many other mineral bodies.

This manner of origin is at the same time the reason why the very heavy and indestructible metals gold and platinum are, in comparison with their rare general dissemination, found so particularly often in surface deposits, and why their production from the same is so much more profitable than from the original deposits. However finely disseminated and sparingly distributed they were in these last, they are being, or have been, concentrated in the surface-deposits as if by an artificial dressing; and hardly any portion of them has been lost. In fact it has already been often found that the working of such deposits was very profitable; while it was impossible to find the original deposits or, when found, to work them with advantage; because the ores were in them too sparingly distributed. The surface-deposits generally possess the advantage of an easy working of their loose, and never thickly covered material.

The origin of the deposits may be twofold, and the deposits have certainly been formed in both ways, the only difficulty being to determine at times in which of the two.

Many surface-deposits lie, even now, over the deposit, from partial displacement of which they originated, covering its outcrop, or on its very site. Others, on the contrary, have been deposited at various distances from their original source. The first were formed on the spot by weathering and partial erosion; the last, through precipitation; in that the brooks, rivers, or streams of some kind, tore the material away and deposited it again in another place, at the same time separating the heavier and lighter portions from each other. The first, those which have been formed on the spot, are the most rare, and generally the poorest. They are characterized by their position on high table-lands or even on mountain declivities, as also by the homogeneous nature of their composition from the products of weather-drift: they are not formed of matter which has been washed together, and in certain cases been rounded, nor of sand and mud.

The last, the deposits which have been washed together, are always found only in indentations of valleys, basin-shaped depressions; or low ground, for example, in true valleys, or at the foot of mountains. They show a much greater complexity in their composition, being composed of mud, clay, sand, boulders, etc. The heavy metalliferous particles are much more concentrated in particular spots, than is the case with the former class. The solid bodies in them are generally rounded by the action of water. They are also very differently composed, according as they were formed by only one water-course, or several. The surface-deposits appear always to belong to a very recent age: many are still in process of formation; in others the operation is long since finished; in, or over, some of them remains of animals, belonging to the Post-tertiary period, have been found. It is doubtful whether any surface-deposits exist, of a more remote age, than the Post-tertiary; all known real metalliferous surface-deposits may be provisionally referred to the same.

From the manner in which surface-deposits originated, certain general and even *a priori* rules about those spots where they are richest, may be deduced from physical laws, which have also been confirmed by experience. Here are the following:

1. Where surface-deposits have been formed over those from which they sprang, the distribution of the metals, corresponds to what it was in these last.

2. When surface-deposits have been washed together, those spots will be relatively the richest, where the current was broken, whether by a more moderate descent, sudden change of direction, or the discharge of a side-stream. The absolute richness, the special relations, must be determined for each particular case by experience; the size and weight of the particles, which have been washed together, being taken into consideration.

3. Slight depressions, holes; channels, and open fissures, in the solid rock over which the current passes, are often particularly rich.

4. The deepest layers of each period of deposit are generally the richest.

5. Sometimes several periods of deposit have followed one another, and then several especially rich layers lie one above another.

6. Not only the present river-channels, but especially ancient channels, must be carefully examined.

Besides such general rules, which every one can deduce for himself, no particular characteristics of the richest spots can be given; especially none which can be deduced from the mineralogical nature of the mass washed together. This varies very much in the different sedimentary deposits according to their origin, being now clay, now sand, again gravel; conclusions as to the origin of the metallic particles can at times be drawn however from their composition.

METALLIFEROUS VEINS.

WHAT ARE METALLIFEROUS VEINS, OR LODES?

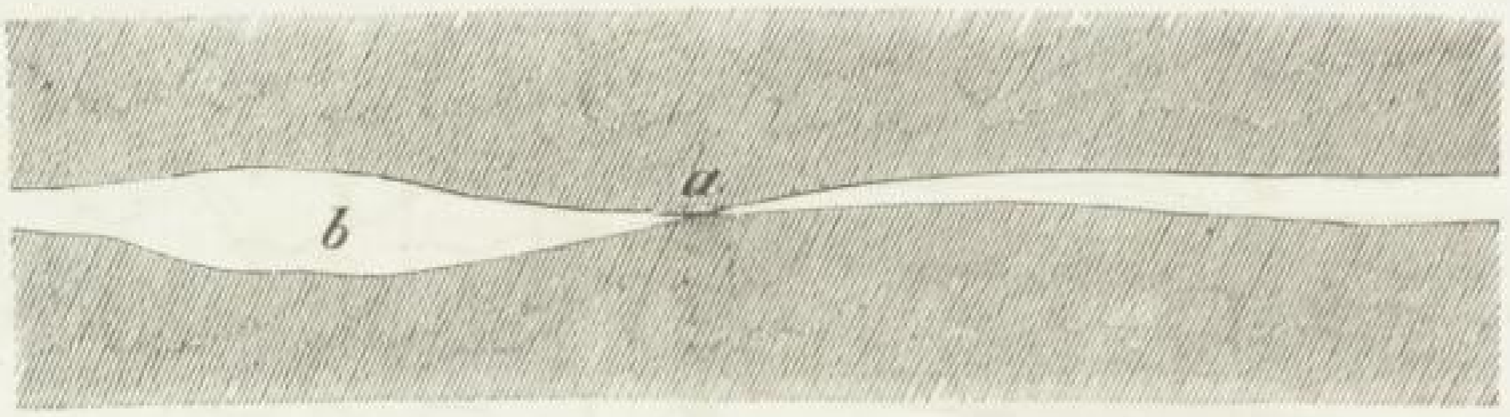
§ 16. Veins are aggregations of mineral matter in fissures of rocks. Lodes are therefore aggregations of mineral matter containing ores in fissures.

As all veins are aggregations in fissures, their form necessarily approaches the tabular. Veins are never really tabular; as they not only thin out gradually towards their ends, but very frequently exhibit irregularities in their whole extent, which are caused by unequal breadth, and deviations from the plane of their course.

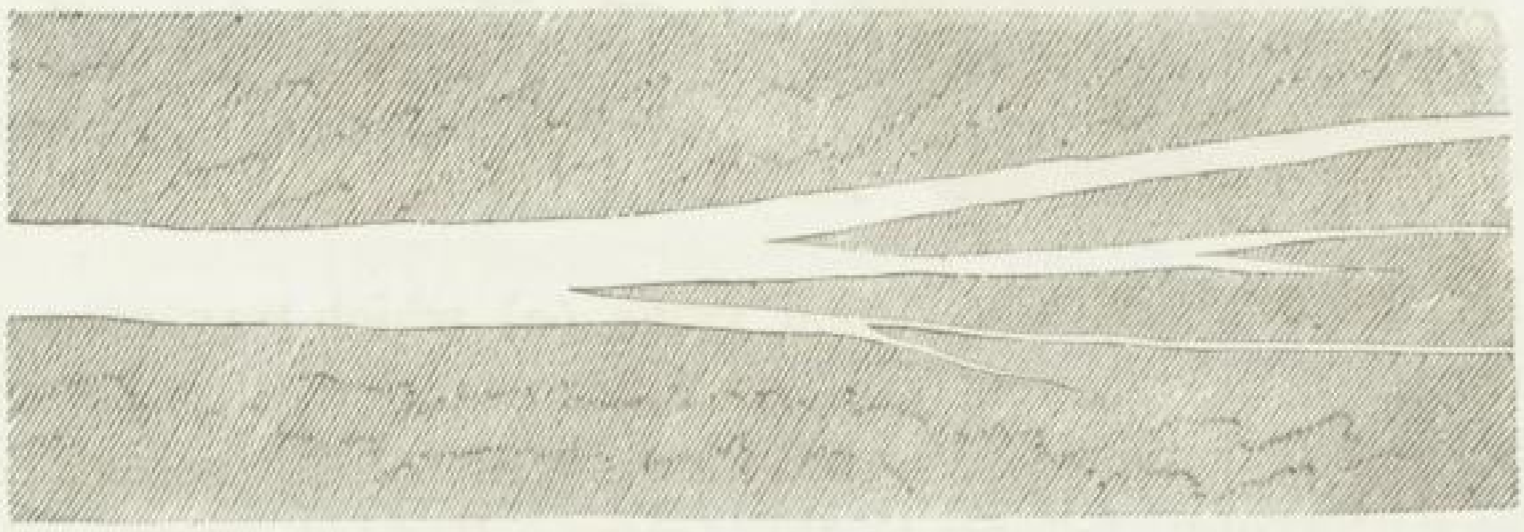
The rock in which a lode occurs is called the *country*, *country-rock* or *wall-rock*; or those sides next to the lode, the *walls*; or when the lode is not perpendicular, the wall over it is called the *hanging wall*, that under it the *foot-wall*. The extension of a lode in a horizontal direction is called the *strike*; the angle which it makes with the plane of the horizon, the *dip*. If the sides of a lode make many undulations, the dip must be taken a number of times: the average of the observations is the true dip. A *cross vein* or *flucan* is a vein containing no ore. A *branch* or *leader* is a small vein striking out from the main lode. A *selvage* is a thin band of earthy matter between the lode and the walls, or the sharp line of demarcation often observed between the lodes and the wall-rock. The *outcrop* is that portion of a vein appearing at the surface.

The breadth or size of veins is very variable: some are not thicker than a sheet of paper, while others are several hundred feet thick. Under these circumstances it is impossible to give a mean breadth for lodes; although, as a rule, most paying lodes average between 6 inches and 5 feet.

A vein is in the cap, when it is much contracted.



A vein is said to split up, when a single broad fissure is divided into several smaller ones.

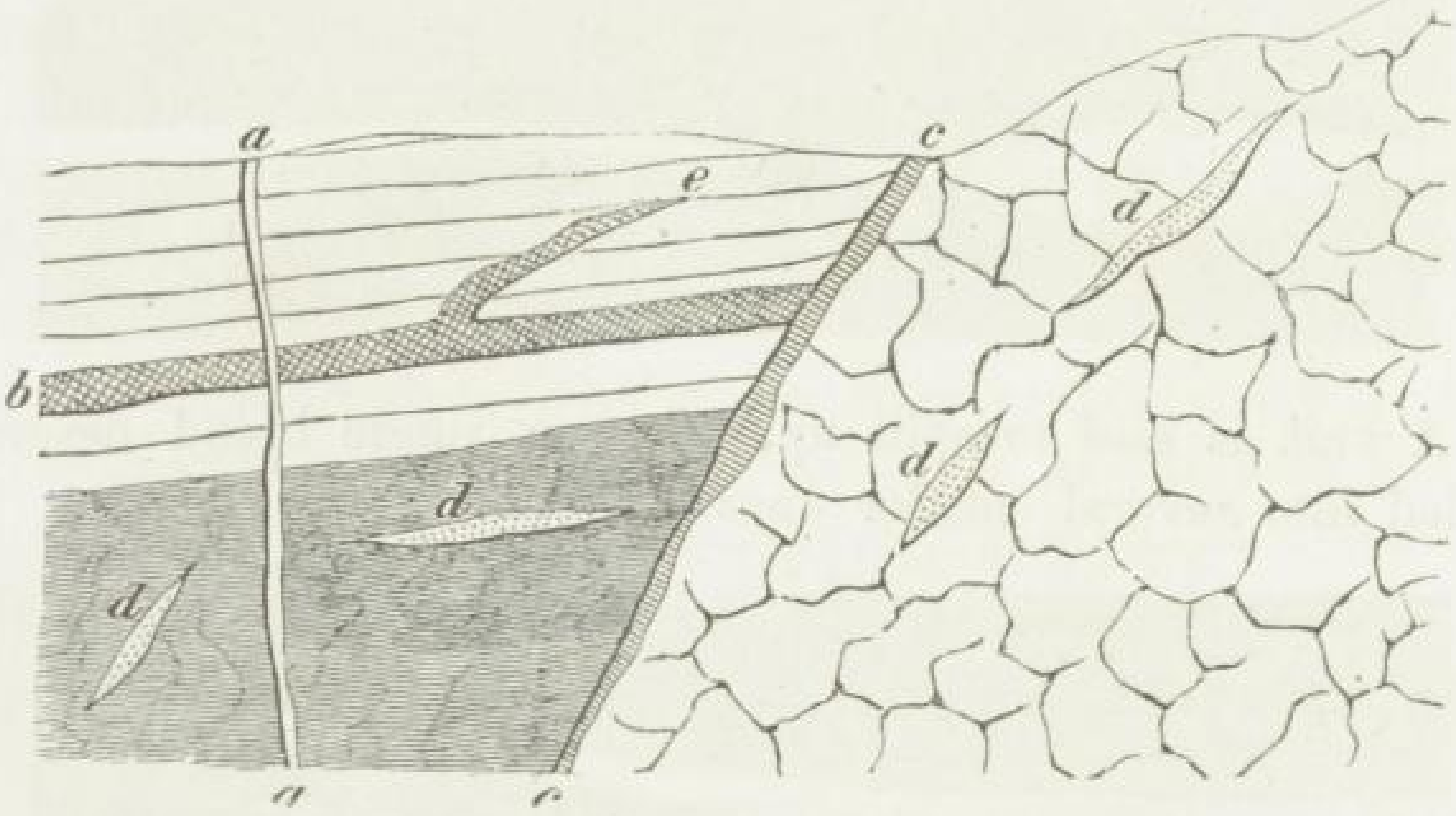


The broader veins are, so much the more regular is their course, and so much the nearer do they approach the tabular form. Very narrow veins are often very irregularly formed. The length of lodes, like their breadth, is very variable. As a rule, the broadest veins are the longest. Many so-called *shorts* or *gash-veins* are only a few inches long, and are generally confined to a single member of the formation in which they occur, while many lodes have been traced for a distance of over five miles. The depth, to which fissures extend, must at all events hold a certain relation to their breadth, and still more to their length. The bottom of *true* veins has probably never been reached; although many *shorts*, as well as many veins which contain only aggregations of rock, thin out towards the surface or the bottom.

CLASSIFICATION OF VEINS.

§ 17. Veins have been divided, according to their texture and the extension of the country-rock, into

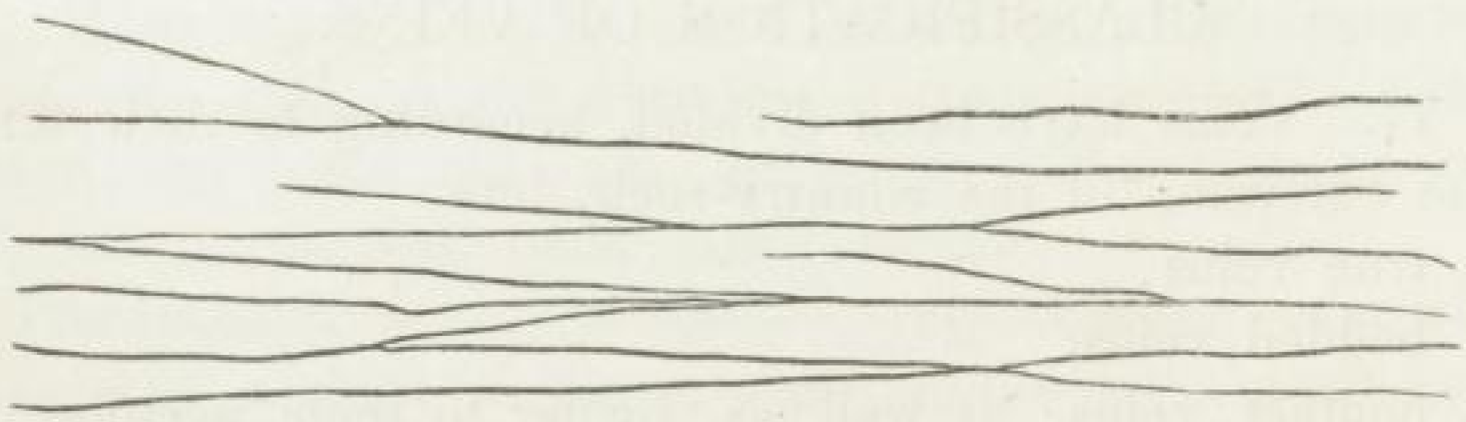
1. true veins,
2. bedded veins,
3. contact veins, as well as, owing to their peculiar form and extent,
4. lenticular veins.



By the first are understood veins (*a*) which traverse a rock or formation independently of its texture and position, and not parallel to its stratification or foliation: most of the veins around Freiberg, Saxony, belong to this class. Bedded veins, on the contrary, are those (*b*) which traverse the *country* parallel to its stratification or foliation: they might be easily mistaken for beds, were it not for their secondary character (fissure-nature), which is characterized by peculiar circumstances, as for example sending out branches as by (*e*). Contact veins are those which occur between two dissimilar formations, as by (*c*), and consequently, separate the formations from one another.

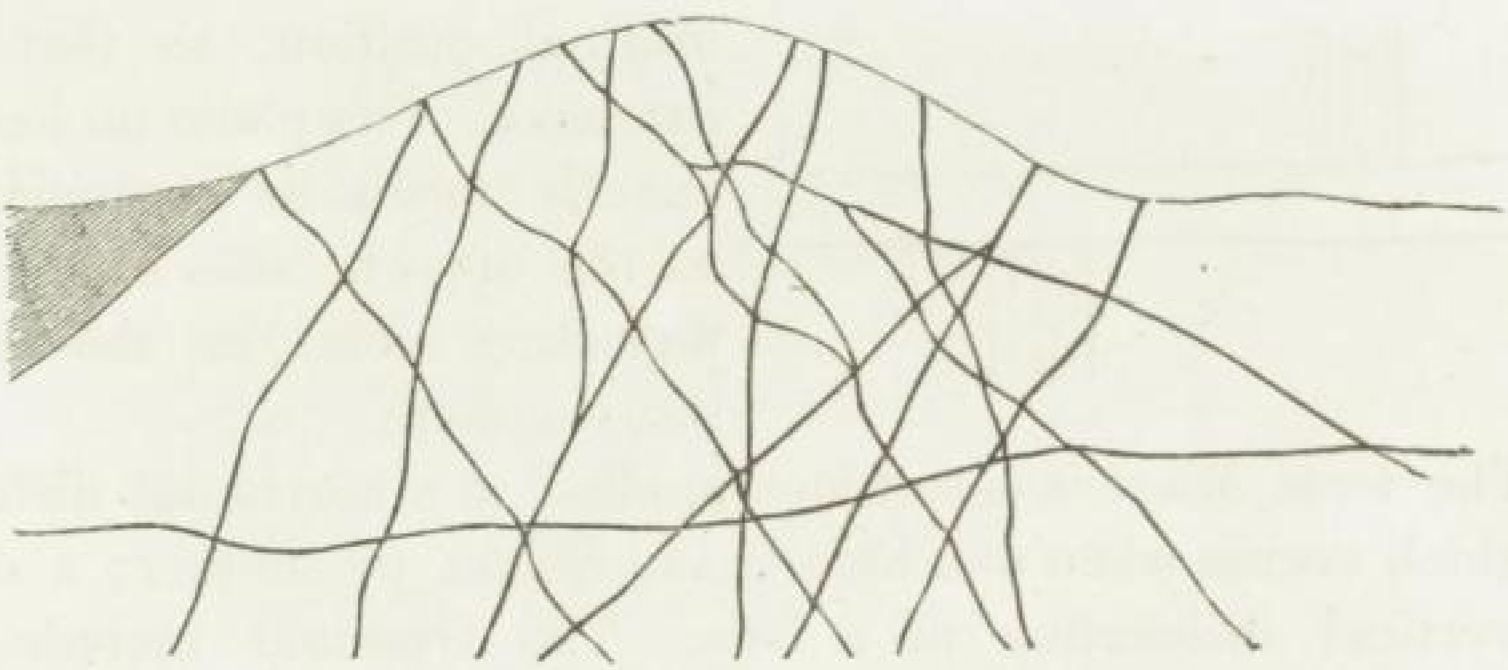
Lenticular veins are those which thin out in all directions, as by (*d*), which are in part, however, only local expansions of really continuous fissures, in part, on the contrary, lentiform secretions, and are not then properly veins.

In every district where metalliferous veins occur, there are generally quite a number of them together, which often seem to form groups in which they are parallel to one another, as follows:



The veins of Clausthal in the Hartz form a very characteristic example of a group.

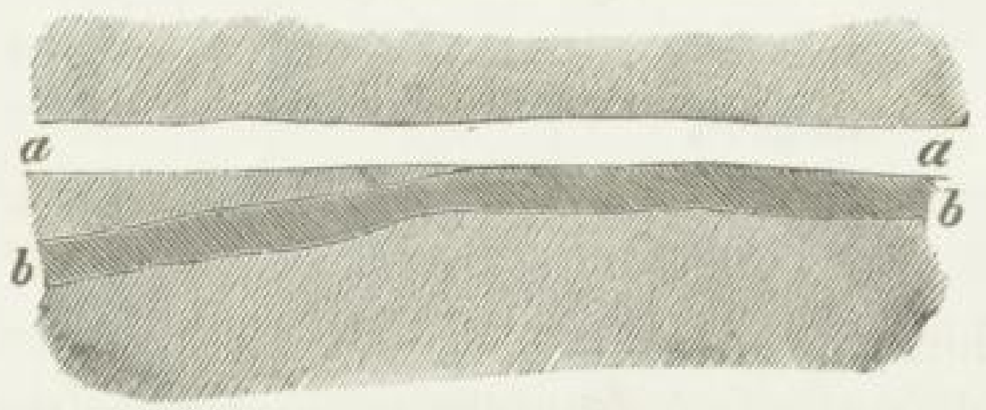
When on the contrary, as sometimes happens, a district or rock is traversed irregularly in all directions by a net-work of



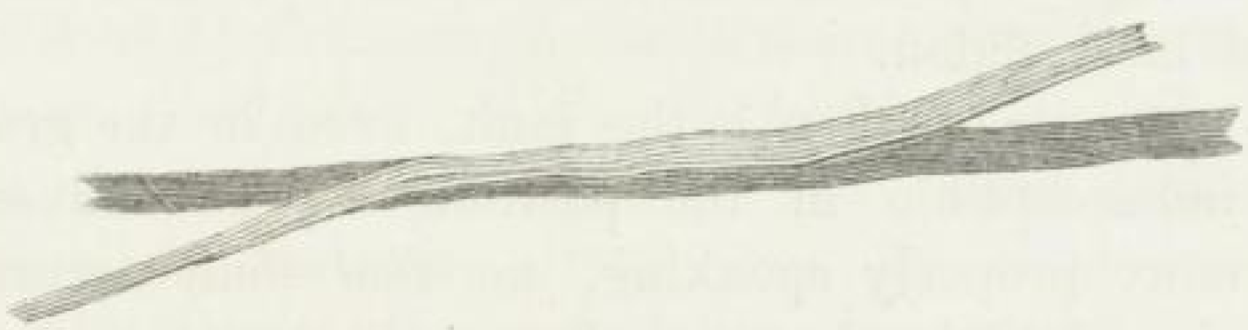
veins, this district or rock is in Germany called a *Truemerstock*; of which Altenburg and Zinnwald in Saxony are examples.

INTERSECTIONS OF VEINS.

§ 18. Where two veins intersect one another, they form *junctions*. It is self-evident that the intersecting vein must be more recent than the one intersected, as it fills a fissure in the latter. All veins which meet one another do not intersect. Some veins are most intimately combined at the point of junction; the fissures, in the earth's crust, in which they lie having been cotemporaneously filled: others which meet at a very acute angle run parallel to one another, one or both of them bending and altering their course. Generally but one of them changes its direction, in which case it is always the one last formed (*b*).



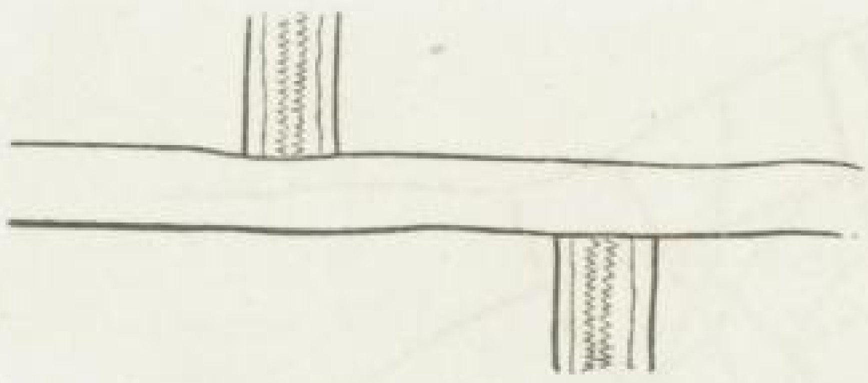
It sometimes occurs, that such veins, after running parallel to one another, form a junction and intersect; as in the following woodcut.



Many veins after once coming in contact continue parallel to one another, and are then called double veins.

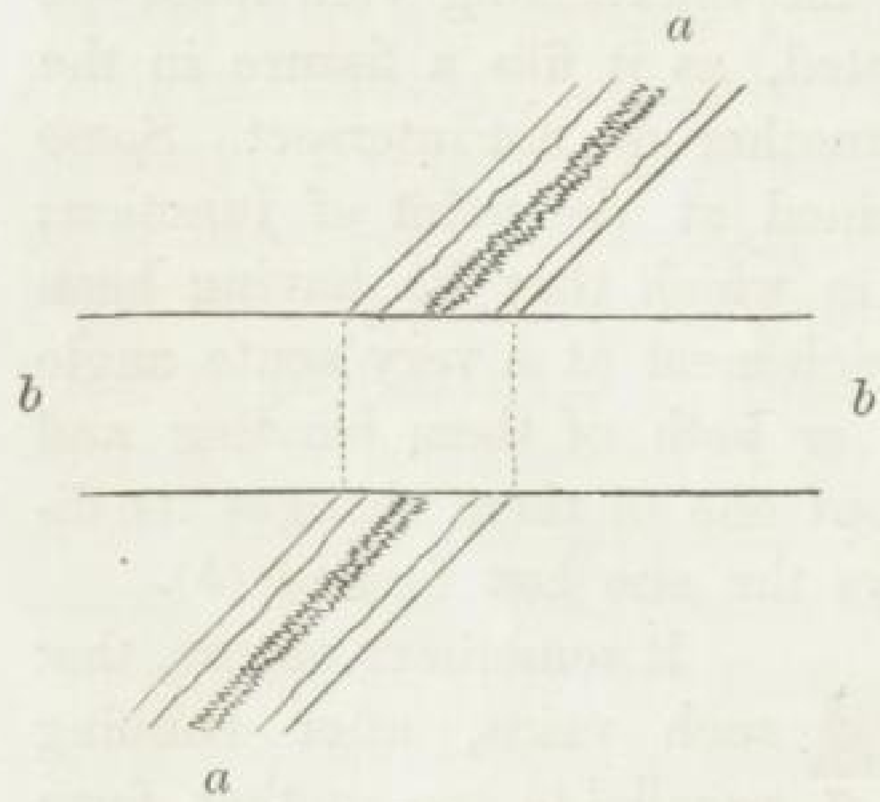
FAULTS.

§ 19. With the intersections of veins is frequently joined a *fault*. A *fault* is a dislocation of an intersected vein from its



original position, so that the extension of its plane no longer exactly meets its continuation on the opposite side of the intersecting vein, as shown in the wood-cut.

The term *heave* is sometimes applied to a horizontal dislocation which occurs when one lode is intersected by another; a *slide* is a vertical dislocation of a lode. The Germans include all the above under the common name *Verwerfung*. All faults are caused by a movement of the country; although such a motion does not necessarily cause a fault. It is only necessary that the hanging- or foot-wall should have been dislocated; on the other hand both walls may have been dislocated in contrary directions or with different degrees of intensity. Most faults are to be



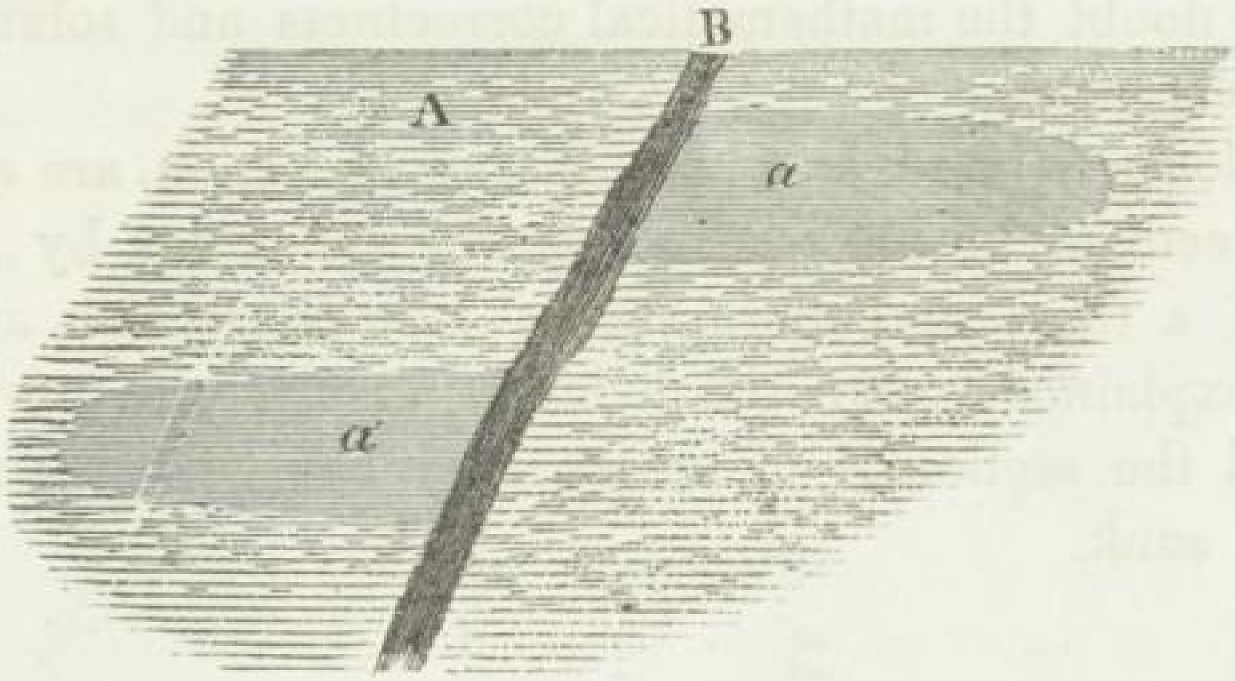
explained by a sinking or rising of the hanging- or foot-wall; some by a horizontal dislocation, or even by a subversion. The appearance of a fault may be caused merely by the opening of a fissure; when, as in the wood-cut, the vein-fissure (*b*) intersects an already existing vein (*a*) obliquely, instead of at right angles.

In all faults the extent to which the vein has been thrown is dependent on

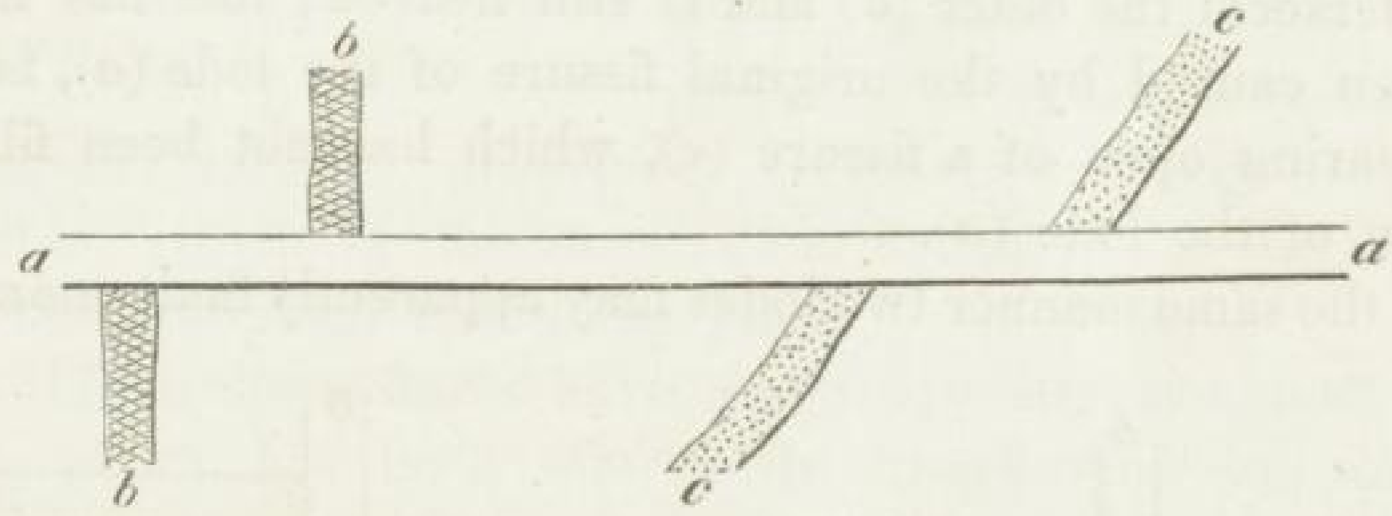
1. the extent of the dislocation, and

2. the angle which the direction of the motion makes with the line of intersection.

If this angle = O, then is the fault, even in the greatest dislocation, imperceptible in the position of the halves of the vein; or more properly speaking, no real fault occurs; it can only be recognised in the dissimilarity of the contiguous halves of the (intersected) vein which have been severed by the intersecting vein. In the following wood-cut the vein *B* has not heaved the lode *A*, which is here supposed to lie in the plane of the paper, out of its plane, but has thrown up the zone (*a*) more on one side than on the other. When this angle = 90°, the fault appears as great as the motion has been.



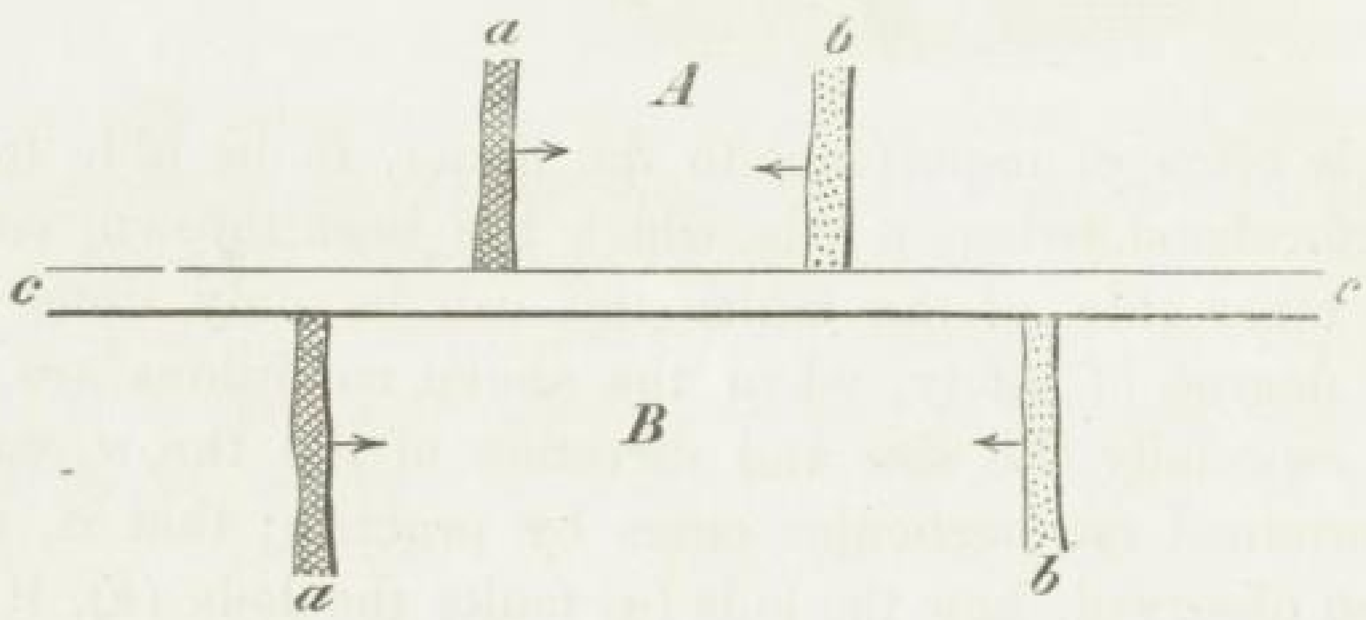
It is often of importance to the miner, to be able to determine beforehand, where a lode, which has been thrown, continues on the other side of the fault: this can be only done with a certain degree of safety, when the above conditions are known. These, especially the size and direction of the throw, can only be determined for particular cases by practice; that is, when it has been observed, how the lode (*a*) faults the lode (*b*), it can be calculated how the same lode *a* would fault a third and older lode (*c*).



It is self-evident, that under such and similar circumstances the position of the lode sought-for can be accurately calculated. This mathematical portion of the Theory of Veins is specially treated of by Schmidt in his '*Theorie der Verschiebungen älterer Gänge*', Frankfurt, 1810; Zimmermann in his '*Wiederausrichtung verworfener Gänge, Lager und Flötze*', Leipsic, 1828; by Von Carnall in *Karsten's Archiv*, vol. IX. 1832; and by Ch. Combes in his '*Traité de l'exploitation des mines*', vol. I.

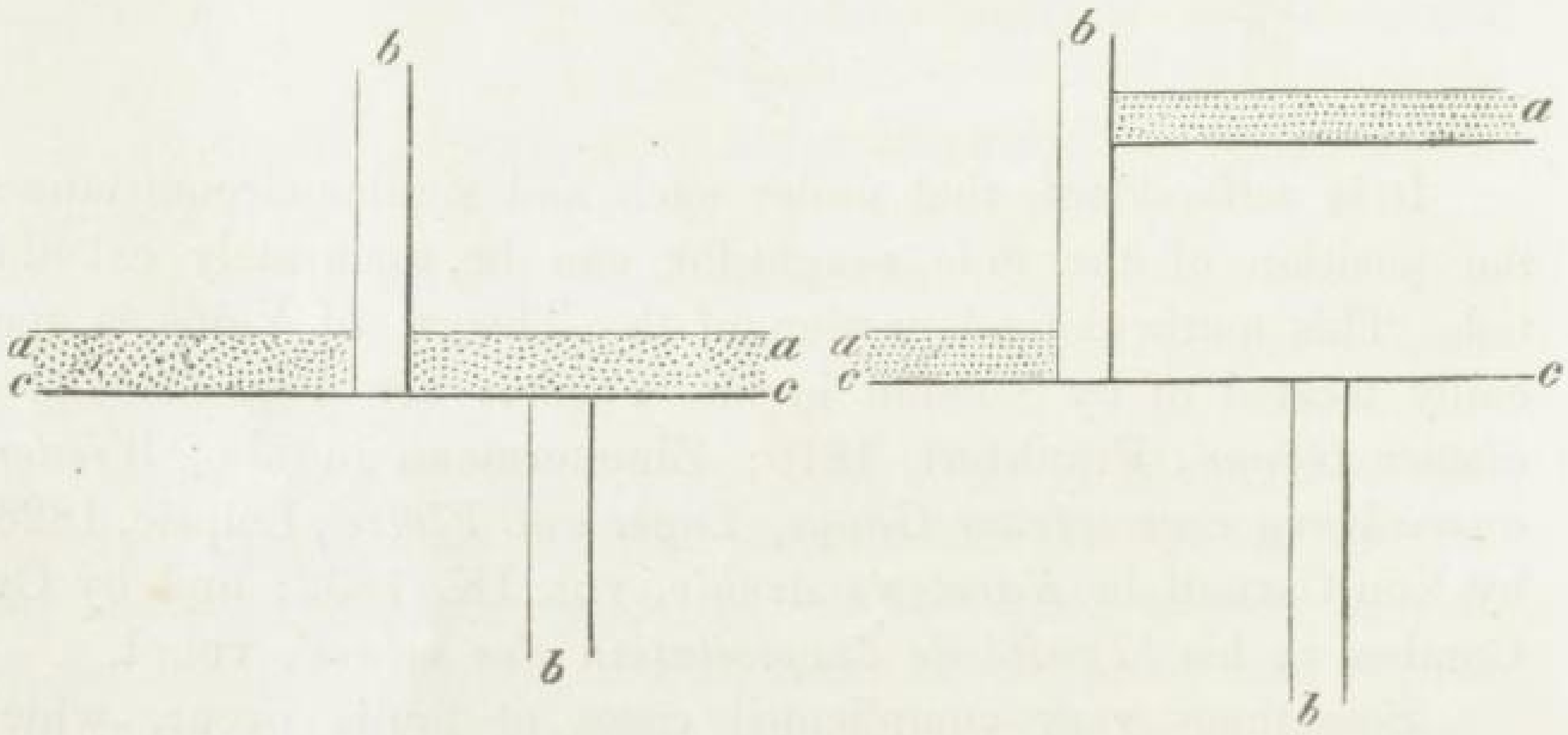
Sometimes very complicated cases of faults occur, which appear hardly explicable; until the position of the planes of the lodes is exactly known, and it has, at the same time, been determined, which of the fissures were combined with the faults. A few examples may serve to give an idea of the great possibility of such complicated cases, whereby no one should permit himself to doubt the mathematical correctness and solution of all these appearances.

Two lodes (*a*) and (*b*), which, in a cross-section, are apparently parallel, seem to be heaved in opposite directions by the intersection of a third and more recent lode (*c*); which appearance is easily explained, when the lodes (*a*) and (*b*) dip towards each other, and the section *A* of the country has been raised, or the section *B* sunk.



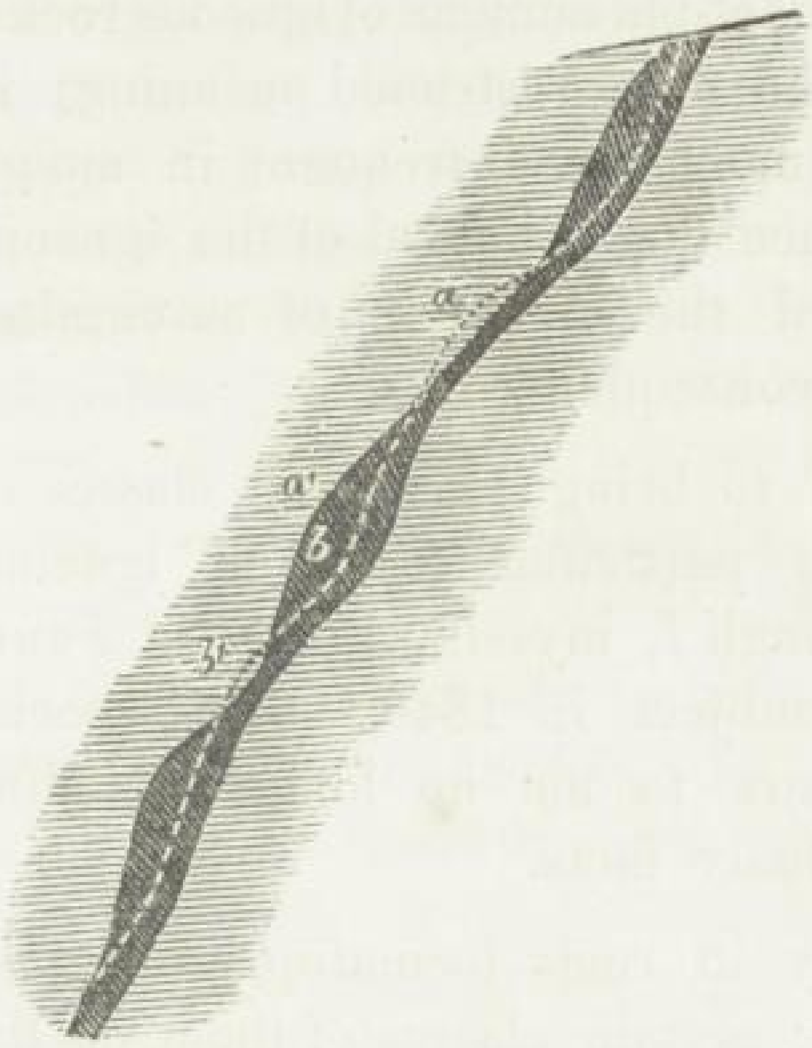
Further, an older lode apparently faults a more recent one; as for example, the more recent lode (*b*), in the following woodcut, intersects the older (*a*) and is still heaved; this has however not been caused by the original fissure of the lode (*a*), but by a later tearing open of a fissure (*c*), which has not been filled, by the side of the lode (*a*).

In the same manner two lodes may apparently fault one another.



RESULTS OF DISLOCATIONS.

§ 20. When one half of a rock-mass, traversed by a fissure, has slidden up or down, other phenomena besides faults may be produced.



The white dotted line is supposed to represent the vertical section of the original line of the fissure, owing to dislocation the parts a and a[1], b and b[2], which originally were opposite one another have taken the positions shown in the figure.

For example: 1. great irregularity in the thickness of the mass filling the fissure of the slide. As the fissures rarely follow true planes, but are more or less curved; it frequently happens, that the convexities, as also the concavities, of one of the walls are opposite those of the other.

In the extreme case, which the woodcut represents, and in all similar ones, the width of the fissure or thickness of the lode must of course be locally very variable.

2. By reason of the dislocations, which cause a violent trituration of the walls on each other, *slicken sides* or *friction surfaces* are very commonly produced, which exhibit a smooth, sometimes, even polished surface: on these parallel furrows, grooves or scratches are very frequently perceptible, which at the same time indicate the direction in which the dislocation has taken place.

3. These dislocations have also frequently produced a fine powder, which has been afterwards transformed by softening into a sort of clay. The origin of many clay veins and clay selvages can be explained in this manner, while some are perhaps only the result of decomposition.

OCCURRENCE OF LODES.

§ 21. As a rule, lodes occur associated together; so that when one lode has been discovered, there is a great probability that others of a similar kind will be found in the neighborhood: they are generally arranged in groups tolerably parallel to one another, and form what the Germans call a *Gangzug*, of which several may traverse the same district in different directions. As for example, at Freiberg.

Lodes are also usually found in regions, in which igneous rocks have burst through crystalline schists or stratified deposits. In a general sense they belong to the contact-phenomena of igneous rocks, many are even contact-veins in the more restricted meaning; in consequence of which, they are much more frequent in mountainous regions than in plains; since the upheaval of the igneous rocks has very commonly caused the elevation of mountains, either directly or, at least, as a consequence.

Fournet has even attempted to bring particular classes of lodes in causal combination with particular kinds of igneous rocks, to co-ordinate them. Although I, myself, translated *Fournet's* instructive treatise on this subject in 1846, still a special co-ordination of this kind appears to me no longer tenable, although the idea is upheld by many facts.

Lodes occur more frequently in rock formations of great age, than in the very recent ones: certain classes of them, as the lodes of tin ore, are found only in the oldest rocks. The more recent the formation of the igneous rocks, so much the more rarely are they accompanied by lodes, the very recent only by lodes of ironstone. The fact of lodes accompanying igneous rocks by no means excludes the possibility, that the last should be traversed by them; it depends, much more, on a similar relation to their respective age; as in the case of the crystalline schists, and the still distinctly sedimentary deposits.

All these circumstances are in the best accord with the hereafter to be proved acceptation; that the fissures of lodes are the consequences of plutonic or volcanic concussions; their filling, the result of more or less deep underground, consequently in this sense plutonic, actions. The formation of fissures, as well as their filling, still continues. This continuous (only locally changing) process gives near the surface a different result from that in the interior of the earth; hence occurs the, to a certain extent, constant difference of age. Metalliferous veins, which, from their nature, were formed at a great depth, could first attain the surface only by means of a great, and consequently very long continued, decomposition and erosion of the rocks covering them. The less, on the contrary, the original covering (depth) was, under which they were formed; so much the more easily and rapidly could it (the covering) under otherwise like circumstances be destroyed, and what lies under it be laid free. All plutonic formations must consequently appear older, the greater the depth at which they were originally formed.

There may, indeed, be exceptions to this rule, when the decomposition and erosion has in any place been very energetic and rapid; but the general rule is not altered by such exceptions. In the prospecting for, and tracing of, metalliferous veins, it is well to keep this rule in mind. I will return to this subject hereafter.

BREADTH, STRIKE, AND DIP, OF LODES.

§ 22. As already remarked in § 16, it is impossible to give a mean breadth for lodes in general; there are some exceeding a fathom in breadth, although the majority remain under this. The breadth of each separate lode also is frequently very variable in different portions. This dissimilarity is, as we have seen, a consequence of slides, which the enclosing walls of the fissure have undergone, whereby every deviation of the fissure from a plane would cause a widening or narrowing of the same.

Nor can any determined general direction of strike and dip, or a measure of their extension in length and depth, be given. The direction of their strike and dip is indeed at times a tolerably constant one; they occur every where more nearly approaching a perpendicular, than the horizontal position. But even locally many variations occur in the strike and dip; and still less can two separate districts of veins be traced back to a special law of the strike and dip. If we consider that the upheaval of igneous rocks has caused the formation of fissures, it cannot well be otherwise, since the extent of their length follows no determined law. What *Rivière* states in the *Compt. rend. Vol.* 45. *p.* 969, about the constant direction of lodes, especially those in Europe containing galena and blende, appears to me to be a fantasy similar to that of *Elie de Beaumont* concerning the law of crystallographic elevation.

The extension of lodes in the direction of their dip is, certainly, in most cases a far greater one, than has yet been attained in mining. It is customary to follow lodes substantially in both directions, only so far as they give hopes of profit. In the direction of the strike, that is essentially conditioned by their contents; for when a vein has been followed, as an almost sterile fissure, for a couple of hundred fathoms, the search in that direction is generally given up; while it is very possible that it would, in the next hundred fathoms, prove very rich. In the direction of the dip, that is in depth, the following of a vein is much more difficult, on account of encreased difficulties in exploitation; and is impossible beyond a certain distance. It may be said that, by the methods employed at present in mining, this distance must occur at a perpendicular depth of 3000 feet; and that probably a distance of 10,000 feet in the interior of the earth will never be reached. Under these circumstances it is very probable, that most lodes continue to a far greater depth, than miners can follow them. Up to the present time it has never been proved, that a lode has been followed to its end, that is to where the fissure actually ceased; most of the stated cases, concerning the wedging out of veins, or their becoming sterile with encreased depth, rest on the fact, that ores are generally irregularly distributed in the veins, and that trial workings are more difficult to drive in the direction of the dip, than of the strike. As long as the fissures exist, there remains a possibility of their widening out and containing ore.

On this subject see *Burat* in the *Annales des Mines XI. p. 27.* and *Pernobet, vol. XII. p. 307.*

The so-called 'Gash veins' play a very peculiar part in the experience of vein miners; they are veins which continue, or are at least only worth mining, for a short distance under the sod; and are always confined to one formation. It is possible that subordinate fissures of the earth's crust were mechanically filled with ore, from above inwards, and only for a very short distance; so for example with stream tin, gold sand, oolithic iron ore, etc. These are then no true fissure veins.

DISTRIBUTION OF ORES IN LODES.

§ 23. The unequal distribution of the ores in lodes is a very important subject for the miner, and interesting in a scientific point of view.

In very many lodes, especially those the gang of which consists chiefly of quartz, brownspar, dialogite, calcite, spathic iron, heavy spar, fluor spar or combinations of the same, the ores mingled with these are by no means equally, much rather unequally distributed; in consequence of which the richer spots are distinguished, from the poorer and sterile ones, by such names as chimneys, bonanzas, finds, nests of ore, etc. Such lodes are very seldom paying in their whole extent: as a rule, only separated aggregations, necessitating the search for other similar ones after these have been worked out. It would, naturally, be not only scientifically interesting, but also practically of the greatest importance, to learn, if possible, the causes or the law of this unequal distribution of ores. Unfortunately this has not, up to the present time, been discovered; approaches to this knowledge having been only recently begun, and most of the researches in this direction being still much scattered.

I shall attempt to collect here the most important researches already made, adding a few remarks:—these researches relate chiefly to differences of depth, breadth, country, local direction of strike or dip; and, as regards the lodes, to still unknown causes.

DIFFERENCES OF DEPTH.

§ 24. In many districts where vein mining is pursued, there exists, or did for a long time exist, the opinion, that lodes are only productive to a certain depth, all below this depth being sterile. This opinion has been caused in most cases by the circumstance, that the opening and working of mines are easier at small depths than at great ones, that the difficulties to be overcome encrease with the depth, and that in consequence much more extended trial-workings have been driven in the horizontal direction of the strike, than in the perpendicular or inclined one of the dip. When a chimney or pocket of ore accidentally ceased at a depth of 100 fathoms, the miners determined with much greater reluctance to sink 50 fathoms farther on a lode destitute of ore, in order perhaps to reach a new chimney, than to drift 50 fathoms in a horizontal direction. All statements relating to a real disappearance of the ore in a vertical direction are therefore to be accepted with a certain degree of distrust, and must be first subjected to a most searching examination. It is *a priori* very improbable, that lodes, as such, should cease at the proportionally slight depth which mining is able to reach. It is entirely another thing, when experience shows that the nature of the ore changes with encreasing depth.

That is already *a priori* probable; and mining experience would give many more proofs of the same, were not the field of observation such a limited one in the direction of the depth. There are but very few metal mines, which have reached a greater perpendicular depth than 2000 feet; by far the greater number of observations relate therefore to the slight zone of 2000 feet beneath the surface of the earth.

A certain kind of difference is very generally observed between the upper and lower depths of lodes; namely, those which are caused by decompositions and transformations of the outcrop. This is not a primary, but a secondary difference, caused by the penetration of atmospheric air, infiltration of water, etc. As really occurring this is important to the miner, but must be most carefully separated from real difference of depth; which, often difficult, is always more so, where both kinds of difference of depth occur together. I will first examine the secondary differences of the outcrop, and then pass to primary differences of depth.

GOSSAN, IRON HAT, CHAPEAU EN FER, PACOS, COLORADOS.

§ 25. The altered outcrop of lodes has received in different parts of the world these various names; which are all to be attributed, according to Haidinger's Terminology, to *anogene*[1] metamorphoses.

In Germany the outcrop or upper portion of many lodes, especially those rich in metallic sulphides, has been called Iron Hat (*eiserner Hut*); since the peroxide and hydrated peroxide of iron are formed by the decomposition of the sulphides containing a large percentage of iron (iron pyrites, magnetic pyrites, chalcopyrite, mispickel, blende); which, being disseminated through the whole gang, gives a predominant red or brown color. This mass resembles iron stone, and can in some cases be used as such. Other substances besides the metallic sulphides and spathic iron have been subjected to decomposition, but contribute less to the peculiar coloring of the iron hat; for example from galena, chalcopyrite and copper glance, all the other lead and copper ores have been formed. This formation of the iron hat in lodes, by the decomposition of the sulphides and spathic iron (frequently extending to a depth of many fathoms), naturally presupposes that the sulphides and spathic iron were originally present; and, as these are frequently combined with silver and lead ores or gold, it may be an indicator of rich deposits of ore. From this circumstance sprang the old German rhyme

[1] See § 171 foot-note.

Es thut kein Gang so gut,
Er hat einen eisernen Hut.[1]

This rule is subject to many exceptions, and only holds good for those districts of veins in which the sulphides occur with rich ore. The Cornish term Gossan has sprung from similar, but not always predominating ferriferous and red-colored, products of decomposition; the same is true of the Pacos, Colorados, and Negrillos of the South American miners, which frequently show a very variegated color caused by different oxides and salts of copper, chloride of silver (bromide and iodide of silver), salts of lead, etc.

The general character of these altered outcroppings of lodes consists in a decomposition and softening of the mass of the wall rock, lack of sulphides, predominance of metallic oxides, metallic salts, combinations with water, carbonic acid, phosphoric acid, arsenic acid, chlorine, bromine, iodine, etc., which frequently produce very dazzling colors: these products of transformation are frequently accompanied by metallic copper and silver, which have separated. With encreasing depth these products of decomposition pass over, often very gradually, into the sulphides and spathic iron, which at last altogether predominate.

PRIMARY DIFFERENCES OF DEPTH.

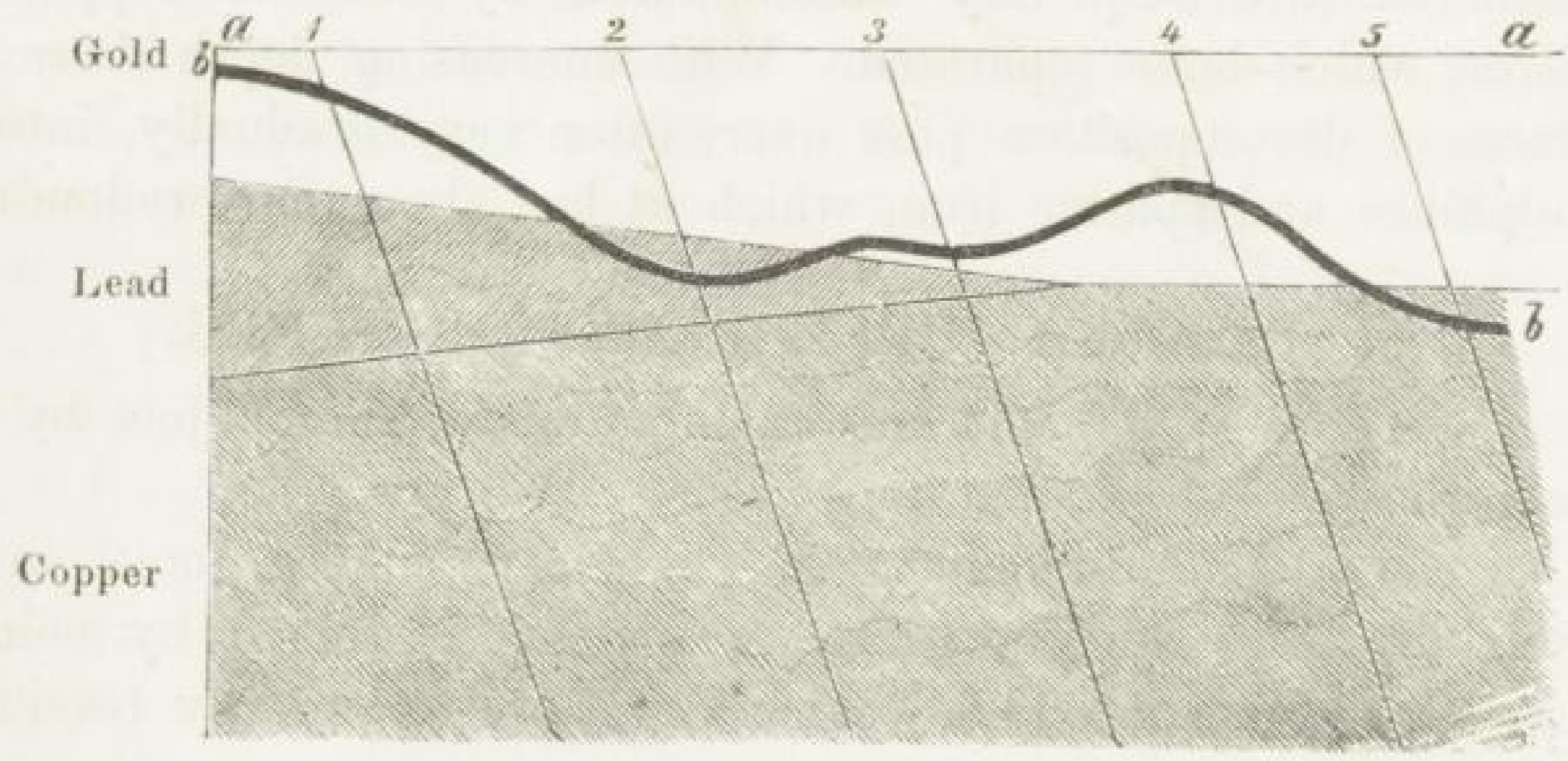
§ 26. I will begin the examination of this subject by enumerating a few examples.

1. On the Rathhausberg, Raurieser Tauern, etc., in the Salzburg Alps the crystalline schists are traversed by veins of auriferous quartz. These same veins are apparently traversing the neighboring valley gorges, which are in some places over 200 feet deep. These veins appear to contain no gold in the niveau of the valleys, at least this is only obtained from them on the tops of the mountains at a height of 6 to 8000 feet above the sea, and consequently under very unfavorable circumstances as regards climate. It would be in every way more profitable, were it possible, to work the lodes from the deep valleys; but the quartz veins appear to contain gold only in their upper portions, it being no longer present in those portions which have been laid open by the deep valleys. As this phenomenon recurs in many lodes of this district, it cannot be

[1] There is no lode like that,
Which has an iron hat.

properly assigned to chance. At Ponte grande, in the Province of Ossola, auriferous pyrites are only obtained at a height of about 3000 feet above the bottom of the valley.

2. According to Oscar Lieber, many lodes in North and South Carolina appear to contain gold in their upper portions, which lower down contain lead and copper ores and hardly any gold. According to Lieber the succession from above downwards was gold, lead, copper; not observed, it is true, in one and the same lode, but deduced from a combination of several observations. He found that lodes in North and South Carolina of otherwise very similar mineralogical character contained, in the depths reached by mining, now gold, now lead ores, now copper ores; and that in some cases lead ores occurred under the gold, in others copper ores; while in still other lodes the copper ores were found under lead ores. From these facts he constructed a plan of the succession of ores as shown in the woodcut.



The line *aa* represents the original, the line *bb* the present surface. The lode 1 would still contain all three of the metalliferous zones, the lode 2 only the lead and copper zones, 3 again all three, 4 only the gold and copper zones, finally 5 only the copper zone.

This representation is certainly very hypothetical; but it is, ac. to Lieber, sustained by facts, many of which he has contributed to the Author's *Gangstudien*; from which it appears to follow that the gold is only found in the upper portions of the lodes. Prof. Shepard and James Eights in the N. Y. Mining Magazine for 1858, *Vol. X. p.* 271 *and Vol. XI. p.* 136, assert, on the contrary, that the quartz lodes in North Carolina and Georgia also contained auriferous copper and iron pyrites at greater depths; but that the gold is only perceptible and easily recognised in their upper decomposed portion (gossan), in the ferruginous quartz and iron ochre, while at great depths it is imperceptible in the undecomposed pyrites. Murchison is also of the opinion, that gold decreases with the depth in all gold veins, and soon entirely ceases: a statement, which is apparently contradicted by the Grass Valley and other mines of California.

3. Near Seiffen in the Erzgebirge many tin lodes are known in the gneiss district, which, according to company reports, gradually pass over with encreasing depth into lodes of argentiferous copper ore.

4. In the ore district lying north and northwest of Freiberg it has been found, that in the so-called *edle Quarzformation* (as for example, the *Alte* and *Neue Hoffnung* mines) the veins became poorer with the depth, while in the lodes of the *barytische Bleiformation* they encreased in richness. Up to the present time it has been impossible to determine, whether this change is dependent on the depth, or has, perhaps, been caused by other circumstances.

5. According to Vogelgesang, the real percentage of iron in the lodes of Przibram in Bohemia is often greater in the gossan than in the undecomposed portions of the lodes; the upper decomposed regions contain, on the other hand, but little silver, even in those places where it occurs in workable quantities beneath. In this case it would appear as if secondary differences of depth were combined with primary ones, a circumstance which may frequently occur without being so easily recognised.

6. Lill von Lilienbach states of these same Przibram lodes, that their contents encreased in richness to a depth of 200 fathoms, but have remained constant from that depth to one of 300 fathoms.

7. Von Tschudi states of Oruro in Bolivia, which lies 12400 feet above the sea, and was renowned in former centuries for its great silver riches, that it is at present in a state of great decay. The observation made in many districts; that argentiferous lodes are very rich in their outcroppings, and becoming poorer with the depth, soon pass over into ores containing no silver; has been found true in each of the numerous mines of Oruro.

Other examples of this kind will be given in the second portion of the book.

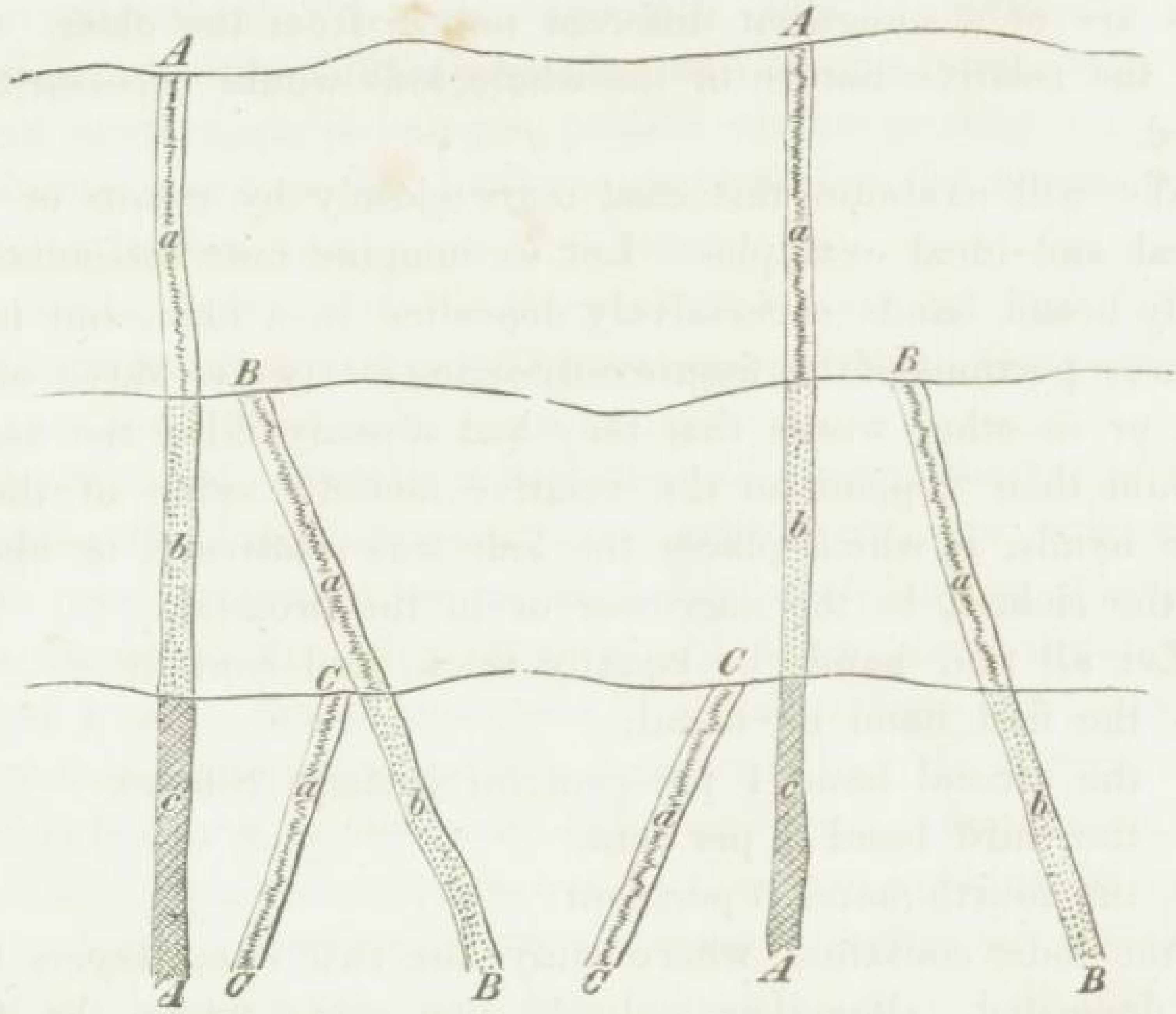
THEORETICAL EXAMINATION.

§ 27. Were it generally proved, that a primary difference in the contents of lodes was dependent on their depth, we could, in the main, easily explain them. It would be easily conceivable, that the continuous encrease of heat and pressure, in fissures extending to great depths, should have had an influence in depositing irregularly on the walls of the fissures the precipitate from a solution. The column of a solution in a fissure 1000 feet high, its hydrostatic pressure, and the necessary encrease of 20 degrees in temperature, might easily have caused differences in the nature of the deposits in the fissure, corresponding to the depth. The dissimilar zones, in the contents of lodes, corresponding to the depth, can be more easily explained in this way, than proved. It is indeed easily supposable, that many dissimilar so-called vein formations, with which we have become acquainted in distinct lodes, are in the main but formations, of unequal depth.

If we imagine, that certain mineral solutions, when deposited in fissures extending to a great depth, give as a result in the upper zone, to a depth of 5000 feet, the vein formation *a*, in the zone of the next 5000 feet the vein formation *b*, and in the third, lower, zone the vein formation *c*; then dissimilar veins *a*, *b*, or *c*, would be accessible to miners, according as the original surface has remained, or has been destroyed to a depth of 5000 to 10,000 feet.

The case is still more striking, if we suppose, that certain fissures *A* were filled with mineral matter, while the original surface still existed; others *B*, after the upper 5000 feet had been eroded; and still others *C*, after the surface had been washed away to a depth of 10,000 feet. We then find at the surface, and within reach of mining operations, the three vein formations *a*, *b* and *c* together, as if being three different vein formations of unequal age; while in reality the upper portions, the original outcrops, of the veins *a* and *b* are wanting; the differences existing are only those of depth.

This is entirely an ideal supposition, at the present time without practical value; but it appears worth mentioning, since it may draw attention to comparative researches, and possibly lead to the right theory.



INFLUENCE OF THE BREADTH OF FISSURES ON THE LOCAL DISTRIBUTION OF ORES.

§ 28. The general or the local breadth of fissures has evidently exerted a double influence on the special development of the mass filling them. In the first place, the solution, whatever might be its nature, could circulate more freely, the minerals which crystallized out had more room for expansion, in broader lodes or the broader parts of a lode. Then, in the second place, in the cases of successive combed deposits, more single layers of like thickness could form over one another during a longer period of time in a wide fissure, than in a narrow one; so long as places of great breadth were not, by narrowing, enclosed on all sides in such a manner, that the solution was not able to penetrate further. In this case geodes were formed.

If we imagine a solution of any kind to flow through a fissure, which is here and there broad and narrow, the motion of the fluid must necessarily be more rapid in the narrow portions, than in the broad ones; for this reason deposits would take place more easily in the broad places, than in the narrow ones.

In a banded structure of the lodes the dissimilarity may, as mentioned, be caused by the last layers finding no place for development in the narrower portions. When the more recent layers are of a somewhat different nature from the older, outer ones; the relative nature of the whole lode would necessarily be altered.

We will examine this case more closely by means of very general and ideal examples. Let us imagine four dissimilar but equally broad bands successively deposited in a lode, but in the narrower portions of the fissure only space for two or three of the same, or in other words that they had already filled the fissure. It would then depend on the relative metallic value of the separate bands, in which places the lode was relatively, or absolutely, the richest, in the narrower or in the broader.

Let all four bands be equally thick, and contain

the first band no metal,
the second band 1 per cent (of perhaps Silver),
the third band 2 per cent,
the fourth band 3 per cent;

then the lode contains, where only the two outer layers have been deposited, altogether only $\frac{1}{2}$ per cent; where the third occurs with them, 1 per cent by $\frac{1}{3}$ more g a n g; and when the fourth is also developed, $1\frac{1}{2}$ per cent by twice as much g a n g.

When however the case is reversed, and they contain

the first layer 3 per cent,
the second layer 2 per cent,
the third layer 1 per cent,
the fourth layer 0 per cent:

it gives inversely the greatest metallic value (= $2\frac{1}{2}$ per cent) in that portion of the lode containing only the two outer layers, the smallest (= $1\frac{1}{2}$ per cent) in that portion which is twice as broad containing all four layers. The absolute value is naturally still the greatest in the last case, since the lode is twice as broad.

It is hoped this ideal example will aid in estimating the extraordinary variety of the possible real cases. Still this examination into the influence of the unequal breadth of a vein fissure cannot, without something additional, be applied to two different unequally broad, fissures; since the conditions of the influx may have been very dissimilar.

The union of branches into a single lode, or the reverse, the splitting up of a lode into several smaller ones, has frequently been assigned as the reason of the richness or poverty of the same. The fact is indisputable. But the reason, strictly speaking, is not the union or splitting up, as such, but only the changes in the breadth of the lode connected with it; when the single branches are not of different ages, and in this case have acted on one another, as if being a portion of the country.

I now come to the influence caused by the nature of the enclosing rocks.

INFLUENCE OF THE NATURE OF THE COUNTRY.

§ 29. Formerly this influence on the distribution of the matter filling the lodes, especially the useful ores, was only known in the most prominent cases, as for example in the junction of veins, in which an older vein formed for a short distance the wall of a more recent one; and in such striking cases, as those observed in Cumberland and Derbyshire, where the lodes are very variable between argillaceous shale, sandstone, limestone and trap.

I will first enumerate a few of the most striking cases.

1. Around Freiberg,[1] and in several similar ore-districts, it has been long known; that two lodes are, as a rule, richer in ores in the neighborhood of their intersection, than in their remaining extent. This is especially perceptible, when a younger vein intersects an older one, so that this last forms for a certain distance one of the walls of the former; and the effect, thus caused, is generally, other relations being equal, so much the greater, the more acute the angle at which the intersection takes place. Which fact is easily conceivable; since with equal breadth, the plane of contact of the lodes is greater, the more acute the angle at which they intersect. This holds good, when two veins of unequal age meet without intersecting, when they join one another so as to form a double lode; no matter whether the fissure for the more recent vein has been formed at one of the selvages, or in the middle of the older one. The planes of contact are naturally the greatest in the last case.

But since in all these cases, in addition to the size of the planes of contact, the nature also of the older vein, and the quantity or quality of the solution which has penetrated into the new fissure (on which the amount of ore is dependent), are of the greatest influence; it is easily comprehensible, that an equal or even considerable enrichment does not always occur when two veins meet. In fact, it has been exceptionally observed, that an

[1] See: Von Cotta's Gangstudien. Vol I. p. 269.

empoverishment of lodes occurs in intersections; which may possibly arise from the older vein being shattered, and by which a subsequent washing out of the ore in the same was facilitated. What is still more striking is the fact, that occasionally an enrichment of the older, intersected vein, has taken place in the neighborhood of the junction. This has very probably been caused by the solution penetrating fine clefts of the same, and in this case belongs to the phenomena of impregnation.

Several examples are added to the above, which are so far similar, in that their metalliferous contents have been caused by the favorable influence of the country.

2. At Schweina[1] and Kamsdorf, in the Thuringian Forest, as also near Riegelsdorf in Hesse Cassel, the *Zechstein, Kupferschiefer, Grauliegendes, Rothliegendes*, granite, gneiss and mica schist, are traversed by veins in which heavy spar predominates. In those places where the veins are enclosed in *Kupferschiefer*, or metalliferous *Grauliegendes*, they contain productive quantities of cobalt- nickel- and copper-ores; while those portions of the veins enclosed in the other rocks, contain hardly any-thing but heavy spar.

3. At Kongsberg[2] in Norway the country consists chiefly of mica schist, hornblende schist, talc schist and chlorite schist. Certain belts or zones of these crystalline schists show themselves for an extent of several miles, with but few breaks, more or less richly impregnated to a breadth of several hundred feet with iron pyrites, copper pyrites and blende. These last are mostly disseminated through the rock in extremely fine and hardly perceptible particles, so that they are, at times, first discovered on the surface, in consequence of their decomposing and imparting a brown color to the rock. These zones are called *'Fallbands'*, and are of great importance to the mining at Kongsberg; since the silver lodes, which intersect the strata diagonally, are as a rule only rich within the *Fallbands*, and outside of them contain but little silver.

4. At Bräunsdorf[3] near Freiberg the veins, of the so-called *Edle Quarzformation*, are enclosed in mica schist, which con-

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[1] See: Tantscher in Karsten's Archiv. 1834, Vol. VII. p. 606; Häuser in Leonhard's Jahrbuch f. Mineralogie, 1819, p. 311.

[2] See: Hausmann, Reise durch Scandinavien, II. p. 12; Daubrée, Scandinavien's Erzlagerstätten, p. 44; Whitney, Metallic Wealth, etc. p. 42.

[3] See: Von Cotta's Gangstudien, Vol. I. p. 217.

tains an irregular layer of black graphitic schist, the so-called *schwarzen Gebirge*. The veins have been only found productive in the black schist: in the common mica schist they are very poor.

5. In Cumberland[1] lodes of lead occur in carboniferous limestone, which alternates with sandstone and argillaceous shales. The lodes are only broad and productive, when enclosed in the limestone, split up into branches; and non-productive in the sandstone and shales.

6. In Derbyshire the carboniferous limestone, with subordinate layers of greenstone, locally called toadstone, encloses lodes of lead-ores; which, as in the preceding case, are broad and productive only in the limestone, split up into branches and unproductive in the greenstone.

7. Near Marazion and Goldsithney[2] in Cornwall the greenstones are crossed by *elvans*; and both are traversed by lodes, which in the greenstones contain copper pyrites, but where they come in contact with the *elvans*, they also yield copper glance.

8. Almost the whole mineral wealth of Cornwall[3] appears to occur within a distance of two or three miles on each side of the junction of the slate and granite. Yet no part of the line itself seems to have been more productive, than any other spot of equal extent within the distance already mentioned; and though the lodes not uncommonly run for several fathoms with granite on one side and slate on the other, yet the portions so contained between dissimilar rocks are not generally the richest.

9. Fox[4] says in addition; 'Lodes in Cornwall are very much influenced by the nature of the rock which they traverse; and they often change in this respect very suddenly, in passing from one rock to another. Thus many lodes which yield an abundance of ore in granite, are unproductive in clay-slate, or killas, and *vice versâ*. The same observation applies to killas and the granitic porphyry called *elvan*. Sometimes in the same continuous vein, the granite will contain copper, and the killas, tin, or *vice versâ*'. Fox attempts to explain this phenomenon by means of electric currents.

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[1] See: Dufrénoy, Elie de Beaumont, Coste and Perdonnet, Voyage métallurgique en Angleterre.

[2] See: Trans. royal geolog. soc. of Cornwall, Vol. V. p. 32.

[3] See: the same, p. 219.

[4] See: Fox on mineral veins, p. 10.

10. At Andreasberg[1] in the Hartz the walls of the lodes consist, partly of Palaeozoic strata and quartzite, in which the lodes are broad and productive in silver; partly of slate, in which they are narrower and poorer.

11. At Kaafjord[2] in Finland the country consists of diorite and arenaceous clay-slate: in the first the lodes are very rich in copper ores, in the last they are contracted and unproductive.

12. In the Salzburg Alps[3] the rock consists principally of gneiss, with subordinate strata of mica schist and granular limestone. The lodes in the gneiss consist of quartz containing gold; in the mica schist they are generally much poorer in gold; and in limestone contain no gold, but in its place silver ores with carbonates.

13. At Przibram[4] in Bohemia the walls of the lodes are generally composed of greywacke, argillaceous shales, and greenstones. In the greywacke the lodes are broad and productive, in the shales narrow, and in the greenstones very much contracted.

14. Near Moschellandsberg in Rhenish Bavaria the coal formation is traversed by lodes of quicksilver ores; and the miners, according to Gümbel, distinguish certain layers by the name of *good rock*, between which the lodes show themselves far richer, than between other so-called *bad rock*; what is the difference, Gümbel unfortunately does not mention.

15. At Lake Superior[5] lodes of copper intersect amygdaloid, compact greenstone, conglomerate, and sandstone. According to Koch and Rivot, they are very rich in the amygdaloid, and mostly two feet broad; in greenstone much narrower, and unproductive; in conglomerate, and sandstone, also thinner, and mostly contain no copper, but calcite and calamine in its place. According to Hague this is not altogether true.

16. At the Pindad mine in the State of Michicacan, Mexico, lodes of dialogite and ruby silver traverse an older and a younger darker hornblende porphyry. According to the obser-

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[1] See: Hausmann im Herzinischen Archiv, p. 677.

[2] See: Daubrée. Scandinaviens Erzlagerstätten, p. 34.

[3] See: Reissacher in Haidinger's Abhandlungen, II. p. 17; Cotta. Geolog. Briefe aus d. Alpen, 1850, p. 144.

[4] See: Von Cotta's Gangstudien, Vol. I. p. 322.

[5] See: Koch, die Mineralgegenden der Vereinigten Staaten; Rivot in Comptes rendus, 1855, Vol. 40. p. 136.

vation of E. Schleidens these contain much less ruby silver in the younger porphyry than in the older and lighter colored one.

17. Lieber[1] in speaking of South Carolina says; every one who has been engaged with us in vein mining must have remarked, that where a lode comes in contact with a vein of rock, intersects it, or is broken through by it; a local enrichment has always taken place. This enrichment is at times so considerable that many lodes have only been productive in such places. The lodes of Carolina contain principally gold and copper ores, the country is generally, itacolumit, talc schist, mica schist, and gneiss; the veins of rock, or dikes, consist chiefly of greenstones, phonolith, etc.

18. Daub[2] thought he observed in the Black Forest a difference of the percentage of silver ores in veins of heavy spar, according as they intersect older or more recent rocks or deposits. According to him they are generally richer in granite and gneiss, while their percentage of silver diminishes, in greywacke and mica schist, carboniferous limestone, variegated sandstone, Muschelkalk, and Jura; in such a manner that in the last formation they consist almost entirely of heavy spar without any ore. This observation was made, not on a single lode intersecting all these rocks, but on a number of lodes, of which some were found in this, others in that rock; and in so far, gives no certain result, even if itself entirely correct.

19. G. Leonhard,[3] on the contrary, observed in the silver lodes of the Teufelsgrund in the Kinzig valley, which intersect gneiss and porphyry, a considerable encrease of richness in the decomposed gneiss, a marked decrease in the porphyry; similarly also in the Rückenbach mine in the Münster valley.

A portion of these cases has long been known as isolated facts. More recently the knowledge and observations of the influence which the country has on the richness of lodes, have been somewhat generalised, and in this way a path broken towards a theory for the same, as well as a general practical application of the knowledge. This progress has been especially incited by the examinations made in the neighborhood of Freiberg by the government Commission under the direction of Hermann Müller.

[1] See: Cotta's Gangstudien, Vol. III. p. 2.
[2] See: Daub in Leonhard's Jahrb. 1851, p. 1.
[3] See: G. Leonhard, Geognost. Skizze d. Herzogthums Baden, 1846.

RELATION OF ORE-DEPOSITS TO THE ENCLOSING ROCK AROUND FREIBERG.

§ 30. The country around Freiberg in which the silver lodes are situated, consists chiefly of gneiss. Although this rock is divided into many different varieties, traversed by dikes of porphyry and greenstone, passes into mica schist, and this contains layers of limestone; still the miners attached but little importance to these variations and distinctions. With the exception of the above-mentioned case at Bräunsdorf, no constant relations were observed between the country and the variable contents of the lodes. This was first definitely proved by the examinations mentioned.

From these examinations it has been found, that, as a rule, every modification of the rock was accompanied by a certain, though but slight, modification in the matrix of the lode, while the difference was frequently a very marked one. By far the greater number of known ore bunches or courses in the Freiberg lodes can be explained by the variations of the country rock, to which the junctions with older veins naturally belong.

Mr. H. Müller says (*Gangstudien I. p.* 209): 'In just the same manner as is the occurrence and formation of veins in this locality in general, do we find the deposits of ore in particular combined with the occurrence of certain rocks. This influence of the country rock makes itself perceptible, not only by different separate veins in particular, but, also, in general and on a large scale, by the various groups or '*Züge*' of lodes occurring in our district.

The lodes in general, without distinction in regard to the character of the formation, have attained a development favorable to mining only within compact rocks, in which feldspar or quartz, hornblende, pyroxene, as also carbon (graphite, anthracite) or carbonate of lime, form an essential ingredient; while on the contrary within less compact or fissured micaceous or magnesian rocks they have been very unfavorably developed. The most striking proof of this is given, by an exact comparison of the extent and course of these rocks, with that of the productive portion of the lodes traversing them, as also by a large number of old reports on the lodes. Although to be sure, the lodes are not always favorably developed in rocks conducive to a deposit of ores, and frequently are even barren of ores within them, still when they do contain ores, it is only in these rocks; while, on the other hand they are always barren and never contain ores in the unfavorable rocks.'

It has been frequently observed, that while rocks were themselves unable to cause any sufficient enrichment of the lodes, still their more favorable influence was observed, in that junctions of lodes, consequently enrichments by means of a lode as wall rock, are only productive within these particular zones of country. So that here the influence of two favorable walls contribute to one result.

The examination of the Freiberg lodes by H. Müller was partly by direct observations, partly by the study of former mining reports and charts. From the form of former workings it is sometimes still possible to see, that they chiefly follow a particular variety of the enclosing rock, which was probably the cause of a particular bunch or course of ore.

From this point I intend to use the term *ore carrier* for those rocks exerting a favorable influence on the deposit of ores.

According to the observations made around Freiberg up to the present time, an absolute influence, favorable or unfavorable, cannot be ascribed to the various rocks, but only a relative one. While, for example, the lodes of Bräunsdorf have been found to contain ores, and even, in parts, be productive in the quartzose or gneissic mica schist varieties, those of the Kurprinz Friedrich August, Alte Hoffnung Gottes, Gesegnete Bergmanns Hoffnung, Michaelis, and Emanuel mines, in similar or apparently the same rocks, have been found barren and unproductive. While further, the granitic gneiss has exerted in other portions of the Freiberg districts a very unfavorable influence on the deposit of ores in the lodes traversing it; still several of them, as the Reinsberg Glück lode, have proved very rich and productive in the same. This variable comportment, or, as it might be called, this various relative carrying of ores in the same or closely related rocks, appears at first sight a contradiction to the fact, that the condition of the lodes depends on the nature of the rocks; in reality however, this is not the case. There is always a certain law in connection with it; thus lodes, like those of Bräunsdorf, occurring in quartzose or micaceous gneiss and in pure mica schist, when they contain ore at all, do so only in the first mentioned rocks, while in the last they are always barren of ore. Lodes occurring both in granulitic gneiss and in quartzose or micaceous gneiss, as those of the Alte Hoffnung Gottes and Gesegnete Bergmanns Hoffnung mines, contain ore principally in granulitic gneiss, while in the quartzose or micaceous gneiss they either contain less or are entirely barren. Lodes which occur both in greenstone and granulitic gneiss, as those of the Alte Hoffnung Gottes mine, have proved richer in the first named rock than in the last. Hence it is possible, that a lode containing but a very small amount of ore may under circumstances prove barren and free from ore in a rock, which is found, elsewhere, to contain the chief deposits of ore concentrated within it.

The number of cases up to the present time is indeed small, in which it is possible to deduce such a relative connection of the rocks with the ore deposits; since a conclusion in this respect can only be drawn, when with the various relations of the rocks the other conditions, which may have had an influence on the nature of the lodes, are the same.

So, for example, the enrichment of the Frisch Glück lode caused by its junction with the Paul Stehender in quartzose and micaceous gneiss, at the Alte Hoffnung Gottes mine, cannot be compared with its poorer and unproductive portion in granulite gneiss, where the reason for such an enrichment is wanting.

DISTINCTION BETWEEN RED AND GREY GNEISS, AND THEIR INFLUENCE ON LODES.

§ 31. In addition to these special effects of dissimilar varieties or kinds of country, H. Müller has recognised throughout the Erzgebirge a general law in regard to the distribution and extension of the lodes, as well as in their local contents. The gneiss of the Erzgebirge may be divided into two great varieties, or rather groups of varieties; of which one has been called *red gneiss* in distinction to the common *grey gneiss*, because its feldspar is very commonly of a red color. Both the grey and red gneiss are subdivided into many varieties both of composition and texture. It is very difficult, at times, to determine whether in particular cases such a modification should be assigned to grey or red gneiss, since up to the present time sharp and positive distinctions have not been proved to exist between the two principal varieties, although in extreme cases they can be easily determined, and then differ most strikingly in their mode of occurrence. Wherever the red gneiss occurs characteristically, it shows itself to be an igneous rock, which is never the case with the grey or normal Freiberg gneiss. The red gneiss even contains, at times, distinct fragments of the grey, or it forms dikes in the same, and may be aptly termed a gneissic (fissile) granite.

The characteristic distinctions between grey and red gneiss are concisely given in the following table.

Grey Gneiss.	Red Gneiss.
Silica; 64 – 67 per cent.	Silica; 74 – 76 per cent.
Ingredients; orthoclase, somewhat of oligoclase, quartz, and an abundance of dark colored mica.	Ingredients; orthoclase, quartz, and a little light colored mica.

There are, however, intermediate grades between the two, which cannot with certainty be assigned to the one or the other. The grey gneiss appears in the Erzgebirge to exert a much more favorable effect in general on the metalliferous contents of the lodes than the red, which contains but few veins.

INVESTIGATION OF THE INFLUENCE OF THE COUNTRY ROCK ON THE CONTENTS OF LODES.

§ 32. From what has preceded, we may consider it as proved, that the nature of the country has exerted a certain influence on the contents of lodes, and especially on the unequal amount of ore they contain; although the observations hitherto made can only be regarded as local, the results of which are not as yet adapted to application, except in the localities, where the observations were made. That is, while it may with good reason be expected, that a dissimilar country will every where act dissimilarly on the nature of the lodes; still the conclusion must not be drawn from this, that because this or that rock, this or that variety, may have shown itself in one or two cases as enriching certain lodes, as a good ore-carrier, therefore the same rock or variety must prove so in all other cases. Local observations must be made concerning this influence, before it can rightly be adopted as a foundation for mining operations. The uncertain limits of that, which must be considered as belonging to a rock; the great difference in the varieties of rocks amongst each other, of such a nature that exactly the same variety but seldom occurs in two different localities; the great variety in the manner in which different rocks occur together; and, finally, the dissimilar nature of the solutions filling the fissures, as well as the many subordinate causes, which may and do have an influence on the distribution of ores; have exerted a modifying influence. For all these reasons it can hardly be expected, that a general and valid law will ever be discovered for the influence of the various rocks forming the walls on the lodes. It is however very possible, that the causes of this particular influence may, to a certain extent, be discovered; that these causes may be traced to particular properties of the rocks, which are in part independent of their names; and that from this, certain general rules may be deduced for the influences they exert; which may, with some caution, be practically applied in ore districts but little known, and particularly in such where no special observations on this subject exist. On this account, it is very important to attempt to form a theory on this influence as nearly correct as possible, and then confirm or correct this by continued observations.

MATERIALS FOR A THEORY.

§ 33. If we examine the examples given more closely, we find some of them, in which the influence of the country appears to have been principally of a mechanical nature. Certain rocks are more adapted to form regular fissures than others: in many, instead of a simple fissure, a very irregular shattering of the rock has taken place. These dissimilar forms of fissure appear to have exerted an influence on the nature of the deposits; and even if, as in some of the cases (see examples 5, 6, 10, 11, 13 and 15, § 29), in addition to the form of the fissure, other causes, founded in the country, appear to have had an effect on the contents of the lodes; these can hardly be isolated from the main cause. In any case we must recognise the form of the fissure as one of the circumstances which affected the contents of lodes.

In other cases, without any perceptible dissimilarity in the formation of the fissure, very distinct and specific differences occur, in the matter filling the lodes, between dissimilar enclosing rocks of the same lode; sometimes of such a nature (as in examples 7, 12, and 15), that not only the quantity of the ores and gang occurring is different, but the ores are of another kind. From this we must infer the presence of some property within the rocks themselves, which affected the particular character of the deposits, which had a particular affinity or repulsion for this or that element, which caused it to precipitate or prevented the same. In what may this property or, when several are combined, in what may these properties consist?

The analogy of similar occurrences, in experiments and technical processes, refers us especially to the following properties, as having possibly been influential:

1. The ability to conduct heat,
2. The density,
3. The greater or less porosity of the rocks,
4. The greater or less smoothness or roughness of the surface of their fissures,
5. The chemical reaction of one or all the ingredients of the rock,
6. Electric currents.

We will consider these separately.

THE ABILITY OF ROCKS TO CONDUCT HEAT.

§ 34. It is a well known fact, that the crystallization, from solutions on the walls of vessels, is variable, according as these consist of wood, stone, burnt clay, or metal. Even the various kinds of wood, stone, or metal, appear to exert an influence on this. Most probably, this difference is chiefly caused by the difference in the power of substances to conduct heat, and probably also by their density, and the smoothness or roughness of their surfaces, which in turn have had an influence on the radiation of heat. This difference exerts itself, not only on liquid solutions, but just as decidedly on the crystallization from a gaseous condition. This is very distinctly shown in the formation of hoarfrost and the beautiful crystallizations of frost on windows.

A difference, so well known to exist in such a number of cases, must necessarily have made itself perceptible in the crystallizations taking place on the sides of fissures in the crust of the earth, consisting of very dissimilar rocks. Many solutions are only possible at a certain temperature; and if a cooling process takes place, until a point beneath this temperature is attained, a partial or complete precipitation takes place. On this account, a rock, which is a good conductor of heat, must certainly have had a far greater effect on the precipitation and crystallization, than one which is a poor conductor.

This is indeed but a theoretical contemplation founded on general observations, which has not as yet been confirmed by special examinations of lodes. At all events it is worth keeping in mind in all examinations on the important subject of the distribution of ores in lodes, or to be followed up by experiments. The differences in the ability of rocks to conduct heat has most certainly not been without an influence on the crystallizations taking place in fissures.

THE DENSITY OF ROCKS.

§ 35. The specific gravity is frequently somewhat related to the conducting power of bodies; the denser bodies, including the more compact rocks, are in general better conductors of heat, than the less dense ones. It is moreover supposable, that a greater attraction will, other things being equal, accelerate the precipitation from solutions. It might be brought, in some degree, into relation with the results of the cases recently mentioned, in which the metalliferous and compacter rocks appear generally to have had a more favorable effect on the ore deposits, than the non-metalliferous and less compact ones. This action of the attraction may possibly vary from that of the difference in the conductibility of heat; thus the cause necessarily becomes more complicated, and the recognition of the causes is rendered much more difficult. On this account the difference in the density of rocks must in any case be constantly considered in researches on the question before us.

THE POROSITY OF ROCKS.

§ 36. Porous rocks are not only penetrated by the water soaking in from the surface, but also by the liquid solutions which circulate in the fissures traversing them. Both can, and do, exert an influence on the precipitate, which takes place on the walls of the fissures. This circumstance is not only of influence in itself, but from the fact, that the ability of a rock to conduct heat is much changed, and its specific gravity encreased, by the water penetrating it. Consequently complicated effects arise here also, the causes of which are difficult to distinguish. The porosity of a rock has an especially modifying influence, when the same contains soluble ingredients, and is in consequence able to essentially encrease the influence to be considered in § 37. Hence it will be certainly so much the more difficult to determine the relative value of the two causes.

THE SMOOTHNESS OR ROUGHNESS OF THE SURFACES OF ROCKS.

§ 37. The smoothness or roughness of rocks stands frequently, although not always, in connection with the greater or less porosity of the rocks; or, to be more explicit, very porous rocks will always have a rough surface; but the converse cannot be asserted, that imporous rocks always possess a smooth surface; since a very rough surface of fracture may be caused by their being composed of very dissimilar minerals; as in granite. Experience has shown, that rough and smooth surfaces act very dissimilarly towards the precipitates deposited on them: which may be caused in part by their encreased or decreased power to conduct heat: in any case the efficaceous surface of the walls of fissures is much encreased by their roughness.

THE CHEMICAL REACTIONS OF ROCKS.

§ 38. There is no doubt, that the water circulating in fissures, (whether it be tolerably pure or already impregnated by solutions of other substances,) does attack, change, or partly dissolve certain or frequently all the ingredients of the neighboring rock. The real proof of this lies frequently before us in the decomposed or in general altered rocks enclosing lodes or even mere clefts.

Gustav Bischof has, in this relation, already led us on the right path. He demonstrated, in von Leonhard's Jahrbuch for 1844, pp. 257 and 341, that a mutual exchange must take place through the reaction between the ingredients of the rocks of veins. In the same manner as the bicarbonates of lime, magnesia, iron, and manganese, are precipitated by alkalies in the laboratory; so must precipitation take place, when water containing these carbonates comes in contact with rocks or minerals containing alkalies as ingredients. When these last are combined with silicic acid, these silicates are decomposed by the carbonic acid of the bicarbonates. This explains both the crystallizing out of the carbonates and the so frequent decomposition of rocks containing lodes, especially those which are feldspathic.

What however has been as good as proved for the carbonates, may easily, with certain modifications, be true of many other minerals in lodes, and even of the ores; by which means certain substances may be principally deposited on the surfaces of certain rocks. The possible encrease of this influence by the porosity of rocks has been already mentioned in § 36. Special investigations on this subject also are unfortunately wanting. Scheerer considers the presence of much darkcolored, ferruginous mica in gneiss to be a favorable agent.

ELECTRIC CURRENTS.

§ 39. It has frequently occurred, that an essential influence on the contents of lodes, and particularly on the unequal distribution of ores in them, has been ascribed to the electric currents, which may possibly arise from the superposition, or contact in any way, of somewhat dissimilarly composed rocks. This hypothesis was founded on the fact, that during the decomposition of a solution by a voltaic current dissimilar substances are deposited at the positive and negative electrodes. Fox[1] in fact, by means of artificially obtained electric currents, not only produced fissures in clay, but also filled these fissures with metallic substances. In consequence of this he is of the opinion, that electricity has exerted a great influence in the arrangement of minerals in lodes; he believes in particular, that the greater richness of many lodes, on passing from one rock into another, can be explained by supposing that the electro-negative acting rock must have caused a greater deposit.

The fact of electric currents existing in the earth's crust is however somewhat uncertain. Prof. Reich[2], indeed, obtained deviations of the needle, when he connected two different points

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[1] See: Philosophical Magaz. 1836. IX. p. 387, 1839. XIV. p. 145; Transact. roy. geolog. soc. of Cornwall. 1840 V. p. 445; Leonhard's Jahrb. 1840. p. 114.

[2] See: Poggendorff's Annalen, Vol. 48. p. 287; Berg- u. Hüttenmänn. Zeitung. 1844. p. 342.

of a lode by means of conducting wires; but he explains this very clearly through the contact of the various ores composing the isolated groups of ore, which are separated by sterile rock acting as a moist conductor. According to this the electric currents were first caused by the distribution of the ores in the lodes; and the reverse cannot as yet be deduced, namely, that this distribution has been caused by such currents. By connecting points free of ore, Reich was unable to obtain the slightest deviation.

The possibility of the effects observed by Fox cannot be denied; but far too few facts are at present known to deduce any thing farther in relation to the distribution of ores.

CHIEF RESULTS.

§ 40. The circumstances mentioned in the preceding paragraphs may have acted singly, or several of them together, on the unequal distribution of the minerals and ores in lodes. The general effect of several may have been one of their mutually supporting each other, or one in which they partially or wholly neutralised one another. As the final result of our observations, thus much remains certain: although we but imperfectly know the causes, the variation in the enclosing rock of lodes has, by means of its physical and chemical properties, exerted an influence on the dissimilarity of the matter filling these; and this is shown, as well by single lodes traversing several rocks, as by different veins, of which some have this, others that rock as country. There are certain rocks, which can, locally at least, be termed ore-carriers, while others are almost the reverse of this. The possible indication of such an effect depends particularly on the absolute amount of ore in the lodes; which is a consequence of the amount of metallic substances carried into the fissures by solutions. From this absolute amount of ore we must distinguish a relative one, which is locally modified by particular causes, by concentration. The modifying influences of the country may be of themselves so slight that they escape observation; they may still, however, become perceptible through combination with other causes. For example, the effect of junction of two lodes may of itself remain imperceptible, and even so the effect caused by a particular enclosing rock; but where they both meet, that is, where the line of junction of the former traverses the, also but slightly favorable, zone of rock, a very perceptible enrichment takes place.

In addition to the influence of the rocks, which showed itself by acting on the solutions coming in contact with them, a much more direct effect may have occurred in separate cases, in that the enclosing rock itself provided certain of the ingredients of the veins, and among these also ores, which were finely disseminated in it from the commencement, and were later somewhat more concentrated in the fissures. I will return to this subject when speaking of the origin of lodes.

INFLUENCE OF STRIKE AND DIP OF LODES ON THEIR RICHNESS.

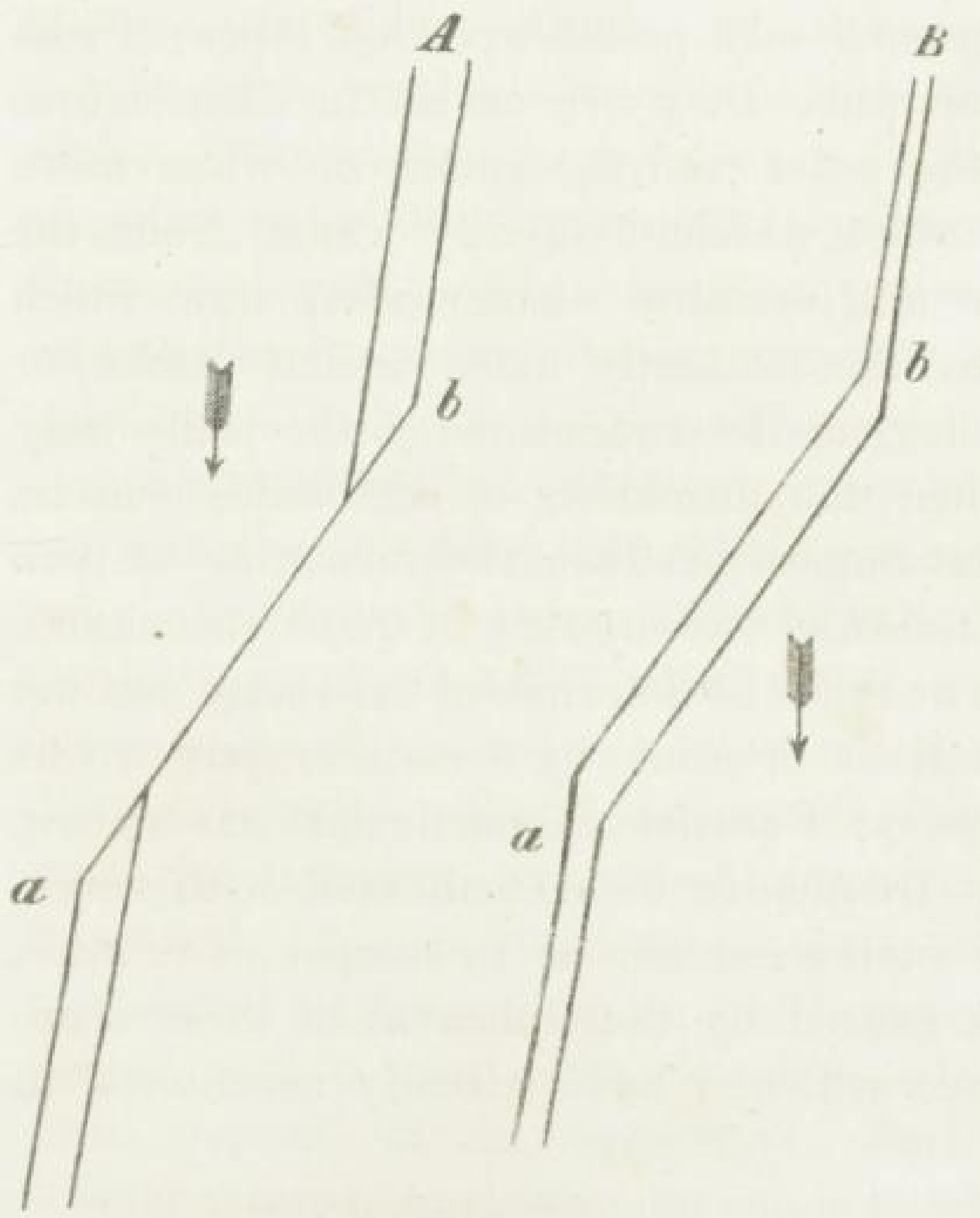
§ 41. It has been thought, that a certain relation existed, as to the amount of ores they contained, between lodes and their direction of strike and dip, the greater or less angle of inclination, which they make with the horizon, or with the planes of cleavage or stratification. Fox went so far as to suppose, that the prevailing direction of lodes could be explained by the influence of the earth's magnetism in the form of electrical currents. To this end, it was his opinion, that lodes must have intersected the magnetic meridian nearly at a right angle at the period of their formation.

All the facts, which have been adduced in favor of this and similar views, appear to me nevertheless to rest on imperfect observations, or a false interpretation of the facts observed.

It is certainly correct, that in many districts, the lodes striking in certain directions are pre-eminently rich in ores, those in other directions containing less or none at all; or that some may contain more of this, others more of that ore. But such a constant parallelism can by no means be proved concerning the lodes of various parts of the earth, or, indeed, all lodes. On the contrary we find lodes generally representing most dissimilar directions. If we reflect, that one and the same process forming the fissures in the same district, and at the same time, will have produced veins predominating in a certain direction; in other districts, on the contrary, such veins in another direction; and when we reflect that the filling of the fissures, as a rule, followed closely on their formation, the fact explains itself very simply. It is the consequence of a chronological difference, and there is no necessity for having recourse to the earth's magnetism. At one period these, at another those solutions circulated in the fissures, at a third period perhaps none at all; in consequence, they are locally, according to their direction, dissimilarly or incompletely filled with ore. From a local point of view, this is of great importance to the practical miner; but in and for itself, it has only to do with the manner in which the lodes were filled, while being in a general sense entirely independent of the direction of the strike. The same is true of the direction of the dip and the degree of inclination.

Fox's views are very soon seen to be erroneous, if we examine a large number of ore districts, or even a single one, in which lodes occur with dissimilar directions of strike, as around Freiberg.

The varied, now greater, now less, dip of the same lode may at times in so far have exerted a great influence on the local breadth, and in consequence on the amount of ore; in that sinkings or upheavals of the hanging- or foot- wall took place, by which the fissure was locally encreased or narrowed in width. An attempt has been made to show this in an ideal manner in the two following figures.



When the hanging wall of the fissure (*A*) sank, or the footwall was raised, the more horizontal portion (*a b*) might have been compressed to an imperceptible cleft; when, on the contrary, in an exactly similar fissure (*B*) the hanging wall was raised, or the footwall sank, the portion (*a b*) would be the one chiefly widened. Similar cases to these have, in fact, often been observed.

Finally, as regards the angle at which a lode intersects the texture or stratification of the country; this may also have been of great influence on the nature of the matrix. But this difference belongs entirely to those which are caused by the peculiar nature of the country. Smoothness or roughness of the surface, porosity, the amount of fracturing, are generally quite different on the cross sections of schistose or slaty rocks, from what they are on those parallel to the cleavage.

DETERMINATION OF THE AGE OF LODES.

§ 42. Every vein, and consequently every lode, is necessarily of more recent formation than the rock it traverses; and when by chance it intersects other lodes, it is necessarily younger than these. In so far the relative age of lodes can be easily determined. But seldom, on the contrary, can their real age be, in some degree ascertained; only, that is, exceptionally can the time of their formation be referred back to well determined sedimentary formations. It is only possible to do this, when some particular circumstance permits us to determine the simultaneousness of origin. It is generally even difficult to determine, positively, whether lodes are older than certain rocks or formations occurring near them, but which they do not intersect. This is, with hardly an exception, only possible; when these rocks lie directly over them, or when they are cut off in their course without penetrating at any point into the rocks, or when these contain fragments or pebbles which evidently came from the lodes. But the question still remains unanswered; how much older the lodes are, than the evidently more recent rocks or formations? The chronological determination of the same only becomes satisfactory, when the formation of the lodes can be referred to the period, that elapsed between the formation of two rocks or formations, that followed one another in quick succession.

The age of lodes can at times be determined indirectly, but not beyond all doubt, when their creation by certain eruptive rocks is recognised. It appears, as Fournet in particular has shown, that the lodes may very frequently be co-ordinated with neighboring igneous rocks, in such a manner as to compel us to infer, that their formation was caused by the upheaval of these eruptive rocks; a circumstance which I have already mentioned in § 21.

THE AGE OF LODES.

§ 43. It has been sometimes assumed, that the lodes in general, or at least certain kinds (formations) of the same, were formed only during particular geological periods. Let us examine in how far such an assumption may be proven.

There is certainly no doubt, that lodes are more commonly found between old, than recent rocks or formations, and but very seldom in the youngest sedimentary deposits and igneous rocks; while, on an average, they are most common in the oldest. Hence it may well be said, the greater the age of rocks and formations, so much the more frequently are they as a rule traversed by lodes. It might be deduced from this, that the process of the formation of lodes has been in general one gradually decreasing with time, and that certain kinds of lodes ceased to be formed much sooner than others. We shall see, however, that the distribution of ores can be explained in an entirely different manner.

If we collect all the known facts and conclusions, which are to some extent reliable, on the age of lodes in general, or separate classes of the same; we find that there is no limitation of their origin to particular geological periods. At the most it can be said of tin lodes, that they have only been found in rocks of the same age or older than the carboniferous period; no other lodes can be limited to particular periods of formation; since even gold, silver, lead, and copper lodes have been exceptionally found in Tertiary deposits, although as a rule they only occur in much older rocks.

As examples of relatively very recent lodes, I need only mention the following. In the Department of Aveyron in France plumbiferous silver-lodes, associated with copper ores, traverse the lias; in Algiers the same traverse deposits of the cretaceous period; the auriferous quartzveins of Vöröspatak in Transylvania traverse Tertiary Carpathian sandstone. If from these examples the same age should be ascribed to all lodes similarly composed; it would follow, that all auriferous lodes should be considered as belonging to the Tertiary, or a still more recent period, and a large class of silver-lodes as being younger than some deposits of the cretaceous. Such a supposition cannot be strictly refuted, but does not coincide with the general occurrence of such lodes.

It appears to me far more natural to assume, that the formation of the various kinds of lodes has been taking place, at all periods since a firm crust of the earth has existed, but at various depths. Whether generally in the same, or in a decreasing ratio, must, as being undecided, remain questionable. And farther, that this has taken place now in this, then in that district, according to circumstances conditioned by general geological events; as a consequence of which the older rocks and deposits more commonly contain lodes, than the recent ones, which were not so long subjected to the possibility of lodes being formed in them.

Were various lodes forming during all periods of time, but at unequal depths; it would then, as just remarked, be easily comprehensible, that the oldest rocks and formations were commonly most affected by this continuous event, being longest subjected to it. It is just as comprehensible, that the kinds of lodes belonging to the greatest depths, can only become accessible to our observation, and to mining; where what was once deep in the interior of the earth, has reached the surface by the upheaval and erosion of what lay above it. A longer period, as a rule, was necessary, to raise such deep inner regions to the niveau of the present surface of the earth, and to destroy the mass lying above them, than for less deep formations. It is, consequently, very natural, that those lodes formed at the greatest depths should appear to us to be relatively the oldest, precisely because the most time was necessary to lay them free, which could but seldom be replaced by greater energy of upheaval and erosion.

Thus it is supposable; that the formation of all kinds of lodes is still taking place, but the majority at such depths that we cannot observe them; and different kinds at unequal depths.

It is certainly supposable, though not in my opinion sustained by facts, that dissimilar lodes belong to dissimilar periods; or that, with the encreasing thickness of the earth's crust, the formation of lodes has generally assumed a somewhat different character. Both of these suppositions might to some extent be combined with each other.

ORIGIN OF LODES. FORMATION OF FISSURES.

§ 44. Since, according to our definition, all true lodes are aggregates of mineral matter in fissures; fissures must necessarily have first been formed and then filled. Both operations may have been independent of each other, and even when this is probably not the case, still the formation of the fissures was an entirely different operation from that of their being filled with mineral matter. On this account I will speak of the former separately.

Even the purely mechanical operation, of the formation of fissures, has been explained in very different ways. Werner[1] considered fissures to be consequences of compression caused by specific gravity, by the drawing off or separation of the rocks in the direction of an exposed side, by the contraction caused by drying, or by the concussions caused by earthquakes.

Fox[2] explained them as being consequences of electrical currents in particular directions, and on this account thought, they were originally formed nearly at right angles to the direction of the magnetic meridian.

Others have considered them to be consequences of the gradual cooling of the globe.

While it must be granted, that fissures could have been formed in all these ways, and perhaps really have been so formed ever since the earth has had a solid crust: while it may farther be granted, that a fissure formed in this manner has sometimes been exceptionally filled with minerals and ores: it is still most probable, as Von Beust in his criticism of Werner's theory (1840) has clearly shown, that the majority of lode-fissures have been torn asunder by concussions caused by volcanic or plutonic activity; or, in other words, by volcanic or plutonic earthquakes. Even at the present time, earthquakes produce entirely similar fissures, which are very frequently formed in groups like those of lodes, and, in so far as they are caused by a single concussion, run parallel to one another. Many irregular branches, on the contrary, may be consequences of cooling or other causes.

There is no difficulty in thus explaining the formation of the fissures themselves. It is, on the other hand, not so easy to explain the circumstance, that the fissures of lodes are so frequently combined with very considerable dislocations of the halves of the country, the so-called faults.

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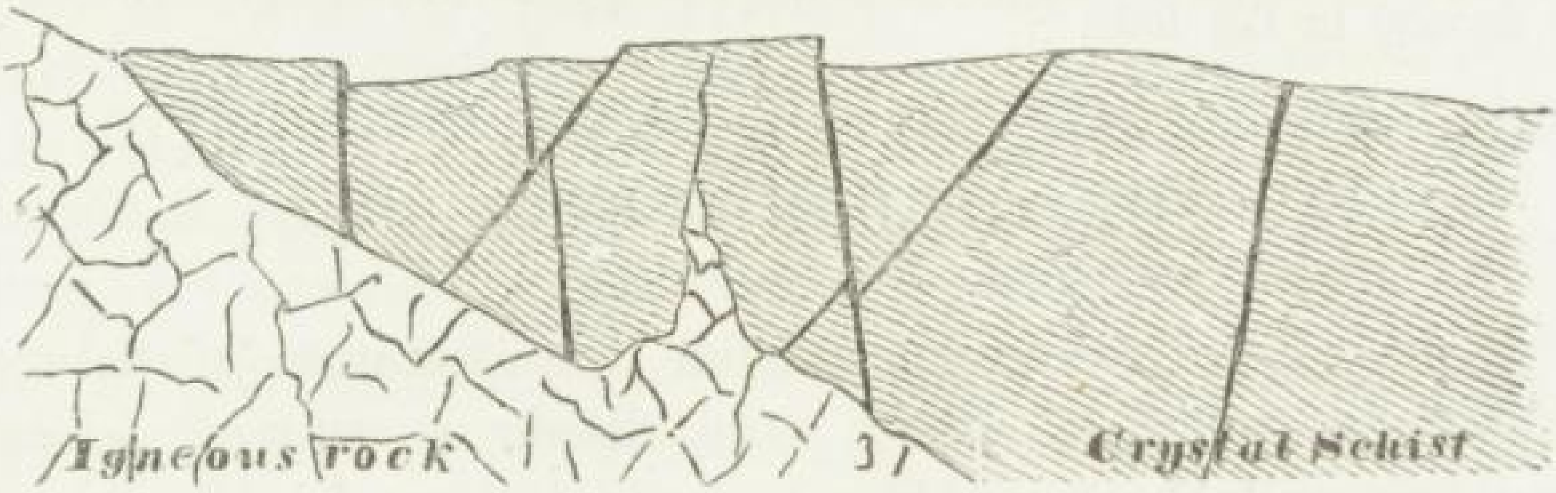
[1] See: Werner, Theorie v. d. Entstehung d. Gänge, 1791.
[2] See: Philosoph. Magaz. 1836, IX. p. 387; 1839, XIV. p. 145.

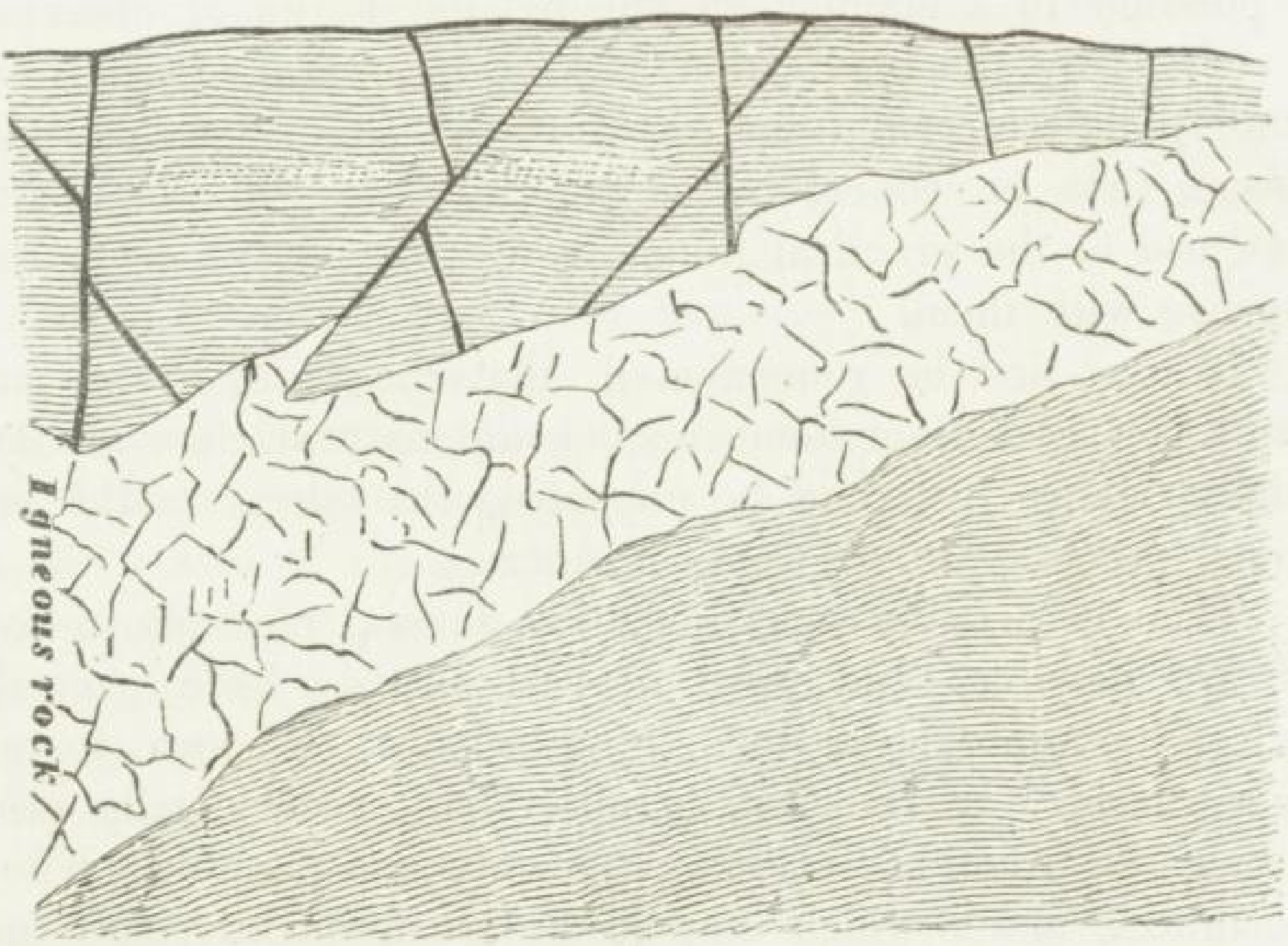
THE POSSIBILITY OF DISLOCATIONS.

§ 45. Leaving the as yet unknown condition of matter in the interior of the earth entirely out of account, the firm crust is certainly over 70 miles thick: how is it, under these circumstances, possible, that fissures of such proportionally short extent, as those which most lodes are known to possess (they are known from 4 to 18 miles in length), should be able to penetrate through the entire hardened crust? when they do not penetrate through the entire crust, how was their formation possible; and still more, how could they have caused such considerable faults? These are the questions before us. Their possibility is shown, not only by the fissures formed by earthquakes at the present time, in which also faults of a few feet in extent have been observed; but the same can be shown in regard to many other solid bodies, which are frequently intersected on their surfaces by cracks, although, indeed, without dislocations. The fissures of glaciers are especially instructive. Ice obviously belongs, according to the general acceptation, to the solid bodies; and yet tolerably wide fissures are commonly formed, and even small faults, which do not traverse the entire mass of the glacier. Here also, greater faults occur, by complete intersection of the mass of the glacier. The cause, of the fissures in glaciers, is the movement of the mass over an irregular surface of ground. Small dislocations in the earth's crust can be explained in this manner, that it every where consists of various rocks which possessed somewhat unequal powers of resistance. But dislocations (faults) of more than 20 or 30 feet cannot be explained by fissures, which do not completely intersect the firm crust of the earth, or rather have not done so during the period of their formation. How then could the often considerable faults, and friction-surfaces frequently accompanying them, have been formed in such a thick crust? The difficulty would be but slightly decreased by saying, the earth's crust was not so thick at the time the faults were formed as it now is; since some of them are of such recent geological age, that the difference of thickness between the time when they were formed and the present can only be very slight.

The formation by means of plutonic activity, seems to me a solution of all these difficulties and doubts. A local thinning of the earth's crust, caused by the solid upheaval of igneous rocks near or under the ore-district, nearly in the manner shown in the following woodcuts, suffices for the explanation.



Crystal-Schist.



If this explanation be correct, it follows, that the lodes cannot, in reality, continue to a perpetual depth; but the lower portion being in most cases unattainable, it may as regards the miner be termed perpetual. I must, finally, remark that many vein-fissures have (probably) been repeatedly torn open, or have been widened during the process of filling. The last appears to have sometimes taken place as a consequence of the process of crystallization in the lode-fissure, to which Von Weissenbach in particular has called attention in Cotta's Gangstudien, vol. I. p. 66.

Fox also believes a gradual widening of the fissures to have been caused by the force of the matter filling them, even in true veins, while Von Weissenbach speaks only of lodes exhibiting columnar structure.[1] (Philos.

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[1] By columnar structure is here meant the contents of the lodes crystallizing at right angles to the selvages. Trans.

Magaz. 1836, V.; IX. p. 387.) This repeated tearing open, of the already filled fissure, by outer force, is shown very distinctly in the occurrence of double lodes, and of such as contain in their interior fragments of the mass first formed in the lode.

THE FILLING OF FISSURES.

§ 46. Let us now pass from the formation of fissures to the manner in which they were filled: a subject, in which hypothesis still has free play, and which must be treated as far as possible in a manner guided by the limits of observation, as well as by the application of known natural laws. Notwithstanding the uncertain nature of the ideas, which may at the present time be conceived concerning lodes, they are still of some use to the practical miner, while science, as such, cannot dispense with them.

It must first be remembered, that the lodes by no means form a clearly distinct homogeneous and natural class of natural bodies. Hence it cannot be expected, that they should be all formed precisely in the same manner.

Then it is to be remarked, that several methods of formation are possible, and have in part already been proved, of most of the minerals predominating in lodes. We can, therefore, never consider an accidentally observed, or chemically proved, manner of formation, as being the only one possible. The circumstances, under which they occur, are frequently more important, than the observations, as yet made, on the manner in which the minerals were formed.

It must not be forgotten, that many lodes are now composed of minerals, entirely different from those of a former period; and that many of the minerals composing the same, were formed after and from others, partly by pseudomorphism.

Finally, the majority of lodes are not only composed differently, but in a much more complicated manner than any widely diffused igneous or sedimentary rock.

This circumstance must cause a distrust of every hypothesis, which attempts to explain the formation of the lodes in general, and those of complex composition in particular, in the same manner as that of the igneous or sedimentary rocks. That they cannot be considered as mechanical precipitates, is evident from their nearly constant crystalline nature.

THEORIES OF THE FORMATION OF VEINS UP TO THE TIME OF WERNER.

§ 47. In his 'New Theory on the Origin of Veins' (1791), Werner has given a concise summary of the older views on this subject. He commences with Diodorus and Pliny, who were the first to mention veins, and then speaks more fully of Agricola, who was the first to propound a theory of veins in his work '*de ortu et causis subterraneorum*' (1546). In this, the principal agents were: water, which dissolved the enclosing rock, heat, and cold. In accordance with the state of science at that time, he considered the metals to have been formed from other substances.

Werner merely mentions Von Elterlein, Meyer, Von Loehneis, and Barba.

Balthasar Roesler (1700) explained the veins, as being mineral matter filling fissures.

Becher (1703) ascribed the formation of ores and metals in the lodes to underground gases; which penetrated upwards from the centre of the earth into the lodes, or rather into the suitable vein-stones and earths existing in them.

Stahl (1700) considered the lodes to have been formed in the enclosing rock at the time the world was created.

Henkel in his 'Pyritologia' (1725) referred the presence of ores in lodes to vapors; which he considered to have been caused and produced by fermentation in the rocks. The vapors penetrated earths and rocks suitable as matrix.

Hofmann (1738), also, considered veins to be the matter filling fissures.

Zimmermann (1746) supposed the veins, together with the ores, to have been formed by a transformation of the rocks.

Von Oppel (1749) explains the veins distinctly as filling fissures; and thus separates these from beds and strata.

Lehmann (1753) first mentions Hofmann's hypothesis, and then adds, that the lodes are branches of a great deposit, which is probably situated in the centre of the earth. He compares the lodes to the branches of a tree. The origin of the metals is in the centre of the earth, whence they found their way into the fissures in a humid and gaseous condition.

Delius (1770) considered the vein-fissures to be a consequence of the contraction caused by the drying up of the earth.

The rain water penetrating the rocks dissolved the elements of the rocks and metals, and conveyed them into the fissures; where by subsequent evaporation they crystallized out.

Von Charpentier (1778) agreed essentially with Zimmermann's theory, which he carried still farther.

Baumer (1779) says: 'the lodes differ in form and matter from the rocks: from various data it follows, that they were formed under the ancient sea; since the out-croppings of the same are frequently covered with several layers of schist; and petrifactions of sea-species have at times been found, as well in the geodes they contain, as also in the vein-stone itself.'

Gerhard (1781) considered the lodes to be the matter filling fissures. The vein-stone and ores have been introduced by water, which had previously dissolved them out of the enclosing rock.

Von Trebra (1785), like many others, considered the lodes to have been formed by a metamorphosis, in consequence of a kind of fermentation and decomposition caused by water and heat. He terms the lodes, regions in the massive rock; in which interior motion, produced by flowing water, has changed the variety of rock, together with the foreign bodies of the animal and vegetable kingdom often occurring in them, into varieties of ore and stone which are no longer the original rock.

Lasius (1789) thought, the fissures were caused by revolutions of nature; and then assumes; that these fissures have been filled with water, which was impregnated with carbonic acid and other solvents, thus rendering it suitable to dissolve the particles of earth, metal, and other substances in the rocks, which it has penetrated from the fissures; and that, according to the degree of solubility, first these, then those particles have been dissolved, and then by reason of various precipitants have been deposited in the fissures.

Werner developed his own theory most fully. The fissures may have been caused, according to him: by compression in consequence of the specific gravity, by the drawing off or separation of the rocks towards an exposed side (as for example the side of a valley), in consequence of the contraction caused by drying, by earthquakes, or by various other causes. The fissures, as well as the matter filling them, have been formed at very different periods. 'The vein-stuff arose from a wet precipitate, which filled them from above; that is, from a wet, and mostly chemical solution, which covered the region where the fissures existed, and at the same time filled the open fissures.'

THEORIES OF THE FORMATION OF VEINS SINCE WERNER.

§ 48. Baron Von Herder, in his work on the Meissen adit (1838), has classified the various theories on the origin of veins up to the commencement of this century; as well as the more recent explanation, that they were formed, similarly to the igneous rocks, by means of an igneous fluid injection; as follows:

1. Theory of contemporaneous Formation: the lodes are not mineral matter filling fissures, but were formed at the same time as the enclosing rock, or subsequently by a metamorphosis in the altered regions of the same. Stahl, Zimmermann, Von Charpentier, Von Trebra.

2. Theory of Lateral-secretion: the lodes are mineral matter filling fissures, the material of which came from the enclosing rock. Delius, Gerhard, Lasius.

3. Theory of Descension: the veins are the filling of fissures, the material came in from above. Baumer, Werner.

4. Theory of Ascension: the veins are the filling of fissures, but the matter was introduced from below.

This last may be divided into the following sub-classes:

a. Theory of Infiltration: the material was introduced in a state of aqueous solution, as mineral water. Lasius at least approaches this view.

b. Theory of Sublimation α: the material was brought into the fissures by ascending steam. Lehmann, and perhaps Becher.

c. Theory of Sublimation β: the matter was introduced in a gaseous condition, by sublimation. Perhaps Becher.

d. Theory of Injection: the material has been introduced by an igneous-fluid injection, and has then solidified in the fissures. Fournet, and others.

Since Von Herder has thus given a sort of scheme of the different theories; it will be sufficient, to speak somewhat concisely of the various opinions with their more recent modifications, opportunely mentioning the chief upholders of the same.

THEORIES OF CONTEMPORANEOUS FORMATION, AND OF DESCENSION.

§ 49. Neither the theory of contemporaneous formation, nor that of descension, has had any upholder since Werner;

unless Kühn in his 'Handbuch der Geognosie' be considered as such, although he only endeavored, as a faithful pupil of Werner to defend his teachings; and attempted to maintain them by numerous interesting, but in no way convincing, examples. Freiesleben, the warm reverer of Werner, in his valuable works on the Saxon metalliferous deposits, has avoided giving distinct views on their origin. All the other pupils of Werner, worthy of notice, have become unfaithful to his teaching; if the yielding, through and from observation, to another conviction may be so termed.

Baron Beust, in his 'Critical Examination of Werner's Theory' (1840), has thoroughly refuted the views of the latter.

It is self-evident, that in the nineteenth century there are no longer any upholders of the theory of contemporaneous formation.

THEORY OF LATERAL-SECRETION.

§ 50. Several modifications of this theory can be distinguished. Delius, Gerhard, and Lasius, merely assumed; that the water percolating through the rocks has, aided by carbonic acid, and other solvents, dissolved out certain ingredients of the same; and that afterwards, whatever may have been the re-actions causing it, a precipitation from these solutions took place in the fissures. This view has recently been carried still farther, especially by Bischof; who has attempted, in his geology, to found it on as scientific grounds as possible.

Where it can be assumed, that the elements of the mineral matter filling the veins exist, or have existed, in the enclosing rock; no objection can properly be made against it. Especially is this the case, when the term 'lateral' is not applied literally, but is understood in the sense, that the solutions after their impregnation, by dissolving out particles of the enclosing rock, still had a free movement in the fissures, so that every particle was not necessarily deposited exactly at the point, where it was dissolved out of the enclosing rock. By this widening of the meaning, however, the theory of lateral-secretion passes directly into the theory of ascension of aqueous solutions (theory of infiltration), which assumes the matter to have been dissolved out of the rocks at a greater depth, than that at which it was deposited in the fissures. The encreased temperature then takes a very necessary part in encreasing the solving power of the solution; and it is not necessary, that the surrounding rock, accidentally known in the neighborhood of the earth's surface, should contain all the elements of the minerals forming the lodes. By such a modification there is no longer any difficulty in explaining the combed texture, as would be the case if the term lateral were taken literally. It is clearly the most simple explanation, that can be given, for many lodes, although not for all. The real origin of the elements of the lodes may then remain partly in doubt, but it may be assumed to occur rather in the unknown interior, than on the known surface.

THEORY OF INFILTRATION.

§ 51. This theory; which of course does not exclude contemporaneous secretions out of the enclosing rock, and indeed necessarily presupposes such to be taking place at greater depth; joins closely on to the preceding; and forms, at the same time, the first sub-class of the theory of ascension, or the explanation by means of volcanic emanations.

Elie de Beaumont[1] explains the lodes, as being essentially products of volcanic emanations: these he subdivides into igneous-fluid (injections), gaseous (sublimations), and aqueous (infiltrations by means of hot mineral springs). In accordance with which, he explains a portion of the lodes by means of such hot aqueous infiltrations.

Durocher,[2] like Beaumont, has declared himself in favor of infiltrations, sublimations, and igneous-fluid injections, and therewith refuted Fournet in several points.

Von Dechen[3] entirely excludes the igneous-fluid injection, as being the origin of true veins of the most various kind; and limits these essentially to infiltrations from below.

These views have been shared by many geologists of the present time; and numerous investigators have busied themselves in researches on the artificial formation of minerals, both in the wet and dry way; especially, G. Bischof, Senarmont, Kjerulf, Daubrée, Deville, Malaguti, Ibbetson, etc. I also have repeatedly attempted to show that the Freiberg lodes, and all analogous to these, can be most simply and easily explained, both as regards their occurrence and their texture, by infiltration from below: especially seeing the frequent combed

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[1] See: Bulletin de la Soc. géolog. d. France, 2nd Series, Vol. IV. p. 1249.

[2] See: Compte rendu, vol. XXVIII. p. 607; vol. XIII. p. 850.

[3] See: Leonhard's Jahrb. 1851, p. 210.

texture of these lodes very strongly points to such a mode of origin, and their mineralogical composition is, in no manner, opposed to it; since Bischof has shown that the minerals, in question, may have been formed from aqueous solutions.

THEORY OF SUBLIMATION.

§ 52. In the views held by Beaumont, Durocher, and Von Dechen, mentioned in the § preceding, the participation of sublimation in the formation of lodes has been already spoken of. Durocher[1] considers the unequal distribution of the minerals and ores in lodes, as a special proof of the formation by sublimation. He believes, that these can only have been so formed, in that dissimilar currents, of gas or vapor, have passed through the fissures; and in accordance with this, distinguishes '*emanations motrices*' (metallic vapors), and '*fixatrices*' (principally sulphur vapors). These have passed through the fissures at different places, in different directions and at different periods, here and there uniting their forces.

It can hardly be doubted, that such an unequal distribution is also possible by an infiltratory formation; and we have learned, that the principal cause is the difference in the character of the enclosing rock.

The possibility of the formation by sublimation of many of the ores and minerals occurring in lodes, especially by the agency of chlorine, fluorine, and boron, has been proved beyond a doubt: first of all in the specular iron, which frequently occurs as a product of sublimation in the volcanic fissures: I add a few other examples.

Plattner[2] proved the formation of magnetite by sublimation in the Freiberg reverberatory furnaces. Minerals are very frequently formed in metallurgical operations; thus, Orthoclase, Galena, and most probably Copper Pyrites and Blende. Very instructive, in this connection, is the formation of a lode in the floor of a reverberatory furnace at Freiberg; where the cracks in the masonry were partly filled with a combed structure consisting of Galena, a galena-like combination, and Copper Pyrites: which Plattner considered to be the product of a long continuous sublimation. Still melting may have played an active part in this case. On the formation of minerals in general by metallurgical operations, see v. Leonhard's Hüttenerzeugnisse (1858), Berg- u. Hüttenmänn. Zeitung, 1852, p. 278; and 1855, pp. 128 and 143.

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[1] See: Compte rendu, 1849, vol. XXVIII. p. 607.

[2] See: Cotta's Gangstudien, vol. II. p. 1.

Daubrée[1] succeeded by means of sublimation, in part with the aid of Fluorine and Chlorine, in forming Tin ore, Oxide of Titanium, and Quartz.

Durocher[2] passed gases and metallic vapors (chiefly protochlorides, although other combinations also) into heated glass-tubes, and obtained crystals of many of the minerals occurring in metalliferous deposits, especially Blende, Iron Pyrites, Galena, Sulphite of Silver, Sulphite of Antimony, Sulphite of Bismuth.

Ebelmen[3] also obtained many minerals, partly by melting, partly by sublimation with the aid of boron and phosphorus; among them several, which are characteristic for lodes.

Bunsen,[4] finally, in speaking of volcanic exhalations has shown, that the same are well adapted to explain satisfactorily many of the mineral formations in lodes.

Under these circumstances it is not impossible, that many lodes have been formed by sublimation only, whether with the aid of steam, or without it. In others, perhaps, only some of the ingredients were sooner or later introduced by sublimation.

THEORY OF INJECTION.

§ 53. When the igneous origin of many rocks, which occur as dikes, had once been recognised, many persons were inclined, during the first half of the present century, to consider all lodes as igneous fluid injections. Petzhold, in his geology (1840), even attempted to maintain, that as being the most recent and consequently deepest ramifications from the interior of the earth, they must necessarily be the richest in metals, and have the greatest specific gravity; a hypothesis, which in any case betrayed a great ignorance of the true nature of lodes. More recently the injective nature of lodes in general, is defended almost alone by Fournet, while de Beaumont and Durocher consider only certain classes of them to be injective, the majority, on the contrary, as having been formed by sublimation or infiltration; all however, as the consequences of local volcanic activity.

It may be, that certain metalliferous, and on this account coming under the category of metallic deposits, igneous-rock dikes, especially green-stones and serpentines, are to be designated as originally of igneous origin, which have been afterwards

[1] See: Compte rendu, vol. XXIX. p. 227.

[2] See: Compte rendu, vol. 32, p. 823; vol. 42, p. 850.

[3] See: Annales de Chimie et Phys. 3 Series, vol. 22, p. 213; vol. 30, p. 129; vol. 32, p. 129; vol. 33, p. 34; Compte rendu, vol. 22, p. 710; vol. 33, p. 525.

[4] See: Leonhard's Jahrb. 1852, p. 501.

to some extent altered. But for the characteristic lodes of every kind it is altogether improbable, that matter forming them has exactly the same origin as the Greenstones, Porphyries, Basalts or Lavas. Their composition, their texture, and the manner of their occurrence, are opposed to it.

Their composition is opposed to it, in that many minerals have often crystallized in them contemporaneously, an impossible occurrence, when the combination proceeds from a common igneous-fluid condition.

Their texture is opposed to it, when the minerals, forming them, are arranged in a symmetric combed texture.

Their occurrence is opposed to it, in so far as they frequently fill narrow, widely ramifying systems of fissures, which it is impossible should have been filled so completely by igneous-fluid matter.

Finally, the very unequal distribution of the minerals, the ores in particular, which shows itself dependent on slight modifications of the wall-rock, is opposed to the theory of solidification, as this must have had a consequent more equal distribution of all the minerals.

In all the cases, therefore, in which lodes show appearances, like the above mentioned—and they form by far the greater number—their origin by igneous-fluid injection is, according to the present standpoint of science, inconceivable. In addition, such a supposition is entirely superfluous, so long as the theories previously mentioned suffice for their explanation.

CONCLUDING OBSERVATIONS.

§ 54. These numerous, and in part contradictory attempts show, how difficult it is, to find a general explanation for the formation of lodes. I, for my part, am of the opinion, that such is impossible; and that various kinds of lodes have been formed in very different ways. Already, from the extremely vague definition of ore, metallic deposit, and consequently of lode, it follows, that the lodes do not form an accurately determined, closely confined and, in themselves, consonant group of geological phenomena; but are, according to their nature, the very variedly composed fillings of the fissures in the earth's crust. These fillings may and must have been formed in very different ways. It is therefore impossible to find a single explanation for all; but rather imperatively necessary, to seek a special explanation, or at least a modification of the same, for every particular occurrence; to which, indeed, a great number of analogous ones can be generally annexed. On this account I here confine myself to a few general remarks, and spare special explanations for the separate cases in the second part.

Without a doubt many lodes, especially such as show a symmetric combed texture, and contain Quartz, Carbonates, Heavy Spar, Fluor Spar, and metallic Sulphurets, have been formed by a gradual precipitation from aqueous solutions. Their texture, as well as the nature of the minerals composing them, point to this; neither is otherwise explainable, than in this manner; and we have especially to thank the researches of Bischof for many explanations on the possibility of solution in, and precipitation from, aqueous solutions, which formerly appeared very difficult. The event appears to have mostly taken place at great depths, and to have required very long periods of time. It is a very marked distinction, that fillings of fissures by secretion, infiltration, and also those by sublimation, presuppose incalculably long periods of time, and a successive formation of the separate mineral portions, while the filling by igneous-fluid injection necessarily gives a result, which was accomplished in a short time, and formed contemporaneously in all its parts.

But whence came the substances, that were dissolved in water? Certainly not from without, and above, but from within; either partially, or entirely, from the immediate wall-rock; or, it would appear, more commonly from a greater depth, than that at which they were deposited; but always from the wall-rock of the continuation of the fissure. It is, also, not impossible, that sublimations may have taken place in the interstices of such infiltrations, or after their conclusion; this however can only be ascertained for the particular case. It is further very certain; that numerous transformations have taken place in many lodes after their first formation, whereby minerals originally existing in them have been altered, and their elements frequently been transposed; and that substances have penetrated from above, which belonged to the atmosphere and organic life: oxygen, water, phosphoric acid, etc. Such transformations are often very important, as regards the observation of the existing condition of lodes.

It is further beyond a doubt, that, at times, clefts in volcanoes are filled with sublimed ores, especially specular Iron, which was reduced from vapors of protochloride of Iron. Lodes of specular or micaceous Iron, and similarly many other lodes, may have been formed in the same manner at earlier periods in the history of the earth. We must also here know the special case, before we are able to form an opinion.

It is, also, by no means impossible, that certain ores, coming in an igneous-fluid condition, not from the central hearth of the igneous rocks, but from the re-melting of already existing metallic deposits, should have penetrated fissures and solidified in them; although no cases of this kind are known, as being formed at the present time, or near the earth's surface. We are as yet too little acquainted in this relation with the results of high pressure.

Finally, fissures which were originally filled with igneous-fluid injections, may have afterwards undergone important transformations; and, in particular, new substances may have penetrated in the way of infiltration or sublimation.

The most of these events probably occurred at great depths; and the lodes now known are but the plutonic portions, formed at great depths, of the results of geological events; the upper, volcanic portions of which have been destroyed, but which were, most probably, analogous to the volcanic phenomena observed at the present time. Similar occurrences may even now be taking place in the interior of the earth.

Thus the formation of lodes shows itself to be not only possibly, but also probably, very manifold; and appears to have always stood in some connection with neighboring, and often shortly before occurring eruptions of igneous rocks. The local re-action of the igneous-fluid interior of the earth created fissures, forced igneous-fluid masses into many of the same, caused gaseous emanations and sublimations in others; and in addition, during long periods of time, impelled the circulation of heated water, which acted, dissolving at one point and again depositing the dissolved substances at another, dissolving new ones in their stead. The whole process is thus not confined to any particular geological period, or any particular locality; but recurs at all times, either in the same or new regions, at the point where a re-action of the interior of the earth has taken place.

So much on the general process of the formation of lodes: in detail it can only be proved for the particular case.

SEARCH FOR LODES.

§ 55. If the preceding delineations and views can be considered as being substantially correct, what rules can be deduced from them for the search after, and following up of lodes?

For the search after lodes, substantially the following:

1. Lodes may be more commonly expected in older, than in more recent rocks, as well sedimentary as igneous; because there is more probability, that the older ones have been covered for a longer time by more recent ones, and were consequently subjected for a longer period to the possibility of lodes forming in them. This has been confirmed by experience.

2. They will be more commonly found in the neighborhood of igneous rocks, than far removed from all such similar eruptions; therefore more frequently in mountainous regions, than in plains: also confirmed by experience.

3. They will be found more commonly in the neighborhood of so-called plutonic rocks, *i. e.* such as have solidified beneath the surface, than in that of volcanic rocks, since the majority of them could only have been formed at some depth under a solid covering: also confirmed; and on this account most lodes appear pretty old, while perfectly similar ones may even now be forming in the interior of the earth.

2. and 3. do not exclude the possibility of veins often attaining a higher level than the igneous rocks causing them; in which case they may occur in regions, in which the latter have not been observed at the surface.

4. Lodes occur most frequently, not only in the neighborhood of igneous rocks, but also in direct contact with them, or even at the line of contact of two rocks, which have been brought in conjunction by dislocations.

The preceding rules are particularly worthy of notice in searching for lodes in districts, the geological character of which is entirely unknown, if once however single lodes are discovered at any point, the following may be also used.

5. It is then very probable, that several or many lodes exist in the some vicinity; since their probable manner of formation infers, that many are formed together. Hence many very

often follow nearly the same direction; since by every forcible convulsion parallel fissures are formed in the earth's crust, when it is not at the same time fissured in all possible directions by very local causes. On this account either broad parallel lodes, or a network of narrower ones, may be expected.

6. Most lodes have proportionally such a slight breadth, and are in addition, from their composition, so subject to erosion; that it cannot be expected, that their out-croppings on the surface will be easily found. They are in fact very frequently covered by a layer, formed of the products of erosion, which hides them from view. Hence, as a rule, a surface examination does not suffice. To find them, it is mostly necessary to search beneath the soil covering them. This is possible:

a. by discerning the products of the decomposition of lodes at the surface; for example, a peculiarly colored zone; or by the presence of efflorescences of a special kind;

b. by following fragments or pebbles from the lodes in watercourses to the point where they cease; in the neighborhood of which the deposits, from which they were torn, probably exist. The indications a and b must, however, always be further confirmed;

c. by uncovering the surface; which may, according to local circumstances, consist in ditches, adits, pits, shafts, borings or even artificial washings away of the surface; and which may of course also be employed, when other causes, besides those mentioned under a and b, lead to the supposition of the existence of a lode.

I approach too nearly here, however, to purely mining operations, and for further information must refer to works on that subject.

FOLLOWING UP OF LODES.

§ 56. When a lode has once been found, it is self-evident, that in order to become better acquainted with it, or to prepare it for regular mining operations, it must be followed up, both in its strike and dip. In doing this, difficulties at times occur, especially local wedgings-out of the lode, or faults. In such cases the re-finding of the lode is by no means entirely dependent on chance, but to a great extent on the right use of geological principles.

The so-called wedging-out of the lodes does not seem to be united with a complete cessation of the fissures, in which they were formed; on the contrary, these nearly always appear to continue farther, either as one or several clefts. These must be followed, in order probably to find a widening and filling of the same with ore. Should there be several clefts not continuing quite parallel to one another; or should the, at its commencement, single cleft branch into several; then such as keep the direction of the principal strike and dip, should be chiefly observed.

If, on the contrary, a fault or dislocation occurs; then those observations and principles must be followed, which have been already given in § 19.

If merely new ore is being searched for in a lode, which only contains it locally; then the circumstances must be considered, which have been already mentioned in §§ 23 to 41.

SEGREGATIONS.

WHAT ARE SEGREGATIONS?

§ 57. Under segregations are classified all those aggregations of ores having irregular form and definite limits. They differ from beds and lodes, by the irregularity of their form; from impregnations, by their definite limits.

The irregularity and dissimilarity of form, combined with definite limits, form the characteristics of this class of metallic deposits.

Within the wide bounds of this definition may be made a great number of subdivisions, which are not more definitely separated from one another, than the segregations are from beds, lodes, and impregnations. There is a large number of characteristic occurrences, which can be easily classified, while others form transition stages.

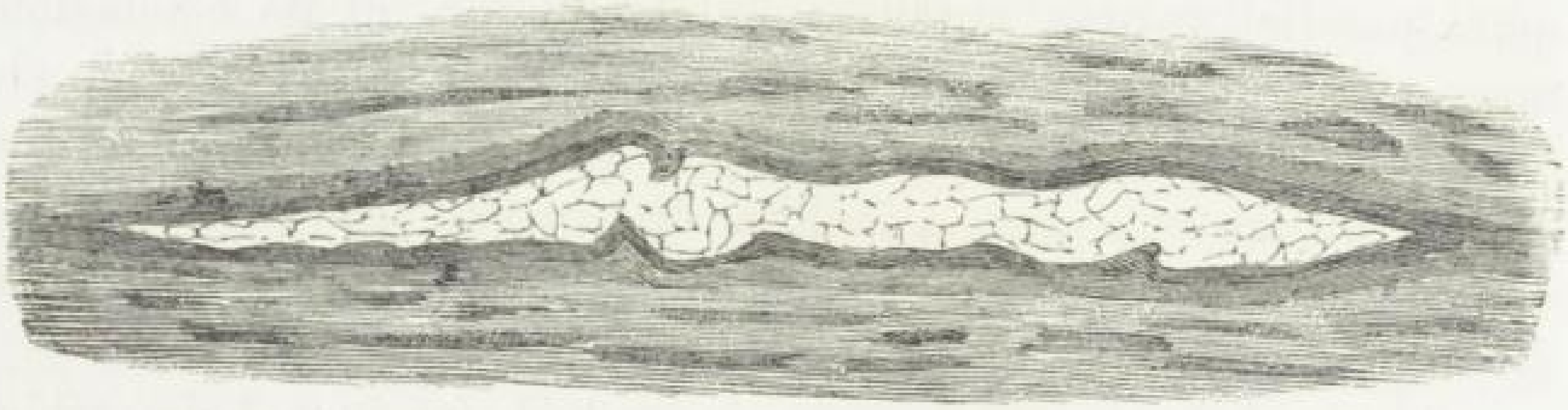
RECUMBENT, AND VERTICAL, SEGREGATIONS.

§ 58. The segregations are divided into

1. bed-masses, or recumbent segregations;

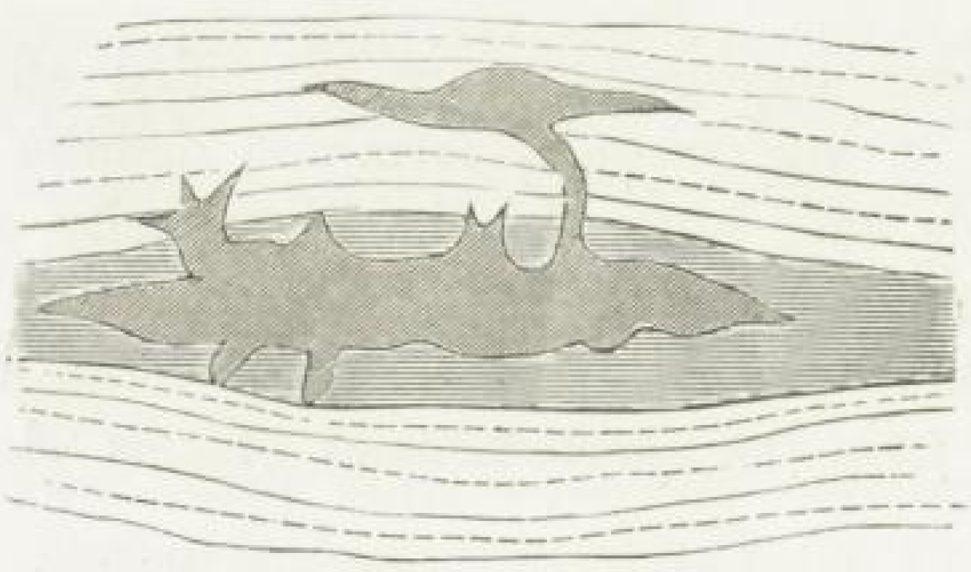
and, 2. vein-masses, or vertical segregations.

The recumbent segregations nearly resemble the beds in their form and position; they have an irregular lenticular form, the greatest dimensions of which are parallel to the stratification, or cleavage, of the rock containing them; as for example, the light portion of the following wood-cut.

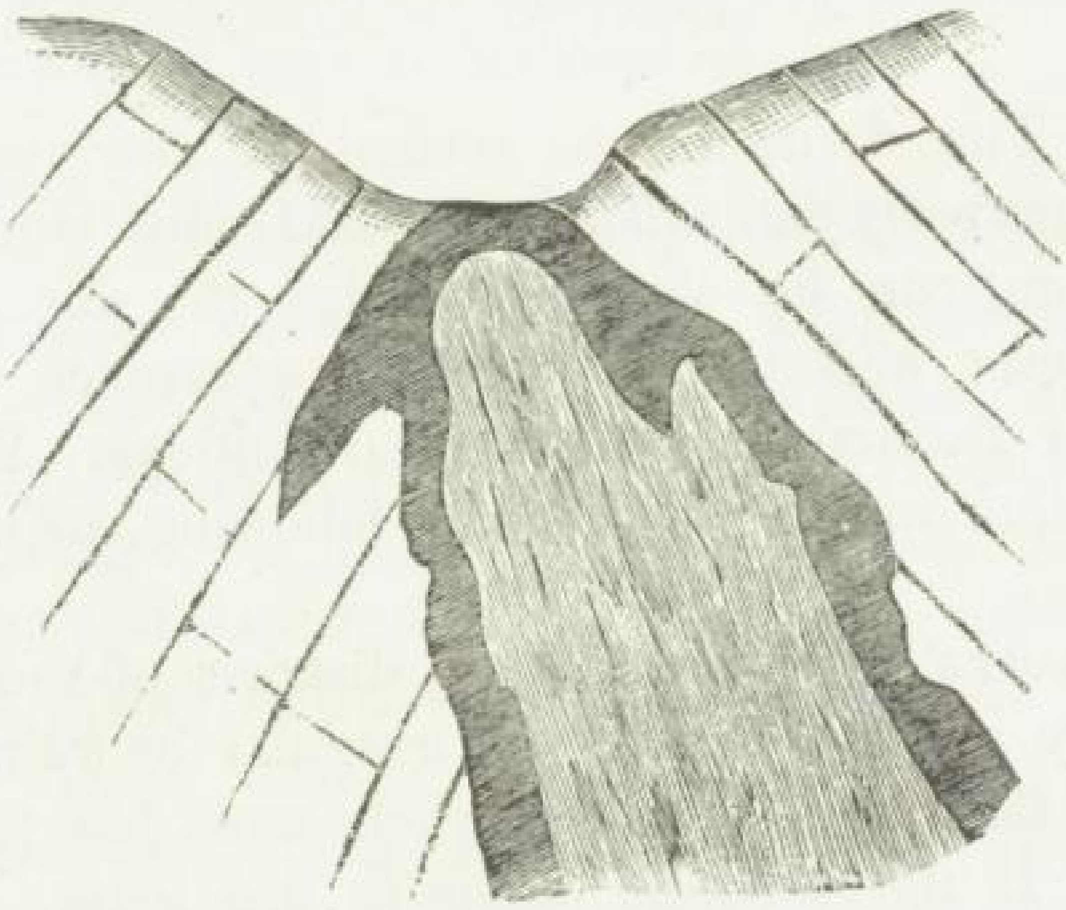


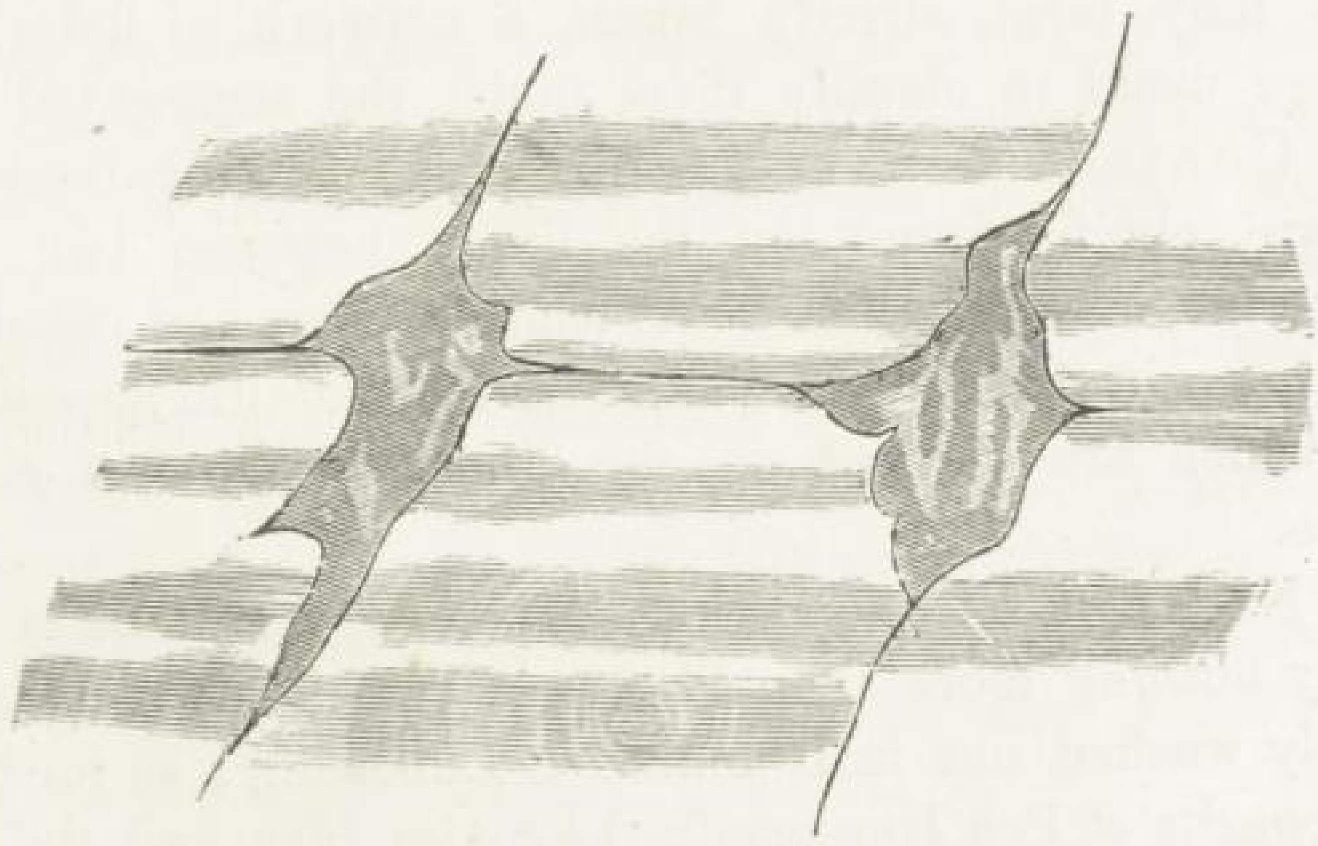
This figure shows the vertical section of a recumbent segregation, which, when several similar ones succeeded each other in the same stratum, might certainly be considered as forming part of a bed.

Recumbent segregations may however send off shoots of all kinds into the surrounding rocks, as is shown in the dark portion of the annexed wood-cut.



Vertical segregations are such aggregations of ore, or irregular metallic deposits, of which the greatest extension is entirely independent of the texture or bedding of the rocks surrounding them; but which are generally more extended in the vertical, than the horizontal direction. At times they are like very irregular lodes, local widenings of fissures; and in fact form transitions to these. At times they have branches in a very similar manner to veins. The following three wood-cuts give ideal examples of vertical segregations; the middle one shows a segregation, surrounded by gang, while the lower one shows two fillings, within widenings, of fissures.





A distinction between the recumbent and vertical segregations has also been made; that the former are more extended in a horizontal, the latter in a vertical direction. Such a distinction appears to me to be yet more variable, as well as more arbitrary, and less real and appropriate, than the one adopted; although it may indeed occur, that a nearly vertical mass, or segregation, may have to be considered as belonging to the horizontal ones. It is then probable, that it is no longer in the position it originally occupied, but has been raised on end together with the surrounding rocks. According to my definition, the expression 'recumbent segregation' can no longer be applied to such as occur in unstratified rocks, and such as show no cleavage; because with these a parallelism can no longer be proved. We must however consider, that in all doubtful cases such fine distinctions of form have no great value. In any case, the approximate parallelism, or the entire want of the same, appears to me to be of more essential value, where either can be proved, than the greater or less inclination of the longest dimensions of an irregular body, the present position of which is frequently no longer the original one.

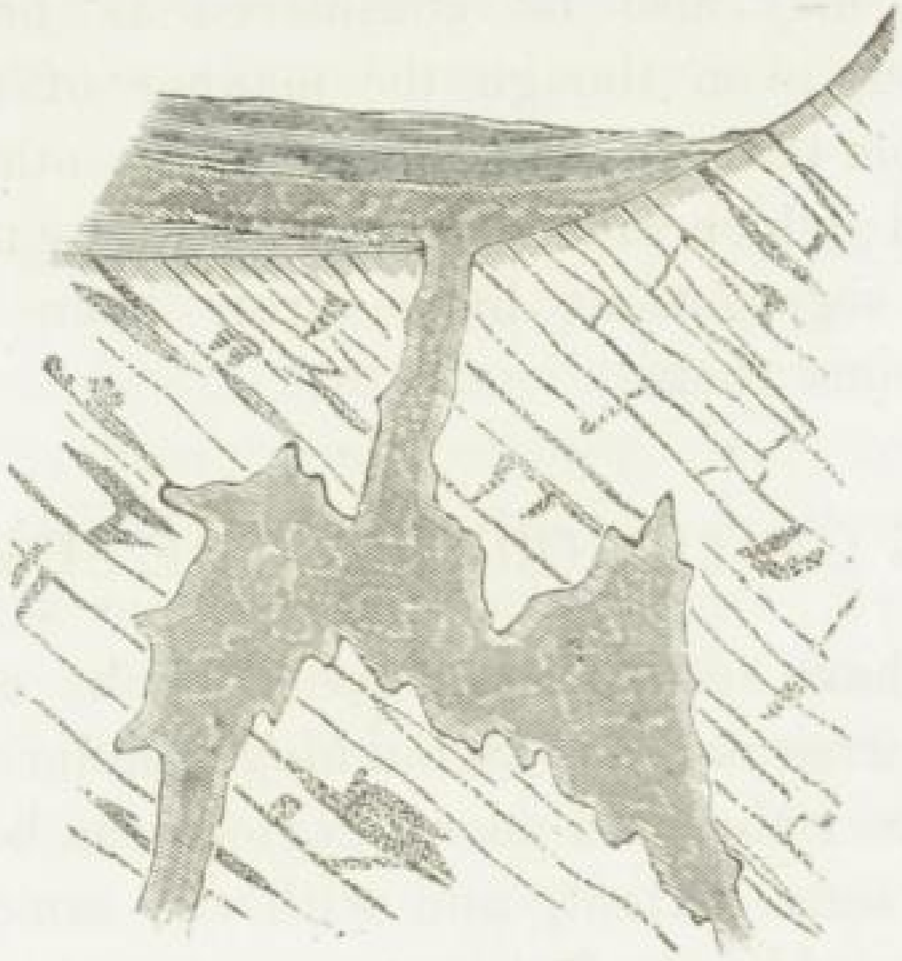
PARTICULAR KINDS OF SEGREGATIONS.

§ 59. The division into recumbent and vertical segregations must properly be called a general one; since every kind of segregation can be classified under the one or the other. Both the form and the manner of occurrence may however cause further distinctions and special definitions. Without laying any great value on these, I give the following, as being the most common:

1. Floors (Stockwerke) are districts of rocks, which are traversed by a great number of irregular or vein-like metallic deposits, so that, as a rule, the whole mass has to be extracted in mining. If the separate deposits are lodes, or fillings of fissures, they form, strictly taken, a network of lodes; though it is more usual to classify them under the segregated masses.

2. Contact-masses are irregular aggregations of ore, which are chiefly found on the limits between two different rocks; as for example, the silver, lead, copper, and cobalt masses of Tunaberg in Sweden, or the irregular metallic deposits of the Banat, which are worked on the limits of igneous rocks and limestone.

3. Fillings of cavities. Many aggregations of ores are decidedly nothing more than fillings of cavities, which had been previously washed out in Dolomite or Limestone; so for example, many deposits of Pea Iron-ore in the Swiss Jura and the Suabian Alps. The following represents the idea of such an occurrence.



Although there are many other terms in use, they are so local, and have such different significations in different places, that it seems needless here to mention them.

OCCURRENCES OF SEGREGATIONS.

§ 60. Irregular collections of ores most commonly occur at the line of contact of various kinds of rocks, or near such lines of contact. Many of these are actually contact formations or contact segregations; although indeed others occur in the middle of a crystalline or sedimentary rock, without it being possible to find any relation between them and the neighboring rock.

These segregations occur most frequently in the crystalline schists, commonly accompanied by granular limestone, or igneous rocks which traverse them; for example, in Norway and Sweden. Others form a part of igneous rocks, especially of amphibolic or pyroxenic green-stones or serpentines. Some are known in the Palæozoic rocks; for example, the pyritic segregation of Goslar in the Hartz, and the spathic iron masses in the eastern Alps; which last, however, according to Von Schouppe are rather irregular beds, than proper segregations. Irregularly formed collections of ores also occur in the Subcarboniferous and Triassic periods; and certain lime-stones in the Alps contain aggregations of ore, which, from their form, can be best considered as belonging to the segregations.

In many lime-stones and dolomites, moreover, cavities exist; which are partially filled with iron ores, especially oolithic iron-ore; and which may also be considered as belonging to the segregated masses, even though the manner of their formation greatly varies from that, in which most of the other segregations have been formed; which indeed is, otherwise, by no means homogeneous. True segregations have rarely been found entirely enclosed by igneous rocks.

DISTRIBUTION OF THE ORES IN THE SEGREGATIONS.

§ 61. We have seen, that in the lodes the ores and gangs are distributed irregularly. Something similar occurs in the segregations, since richer and poorer regions can be distinguished, only not to the same extent, and with the same precision, as in the lodes. In addition the causes or relations of these differences are less distinctly understood in the segregations than in the lodes. The difference of those portions situated nearest the surface is frequently brought about by decompositions, which have been caused by the effect of air and water. The appearance of Gossan, Iron-Hat, Pacos, and Colorados, repeats itself here also.

The influence of the unequal breadth may have caused the ramifications of the masses to be somewhat differently composed from the main body.

The influence of dissimilar wall-rock is hardly perceptible; partly because segregations but seldom traverse different kinds of rocks; partly because the manner of their formation was mostly different, and accompanied by different circumstances, from those of the lodes; and moreover, such an influence could hardly be extended to the interior of such wide masses. The wall-rock appears to have exerted only a general, and not any special influence; *i. e.* certain kinds of segregations appear principally in certain kinds of rocks, or, as contact-masses, at the lines of contact of different rocks. Thus, for example, Zink ore masses are chiefly found combined with Dolomite or dolomitic Lime-stone; similarly the segregations of manganese ores, and also the oolithic Iron-ore segregations, are chiefly confined to cavities in such rocks as have been eroded by water.

The origin of the segregations is evidently, like their form and manner of occurrence, a still more irregular one, than that of the lodes. Not only their masses, but also the space which they occupy, would seem to have been formed in most dissimilar ways. It therefore becomes imperatively necessary, to explain each separate occurrence.

SEARCH FOR AND FOLLOWING-UP OF SEGREGATIONS.

§ 62. Through the great irregularity of this kind of deposits; in regard to their form, inner nature, and manner of origin, as well as their occurrence; no rules can be given for the search for and following up of the segregations. At the most, this could be done only for certain classes of them; and even then but with difficulty. The rules would have to be so variable and indefinite, they would be of no use to the miner. The principle holds good, that local experiences must be used locally. The experience gained in one district, can only be used with the greatest caution, and constant consideration of the altered circumstances, in another. But within certain districts, indeed, the general character of these, otherwise irregular deposits, remains tolerably constant. Fortunately this uncertainty is counterbalanced, to a certain extent, by the large masses in which the segregations occur.

IMPREGNATIONS.

WHAT IS UNDERSTOOD BY, OR COMPRISED IN IMPREGNATIONS?

§ 63. The impregnations (disseminations) differ from all other metallic deposits in having undetermined and in no way sharply defined limits; which is, in all probability, frequently caused by the ores having penetrated certain portions or zones of a rock subsequent to its formation; still there may be certain deposits corresponding to them, in which particles of ore were originally thus disseminated. The rock forming the matrix continues, therefore, between the separate particles of ore; which is not the case with the other classes of deposits. Their form, although undefined, is in part like that of beds, in part of veins, in part of segregations; and they can, in accordance with this, be divided into bedded, vein-like, and segregated impregnations; of which the former two may also be termed impregnation-zones.

They occur, either alone and independently, or dependently, in combination with other metallic deposits of defined limits, which then form their nucleus. In the last case their formation may have generally proceeded from the defined deposits, in so far that they are only consequences and companions of the same; still the reverse is possible: namely, a local concentration proceeding from a disseminated distribution.

OCCURRENCE OF IMPREGNATIONS.

§ 64. Impregnations of ores are found in all the principal classes of rocks, in crystalline schists, in distinctly sedimentary formations, and in igneous rocks. In the last, the older the rocks, the more frequently do they occur.

The ore impregnations, which occur in combination with other metallic deposits, form the local wall-rocks of lodes, the hanging- and foot-walls of beds, or their undefined continuation in the direction of strike and dip, or finally the outer borders of segregations, forming essentially a portion of the wall-rock.

Those, on the contrary, which occur independently, and without apparent connection with other kinds of metallic deposits, form zones, which are undefinedly bounded, and at times even bedlike; or regions in rocks extending in many directions, in such a manner that these rocks, essentially, continue through them, and are only within their extent in some degree more or less impregnated with ores. Perhaps these apparently independent impregnations are, in part, in connection with metallic deposits of another kind lying deeper, but on that account not observable or at least not yet discovered. In any case their general occurrence corresponds with that most common to all other metallic deposits.

MODES OF OCCURRENCE OF ORES IN IMPREGNATIONS.

§ 65. The ores are distributed in various modes in the rocks in which they form impregnations.

1. They form crystals, or grains, which are porphyritically disseminated in the rock. The size of these crystals, or grains, may be very variable; and at times they become imperceptible, so that the impregnation cannot be recognised by the naked

eye, while the apparently homogeneous mass still contains, perhaps, many particles of ore or metal: for instance, much of the auriferous quartz in the West, and the Fallbands in Scandinavia.

The ores form small globules, lenticular masses, or bunches, lying distributed through the rock; each of which consists of a collection of individual particles of ore, sometimes even of very heterogeneous matter: for example, the lead-ores in the sandstone of Commern near Aix-la-Chapelle.

3. The ores fill extremely fine clefts, which either correspond to the cleavage, or even traverse it: as, at times, in the wall-rock of the lodes around Freiberg, etc.

4. The rock is only impregnated, and hence colored, by a metallic oxide; which indeed would but seldom give occasion to a profitable working, but may on the other hand be frequently regarded as a leader to deposits of greater value. This frequently occurs in the neighborhood of iron- or copper-ore deposits.

There is no reason, why all kinds of ores may not occur as impregnations; and, in fact, impregnations of the most various kinds are already known. It appears to me superfluous to recount here the various kinds of impregnations, as we shall become acquainted with the greatest variety of the same in the second portion of this work.

DISTRIBUTION OF IMPREGNATIONS.

§ 66. The impregnations do not follow any general law in regard to their distribution, but are chiefly found in certain kinds of rocks. Thus the tin-ore impregnations in crystalline Schists, and granitic rocks, the impregnations of Zink-ores in Dolomites and dolomitic Lime-stones, gold-impregnations in quartzose rocks, chlorite-schist, talc-schist or micaceous iron-schist.

The impregnations, which occur with lodes, take a still greater choice of wall-rock. Chiefly those rocks; which were much cleft, were previously subjected to great decomposition, or contained much coal or bitumen; are richly penetrated by impregnations: a circumstance, which can be easily explained, partly by the mere mechanical resistance which the others offered to a penetration of the solutions, partly from the want of a re-acting exchange of ingredients.

It frequently occurs, in lode-fissures, that only a portion of the ingredients forming the lode have penetrated the wall-rock as impregnations.

ORIGIN AND AGE OF IMPREGNATIONS.

§ 67. The impregnations occur, as we have seen, partly in company with other kinds of metallic deposits, partly quite independently of any. The first, generally, contain the same, or a portion of the same ores, as the deposits which they accompany; and are, as a rule, consequences of the formation or the transformation of these.

When lodes are accompanied by ore-impregnations, it is to be assumed, that, generally, the solutions from which the materials of the lodes were precipitated—they may have been aqueous, igneous-fluid, or gaseous—also penetrated the wall-rock, and there caused certain deposits in fine clefts or in the rock itself. In the last case, crystals have made room for themselves by their power of crystallization; or an ore took the place of a mineral dissolved; for example, tin-ore that of feldspar.

It is not necessary, that the impregnations should have taken place contemporaneously with the principal filling of the fissure; a case is known, by the side of a lode, in the Morgenstern-mine near Freiberg, in which Mispickel has penetrated the Gneiss, probably long after the formation of the lode, from a partial decomposition and re-depositing of the same. This may occur in many cases of impregnation; but especially in such, as are produced by the decomposition of the ores in the adjoining deposits.

It is, however, possible, that many impregnations are really the cause of the lodes accompanying them. The impregnations existed first, and the filling of the fissure followed by a process of concentration.

That the formation of ore-impregnations is not confined exclusively to the action of water, is very conclusively shown by the impregnations of the bricks and blocks of Gneiss, in the floor of a reverberatory furnace, combined with lodes of metallic sulphurets, which are described in von Cotta's Gangstudien, vol. II. p. 1.

Impregnations which accompany segregations, may, like those accompanying lodes, have been formed contemporaneously with these; *i. e.* have penetrated from the principal mass into the surrounding rock; or they may have been formed by a subsequent partial decomposition of the segregations. The segregations of Zink-ore, which are accompanied by impregnations, appear to have been formed contemporaneously and, perhaps, even homogeneously with these. The products of decomposition, on the other hand, of segregations of copper-ore, consisting chiefly of Pyrites, appear to have penetrated all the clefts of the surrounding rock. Owing to their large bulk, it is very improbable, that the segregations have ever been formed by subsequent concentration from impregnations.

Impregnations, accompanying ore-beds, may also have been formed contemporaneously and homogeneously with these, or from a subsequent lixiviation of the same. In the first case, they are evidently only a modification of the beds, having been a result of contemporaneous deposit with the adjoining rocks. The normal rock-deposit was not instantaneously, or every where completely interrupted; but more or less ore-particles were mixed with it. Where this mingling was locally very great, a true ore-bed was formed with determined limits towards the hanging- and foot-wall, while in other places its continuation was only intimated by scattered particles of ore. Such transitions may have also taken place in the direction of the hanging- and foot-wall. The bed of copper and iron Pyrites at Poschorita in the Bukowina shows similar phenomena. The copper-slates *(Kupferschiefer)* of Thuringia may, in this sense, be also classified under the bed-like impregnations.

It is self-evident, that a formal distinction between beds and impregnations is rendered much more difficult by such circumstances. It would be theoretically more correct, although practically more difficult to determine, were only those ore-deposits called impregnations, which have penetrated an already existing rock or clefts in the same.

That beds or impregnations of Magnetic-iron or Specular-iron were not originally deposited by water as such, is self-evident; but they are always and only found in metamorphic rocks as chlorite-schist, mica-schist, etc., and were consequently subjected to the same catogene[1] influences, as the matter from which the rocks sprang. The peroxide of iron, and under certain circumstances the protoxide, might be formed from the hy-

[1] See foot-note to § 171.

drated peroxide of iron. Similar events might have taken place in other metallic beds, and the accompanying or independently occurring ore-impregnations, which are found in crystalline schists. This circumstance may explain many, otherwise unintelligible, phenomena.

SEARCH FOR AND FOLLOWING UP OF IMPREGNATIONS.

§ 68. Impregnations, which are combined with other ore-deposits, can only be expected in combination with these; and, if they have been discovered, must be followed on the sides, either in an upward or downward direction, wherein the special character of the rock at times furnishes a limit.

The impregnations, which penetrated already existing rocks, very frequently followed, with a certain preference or choice, certain kinds of rocks or modifications of the same, which either were more easily penetrated than the others, or exerted a certain chemical re-action, and by this means induced the precipitation of metallic particles from widely extended solutions.

As regards this case also, the time has not yet arrived to lay down general rules: local observations are the only ones that can be given.

For independently occurring segregated and bedded impregnations no other general rules can be given, with respect to their search and following up, than those which have been given for beds and segregations. In the use of such regard must be had to the more undetermined character of the impregnations in comparison with the clearly defined beds and segregations.

ORE-DISTRICTS.

§ 69. By ore-districts are understood combinations of several ore-deposits into one common whole.

We have now learnt the most important circumstances and differences of form in the occurrence of the separate metallic deposits; and have distinguished:

A. Regular metallic deposits;
   1. Beds,
   2. Lodes.

B. Irregular metallic deposits;
   1. Segregations,
   2. Impregnations.

Very frequently two or more metallic deposits are united into one common whole, that is, a district (region, or depôt); and not only deposits of the same form and kind are thus combined, but such also as are differently formed and differently composed.

Beds of the same ore frequently alternate with beds of rocks, forming in this manner a common ore-stratum; as, for example, the beds of iron-ore in the brown Jura of the Suabian Alps, or the spherosiderite bed in the Carpathian sandstone between Teschen and Kimpolung in the Bukowina.

Many segregated masses of analogous composition occur at times in one rock-district; as the masses of Magnetite near Arendal, the Silver, Lead, Copper, and Cobalt masses of Tunaberg; or several independent zones of impregnations occur together, as the Fallbands of Kongsberg and of Tuna in Dalecarlia.

Such combinations of homogeneous metallic deposits have clearly a common origin, and are the consequences of the same geological event.

But deposits, which are dissimilar in form or composition, are also frequently found so combined with one another, that they must be considered as formations belonging together or dependent on each other, or can at least be united to one geographical group. We have already become acquainted with this combination of dissimilar deposits in the case of the dependently occurring impregnations; several such combinations are frequently again united in groups, as in the case of the Zinc-deposits of Upper Silesia. Lodes and segregations, or beds and segregations, or even beds and lodes, are frequently found combined; examples of these are the Zinc-deposits of Upper Silesia and the district of the Ruhr in Westphalia, or the bedded veins and segregations of spathic iron in the eastern Alps.

But, as already stated, even entirely dissimilar and perhaps independently formed deposits are considered as forming one district, when they are to some degree geographically combined. The boundaries of such divisions, or groups, are of course always more indefinite and to a certain degree arbitrary, the greater the extent they comprise.

It would appear judicious to unite into one Group only those deposits which have some geological connection, and to lay no stress on the geographical combination; but such differences are often difficult to determine.

SPECIAL PART.

A COLLECTION OF EXAMPLES.

SUMMARY.

§ 70. I confine myself to a description of the most important ore-districts of Europe, without particular reference to their geographical distribution. The general order described will be as follows:

1. Germany, commencing with the Erzgebirge.
2. The Carpathian countries; Gallicia, Transylvania, Hungary, Banat, and Servia.
3. The Alps in their entire extent.
4. Italy.
5. France.
6. Spain.
7. Great Britain.
8. Scandinavia.
9. European Russia.

GERMANY.

I. THE ERZGEBIRGE.

THE GEOLOGICAL FORMATION.

§ 71. The Erzgebirge forms a broad, nearly quadrilateral, elevated plateau with a precipitous southeasterly descent towards Bohemia, and a gentle northwesterly slope towards Saxony. This plateau is traversed by winding valleys, but is not overtopped by high peaks. Its crest rises on an average 2000 to 2500 feet above the sea, being at its highest point about 3800 feet. The mass of the Erzgebirge consists predominantly of gneiss and mica-schist, which last gradually passes, towards the northwest, into a fossil-free clay slate. These crystalline schists have been penetrated by granite in several large and many small masses and dikes; by granitic gneiss (distinguished by the name of red gneiss); by masses and dikes of quartz, granitic and syenitic porphyry; by various greenstones and wackes, which however never cover large extended districts; and finally by basalt, which rises here and there in the form of small conical hills. Somewhat of greywacke is found on the northwestern declivity, mostly covered by the carboniferous formation and *Rothliegendes*; the last mentioned formations occur also scattered here and there on the eastern portion of the high ridge, and form, in addition, a coherent basin at the northeastern edge of the mountains by Potschappel. *Quadersandstein* reaches but a short distance on to the eastern portion of the mountains; and entirely isolated tertiary deposits are found at the foot of a few basaltic elevations. All these sedimentary deposits have no recognisable connection with the ore-deposits of the mountains: these last have been found only in the crystalline schists and igneous rocks of the Erzgebirge.

ORE-DEPOSITS OF THE ERZGEBIRGE IN GENERAL.

§ 72. The ore-deposits of the Erzgebirge are of very great diversity; and although, as a rule, not very rich, are still frequent, and are known to exist in great numbers. Of useful metals they contain; silver, lead, copper, cobalt, nickel, bismuth, arsenic, antimony, tin, zinc, iron, and manganese, as well as traces of gold and mercury. Hence all the ore-deposits of the Erzgebirge may be classified as:

1. Tin ore deposits: these are the oldest of this region; and lie in groups, divided into zones of 10 to 20 miles broad, which extend along the crest of the mountains. They form lodes, impregnations, and surface-deposits. The chief points, where groups occur, are: Altenberg, Seiffen, Marienberg, Ehrenfriedersdorf, Eibenstock, Platten, and Johanngeorgenstadt.

2. Lodes of silver and lead ores: often combined with copper, lie chiefly, although not all, in a single zone; which extends in a direction from NE. to SW. obliquely over the broad crest of the mountains, from Meissen, through Freiberg, Langenau, Oederan, Wolkenstein, Marienberg, and Annaberg, to Joachimsthal. They form groups of lodes, and scattered veins, extending in various directions.

3. Veins of cobalt and nickel ores: frequently containing bismuth, and also silver, lead, and copper ores; are chiefly found in the neighborhood of Schneeberg. Cobalt and nickel ores are also found at times in the silver lodes of Freiberg, Marienberg, Joachimsthal, etc.

4. Lodes of limonite and hematite: frequently containing ores of manganese; lie chiefly, like the lodes of tin ore, in a zone corresponding to the crest of the mountains; but often have a strike at right angles to their greatest extent.

5. Deposits of magnetite: beds, bedded veins, and cross veins, frequently combined with other ores, and with greenstones, are found distributed in groups all through the mountains.

6. Deposits of quicksilver ores: or rather traces of fissures, bedded veins, or impregnations, containing cinnobar; in the clay slate near Hartenstein.

7. Ores of antimony, arsenic, and zinc, are found in most of the above-mentioned deposits; manganese ores, chiefly with those of some iron ores. Gold, of which traces are found here and there, is no longer the object of exploitation.

The deposits of the Erzgebirge may be divided, according to their geographical distribution, and grouping, and named from the following places near which they occur:

1. Freiberg (Siebenlehn, Brand, Frauenstein).
2. Altenberg—Zinnwald—Graupen (Pöbel).

3. Berggiesshübel (Liebstadt, Lauenstein).
4. Seiffen—Katharinenberg (Sayda).
5. Marienberg.
6. Ehrenfriedersdorf—Geyer.
7. Annaberg.
8. Kupferberg (Presnitz).
9. Joachimsthal (Gottesgabe, Platten).
10. Schwarzenberg.
11. Johanngeorgenstadt—Eibenstock.
12. Schneeberg.
13 Bleistadt.

To which the following less important districts, lying outside of the Erzgebirge proper, may be added:

14. Langenstriegis—Mühlbach.
15. Mittweida—Hohnstein.
16 Scharfenberg—Munzig.

ORE-DISTRICT OF FREIBERG.[1]

§ 73. This comprises the district between Nossen, Oederan, Erbisdorf, and the stream Bobritzsch; but a few of the deposits extend beyond these limits. The whole district consists predominantly of gneiss; which forms many varieties, and is toward the west overlaid by mica-schist and clay-slate. These schistose rocks are intersected by dikes of quartz-porphyry, and by gabbro, which is somewhat altered into serpentine.

Both grey and red gneiss occur, in the Freiberg district, in a number of different varieties; which generally alternate with one another in parallel layers. The foliation, and stratification, of both lies here nearly horizontal, and gradually dips only in two directions, so as to form a gently sloping saddle. The red

[1] See: Von Herder, der Meissner Erbstolln, 1838; Von Beust, Porphyrgebilde bei Freiberg, 1835,—Gangcharte des Freib. Revier, 1842,—die Erzgangzüge im sächs Erzgebirge, 1856,—Ueber ein Gesetz der Erzvertheilung auf den Freiberger Gängen, 1855 und 1858,—Ueber die Erzführung der Freiberger Gänge, 1859,—Die Erzzonen im sächsichen Erzgebirge, 1859; Freiesleben, die sächs Erzgänge, 1843—1846; Müller, Zinn in der Blende bei Freiberg, Berg- u. hüttenm. Zeitung, 1851, p. 353,—Die Erzgänge nordwestl. von Freiberg, Gangstudien, I. p. 101; Vogelgesang, die Erzlagerstätten südöstl. von Freiberg, Gangstudien, II. p. 10; Gätzschmann, Beitrag zur Geschichte des Freib. Zinnbergbaues, Berg- und hüttenm. Zeitung, 1844; New chart of the lodes in the Freiberg district, issued by the chief mining office.

gneiss generally contains but few lodes. The grey consists, in its most extended and most characteristic variety, of the so-called Freiberg Normal-Gneiss; a distinct compound of orthoclase, quartz, and dark colored mica, with regular granular, foliated texture, separated into distinctly parallel tables or layers. Both, the red as well as the grey, are divided into a great number of subordinate varieties, and contain besides layers, which can hardly any longer be called gneiss.

The deposits of this district; containing silver, lead, copper, arsenic, and zinc ores; are collectively lodes. According to Von Herder's enumeration, more than 900 such are known in the Freiberg district. Their breadth is but seldom more than 1—2 feet. They have been divided, according to the matrix filling them, into four different formations, which have been named as follows:

1. Noble quartz formation, or Bräunsdorfer formation.
2. Pyritous lead formation.
3. Noble lead formation, brown-spar formation, or Brand formation.
4. Barytic lead formation, or Halsbrücke formation.

This is, at the same time, about the order of their relative age: the first-named formations are the oldest, although the difference in age between 1, 2, and 3, appears to be very slight, and almost variable, while 4 is decidedly younger than the others.

In addition to these comes, 5. the so-called Copper formation, which can however be only regarded as a local modification of the pyritous lead formation in which copper ores predominate.

1. The lodes of the noble quartz formation consist predominantly of white quartz, or hornstone varieties of the same, containing numerous fragments of the country rock; gneiss, mica-schist, or black-schist. The fragments lie free in the quartz, which frequently radiates from them as a centre. These lodes contain ores, chiefly in the geodes only, more seldom disseminated. The ores are very rich silver ores; but they only occur in small quantities, and very unequally distributed in nests; especially ruby silver, silver glance, native silver, argentiferous mispickel, silver tetrahedrite, tetrahedrite, myargyrite, stephanite, and polybasite; pyrites, galena, and blende, occur only to a very subordinate degree; the same is true of some other minerals, as calc. spar, brown spar, fluor spar, heavy spar, etc., which occur

almost only crystallized in dispersed drusy cavities. In addition to the above the following minerals are found in the lodes of this formation, in part only as varieties; gypsum, strontianite, pearl spar, spathic iron, dialogite, cerusite, metaxite, hypochlorite, antimonic ochre, valentinite, limonite, specular iron, geocronite, galena, boulangerite, zinkenite, stibnite, heteromorphite, berthierite, bournonite, copper pyrites, pyrites, millerite, blende, kermesite, fireblende, manganblende. The quartz forming the chief portion of the gang, is always firmly united to the country rock. Some of these lodes attain a breadth of 7 feet. Near Bräunsdorf, where they occur most characteristically, they have only been found worth exploiting in a black bituminous schist, the so-called *schwarzen Gebirge*; while they are nearly barren in the common mica-schist. Near Höckendorf they have been found at times locally very rich in the common gneiss.

Over 150 lodes, belonging to this formation, are known to exist in the Freiberg district. The following are very characteristic of this formation; Verlorene-Hoffnung and Segen-Gottes lodes of the Neue-Hoffnung-Gottes mine near Bräunsdorf, the Peter and Frisch-Glück of the Alte-Hoffnung-Gottes mine at Gross Voigtsberg, the Wolfgang lode of the Segen-Gottes mine near Gersdorf, the harder branch of the Reinsberg Glück at Emanuel mine (the softer branch of this double lode belongs to the barytic lead formation) and the Helmrich vein of the Romanus mine near Siebenlehn, finally the Gottlieb lode of the Gesegnete Bergmannshoffnung mine at Obergruna.

2. The pyritous lead lodes consist chiefly of sulphurets with quartz. The first consist of galena containing 15 to 100 grammes of silver, blende, pyrites, copper pyrites, and mispickel. At times the copper pyrites, together with other copper ores, predominate; and then occurs the modification called the copper formation.

Rich silver ores, heavy spar, carbonates, fluor spar, etc. occur only to a very subordinate degree, for the most part only in drusy cavities, in which they may be regarded as being a more recent formation. In addition to these, the following minerals have been found, in part only as varieties, in these lodes; hornstone, opal, gypsum, cerusite, pyromorphite, malachite, azurite, tyrolite (copper froth), pharmacosiderite, scorodite, pharmacolith, erythrine, pittizite, copperas, nacrite, allophane, chlorite, chrysocolla, scheelite, atacamite, stilpnosiderite, kupfermanganerz, melaconite, limonite, red copper, specular iron, cassiterite (traces in blende), native silver, native copper, copper glance, stromeyerite, bournonite, polybasite, silver glance, freieslebenite, silver tetrahedrite, tetrahedrite, tennantite, zinc tetrahedrite, erubescite, pyrargyrite, and *weisskupfererz.* The outcroppings of these lodes are frequently very much decomposed, of the sulphurets only the peroxide and hydrated peroxide of iron have remained (gossan).

This formation occurs chiefly in the lodes south-east of Freiberg; the Himmelfahrt mine exploits many of the same. Von Herder has enumerated over 300 lodes as belonging to this formation. The following may be mentioned as being very characteristic of this formation; the Frisch-Glück, Gottlob, Abraham and Jung-David lodes of the Himmelfahrt mine, the Laura and Abendstern lodes of the Neuer Morgenstern mine near Freiberg, the Jung-Andreas of the Kröner mine, the Leander of the Alt Mordgrube, and the Hochbirkner mines of the Junge hohe Birke.

I have already mentioned the so-called copper ore lodes, as being a modification of the pyritous lead formation: they contain, in combination with quartz, chiefly the following minerals; copper pyrites, erubescite, copper glance, tetrahedrite; and, as products of the decomposition of these, azurite, malachite, chrysocolla, and red copper. The Gottlob, Franzer, and Heinrich lodes of the Morgenstern mines are characteristic of this modification. Their texture, like that of the pyritous lead lodes, is irregular granular.

3. Noble lead lodes. The predominant gang consists of carbonates, especially brown spar and dialogite, with quartz. The chief ore is galena, somewhat richer in silver than in the preceding formation; this occurs combined with blende and pyrites, and frequently forms the middle layer of the very commonly symmetrically formed lodes. These are accompanied, more frequently than in the pyritous lead formation, by rich silver ores; such as silver tetrahedrite, ruby silver, silver glance, and native silver. In addition to which the following minerals, some of them but varieties, occur in the lodes; hornstone, opal, fluor-spar, gypsum, heavy spar, calc. spar, pearl spar, spathic iron, cerusite, pyromorphite, pittizite, nacrite, stilpnosiderite, kerargyrite, limonite, white arsenic, specular iron, rutile, pitch blende, arsenic, polybasite, stephanite, acanthite, freieslebenite, tetrahedrite, copper pyrites, mispickel, xanthocone, and realgar. These lodes are chiefly found in the neighborhood of Brand and

Erbisdorf. Von Herder has enumerated about 340 veins as belonging to this formation.

The following are especially characteristic for the dialogite variety of these lodes; the Traugott, Carl, Ludwig, Hülfe Gottes and Gottholder lodes of the Beschert Glück mine, the Felix and David lodes of the Himmelsfürst mines. On the other hand the following lodes have as gang much more quartz or opal, and proportionally but little brown spar; Segen-Gottes, Benjamin and Gesellschafts-Freude of the Einigkeit mine, as well as the Beschert Glück of the Himmelsfürst mine.

4. Barytic lead lodes. Heavy spar forms the predominant and most characteristic gang: this forms numerous parallel and symmetrically arranged layers, between which occur thin bands of galena, blende, pyrites, fluor spar, or also quartz. The centre of the lode consists at times of large drusy cavities; in which occur the above mentioned minerals, or also rich silver ores and carbonates, beautifully crystallized. In addition to the above characteristic minerals the following also occur; agate, opal, gypsum, pseudo-apatite, calc. spar, brown spar, pearl spar, spathic iron, cerusite, pyromorphite, erythrine, nacrite, beryl, fettbol, singuite, stilpnosiderite, kerargyrite, limonite, specular iron, pitch blende, native silver, native copper, arsenic, bismuth, clausthalite, bournonite, stephanite, polybasite, silver glanze, tetrahedrite, copper pyrites, cobaltine, smaltine, chloranthite, copper nickel, millerite, fireblende, pyrargyrite, realgar. Portions of these lodes are at times found reduced to breccia, from the repeated bursting open of the fissure, especially in such a manner, that fragments of the lodes having a banded texture are cemented together by more recent crystallizations of the same minerals with irregularly distributed drusy cavities. Curved and concentric banded texture, forming cockade ores, also occurs in these lodes. Some of them attain a breadth of over seven feet; Von Herder enumerates about 130, the finest example of which is the broad Halsbrückner lode.

These so-called formations do not always occur characteristically, in some cases the classification is extremely difficult; it frequently appears as if more recent minerals had been formed in the same fissure with older ones, which may be explained by previous incomplete filling or repeated bursting open of the fissures.

They form in part parallel zones, of which a map was first given by Baron Von Beust in his chart of the Freiberg mining district, 1842; in which, however, the western group of the noble quartz formation is wanting. Von Beust distinguishes the following chief directions of strike, and groups of lodes.

1. A group of lodes, whose principal strike is from NE. to SW. Towards the South they bend somewhat more in a southerly, towards the North in a more easterly direction, consequently describing a gentle curve. The matrix they contain belongs partly to the noble lead, partly to the pyritous lead formation, and to the copper formation. To the extreme Northwest some lodes of the noble quartz formation have also this direction of strike. The breadth of the entire group is about 21,000 feet, the known length nearly twice as great. If the whole group be regarded, as a system of fissures formed contemporaneously; then the length appears far too small, and permits the hope that still unknown continuations exist. The dip of most of the lodes of this system being nearly perpendicular, they consequently cut through the but slightly inclined layers of gneiss nearly at right angles.

2. A second chief direction of strike is from nearly S. to N. with a much more gradual dip. These lodes form two nearly parallel groups; the one southerly from Freiberg between the Striegis and the Three Crosses, the other between Freiberg and the Mulde. In the former and more southerly group the matrix, filling the fissures, belongs principally to the noble lead formation; in the latter, on the contrary, to the pyritous lead formation. Both of these intersect group 1 at acute angles; and form, in consequence, many junctions, which are distinguished by a special richness in ores. From this circumstance two principal regions of junctions have been formed, which were and still are important in a mining view: between these lies a less productive district.

3. A third principal direction of strike is from NW. to SE. The lodes of this direction are scattered over a great extent of country between Langenau and Freiberg, and nearly all belong to the barytic lead formation. Southwest of Freiberg they mostly dip towards SW.; northeast of Freiberg, on the contrary, they dip almost perpendicularly towards NE. They form no such closed group, as the lodes of the other groups; while on the other hand some of them, as the Halsbrückner lode, are known to be of great length, and, in part, of great

breadth. They also form junctions with the lodes of groups 1 and 2; in which, as being the younger, they always intersect, and frequently throw these; the junctions formed are frequently distinguished by a richness in ores.

4. A fourth group, about 5 miles broad and 15 miles long, striking from NE. and SW. is formed by the lodes of the noble quartz formation in the district between Nossen and Oederan to the Northwest of Freiberg; and, on this account, stands in little known relation with the other lodes. Most of these lodes dip towards the Northwest. Their chief direction of strike nearly corresponds to that of the first group; but they are widely separated from this, have a different matrix, and are less constant in their special direction of strike. They are enumerated here, as forming a special group: which might with the same right be done with the two divisions of group 2.

Besides these principal directions of strike, many lodes, having intermediate directions of strike, occur in the Freiberg ore district; so that each separate known one, cannot, with certainty, be classified under the preceding groups. Single lodes frequently occur towards the limits of this great network of fissures, especially in the neighborhood of Frauenstein, Ammelsdorf, Höckendorf, and Dippoldiswalde; they mostly belong to the noble quartz formation, which thus encloses on two sides the other somewhat more recent lode-formations. In the interior of these districts the chief junctions are, naturally, the points which have been mostly exploited, thus in the neighborhood of the Himmelfahrt mine and town of Brand.

That the quantity of ore in all the Freiberg lodes is a very unequal one, not only in the separate lodes, but in different portions of the same lode, has been already shown in the general part, where an attempt was made to trace back this inequality in the distribution of ores to determined causes, especially the modifications of the country rock.

All these lodes, with, perhaps, the exception of those belonging to the barytic formation, appear to stand in some causal connection with the dikes of quartz-porphyry which traverse the gneiss of the same region; but these last are nearly always intersected by the lodes, where they come in contact with them. The only known exception is that of the Reinsberg Glück lode, belonging to the oldest or noble quartz formation, which is faulted by a dike of porphyry, and is consequently older than this last.[1]

It would appear, that the ages of the three first mentioned formations of the Freiberg lodes vary but slightly. Since the eruptions of porphyry of this district did not necessarily all take place at the same period; it may be concluded, from the exceptional case mentioned, in connection with other circumstances, that the formation of the Freiberg lodes took place at about the time at which the irruption of porphyry ceased; and that they are to be regarded as being, in a certain degree, consequences, or secondary effects of the same. Now, since boulders of this porphyry have been found in neighboring upper Rothliegenden, while tuffa formations are found in the lower Rothliegenden between Freiberg and Chemnitz, which appear to have had some connection with the quartz-porphyry irruptions; it may be concluded, although not with certainty, that the Freiberg lodes, in general, according to their formation, belong to about the same period as the upper Rothliegenden.

Their matrix appears to me, without a doubt, to have been formed by infiltration; all the facts favor this view, none speak against it: what has been previously said, about the manner of formation by infiltration, will equally apply to the Freiberg lodes. All their ingredients are consonant with it, their texture, especially the banded texture, the order of the mineral succession, the wide branching in narrow fissures, the frequent impregnation of the neighboring rock, the great influence of the country rock on the local composition of the lodes; all these circumstances agree in proving this manner of formation.

ORE-DISTRICT OF ALTENBERG.

§. 74. I consider the tracts around Zinnwald, Graupen, and Pöbel, as belonging to this district.

The gneiss of the Erzgebirge is here much intruded into and broken through by granite, chloritic granite porphyry, porphyritic granite, quartz porphyry, greisen, and basalt. The last is more recent than all the other rocks, and is, probably, younger than the ore deposits of this region. The chloritic granite porphyry appears to be more recent than the remaining igneous

[1] Gangstudien, I. p. 168.

rocks: it is difficult to determine the relative ages of the rest. The gneiss passes locally over into mica-schist, which contains intermediate parallel beds of granular lime-stone or cipolline. Isolated fragments of the coal formation, containing beds of anthracite two to three feet broad, occur in a few localities; they are partly overlaid by quartz porphyry, which is probably more recent. These coal formations have no assignable connection with the ore deposits. The last are partly tin, partly iron ore deposits, partly also cupriferous. The cassiterite occurs both as impregnations in greisen or granitic rocks, as also in lodes.

ALTENBERG TIN STOCKWERK.[1]

§ 75. This tin ore deposit consists of a broad mass of rock of irregular form, apparently of igneous origin, and yet without any sharp line of contact with a portion of the rocks surrounding it; the latter are granite, chloritic granite porphyry, and quartz porphyry. This rock-mass contains tin ore throughout; but this is so finely disseminated as to be almost imperceptible, and in such small quantities that only $^1/_3$ to $^1/_2$ per cent of tin can be produced from it. The rock has a dark, often almost black, color; and consists of quartz, and a silicate of alumina, with fine coloring admixtures of mica, chlorite, specular iron, tin ore, and, probably, also wolfram. Pyrites is disseminated through the rock in fine particles, but the quartz alone can be distinctly recognised, it often occurs as grains, without crystalline structure, in the fine granular rock. Numerous quartz-veins traverse this fine granular mass of rock in all directions; and molybdenite, bismuthine, copper pyrites, pyrites, fluor spar, topaz, pycnite, and nacrite, also occur. The rock might perhaps be termed a fine granular variety of greisen; but it differs from this in texture, color, and in that it contains chlorite and specular iron. The miners call it '*Zwitter*' or '*Stockwerksporphyr*'; the first name may be very appropriately retained, the last is inappropriate, since it neither possesses a compact felsitic mass, nor contains regular crystals.

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[1] See: Nöggerath in Leonhardts Taschenbuch, 1825, p. 562, and 1830, p. 256; Daubrée in Annales des mines, 1841, p. 61, 72, and 83; Cotta in Berg- u. hüttenm. Zeit. 1860, p. 1; and Freiberg Bergakademische Festschrift, 1866, I. p. 157; Müller in Berg- u. hüttenm. Zeitung, 1865, p. 178.

On the walls of rock of the great Altenberg *Pinge*, which is a large crater-shaped hollow, formed by the breaking together of extensive underground workings, a fine granular granite occurs by the side of this dark stanniferous rock, or Zwitter, which passes, in a peculiar manner, into the zwitter. This tolerably feldspathic granite is traversed at this point, like the zwitter itself, by a number of small and irregular quartz-veins, in which the same minerals are now and then observed as in the veins of zwitter. Each of these quartz veins is enclosed on both sides by, more or less broad, dark stripes, in which feldspar is no longer to be recognised, and which has entirely the appearance of the zwitter; it probably also contains somewhat of tin ore. These dark stripes abruptly merge, without any distinct line of junction, into the reddish yellow, fine granular granite, with considerable and very distinct feldspar. Hence the whole appears, as if the dark stripes proceeded from a transforming impregnation of the quartz veins, or the cracks which preceded them; such is its probable origin. If the additional circumstance is considered; that the zwitter proper, worth exploiting, is traversed by quartz veins precisely similar to those in the adjoining granite; and that scattered lighter, fine-grained spots, containing feldspar, occur at times between these veins; which therefore must consist of a fine granular granite; the thought necessarily arises, that the whole mass of zwitter may originally have been a fine granular granite, similar to that now adjoining it; but into which local solutions, containing oxide of tin in combination with other substances, have, aided by numerous fissures, penetrated. The metals have combined with the quartz and mica already existing in the granite, at the expense of the feldspar, which was destroyed by the same solutions. According as the metamorphosis was complete, or only partial; there was formed either real zwitter, or only a granite traversed by veins of quartz or zwitter. If the facts are correctly stated, then the segregated tin deposit only forms the extreme result of this metamorphosis, the continuation of which is found in traces, as quartz veins having a dark border in granite or porphyry, on the footpath between Altenberg and Zinnwald. It appears to me, that traces of such a metamorphosis occur in the chloritic granite porphyry adjoining the zwitter in the direction of Geising. These consist in the fact, that the matrix of this porphyry is frequently darker, poorer in feldspar, and richer in chlorite, than is otherwise common. This rock has not yet been examined, to see whether it contains any tin ore. The preceding results of a geological examination, have been completely confirmed by the chemical analyses of Dr. Rube in Freiberg. They gave the following composition; A denoting the unaltered granite, B the dark colored stripes alongside of the quartz veins, and C the zwitter.

	A.	B.	C.	Difference.		
				B : A	C : A	B : C
Silicic acid	74,68	71,57	71,84	— 3,11	— 2,84	— 0,27
Titanic acid	0,71	0,52	0,90	— 0,19	+ 0,19	— 0,38
Alumina	12,73	12,40	14,40	— 0,33	+ 1,67	— 2,00
Protoxide of iron	3,00	7,22	7,00	+ 4,22	+ 4,00	+ 0,22
Lime	0,09	1,55	0,63	+ 1,46	+ 0,54	+ 0,92
Magnesia	0,35	0,05	0,79	— 0,30	+ 0,44	— 0,74
Potash	4,64	2,80	2,30	— 1,84	— 2,34	+ 0,50
Soda	1,54	1,60	0,67	+ 0,06	— 0,87	+ 0,93
Water	1,17	1,30	1,11	+ 0,13	— 0,06	+ 0,19
Oxide of copper	0,50	0,27	trace	— 0,23	— x	+ x
Peroxide of tin	0,09	0,69	0,65	+ 0,60	+ 0,54	+ 0,04
	99,50	99,97	100,29			

From the above analyses we find, that the composition of the stripes and zwitter may be regarded as identical, while that of the granite varies but slightly from them. This last has lost somewhat of silicic acid and potash by the metamorphosis, and received oxides of tin and iron in their stead; the silicic acid lost may have been deposited in the cracks as quartz.

The *stockwerk* at Geyer is a somewhat analogous case. Should it be questioned, whether the present condition of the Zinnwald greisen may be explained by a similar metamorphosis, I cannot attempt a direct answer. In its favor may be mentioned the enclosed granite masses, and the impregnations proceeding from vertical fissures. Against it, I would cite the very distinct, and often coarse granular texture of this mixture of quartz- and lithion-mica; it being incomprehensible, how previously existing feldspar could have been replaced in such a form.

As regards the Altenberg stockwerk, the theoretical possibility of such a metamorphosis appears to me both possible, and unobjectionable; provided it may be assumed, that a gradual and consequently protracted action took place at a great depth below the surface.

It is known, that tin ore occurs pseudomorphous after feldspar in the granite of Cornwall; consequently it fills the place formerly occupied by the destroyed feldspar. Kjerulf has produced tin ore from aqueous solutions, Daubrée by sublimation. That silicic acid may displace and replace feldspar, is a frequently observed fact; as also the formation of chlorite by the metamorphosis of rocks (for example, in the formation of serpentine) is by no means a new occurrence. The presence of specular iron, and metallic sulphurets, which were not necessarily all formed contemporaneously, can be explained; even though the circumstances and actions cannot be specially marked, during which the assumed metamorphosis may or must have taken place. The totality of the phenomena is in favor of a gradual metamorphosis in the wet way, rather than by a process of sublimation.

TIN DEPOSITS OF ZINNWALD.[1]

§ 76. The *greisen* of Zinnwald consists of a distinct, often coarse granular mixture of quartz and white lithion mica, without feldspar; and forms, so to speak, an underground mountain-top: wolfram, somewhat of tin ore, and at times a little feldspar, occur as accessory ingredients; the last of which, where it encreases in quantity, causes natural transitions into granite; while, from the miners' statements, horses of granite occur scattered here and there in the granite proper. The greisen mass is much intersected by two different kinds of tin deposits, which both belong to the class of lodes. The broadest, being over a foot wide, lie tolerably flat under one another, and are nearly parallel with the dome-shaped outline of the greisen. The others, far less broad, are nearly perpendicular; and when they intersect, frequently fault the other, older concentric ones. The first class, nearly horizontal and broader lodes, are formed chiefly of the same minerals as the greisen; viz. quartz and lithion mica, which have crystallized symmetrically from the selvages,

[1] See: Manès in Ann. d. min. 1823, VIII. p. 513; and 1824, XI. p. 463; Daubrée in same, 1841, XIX. p. 61, 72, and 83; Jokély in Jahrb. d. geol. geog. Reichsanstalt, 1858, p. 566.

and are intimately combined with wolfram and tin ore. They contain, at times, in the middle of the lode: galena, tin pyrites, copper glance, copper pyrites, tetrahedrite, blende, fluor spar, scheelite, cerusite, pyromorphite, uranite, spathic iron, heavy spar, feldspar, apatite, tourmaline, topaz, and pycnite. Sixteen such lodes, from four inches to three feet wide, are known to exist one over another. The miners generally call them beds, from their nearly horizontal position, while the symmetrical arrangement of the minerals from the selvages towards the middle are the clearest proof of their formation in fissures. Still their nature remains very remarkable, and problematical; since, as already mentioned, their outer portion forms only a more distinctly crystallized continuation of the greisen. The quartz occurs at times in very large crystalls; and some of them consist of so-called Haubenquartz; *i. e.* they are composed of opposed plates parallel to their crystal faces, the result of having been deposited in successive layers. The other minerals and ores occur distributed, in the middle portions of the lodes, between the two outer bands; which are composed of quartz and mica with somewhat of wolfram. Hence they are lodes which only vary mineralogically, in part, from the greisen; and occur mostly in a horizontal position, which is a very unnatural one for broad fissures. The perpendicular and narrower lodes, which intersect and frequently fault the preceding, consist on the other hand often merely of cracks or small quartz veins, similar to the irregular quartz veins in the Altenberg zwitter, but differing from these in having a constant strike and dip. They but seldom contain ores, while the country rock is commonly very much impregnated by the side of these with tin ore and wolfram. As being the more recent, they may have formed the passage-way for the mineral solutions; but it is difficult to conceive, that they were also the cause of the destruction of the feldspar; *i. e.* the formation of the greisen from granite, although indeed masses of true granite are found in the greisen. Since the Zinnwald greisen is formed from a coarse granular mixture of quartz and mica, it is difficult to conceive, what has become of the feldspar.

TIN-DEPOSITS OF GRAUPEN, AND POEBEL.[1]

§ 77. Both localities have been but slightly examined; and on this account I describe them together, although situated at the opposite extremities of the Altenberg district. Between Graupen and the Mückenthürmchen, on the crest of the Erzgebirge, are found in great quantities remains of former mining; which come from former tin-mining in grey gneiss and porphyry. According to Jokély, the 1—10 inch broad lodes in the gneiss consist of fissile or micaceous, talcose, and somewhat feldspathic, greisen; in which the tin ore forms threads, layers, or pockets; while in addition talc, steatite, and fluor spar, occasionally occur. They mostly have a gentle dip of only 10° to 20°. The lodes in the porphyry are on an average poorer. At Seegrunde their matrix is chiefly clay, quartz, and hornstone; easterly of this again, of a flintlike mass resembling greisen, with somewhat of tin ore, wolfram, galena, mispickel, copper pyrites, millerite, malachite, talc, and feldspar. Irregular pockets of, often, crystallized tin-ore may be seen in a kind of friction-breccia, between porphyry and gneiss, near the Mückenthürmchen.

At Pöbel the gneiss is frequently intersected by tin lodes, and impregnated with tin ore. Mining there has been recently abandoned.

HEMATITE DEPOSITS OF THE ALTENBERG DISTRICT.

§ 78. Hematite lodes, containing many fragments of the country rock, traverse the granite and quartz porphyry in the region between Bärenburg, Schellerhau, and Schmiedefeld. The mineral matter filling these fissures consists partly of a breccia, principally formed from fragments of the quartz porphyry, the binding medium consisting of compact earthy and fibrous hematite. Besides the hematite, these lodes often contain considerable quartz; and it appears, that certain breccia-like quartz veins, with ferruginous quartz as cementing medium, that occur in the same district, are contemporaneous formations with these.

The iron ore lodes of the Erzgebirge lie in a zone nearly parallel to the crest of the mountains; while the individual

[1] See: Freiberg Jahrbuch, 1844, p. 35; Jokély in Jahrb. d. geol. Reichsanst. 1858, p. 562; Müller in Beiträgen zur geol. Kenntniss des Erzgebirges, II. 1867.

members mostly strike almost at right angles to the general extension of the whole zone. From this fact they form a group of but slight length, but far greater width; whose individual members occur much scattered, and in addition appear to be generally combined with the occurrence of igneous rocks, such as porphyry and granite. We shall hereafter become acquainted with cases, of this iron ore zone of the Erzgebirge, in the Schneeberg and Eibenstock districts. Those of the Altenberg district are some of them exploited, but have never been carefully examined.

ORE-DISTRICT OF BERGGIESSHUEBEL.[1]

§ 79. The district is confined to the immediate neighborhood of this small town. The ore-deposits occur in a dark grey or black clay-slate; which encloses more or less broad layers of hornblende schist, diorite slate, and black chert; and is traversed by dikes of claylike quartz porphyry: they are partly overlaid by *quadersandstein*. This last has no connection whatever with the ore-deposits, but from its overlying prevents in part a farther tracing of the others.

The composition of the ore-deposits appears, according to Vogelgesang, to vary with the depth. In the upper workings of the flat veins, limonite and hematite, with heavy spar, predominate. Deeper are found magnetic iron, garnet, sahlite, pistacite, allochroite, colophonite, quartz, feldspar, etc. At a still greater depth, magnetic iron predominates; and intimately associated with it are erubescite, copper pyrites, copper glance, tetrahedrite, red copper, azurite, malachite, chrysocolla, native copper, pyrites, blende, galena, and (very rarely) native silver; while chlorite, mica, tremolith, calc. spar, brown spar, and fluor spar also, accompany the same. Among these are some minerals evidently of secondary origin, and first formed by pseudomorphous action. Not only are the outcroppings of the deposits formed of gossan, but decompositions have also taken place at a greater depth. Several of these deposits, from a few inches to 20 feet broad, follow parallel to each other, as if they were beds; in addition, a ribbonlike striped limestone, with copper

[1] See: Von Charpentier, mineral. Geograph. d. Chursächs. Lande, 1778, p. 145; Vogelgesang, in Berg- u. hüttenm. Zeit. 1852, p. 635.

pyrites, blende, and galena, also occurs. These beds, which might, from their multiferous composition, be considered as being contact veins, are intersected by lodes which appear to have been formed at different epochs. The older consist chiefly of quartz with copper pyrites, the more recent of calc. spar with copper glance and tetrahedrite; their breadth never exceeds a few inches.

The occurrence of these lodes, connected with the circumstance, that the dikes of porphyry intersecting the clay-slate also follow the slates in their principal direction of strike, appears to afford the best evidence for the determination of the nature of those beds. If the iron ores are considered as forming the original beds, there can hardly be any doubt, that the other ores are of much more recent origin, and have first penetrated into the beds through the fissures in which the lodes occur, in such a manner that the minerals have penetrated at separate successive epochs; since the copper glance and tetrahedrite are here always combined with the hornstone and quartz. These may have penetrated by a sort of infiltration.

ORE-DISTRICTS OF KATHARINENBERG AND SAIDA.[1]

§ 80. The region between Katharinenberg and Saida consists almost entirely of gneiss, the red (igneous) gneiss frequently alternating with the gray; in some places near Grünthal the red gneiss can be distinctly seen to have cut through the gray. Although small masses occur of granite, serpentine, and *Rothliegendes*, they have no connection with the lodes; which are only found in the red and gray gneiss.

The Katharina-Frisch-Glück and Nicolai mines, at Katharinenberg, are now worked on six lodes, which occur in red gneiss; while this last, in the Erzgebirge, is generally destitute of lodes. Besides the lodes now exploited, several others are known. The Nicolai and Katharina lodes appear to be the most important: they consist of decomposed gneiss and clay, quartz, and hornstone, with copper pyrites, copper glance, erubescite, galena, blende, silver glance, ruby silver, and tetrahedrite; more rarely, they contain also calc. spar, fluor spar, and

[1] See: Jokély in Jahrb. d. geol. Reichsanstalt, 1857, p. 578, and 1858, p. 556; Freiesleben in Berg- u. hüttenm. Zeit. 1846, p. 145.

pyrites. The gneiss immediately adjoining the lodes is at times impregnated with ruby silver. Similar lodes occur on the Bohemian slope of the Erzgebirge. At Klostergrab about 40 are known, whose matrix consists of clay and quartz, with galena, blende, pyrites, ruby silver, and stephanite; while those in the red gneiss at Tellnitz contain somewhat of feldspar.

Some copper ore deposits occur in the gneiss near Saida; according to Freiesleben's description, there can be no doubt, that they are bedded veins. The most important of the lodes is the Eschig, which has been traced for a length of 2800 feet, its breadth varying between 3 and 40 inches. The matrix consists principally of quartz, in which hematite, malachite, chrysocolla, erubescite, copper pyrites, black copper, red copper, azurite, zinc tetrahedrite, tetrahedrite, chalcophyllite, aphanesite, and pharmacosiderite, occur in pockets; and more rarely galena, blende, fluor spar, heavy spar, lithomarge, and red jasper.

MARIENBERG.[1]

§ 81. The ore-district of Marienberg, which was discovered in 1520, consists of a gneiss plateau between the Rothen Bockau, the Schletten and the Zschopau rivulets. The gneiss dips 40—60° towards NE. and NW. and is traversed by so-called wacke, silver, and tin, ore-veins. About 140 silver lodes are known, varying from 2 to 30 inches in breadth; which cross one another in such a manner as to produce a network; and whose gang, consisting of decomposed gneiss, clay, quartz, fluor spar and heavy spar, contains copper pyrites, hepatic pyrites, arsenic, ruby silver, silver glance, native silver, and here and there pockets of galena, blende, and cobalt and nickel ores. We shall hereafter become acquainted with a very similar formation in the mica-schist of Joachimsthal on the Bohemian side of the Erzgebirge.

The tin ore lodes, which were formerly chiefly exploited in the Marter and Wilde mountains, consist essentially of quartz and clay in which tin ore is disseminated, in addition to which the tin ore was generally found as an impregnation for a dis-

[1] See: Von Trebra, Erklär. d. Marienb. Bergwerkskarte, 1770; Von Charpentier, mineral. geogr. Chursachs. 1778, p. 180; Bergwerksfreund, vol. 22, p. 40; Berg- u. hüttenm. Zeit. 1860, p. 141; Müller, in Gangstud. III. p. 290.

tance of 2 to 3 feet in the country rock. Quite remarkable, according to Von Charpentier's description, must have been the lode, on which the Einhorn mine was worked in Mount Marter, whose 1 to 2 feet broad matrix consisted of heavy spar and fluor spar with silver ores and bismuth, while the country rock between this and several parallel branches was impregnated with tin ore. It almost appears as if the tin ore had first penetrated into the rock through extremely narrow cracks; which had afterwards been widened, and had then been filled by the younger argentiferous lode formation.

In addition to these silver and tin ore lodes, the same district, as mentioned, is traversed by numerous so-called wacke or 'lime dikes'. These appear to consist of decomposed porphyries and greenstones, and are not of sufficient breadth to form distinct out-croppings at the surface. Not improbably these stand in a certain genetic relation to the lodes, like that of the porphyry dikes to the Freiberg lodes.

EHRENFRIEDERSDORF AND GEYER.

§ 82. This ore-district lies in the narrow portion of the Erzgebirge mica-schist district, and appears to stand in some connection with three eruptive masses of granite, the most important of which forms the beautiful rock of Greifenstein. That the granite, as being the more recent, has burst through the crystalline schistose rock, is most clearly proven from the numerous fragments of this which it contains. This outbursting appears to stand in connection with the tin ore formation of this district, and perhaps also caused the fissures filled by the silver lodes. The most important deposits are the tin and silver ore lodes of the Sauberg near Ehrenfriedersdorf, and the tin stockwerk at Geyer.

In the Sauberg[1] the crystalline schists are traversed by so-called *'Wackengänge'* (dikes of wacke), and also by silver and tin lodes. The tin lodes strike from E.—W. and dip at a considerable angle towards S. The breadth varies from 1—10 inches: they consist mainly of compact white quartz, which is firmly united to the country rock. The following minerals occur

[1] See: Von Charpentier, mineral. geogr. v. Chursachs., p. 192; Naumann, Erläuterungen z. geogn. Karte v. Sachsen, 1838, pt. II. p. 250.

with the quartz; lithomarge, steatite, fluor spar, tin ore, mispickel, copper pyrites, and pyrites: of more rare occurrence are; wolfram, molybdenite, blende, topaz, herderite, gilbertite, beryl, apatite, scorodite, oligonspar (a variety of spathic iron rich in manganese), plinian and pharmacosiderite, the last formed by the decomposition of mispickel. The ores, especially the tin ore, have often penetrated the country rock, or the imperceptible clefts in the same, as impregnations. Where the quartz predominates in the lodes, at times only a thin layer of tin ore and mispickel occurs in the middle, at times the middle of the principal portion of the lode consists almost entirely of mispickel, enclosed at the selvages by thin bands of tin ore and quartz. These lodes often lie close to and parallel with one another as branches, so that they, with the rock enclosed between them, can be exploited and removed at the same time.

The silver lodes strike N.—S., have different dips, attain over a foot in breadth, and always fault the tin lodes when they meet. Their matrix consists of quartz, heavy spar, and fluor spar, with silver glance, ruby silver, and copper ores. At the junctions both these classes of lodes are said to enrich one another, and their contents are mixed together; so that tin, silver and copper ores, are found together with mispickel. Von Charpentier has, unfortunately, not given a more special account of this; nor does he mention, whether the dikes of wacke have had any influence; but only mentions, that they are intersected by the lodes.

The Geyer stockwerk[1] consists of a small granite mass, which has broken through the mica-schist. It has an irregular cone shape, truncated above, and encreasing in thickness with the depth; it is surrounded by the so-called *stockscheider*, which, 1—10 feet thick, consists partly of coarse granular granite, partly of an intimate mixture of quartz and feldspar with numerous angular fragments of gneiss. The form of this granite mass has been well laid open by mining operations, and the breaking together of old workings. The rock varies from middle and granular to compact, in addition to the but sparingly

[1] See: Von Charpentier, mineral. geogr. v. Chursachs. p. 203; Hawkins, in Trans. of the roy. soc. of Cornwall, II. p. 43; Mohs, in Molls Annal. 1805, p. 353; Bonnard, in Ann. d. mines, vol. 38, p. 372; Manès, in same, 1823, vol. 8. p. 515; Naumann, in Erläuter. z. geogn. Karte v. Sachsen, II. p. 176, and 248; Stelzner, im Beitrage z. geogn. Kenntn. d. Erzgebirges, I. 1865.

occurring mica: chlorite, tourmaline, and apatite, also occur. The whole granite mass is traversed by numerous lodes, which strike NE.—SW. and dip 70—80° towards NW.; they are nearly parallel, intersect only at very acute angles, are besides collected in groups, in that several lodes occur near one another at but slight intervals; and are separated from the next group by a mass of rock. They vary from 1 to 8 inches in breadth, and consist principally of quartz, but hold in addition steatite, tin ore, wolfram, mispickel, and pyrites. The tin ore is not confined to the lodes, but occurs also in the country rock, which is more or less impregnated with it, especially in the jointing fissures. It then loses its granitic nature, consists in general only of quartz, and gradually passes into the matrix of the lodes. 'It is impossible,' says Von Charpentier, 'to determine the limits between the quartz of the lodes and the stanniferous quartzose country rock, as also between this and the granite adjoining it, so imperceptibly does the one merge into the other. On this account flucans are extremely rare, and are only indicated in the broader lodes; the lode generally passes as a whole into the rock.' It might well be supposed, that the tin ore had penetrated the granite, subsequently to its formation, through the fissures with the quartz, and in doing so had partially replaced the feldspar. The whole appearance reminds one very much of the Altenberg stockwerk: this last might be marked as a more complete result of the same operation.

An interesting observation of Von Charpentier is: that the tolerably horizontal fissures, which divide the granite into floors, also intersect the lodes, and are either empty, or at times filled with tin ore for a considerable distance. The entire Stockwerk together with its lodes, and the gneiss and mica-schist enclosing, are traversed by a vein of an entirely different kind, the so-called '*rothem Falle*'. This strikes E.—W., dips 65° in North, and consists of quartz, hornstone, and red ochre, together with numerous horses, which are of granite within the granite, of mica-schist within the mica-schist. This lode belongs from its entire nature to the common iron lodes of the Erzgebirge.

To the West of Geyer there occurs a pyrites deposit about 140 feet wide, which contains iron pyrites, with somewhat of copper pyrites and galena. It is doubtful, whether it should be considered as belonging to the beds, or lodes. From its general nature it is to be probably attributed to the metalliferous greenstones, with which we shall become acquainted in the Schwarzenberg district.

ANNABERG DISTRICT.[1]

§ 83. On the Pohl mountain near Annaberg the gneiss is frequently broken through, and partly overlaid, by basalt; near Buchholz it is intersected by dikes of porphyritic granite. Several silver lodes are known to exist, and have some of them been exploited for a long time. The most important have been opened by the Markus Röling mine. They are lodes striking E.—W., having a breadth of 2 - 8 inches, whose gang consists of quartz and fluor spar with somewhat of heavy spar, in which are found ruby silver, silver glance, native silver, cobalt, nickel, and bismuth ores; as well as somewhat of copper pyrites, tetrahedrite, and native copper. This is a similar formation to that of Joachimsthal. Numerous remains of former tin placers are found in the woods South of Annaberg.

JOACHIMSTHAL DISTRICT.[2]

§ 84. The district of Joachimsthal consists of mica-schist with subordinate layers of hornblende schist and limestone, traversed by numerous dikes of quartz-porphyry and basalt; which last occurs partly in a decomposed condition as wacke, and as so-called *Butzenwacke*, even contains the remains of tree trunks. Two large granite masses arise out of the same mica schist to the West. The dikes of porphyry chiefly strike NNW.-SSE., those of basalt, which intersect them, WSW.—ENE., some of them even WNW.—ESE.

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[1] See: Von Charpentier, min. geogr. v. Chursachs., p. 326; Naumann, in Erläuterung d. geogn. Karte v. Sachsen, II. p. 251.

[2] See: Paulus, Orographie des Joachims. Distrikt, 1820; Maier, geogn. Untersuch. z. Bestim. d. Alters d. Silber- u. Kobaltgänge z. Joachims. 1830; Vogl, Gangverhältnisse u. Mineralreichthum Joachims. 1856, and in oester. Zeits. f. Berg. u. Hüttenwesen, 1855, no. 5; Jokély, in Jahrb. d. geol. Reichsanstalt 1857, p. 49, and 569.

The lodes are tin, silver, and iron-lodes.

The tin lodes are only known in the granite region North-east of Abertham, at Neuhammer, Hirschenstand and Sauersack. They were actively worked formerly by the Maurizi mine. About 20 of them have been opened, which strike in such various directions, as to form a network. They consist of fine granular granite, with but little quartz and mica (consequently altogether unlike greisen); which contains as accessories, tourmaline, talc, mispickel, pyrites, and tin ore. These and similar lodes are, near Platten, accompanied by tin placers.

The silver lodes are divided into four groups, tolerably distinct from each other. One principal group lies directly alongside of the town of Joachimsthal, a second near Abertham, a third at Dürnberg, and a fourth at Gottesgabe. Vogl considers the first three to form one zone; which strikes WNW.—ESE., and has been principally exploited at the three points named; and many of the lodes possibly extend through all three without a break. There are two lines of strike, nearly at right angles to each other, which all these lodes follow, and are accordingly distinguished as *morgengänge* and *mitternachtgänge*. The *morgengänge*, of which about 17 are known around Joachimsthal, all strike nearly parallel to the mica schist from WNW. to ESE., but have a greater dip than this towards NNE. Twenty one *mitternacht* lodes are known, of which the Geschieber lode is nearly perpendicular, while the lodes on both sides generally dip away from it. Maier states, that they frequently do not come to the surface, but wedge out towards it, while they encrease in breadth with the depth. The *morgen* lodes, being the more recent, intersect the *mitternacht* ones; but Maier states, that the reverse also takes place. Both classes always intersect the mica-schist with all its subordinate strata, the quartz porphyry, and often even the dikes of basalt and wacke. Still the case appears to occur, where dikes of the last have intersected lodes, or have penetrated into their fissures; from which may be deduced: that the silver lodes were almóst contemporaneous with the formation of the basalt, in that their fissures in part follow the basalt dikes, in part are intersected by the basalt. At all events they also stand in a certain genetic connection with the porphyry, which here is evidently of much greater age than the basalt. This subject is still somewhat obscure. The silver lodes have not yet been found in the granite.

The matrix of all these lodes consists principally of clay and fragments of schist, which have evidently been formed by the friction of the walls on each other. The remaining gang stones are most generally quartz and calc. spar, the last especially in the neighborhood of intersected limestone: more rare are brown spar, dialogite, and fluor spar. The ores are more frequent and varied in the *mitternacht* lodes, than the *morgen* ones. Vogl enumerates 42 minerals, mostly metallic ones, as occurring in the Geister lode, which belongs to the first class. I recapitulate only the most important ones; viz. ruby silver, silver glance, native silver, stephanite, acanthite, galena, blende, tetrahedrite, copper pyrites, pyrites, marcasite, arsenic, bismuth, smaltine, copper nickel, chloanthite, bismuthine, and ores of uranium.

The distribution of the ores in the lodes is by no means an equal one. Maier states, that they were mostly collected in the upper, now exhausted, workings; and he attempts to explain this by the theory of sublimation. Ruby silver and arsenic were found particularly in the neighborhood of the limestone, very seldom near the porphyry; where, on the other hand, other silver ores were collected, and also penetrated, as impregnations, into the cracks of the porphyry. Galena, blende, and pyrites, have repeatedly penetrated the wacke dikes. The cobalt ores are more frequent in the *mitternacht*, than the *morgen* lodes, and more commonly near Abertham, than at Joachimsthal. At greater depths the ores are for the most part only found at the junctions. Vogl considers the lodes to have been formed by infiltration. He found altogether 83 different mineral species in this district, of which the greater portion were found in the silver lodes.

ORE-DISTRICT OF SCHWARZENBERG.[1]

§ 85. The Schwarzenberg district consists chiefly of mica; under and out of which stand out several masses of granite, generally surrounded by gneiss; the most important of which, the Rackelmann, occurs in the immediate neighborhood of the town. The

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[1] See: Cotta, in Erläut. z. geogn. Karte v. Sachsen, II. p. 219; Von Beust, in Gangstudien, vol. 3, p. 224; Müller, in same, vol. 3, p. 174, and 286; Freiesleben, in his geological works; Sternberger, in oester. Zeits. f. Berg- und Hüttenw. 1857, p. 122.

crystalline schists all have a gentle slope away from this granite dome, so that their lines of strike surround it concentrically. The ore-deposits of this district occur as:

1. bedded veins, combined with greenstone, and containing many different ores;
2. hematite lodes.

The bedded veins surround the granite of the Rackelmann also concentrically, as they follow the schistose structure of the mica schist, not as a continuous circle, but as small fragments of rings. These often attain a great breadth in the central portion of their extent; and from this cause approach, in horizontal section, an irregular lenticular form. They are always so firmly combined with the greenstones, that they are only with difficulty separated from these, and are frequently accompanied by granular limestone, or dolomite. Their composition is very manifold, and they can also be classified in groups according to their distribution. Although, in a mining point of view, of but little importance, they seem to me geologically very interesting. They are certainly characteristic of a particular type of ore-deposits; on which account I will describe them more fully than their actual usefulness would warrant. The variety of their mineral composition is striking, in that no determined arrangement can be recognised.

a. The Breitenbrunn Group. The champion deposit of this group, which is exploited by the Fortuna and St. Christoph mines, falls into two divisions. The upper, the so-called '*Kamm*', consists of a mixture of quartz, prase, hornblende, actinolith, and chlorite; the lower, the so-called '*Erzflötz*', of magnetic iron, pyrrhotine, pyrites, copper pyrites, mispickel, black and yellow blende, somewhat of tin ore, garnet, idocrase, actinolith, chlorite, hardened clay, and hornblende; forming an irregular granular mixture together with the more seldom occurring quartz, calc. spar, brown spar, fluor spar, apatite, diopside, sahlite, pistacite, tourmaline, mica, talc, and picrolith; under which follows the so-called '*Sohlgestein*', consisting of an intimate mixture of quartz and feldspar with somewhat of pyrites. Its greatest known breadth is 7 feet, the strike and dip parallel to that of the mica-schist, the last being about 25° towards Southwest. More recently the chief object of exploitation has been blende.

b. The Klobenstein Group. A metalliferous greenstone, in the Sechs-Bruder mine, contained: hornblende, actinolith, pistacite, quartz, garnet, chlorite, serpentine, tremolith, apatite, steatite, copper pyrites, and magnetic iron. The Wohnhüttenstein group is similarly composed.

c. Raschau Group. The Stammasser mines, at Graul and Katharina, exploit pyrites deposits 50 to 120 feet broad, which belong to a greenstone mass. Where but little pyrites occurs, the greenstone is always compact and firm; in those workings, on the contrary, where pyrites and mispickel predominate, the greenstone is decomposed, assumes the nature of wacke, and is no longer recognisable. Besides the pyrites, the following minerals also occur: hornblende, sahlite, kaolin, lithomarge, calc. spar, pyrrhotine; and in fissures, as products of decomposition, copperas, cyanosite, native copper, pharmacosiderite, and scorodite.

d. Unverhofft-Glück Group. Seven mines have exploited deposits in the neighborhood of the Anton smelting works. The rock consists of greenstone with actinolith, quartz, erlan, dialogite, brown spar, blende, copper pyrites, mispickel, pyrites, and argentiferous galena; to a subordinate degree occur picrolith, pistacite, helvin, allochroite, serpentine, and fluor spar; while native silver, pyromorphite, and cerusite, are found in the geodes. This so-called '*Erzflötz*' is accompanied by a parallel layer, consisting of granular limestone and dolomite, (which occur to the West as foot-wall, to the East as hanging-wall,) and contains at times fragments of the ore-deposit, and must consequently have intersected it. The Schützenhaus group is exactly like this; and the Gross-Pohla, Fürstenberg, Wildenau, and Bermsgrün groups are very similar.

e. Teufelsstein garnet rock. A formation allied to the preceding occurrences crops out on the Teufelsstein near Sachsenfeld; in which allochroite predominates, accompanied by pistacite, hornblende, tremolith, fluor spar, quartz, magnetic iron, pyrites, and erlan.

All these deposits appear to belong together, and to be the common result of some geological event. That the greenstones, with which the ores are so intimately combined, have been forced, as igneous rocks, through nearly parallel fissures in the direction of cleavage—widening the fissures in their passage—can hardly be doubted. Besides their analogy to the other greenstones of the Erzgebirge, the great breadth of these veins, with their dip of but 20°—30°, also confirms this view. How could such broad, flat fissures have remained open, and been filled, in any other manner? Still, it was not necessary, that the mineral matter, forming the ores and many of the other minerals, should have been originally present in the greenstones. The fact, that the greenstones are only locally metalliferous, and rich in minerals, favors the view; that the contents of the metalliferous deposits have in some manner subsequently penetrated the greenstones, either by infiltration, or sublimation. Baron V. Beust has attempted to explain the ore distribution in these greenstones by the formation of fissures in determined belts, through which the solutions might have come in contact with the greenstones; and that the influence of the different kinds of rocks must have been of such an energetic nature, as to cause the deposits from the solutions only to take place within, and partly at the expense of, the greenstones. The so frequent occurrence of these rocks together with granular limestones and dolomites, is almost more difficult to explain, than the local contents in ores; the limestones, it is true, lie over, or beneath them; in some cases, however, show by their intersecting and containing fragments, that they have subsequently penetrated. An intersection appears to take place at Unverhofft Glück, fragments of the greenstone are found here in the limestone. Have the parallel limestone beds been subsequently softened under great pressure, and moved from their original position?

DISTRICT OF JOHANNGEORGENSTADT AND EIBENSTOCK.[1]

§ 86. This district, situated near the highest portion of the Erzgebirge, consists mostly of granite and mica schist. The schist passing at times into clay slate, forms here a portion of the great district of this rock in the Erzgebirge; it also forms tourmaline schist, and a few subordinate beds in granite. It passes but exceptionally into gneiss. There is found, in this district, a large number of tin and iron lodes, chiefly in the granite; while a few lodes, containing ores of silver and cobalt, traverse the mica schist of the Fasten Mountain.

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[1] See: Von Charpentier, min. geog. v. Churs., p. 249; Oppe, in Gangstudien, vol. II. p. 132, with map; Manès, in Annal. d. mines, 1823, vol 8.

The tin lodes strike either E.—W. or N.—S.; but they at times deviate from this in the eastern portion of the district. Their dip is in every way irregular. The content of the lode resembles granite; it consists principally of quartz, kaolin, lithomarge, mica, talc, chlorite, and tourmaline, with somewhat of tin ore. The last occurs in pockets, or ribbons. The distribution of these minerals in the lodes is more irregular, than in common granite; so that they cannot, without reservation, be termed stanniferous granite veins. The following minerals are found at times in the lodes; viz. apatite, fluor spar, nacrite, precious serpentine, garnet, micaceous iron, wolfram, molybdenite, mispickel, pyrites, copper pyrites, copper glance, malachite, red copper, and very rarely galena, and native gold. Near iron ore lodes they also contain; hornstone, hematite, specular iron, and uranite; near metalliferous greenstones (not far from Schwarzenberg), actinolith and silver, cobalt and bismuth ores.

These subordinate minerals appear to be mostly of secondary formation; and either penetrated into the granitic rock subsequently, or were formed by the occurrence of peculiar circumstances. The general character of the lodes is so like that of granite; that they might be considered to have been injected in an igneous-fluid state; with which, however, do not agree their slight breadth, and at times banded, even though not exactly symmetrical, texture, as well as the irregular distribution of the ores in them. Since feldspar and mica may also be formed in the wet way, a decision can only be arrived at with great difficulty. In any case these lodes form a common district with those previously mentioned at Abertham near Joachimsthal. The distribution of the tin ore in the lodes appears, according to Oppe, to have been much governed by the nature and influence of the wall-rock. According to Oppe the lodes are richest in

tourmaline schist; after which, following the order in which they have had the most favorable influence,
foliated mica-schist containing tourmaline,
granite,
foliated mica-schist, without tourmaline,
common mica-schist; and lastly, as most unfavorable,
clay-slate.

It is stated, that the order should be nearly reversed as respects the iron lodes.

These tin lodes are the oldest lodes of the region, but are among themselves not all of the same age. Where in them the granitic gang comes in contact with other gangstones, the first always appear as the eldest.

In addition to the above is the tourmaline schist of the Auersberg, which forms an insulated mass in the granite, partly containing tin itself, partly traversed by very slender tin veins; and this stannous rock appears to have been the source, whence were formed the formerly worked tin placers around Eibenstock.

The lodes of iron-ore occur sometimes singly, sometimes united in groups. They appear most thickly, united in a group which intersects the granite mass almost N.—S., passing eastwardly of the town of Eibenstock. A great number of lodes intersect one another at very acute angles, and nearly at one point, near Rehhübel. They often occur here, as generally in the Erzgebirge, as contact-lodes, between granite and mica-schist. They are much rarer in the mica-schist itself, than in the granite; but, as bedded lodes, follow the mica-schist at times in its line of strike. The majority of these lodes have a sudden dip towards West. Their gangs must be regarded, as having been mostly formed from the granite; but they have no such resemblance to this, as those of the tin lodes; on the contrary they appear more as masses, which have been formed by a lixiviation of the adjoining rock, partly with, partly without a crystalline texture. They consist of hornstone, quartz, and ferruginous clay with hematite, more rarely combined with specular iron. The hornstone passes into ferruginous quartz, and jasper; the quartz, into amethyst, and chalcedony, or opal; the clay, into kaolin, or lithomarge; the hematite, into black iron stone (a variety of limonite rich in manganese), limonite, and xanthosiderite. As subordinate minerals, occur polianite, psilomelane, cobalt ores, bismuthine, bismuth ochre, bismuth, copper pyrites, copper glance, erubescite, malachite, and red copper.

A local, and certainly very remarkable, occurrence was the discovery, in 1834, of seams of anthracite, $^1/_2$ to 5 inches thick, extending about 40 feet in a hematite lode of the Lorenz mine at Rehhübel. The iron lode consisted, at this point, principally of schist and granite fragments with quartz, hornstone, and clay. The anthracite appears to have been derived from the adjoining mica-schist, the latter at this point containing thin seams of the coal, which may have penetrated entirely in a mechanical way, like the fragments of rock in the lode.

The texture of these iron lodes is, as a rule, an irregular granular one; and they but seldom show traces of a combed arrangement. The wall-rock is often strongly impregnated over a great breadth; the lodes are at times as much as 100 feet broad.

Lodes of silver and cobalt ores at the Fastenberg. This mountain consists, for the most part, of mica-schist; which is traversed by numerous granite dikes, striking S.—N. or SE.—NW.: to the North it is joined by a mass of granite. A broad lode of iron ore cuts through the mica-schist and granite. A large number of silver lodes occur in the mica-schist, traversing this, and the granite dikes, and faulting these last. They also penetrate the granite mass, appear to contain fewer ores in this, are cut off by the iron ore lode, but are again found beyond this. The gang of these lodes is quartz, and hornstone, with somewhat of fluor spar, calc. spar, clay, and particles of the wall-rock, in which occur many ores containing silver, lead, copper, cobalt, nickel, bismuth, arsenic, iron, and, as it appears, tin. Von Charpentier mentions especially native silver, ruby silver, silver glance, kerargyrite, tetrahedrite, galena, cerusite, mimetene, native copper, copper glance, blende, pitchblende, mispickel, arsenic, and copper nickel.

SCHNEEBERG DISTRICT.[1]

§ 87. The district of Schneeberg consists chiefly of mica-schist, at times passing into clay-slate, and burst through by large granite masses, as well as smaller ones of greenstone. The ore-deposits are lodes, which mostly occur in the mica-schist and clay-slate, but at times also extend into the granite. The most of them occur in the immediate neighborhood of Schneeberg and Neustädtel. Müller has classified them, according to their ores and relative age, into:

1. copper lodes,
2. quartz veins,
3. pyritous lead lodes,
4. heavy spar lodes,
5. cobalt lodes,
6. iron lodes, and
7. so-called *Schwebende*.

[1] See: Müller, in Gangstudien, III. p. 1; Von Charpentier, min. geog. von Chursach.; Freiesleben, in his geological works of 1843, 1844, 1845, and 1846; Martini, in Karsten's Archiv, 1829, XIX. p. 531; Berggeist, 1860, p. 517, 525, and 527.

Tin lodes are also found in a more southerly direction, with which we became acquainted in the preceding §; while, to the North, traces of quicksilver lodes are found in clay-slate near Hartenstein; which are, however, of no importance.

The total of the Schneeberg lodes forms an apparently irregular network; the like lodes generally, however, have the same strike; from which it follows, that fissures have been burst open in various directions and filled at different periods.

The copper lodes strike NE.—SW. and mostly have a steep dip toward SW. They are formed of quartz with copper pyrites, erubescite, copper glance, tetrahedrite, and red copper; at times also galena, black blende, pyrites, and mispickel. The chief representatives of this formation are the König-David lode, and those on which the St. Michaelis, St. Christoph and Grün-Schild mines are exploited. The first-mentioned traverses granite and mica-schist, and contains in addition to the above mentioned ores, chrysocolla, malachite, azurite, native copper, allophane, tyrolite, linarite, cerusite, pyromorphite, anglesite, native silver, as well as jasper, heavy spar, and brown spar. The greater part of these minerals have evidently been formed by the decomposition of the original sulphurets. The texture is chiefly irregular granular, although at times the sulphurets form leaders in the quartz, from which it follows, that they are in general of more recent formation than this.

The quartz veins have a similar strike to the copper lodes, with a northwesterly dip of 45° to 80°. They cross the cobalt lodes nearly at right angles, and occur for the greater part in mica-schist and clay-slate, but also penetrate the granite. Their matrix in the main is only quartz and clay; but still they now and then contain somewhat of galena, copper pyrites, pyrites, mispickel, black blende, chrysocolla, chlorite, tourmaline, and fluor spar. At the junctions with the cobalt lodes, which intersect them, they are also impregnated with cobalt ores.

The pyritous lead lodes strike NW.—SE. and dip toward SW. They occur in the clay-slate and mica-schist, and contain principally quartz, chlorite, mispickel, blende, pyrites, copper pyrites, galena, and decomposed wall-rock. They more rarely contain tetrahedrite, erubescite, molybdenite, brown spar, calc. spar, and some minerals formed by decomposition; such as pyromorphite, cerusite, malachite, and nacrite. They are of no mining importance; since up to the the present time they have not been found prolific in ores.

These three types of lodes do not probably differ much as regards their age, and in this respect closely follow the more southerly tin lodes. The following classes are much more recent.

The heavy spar lodes of this district, which were formerly noted for their richness in silver, but have been now mostly exhausted or abandoned, frequently occur as companions of other lodes. When they occur alone, they strike N.—S. and are perpendicular. They generally occur in the mica-schist and clay-slate, near where granite or greenstone have burst through the same. Their gang is principally heavy spar; with which are associated fluor spar, brown spar, calc. spar, and quartz; and which contain at times rich silver ores, lead ores, cobalt, nickel, bismuth, manganese, and iron ores.

The cobalt lodes are now the most important objects of the Schneeberg mining. More than 150 of them are known, mostly found in the mica-schist and clay-slate; still in their lower workings they have been followed into the granite. They are mostly collected around Neustädtel; and strike NW.—SE., although many vary greatly from this, and dip toward NW. and SE. The chief matrix, filling these complexly composed lodes, is hornstone, with somewhat of chalcedony and amethyst; at times traces of the former presence of heavy spar is remarked. The hornstone forms the oldest, and generally also the broadest layer. From this oldest layer, to the middle of the lode, three or four layers may be distinguished, which follow, but are not sharply separated from one another, and which have a very complex composition. The first of these, or the second layer, contains: quartz, brown spar, safflorite, smaltine, copper nickel, chloanthite, bismuth, bismuth ochre, bournonite, tetrahedrite, hematite, specular iron, spathic iron, limonite, and psilomelane. The third contains: fluor spar, dolomite, calc. spar, arsenic, pyrites, lonchidite, pitchblende, copper pyrites, galena, red blende, and polianite. The fourth: realgar, earthy cobalt, cobalt bloom, roselite, millerite, bismuthine, bismuthite, bismuth ochre, eulytine, hypochlorite, marcasite, pyrrhotine, polybasite, stephanite, proustite, pyrargyrite, sternbergite, silver glance, kerargyrite, native silver, ganomatite, gummite, uranite, liebigite, uranium ochre, kupferpecherz, pharmacosiderite, malachite, chrysocolla, native copper, pyromorphite, wulfenite, cerusite, pyrolusite, and psilomelane. Of still more recent origin from decomposition are calc. sinter, gypsum, cobalt-beschlag, arsenious acid, annabergite, iron sinter, köttigite, and manganese ochre. These numerous minerals by no means form constant layers in the lodes; some of them occur but very seldom, and much scattered; but the order of succession in which they were formed, which appears to have been partly by transformation, remains in general the one here mentioned.

About 60 iron-lodes are known in the neighborhood of Schneeberg; they mostly occur, at the outer limits of the granite, as contact-lodes, and in the granite; more rarely within the mica-schist. Their general direction of strike is NW.—SE., but at times varies greatly from this. One lode in particular, the so-called *Rothe Kamm*, forms a contact-lode along the nearly straight Northeast boundary of the Oberschlema granite-mass. The same can, toward the Northwest, be followed for quite a long way in the mica-schist, and finds, to the Southeast, an almost straight continuation at the limit of the Auerhammer granite-mass. Nearly in the prolongation of its direction of strike is found the Rothberg lode, not far from Schwarzenberg; while between these two points, where the rock consists almost entirely of mica-schist, it appears seldom worth mining. This occurrence on the the limits of, and in the granite, is repeated near Schwarzenberg and Eibenstock. The predominating minerals in these lodes are: red and brown hornstone, jasper, ferruginous quartz, rock crystal, amethyst, kaolin, clay, hematite, limonite, and manganese ores. Subordinate to the preceding are chalcedony, opal, heavy spar, brown spar, spathic iron, calc. spar, specular iron, stilpnosiderite, chalcolith, uranite, as well as cobalt, bismuth, and copper ores.

All these Schneeberg lodes must, from their entire character, be considered as lodes formed by infiltration, but in which, after their formation, an extraordinary number of transmutations must have taken place. Especially does this seem to have been the case with the cobalt lodes. The granite appears to have played the most important part, as causal igneous rock; still all the lodes are of much more recent origin than this.

BLEISTADT.[1]

§ 88. This district is mostly formed of mica-schist, locally passing into gneiss, and traversed by a dike of porphyry, whose course is nearly parallel to the axis of the Erzgebirge. Near Bleistadt are found a few lodes, which strike N.—S. or WSW.—ENE. To the first class belong 6 lodes, which in places cross one another at very acute angles. The most important of them is the Karl-Leopold, properly composed of two lodes, which frequently unite and again separate. Since, however, the horse between the two, consisting of clay, fragments of schist, and quartz, is also metalliferous, it is worked like a Stockwerk. The lodes proper are 1—2 feet broad, the horse between them at times 7 to 8 fathoms. In the other N.—S. lodes the gang is also chiefly clay and quartz, in which occur galena, blende, and pyrites. Pyromorphite and cerusite have been formed by the decomposition of galena. The two lodes of the second class, which are the best known, have the same composition. The ores occur in them in bands or nests, in which blende forms the outer layer of the galena nests. In the upper workings, besides pyromorphite, and cerusite, much limonite has been found. No connection has been discovered between the se lodes and the dikes of porphyry.

II. THE FICHTELGEBIRGE.

GEOLOGICAL FORMATION.

§ 89. I include under the Fichtelgebirge the entire mountain-district, forming an elevated plateau, included between the Erzgebirge, the Bohemian Forest, and the Thuringian Forest. Consequently, I include (in addition to the granitic mass of the Fichtelgebirge, in its more narrow sense), the Voigtland and the Franconian Forest. While the broad elevated plateau is generally 1500 to 2000 feet above the sea, the granite peaks rise to a height of 3000 feet.

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[1] See: Jokély, in Jahrb. der geol. Reichsanst. 1857, p. 46; Sternberger, in öster. Zeitschr. f. Berg- u. Hüttenw. 1857, p. 71.

But few ore-deposits are known to exist in the granite district; while more have been found in the rocks, generally slaty, surrounding the granite: they are of far less importance than those of the Erzgebirge.

Devonian and Silurian rocks, as well as azoic clay-slate, predominate in the broad plateau. The last passes into mica-schist, and this into gneiss, which last occupies but a small extent. The gneiss is found, partly on the walls of the granite, partly, combined with mica and hornblende schist, as an isolated mass of elliptical form, in the middle of the silurian formation near Münchberg, whose strata, remarkably enough, it overlies. The mica-schist contains subordinate layers of granular lime-stone, dolomite and quartzite. Eclogite and serpentine frequently traverse the Münchberg gneiss. Numerous greenstone masses (diorite and diabase) intersect the Silurian, Devonian, and clay-slates; which greenstones are mostly divided into two zones, nearly parallel to the strike of the strata, from NE. to SW. Besides these two zones, numerous masses of greenstones occur scattered through the strata. Limestones and iron ores are principally found within the zones.

True porphyries are extremely rare within this large mountain-district, which may be the cause, that the characteristic lode-formations of the Erzgebirge are wanting.

Isolated masses of basalt occur in various places but appear to stand in no relation to the ore-deposits.

The lodes are found principally in the northern portion of the plateau, in the region occupied by the Silurian, Devonian, and azoic slates, and in the crystalline schists near Goldkronach.

The iron bed, in the mica-schist of Arzberg, is the most important of the ore beds; and traces of tin ore are found in granite near Weissenstadt, which are worth noticing, in that it occurs in a southwesterly prolongation of the Erzgebirge tin-ore zone.

Most of the ore-deposits of this district have been but slightly examined and described; since they are not of very great importance, I will describe them concisely.

The lodes mostly contain iron, copper, nickel, cobalt, antimony, and gold ores. Iron, copper, nickel, and cobalt ores frequently occur in the same lodes; but the iron generally predominates. Lodes of this nature are the most extensive; they are not confined to one locality, but occur scattered over nearly the whole region occupied by the slates, and are only to a slight extent combined with the greenstone intersections of these.

LODES IN THE VOIGTLAND SLATES.[1]

§ 90. In the graywacke rocks between Christgrün, and Stenn near Zwickau, occurs a succession of greenstones, which are accompanied by iron ore deposits of a peculiar kind.

As these deposits principally occur at the limits of the greenstones, they may be comprised under the general name of contact-deposits; though at times they are found altogether within the greenstones, or at some distance from them in the slates. Though clearly of a veinlike character, these deposits are distinguished from the iron lodes of the upper Erzgebirge and western Voigtland (occurring as true fissure lodes), not only by the irregularity of their extent, as well as of their strike and dip; but also by the frequent absence of salbands. The frequent transition of their matrix; from limonite, and hematite; either pure, or somewhat deteriorated by intermixture with chlorite, quartz, and calc. spar; through more or less ferruginous greenstone, or slate; into the totally barren country rock; shows a greater resemblance to certain classes of beds. They appear at times, extending for a considerable distance in length and breadth, forming veinlike masses several fathoms broad, at times following the greenstone limits and slates in the most fantastic curves; at times occurring as broad, bedlike zones, of extremely ferruginous azoic or silurian slate, between non-metalliferous layers of this rock; again, as pockets or nests in the midst of decomposed greenstone, which not seldom are of considerable breadth and extent. Near the surface their ore is chiefly massive or earthy limonite with somewhat of goethite of at greater depths these are replaced by hematite in various degrees of purity.

With the occurrence of the greenstone zone, extending from the Elster valley near Plauen to the neighborhood of Hof, are found a large number of iron lodes of another formation. They

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[1] See: Müller, die Eisenerzlagerstätten des ob. Erzgebirges in Voigtland, 1856; Spengler, Zeitsch. d. deutsch. geog. Gesellsch. 1851, vol. III. p. 384 Berggeist, 1860, pp. 527, and 708; Humboldt, in bergm. Journal, 1792, vol. II. p. 74; Goldfuss and Bischof, Beschreibung d. Fichtelgebirges, 1817, vol. II. p. 213.

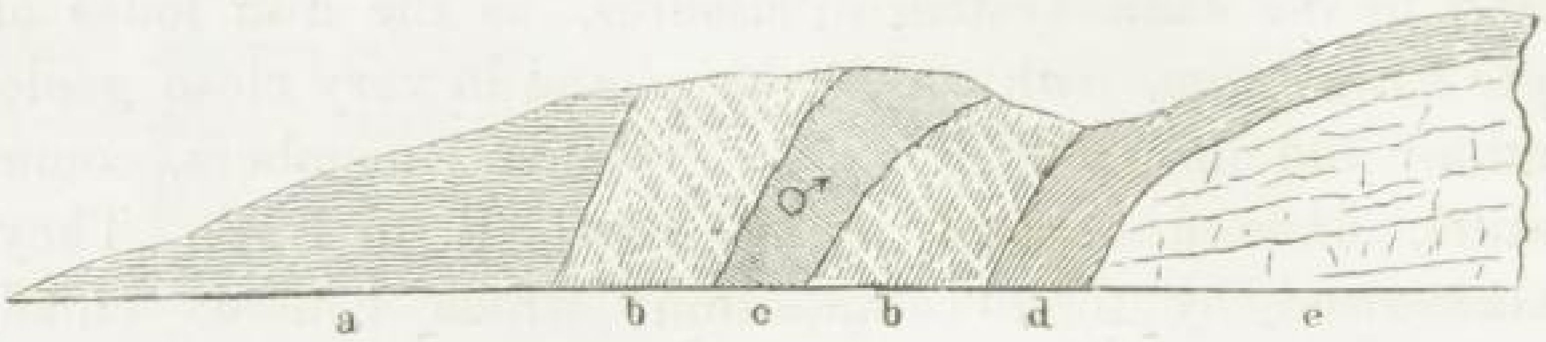
belong to the same system of fissures, as the iron lodes of the upper Erzgebirge, with which they stand in very close geological relation; and form a belt, whose individual members, commonly parallel, have a general strike from SE. to NW. They are characterised by their composition; which consists chiefly of limonite and spathic iron, together with quartz, hornstone, and clay; while heavy spar, goethite, and small quantities of copper sulphurets, or salts, are more rare occurrences. Breithaupt has discovered three new minerals in these lodes; homichlin, roettisite, and conarite. The separate members of this belt, whose breadths vary from 2 to 14 feet, are found throughout the whole extent of the greenstones mentioned, which they generally intersect at right angles to their axis. It is true, that several of them extend beyond the greenstones into the slates; but their ores diminish so rapidly in these, that they are mostly unprofitable to work.

Another very important iron locality occurs above Plauen, and is also in the zone of the Voigtland greenstones: it extends from the river Elster Southwest nearly to Hof. The most important of the lodes is the Grüne-Tanner, which can be traced from Bösenbrunn almost to Pirk for a distance of 8400 feet, and in whose different branches, five mines are or have been exploited, but only to a slight distance beneath the surface. The lode, which has at times a breadth of upwards of 14 feet, consists chiefly of limonite, somewhat of spathic iron, and goethite, with quartz, and small quantities of copper ores; it is stated to have been at no point exploited to a greater depth than 25 fathoms. Not far from this occurs the Dreifaltigkeit lode, which has a known length of 1050 fathoms, and has been worked to a slight depth for copper, as well as iron ores.

The iron ore deposit of Oberböhmsdorf near Schleiz also belongs to this class.

It is, according to Spengler, a hematite lode in aphanitic greenstone, having a texture resembling conglomerate.

This lode strikes parallel to the greenstones from NE. to SW., dips towards SE. and attains a breadth of 20 feet. Both its breadth and relative percentage of iron appear to diminish with the depth. The following wood-cut gives an idea of the stratification. The percentage of iron in the red clay ironstone decreases with the depth; and it passes into a still ferruginous mass, containing pyrites, which resembles greenstone.



a. Quartzose mica-schist.
b. Aphanite and slaty greenstone.
c. Iron-stone deposit.
d. Clay-slate.
e. Compact mica-schist.

The analogous lodes in the neighborhood of Steben, Naila, and Selbitz, were concisely described by Humboldt in 1792. The great Silurian and Devonian slate-district of the Fichtelgebirge is here bounded to the North by azoic clay-slate; while both are frequently burst through by diorite, and diabase. The lodes frequently intersect one another at acute angles; attain a breadth of 10 to 20 feet, and consist principally of spathic iron, and limonite, with quartz. As subordinate minerals, occur: chalcedony, lydian stone, fluor spar, actinolith, hematite, copper pyrites, and malachite. According to Goldfuss and Bischof, they also contain azurite and iron pyrites; while the Ehrlich lode at Steben contains ores only in the clay-slate cleaving into thick slabs, while in that, which cleaves into thin plates, it is very narrow and contains no ores.

IRON-DEPOSITS IN THE SOUTH-EASTERN SCHIST-REGION.[1]

§ 91. The mica-schist, between Wunsiedel and Eger, contains, parallel to its strike, from SW.—NE. two strata of granular limestone, of which the immediate hanging-wall frequently consists of limonite deposits. These are best opened up by mines near Arzberg and Biebersbach.

The limonite, which is frequently covered by a crust of clay, contains concretions of jaspery brown ferruginous quartz, and considerable hausmannite.

These limonite deposits have probably been formed by the alteration of spathic iron beds; since, in the deeper workings of the mines, are still found traces of spathic texture. Under dif-

[1] See: Goldfuss and Bischof, Beschr. d. Fichtelgeb. II. pp. 90, and 127; Flurl, die Gebirge Baierns u. d. Oberpfalz, pp. 424, and 683.

ferent circumstances the spathic iron might have been altered into magnetite deposits, combined with pyroxene or amphibole, like the magnetite deposits in the greenstones of the Erzgebirge, which so frequently occur in immediate contact with granular limestone.

GOLD AND ANTIMONY ORE-DEPOSITS AT GOLDKRONACH.[1]

§ 92. Goldkronach lies at the extreme southwesterly end of the Fichtelgebirge, where hornblendic gneiss joins slates traversed by greenstones, which Hahn considers as being azoic. These only occupy a small extent, surrounded on three sides by gneiss. This district contains gold lodes, which Hahn describes nearly as follows.

The auriferous lodes, occurring in the older crystalline clay-slate (azoic clay-state) near Brandholz, are frequently recognised only as thin fissures. These are distinguished by thin bands of clay of dark brown, light brown, or almost white color, which divide the hanging- and foot-walls like a mathematical plane. Both the hanging- and foot-walls of these fissures have a quartzose character for a distance of several inches, and are impregnated by auriferous iron pyrites and mispickel, being but seldom entirely barren. He never found native gold in such places, and but seldom stibnite.

These appearances, especially the thin leaflike nature of the lodes, are observed with satisfaction, since they are frequently the forerunners of an approaching advantageous change in the breadth and contents. To these single leaves (if I may be permitted to use the term) is suddenly joined a second leaf, as if springing out of the rock. The rock becomes softer, and both the leaves separate from each other, enclosing between themselves, as selvages, the lode proper, which in this manner frequently attains a breadth of a foot or more.

The lode gradually contracts in the same manner as it expanded. The selvages again approach each other, and the lode returns to its empoverished condition. The lode acts in this

[1] See: Hahn, in Berg- und hüttenm. Zeitung, 1855, p. 97; Goldfuss and Bischof, Beschr. des Fichtelgeb. I. p. 184. The last describe the country-rock as mica-schist.

manner, not merely in one, but in all directions, in which it is exploited. The places, where the ores occur, have a lenticular form, whose greatest diameter is 30 to 60 feet or more. The gang of these lodes is generally a hard, fine, fibrous white quartz, frequently traversed by threads of the same having a blue color; it is richly impregnated with auriferous mispickel, and iron pyrites; and generally contains grains, or lamina, of gold. Stibnite also occurs, as a rule, with the encreasing breadth of the lode; partly in larger masses with a crystalline texture, partly in fine geodes as completely formed glancing needles, frequently having a radiated structure. Kermesite and Jamesonite (?) occur as rarities; the former having a spendid silk glance. Hahn found, as still greater rarities, valentinite and native antimony, the last of which he supposes to have been formed from the stibnite by the action of vapors.

III. THE THURINGIAN FOREST.

GEOLOGICAL FORMATION.

§ 93. The Thuringian Forest is geologically divided into two very unequal parts. The southeastern portion which joins the elevated plateau of the Fichtelgebirge, without any natural boundary occurring between them, forms like this a broad plateau, consisting principally of Silurian rocks; which are to the North bounded by Zechstein, to the Southwest by the carboniferous formation, *rothliegendes*, and *buntsandstein*. In this broad Silurian district, whose chief direction of strike is NE. to SW., but few igneous rocks occur; and these are small masses, and dikes, of granite, porphyry, and greenstone. Perhaps in consequence of this, it but seldom contains ores.

The northwestern portion forms a small mountain-ridge with hilly surface striking from SW. to NE. Its geological formation differs from the other portion, and is much more varied. Granite, syenite, gneiss, and mica-schist, appear to be the oldest rocks; and are frequently traversed by various porphyries and greenstones. The porphyries, in particular, which may be divided into quartzose and quartzless (mostly mica porphyries), play an important, and frequently predominant part. Combined with these, partly overlying, partly traversed by them, are the carboniferous formation and *rothliegendes*, which form very important strata among the mountains. Silurian rocks are entirely wanting; the *zechstein* formation forms a small border, frequently much tilted, on the outer edge of the mountains.

ORE-DEPOSITS IN THE EASTERN SILURIAN FORMATION OF THE THURINGIAN FOREST.[1]

§ 94. 1. Iron ores. In the neighborhood of Steinach, not far from Sonnenberg, considerable quantities of limonite and hematite are obtained in the silurian rocks, whose bedding corresponds to that described in § 90.

At Schmiedefeld, near Gräfenthal, a belt of iron ores occurs in the Silurian district; which is parallel to the strike of the slates, and is about 100 feet broad. The veins have a greater dip than the Silurian strata, being about 85° in the NW. They consist, at the surface, of limonite with lumps of oolithic, black, manganiferous ironstone. Hematite has been found, at greater depths, in several of the lodes; so that the limonite appears to be a product of alteration from this; or perhaps more correctly, both are to be regarded as being products from the alteration of spathic iron; in which case these lodes would correspond to those of the Silurian district in the Fichtelgebirge. The ironstone of Unter-Wirrbach near Blankenburg appears to be analogous to these, but existing in larger quantities.

2. Gold, silver, and copper ores. Near Steinhaida, in the same region, a small remnant of *zechstein* and *buntsandstein* is found on the top of the Silurian plateau. Gold was formerly obtained from quartz veins in the Silurian rocks; which is also the probable origin of the gold occasionally found in the bed of the Schwarze.

At Weitisberga, not far from Lehesten, near the place, where a mass of granite has burst through, are several lodes. These appear to be more in small masses of greenstone occurring in the slates, than in the slates themselves; and contain

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[1] See: Voigt's Bergbaukunst, 1789, vol I. p. 182; the same, Magazin d. Naturkunde, 1806. p. 472; Moll's Annalen, 1808, vol. VII. p. 174; Tantscher in Karsten's Archiv, 1829, vol. 19. p. 346; Berggeist, 1860, p. 637.

galena, blende, and copper pyrites, intimately combined with hornblende, and calc. spar. Tantscher thinks, these ores form a bed, or segregation, in the clay-slate.

Near Neustadt, a copper lode traverses the Silurian slate nearly parellel to its direction of strike; it is at times 9 feet broad. It consists on each side, for a breadth of 3 feet, of quartz, and calc. spar, with copper ores; while the middle of the lode is formed of a breccia of clay-slate 3 feet broad.

MAGNETITE DEPOSITS OF THE NORTHWESTERN THURINGIAN FOREST.[1]

§ 95. The small granite mass, which comes to the surface between various kinds of porphyries near Schmiedefeld, contains, westerly of this village, at the Krux mines, some iron ore deposits of irregular form, and whose true character is not yet accurately known. The surrounding rock is hornblende granite; which appears to pass into a kind of greenstone, or is combined with this. The form of the deposits may be best described as a segregation, although their true nature is not yet determined. The most important is the Schwarz-krux, consisting of magnetite, which is partly very pure, partly mixed with quartz, and garnets; and frequently also contains iron pyrites, mispickel, copper pyrites, specular iron, and fluor spar. From the analyses of the ore, it contains somewhat of tin. The impurities generally appear at the outer limits. It is remarkable, that these deposits are intersected by small granite dikes; which differ in their character from the surrounding granite, and probably traverse it. Notwithstanding this, a supposition might be drawn, that this extensive mass of magnetite was in fact only an altered mass in granite, torn away by this, as it came to the surface, from an iron ore deposit in the Silurian rocks; but such a supposition lacks confirmation.

The Roth- and Gelb-krux, near the Schwarz-krux, contain similar iron deposits; but which consist, partly of hematite, partly of very pyritous, and consequently poor, magnetite.

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[1] See: Krug von Nidda, in Karsten's Archiv, 1838, vol. XI. p. 13; Heim, Geogn. Beschreibung d. Thüringer Waldes, 1803, vol. II. p. 100.

MANGANESE AND IRON LODES IN THE PORPHYRIES OF THE THURINGIAN FOREST.[1]

§ 96. The quartz porphyries, as well as those free of quartz (mica porphyry and melaphyr), are traversed in various places by manganese lodes, whose strike is parallel to the ridge of the mountains. These lodes exceptionally penetrate the granite. They contain chiefly pyrolusite, and psilomelane, with heavy spar, and calc. spar; with these are combined wad, hausmannite, braunite, and more rarely manganite. They often contain also hematite, and limonite.

Credner says: 'These ores are found on the Rumpels and Mittel Mountains near Elgersburg, which are the chief localities of the same in the Thuringian Forest, mostly without gang. They have but exceptionally, small quantities of tabular heavy spar, and calc. spar. Large and small horses, of the porphyry, in which the lodes occur, are frequently found in the matrix of the lodes. When the pyrolusite occurs pure, it is found forming parallel bands with the selvages of the lodes, or its needles are all turned towards the middle of the lode. More commonly such a regular arrangement does not occur. Pyrolusite and psilomelane occur in irregular masses between the fragments of porphyry, clay, and clayey wad, in the lode-fissures. The breadth of the lodes is liable to great variations, being in some places 10—15 feet; while in others they are but the thinnest lines; and then the whole porphyry mass is covered by a network of threads, as in a stockwerk. Frequently a lode varies in breadth with its strike and dip; so that at close intervals it changes from a considerable width to a barren cleft; which appears to depend on the difference in the power of resistance of the wall-rock. The length is just as variable. On the Rumpels Mountain, lodes are known extending 3500—4000 feet; while others have been found workable only for short distances. Their extreme depth has not yet been reached; and the frequently expressed opinion, that they wedge-out, has never been confirmed. At the Gottesgabe mine, pyrolusite has been found five feet broad, at a depth of 50 fathoms, and extends

[1] See: Credner, Geogn. Verhält. Thüring. u. d. Harz. 1843, p. 130; Von Nidda, in Karsten's Archiv. 1838. vol. XI. pp. 48, 70, 76; Fritsch, in Zeitschr. d. deutsch. geol. Gesellsch. vol. XII. p. 137.

still deeper. The contact of the lode with the wall-rock does not always remain constant in its character, the nature of the last exerting an unmistakable influence. Where the rock is firm, the matrix of the lode is easily detached from it. The foot-wall is distinguished by a regular line of contact, which at times is almost a mathematical plane, and by so-called slicken-slides. The last can be traced for considerable distances by thin parallel furrows, mostly inclined 10—25°, and by the deep red coloring of the wall-rock at the foot-wall. The manganese lodes around Elgersburg can be classified into five groups; some of which apparently unite: they all strike from N. or NE. to S. or SW.

The analogous occurrence of pyrolusite near Ilmenau, and that near Friedrichsroda, are less important. At the last locality the pyrolusite occurs in melaphyr conglomerate, in conchoidal layers, parallel to the salbands of the lodes. The veins have the uncommon strike of N. or NW. to S. or SE.'

The iron lodes, in the porphyry district, and on its edges, are more widely extended, than the manganese lodes. They are closely related to the veins of manganese, essentially in fact a modification of these. Their line of strike is SE.—NW., parallel to the ridge of the mountains. Quartz and calc. spar are the principal vein-stones, more rarely heavy spar. One of the lodes occurs, on the Dom Mountain near Suhl, where the porphyry and *buntsandstein* join; while the others strike parallel to this in the porphyry, but are inclined to it, so that they probably unite at some distance beneath the surface.

ARGENTIFEROUS ORE-DEPOSITS IN THE CARBONIFEROUS FORMATION.[1]

§ 97. A dark clay-slate overlies the granite at Goldlauter near Suhl, which belongs to the carboniferous formation. This slate dips towards NW. and attains a thickness of 70—100 feet. At times it passes into pyroschist, and contains very thin layers of anthracite, as well as impressions of ferns, stigmaria, and fish. A bed of particularly dark color can be distinguished in

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[1] See: Krug von Nidda, in Karsten's Arch. 1838, vol. XI. p. 34; Cotta, in Berg- u. hüttenm. Zeit. 1858, p. 352.

this, having a very irregular slaty cleavage, and which varies considerably in thickness. This is the bed containing the ores; which is here described, more from its geological interest, than its economic value. The ores form very regular thin ellipses, or lenticular masses, from 1 to 6 inches in diameter, with a concentric arrangement in their interior, whose regularity is at times disturbed.

Krug von Nidda says of them: 'Their composition is peculiar, and deserves notice. The interior kernel generally consists of a brown earthy or compact mineral, which is probably spherosiderite; in the place of this occurs at times a black crystalline granular limestone, which contains small geodes lined with crystals of calc. spar. This kernel is generally surrounded by copper pyrites, tetrahedrite, native silver, and a silvery white ore, containing a considerable percentage of silver, and crystallizing in extremely fine needles. This last mineral, to judge from its crystals, is probably mispickel, which apparently crystallizes in quadratic prisms having their acute edges replaced. A layer of reddish brown spar, containing but slight traces of metals, surrounds the preceding minerals. Over this follow alternating bands of mispickel, iron pyrites, and argillaceous shale. The mispickel occurs only massive; the iron pyrites is partly massive, partly in small pentagonal dodecahedrons. The shaly substance always encreases towards the exterior; the separate bands of mispickel, and iron pyrites, are thinner, and occur at greater intervals. Mispickel and iron pyrites replace one another: first the one, and then the other, predominates. A very thin band of calc. spar sometimes forms the exterior limit, on which are disseminated very thin laminæ of ruby silver. The ellipses are seldom so perfectly formed, as to permit the observation of all the layers mentioned on a single piece. At times the argentiferous kernel occurs, and the outer rings are wanting; at times one or the other of the bands surrounds the kernel; at times the last is wanting, and one of the bands takes its place.'

Whether in this case the ores were originally deposited with the carboniferous strata, or subsequently penetrated by some peculiar process of impregnation, I will not attempt to decide. The nature of these deposits is somewhat similar to that of the *Kupferschiefer* (copper slates); but the strata, in which they occur, are much older.

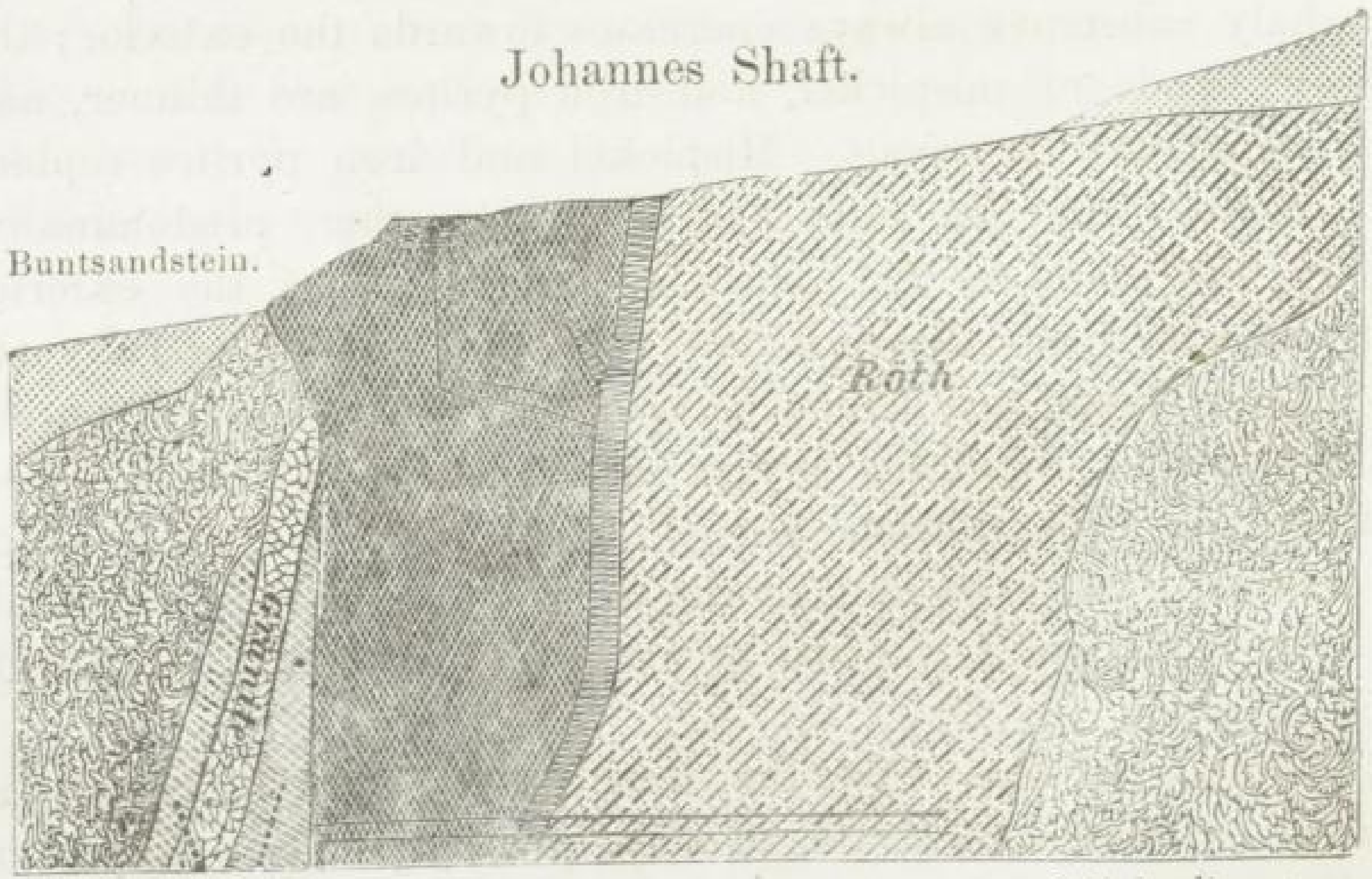
IRON-DEPOSITS IN THE ZECHSTEIN FORMATION.[1]

§ 98. The *zechstein* formation is the most metalliferous of those occurring in the Thuringian Forest. In it are found the copper ore beds, copper, silver and cobalt-lodes, as well as iron deposits. I will here pass over the copper-slate *(kupferschiefer)*, and the lodes combined with it; as it belongs not merely to the Thuringian Forest, but is extended over a large extent; and will describe the whole hereafter.

The iron deposits, in the *zechstein* of the Thuringian Forest, are of various kinds. The most important occur in the neighborhood of Herges on the southwesterly border; and are exploited by the Stahlberg, Mommel, and other mines. Danz has described these deposits very minutely. They evidently consisted originally of spathic iron; but have been altered from the surface into limonite.

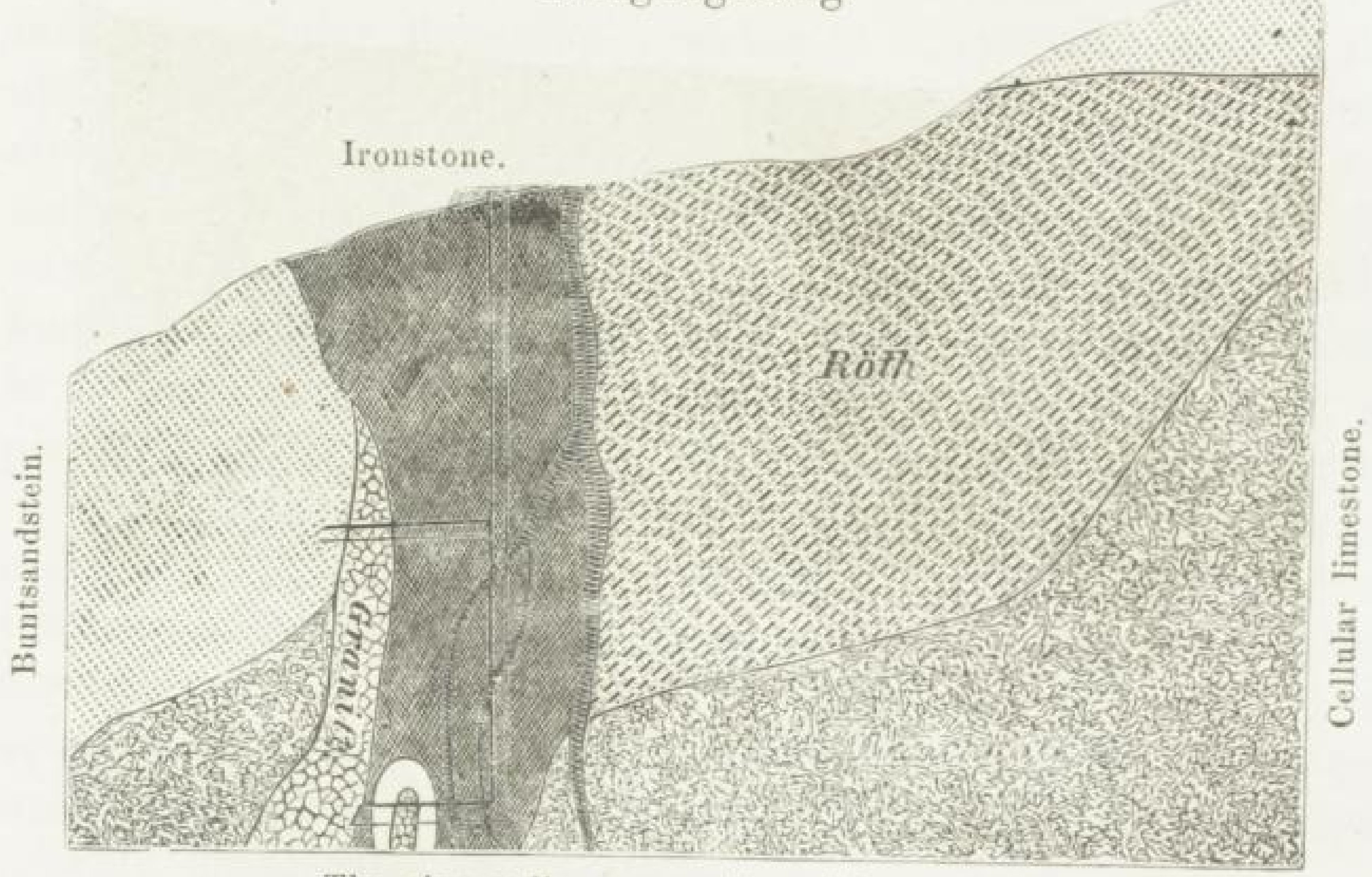
Their form is very irregular; and they must hence be described as segregations. They approach a lode in form, in that they lie in a row from SE. to NW., and even appear to be united with each other; while the fact of their being confined to a *zechstein* zone suggests the idea of a contemporaneous deposit. Their manner of bedding is very remarkable, and not yet entirely clear.

Johannes Shaft.



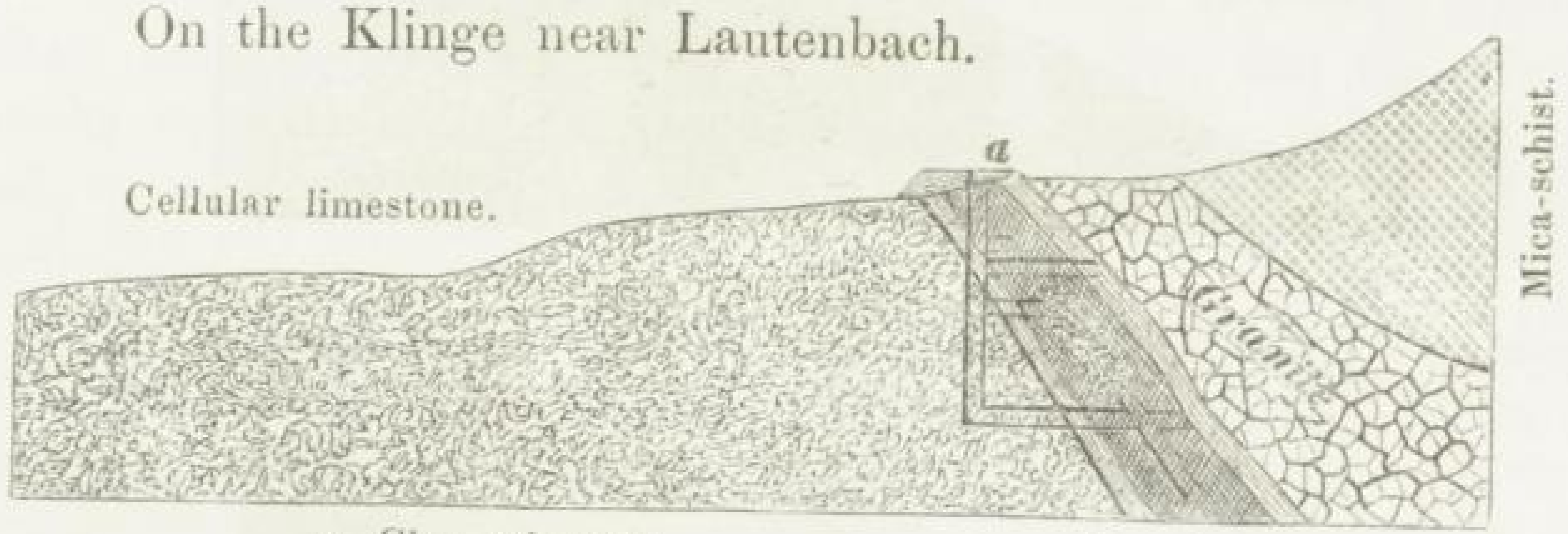
[1] See: Freiesleben, geogn. Arbeiten, vol. II. p. 113; Credner, geogn. Verh. Thüring. u. d. Harz. 1843, p. 129; Tantscher, in Karsten's Archiv, 1829, vol. 19, p. 364; Danz, Topographie des Kreises Schmalkalden, 1848.

Morgengesang.



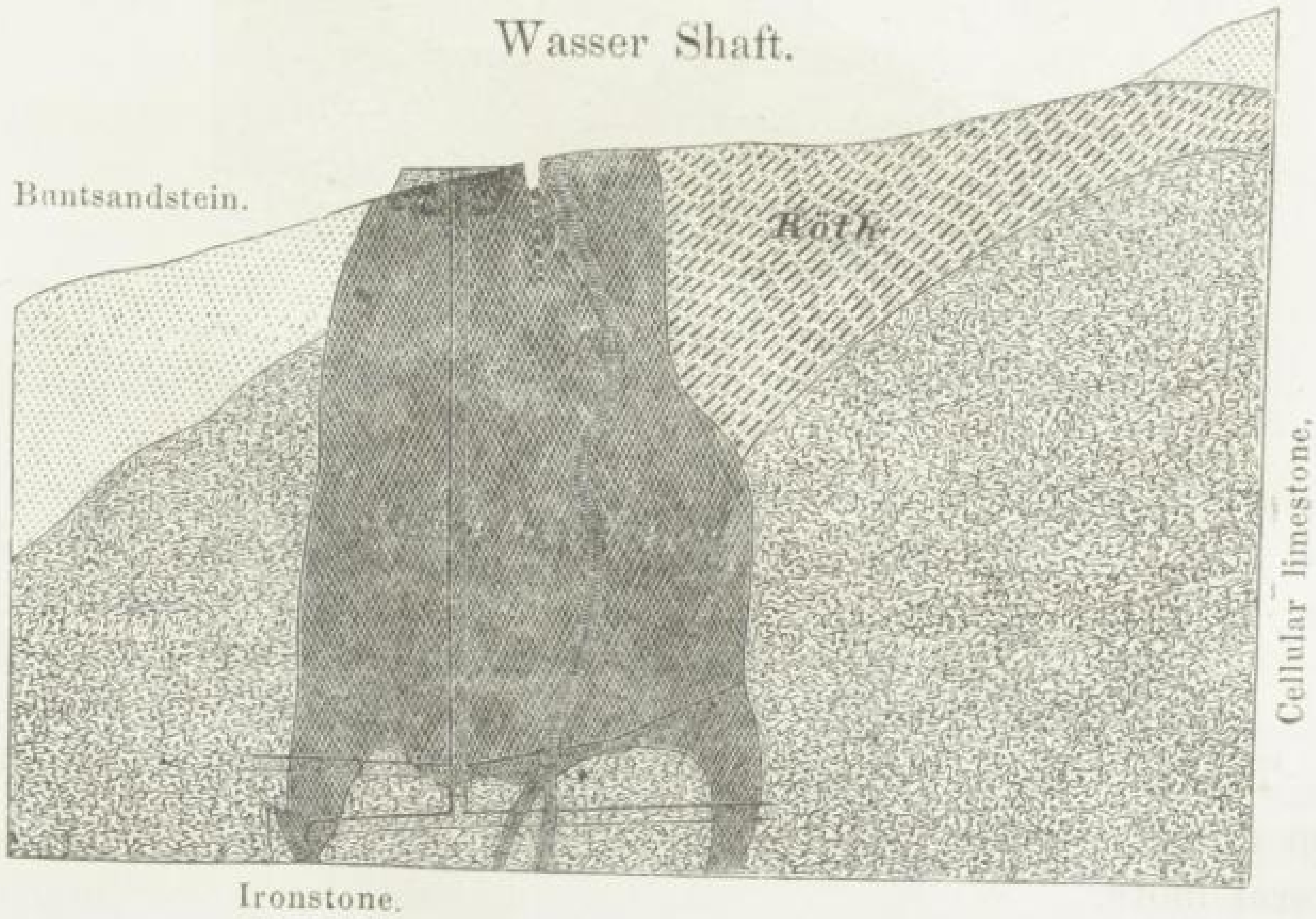
The zigzag lines are veins of heavy spar.

On the Klinge near Lautenbach.

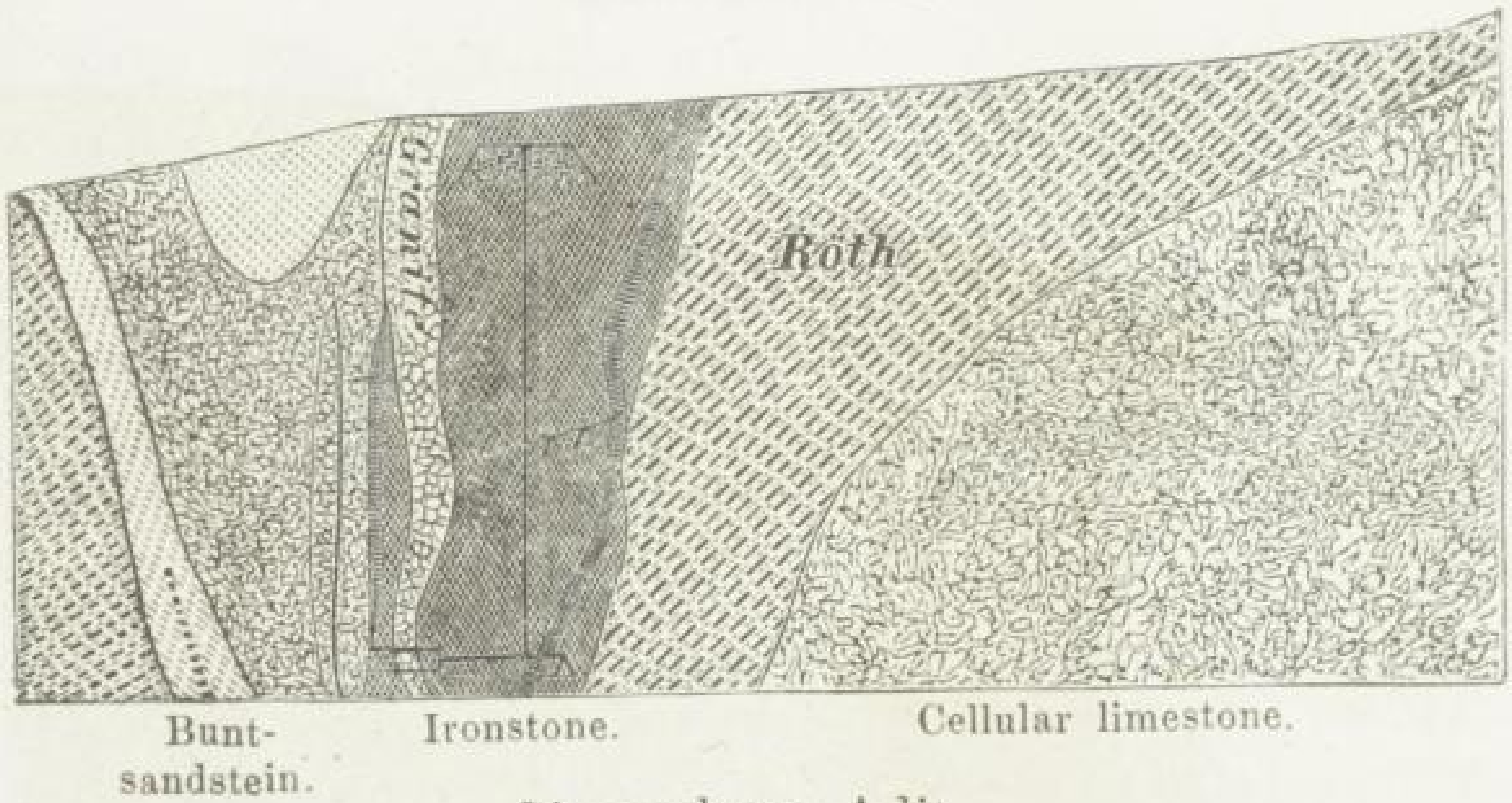


a. Clay selvages.

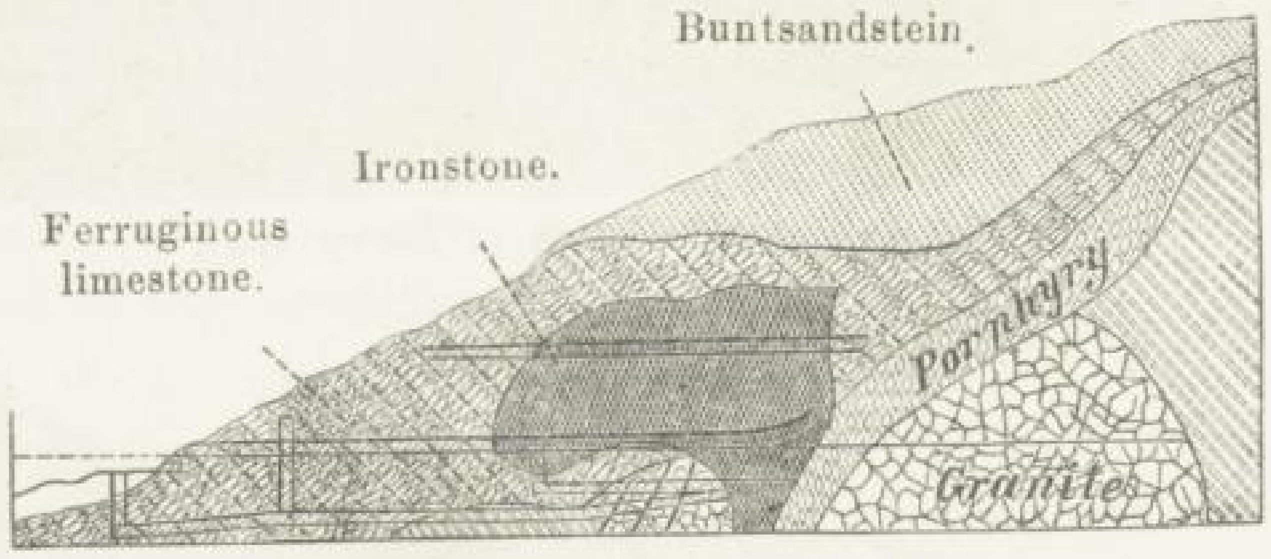
Wasser Shaft.



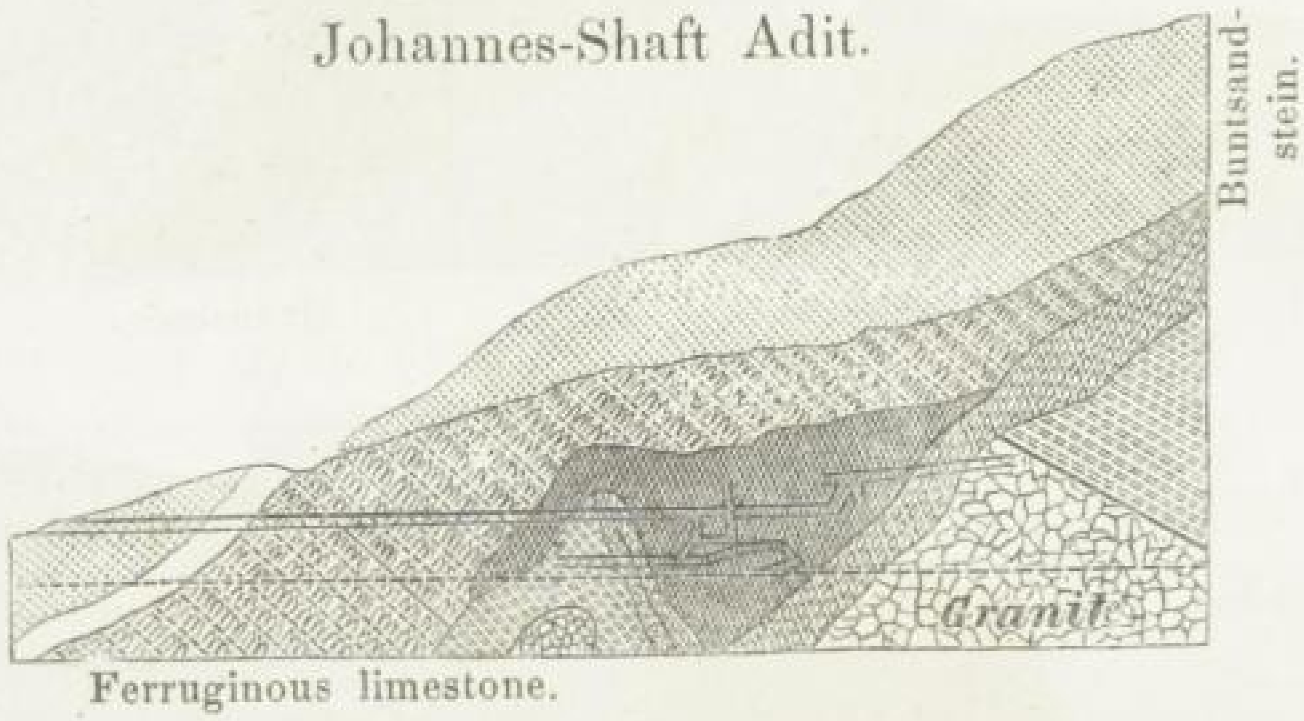
Freundschaft Mine.



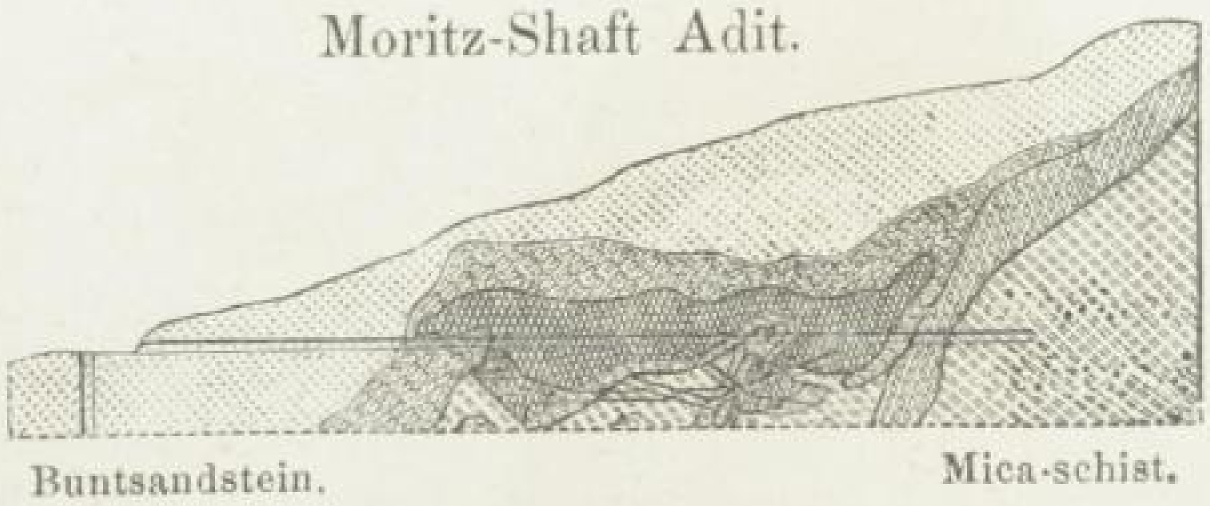
Simonsberg Adit.



Johannes-Shaft Adit.



Moritz-Shaft Adit.



The preceding woodcuts represent eight successive sections from actual surveys. Danz, from whom they are copied, gave several more.

In explanation of these wood-cuts I would only remark, that the cellular limestone *(rauhkalk)* is at this locality the upper member of the *zechstein* formation, whose lower strata are apparently missing. The *Röth* is the upper member of the *buntsandstein* formation, and consequently belongs over the variegated sandstone *(buntsandstein)* proper. The ferruginous limestone *(eisenkalk)* is a variety of the cellular limestone, which in all probability originally contained spathic iron, but now the peroxide of iron. The zigzag lines denote veins of heavy spar.

The strata, of the *zechstein* and *buntsandstein* formations, are much dislocated, in part overturned; as may be seen from the wood-cuts. Granite and porphyry appear to have burst through with violence; which is the more remarkable as at every other locality in the Thuringian Forest, these rocks occur under such circumstances, as prove them to have been formed previous to the *zechstein* period.

I will not attempt to solve the question; and only remark, that, though it appears difficult, it is possible, that the igneous rocks were brought, into their present relations with the mica schist, when already hardened, and consequently not by igneous action.

It is worth noticing, that the bituminous shales, the copper slates, and the *Weissliegendes*, appear to be entirely wanting; while they recur, more to the South, near Aschbach.

IV. THE HARTZ.

GENERAL GEOLOGICAL FORMATION.

§ 99. The Hartz rises, out of more recent formations, as a nearly elliptical district, immediately surrounded by a complete border of the *Zechstein* formation, which may be designated as the boundary of the mountain district. Between the border of *Zechstein*, and the older formations, crop out somewhat of *Rothliegendes*, and a little of the Carboniferous formation with coal beds. But the chief mass of the mountains is of older origin.

The mountains proper consist principally of slaty and sandy rocks, with subordinate strata of quartzite, siliceous slate, and limestone; which were until recently classified under the gray-wacke group. These old and mostly much tilted rocks, whose chief direction of strike is SW.—NE., intersect the axis of the mountains obliquely. They are frequently broken through by various kinds of igneous rocks, especially by two large masses of granite, that of the Brocken and that of the Ramberg: also, by various small masses of greenstone (diabase and diorite), which have some of them penetrated in a bedlike form; by quartz-porphyry and by quartzless porphyries often called melaphyr. The older sedimentary rocks are at times much disturbed, where they come in contact with these igneous rocks; and are changed in their lithological condition, being altered into hornstone, etc. Crystalline schists proper, and basaltic rocks, are entirely wanting.

The old slaty sedimentary formations, which were formerly all comprised under the so-called graywacke group, belong, according to the more recent researches of Römer, by whom their fossils have been more accurately examined, to at least three different periods; namely, the Silurian, the Devonian, and the Subcarboniferous.

The total slate district of the Hartz is Silurian, southeasterly of a straight line which would connect Stollberg and Harzgerode. From there the Silurian slates form a broad western branch, between parallel formations of the Subcarboniferous, through Güntersberg and Hasselfeld, nearly to Andreasberg.

The occurrence of the Devonian strata is confined to three larger districts, at Elbingerode (much limestone), Andreasberg, and Goslar; and several smaller ones, in the neighborhoods of Clausthal and Wildenau.

The slates, sandstones, and limestones, of the Subcarboniferous or Culm formation, occupy the greater portion of the surface of the entire Hartz northwesterly o fStollberg and Harzgerode.

The ore deposits of the Hartz may be classified, according to the metals predominating in them, into:

1. Iron ore deposits, lodes, and beds.
2. Manganese ore deposits, lodes, and segregations.
3. Antimony lodes.

4. Silver, lead and copper ore deposits, with cobalt- and nickel-ores.

a. Lodes in the Subcarboniferous, Devonian and Silurian districts.

b. Segregation of pyrites in the Devonian district near Goslar.

c. Copper slates in the *Zechstein*.

The iron ore deposits occur much scattered, chiefly in the Silurian, Devonian, and Subcarboniferous districts. The manganese deposits are mostly confined to the porphyry region around Ilfeld. The silver, lead, and copper deposits are distributed in groups, which may be named after the following localities: Goslar, Clausthal, Andreasberg, and Harzgerode. The antimony deposits are essentially confined to the Wolfsberg (Wolfs Mountain).

IRON ORE DEPOSITS.[1]

§ 100. Those in the Hartz are, similarly to those already described, distributed over the entire surface of the mountains. They contain principally hematite, and limonite; but exceptionally magnetite, or spathic iron. The relative rarity of the magnetite can be most simply explained by the fact that metamorphic crystalline schists are entirely wanting, while it is commonly only in these that iron deposits are changed to the condition of magnetite by catogene metamorphosis.

In the Hartz, as in the Erzgebirge, and Fichtelgebirge, the iron deposits mostly accompany the igneous rocks, are even frequently contact-formations, or are enclosed in them. They occur here, as in the Voigtland, principally combined with certain pyroxenic greenstones (diabases); but are also found, at least apparently, independent of these. They occur as lodes, and beds.

The dome-shaped masses of greenstone, in the Silurian district of the Eastern Hartz near Tilkerode, contain hematite deposits, which, according to Zinken, do not extend into the clay-

[1] See: Freiesleben, Bemerk. über d. Harz, 1795, p. 259; Zimmermann, in Karsten's Arch. 1837, vol. X. p. 26; Schultz, in the same, 1821, vol. IV. p. 229; Zinken, der östliche Harz, 1825, vol. I. p. 135; Credner, Geogn. Verh. Thür. u. d. Harz, 1843, p. 127; Jasche, Mineralogische Studien, 1838, p. 4; Perdonnet, in Ann. des Mines, 1828, vol. III.

slate: this is at the most colored red by peroxide of iron near the same, or is traversed by small threads of iron-stone. They form irregular lodes in diabase, especially where it joins the clay-slate. They chiefly strike N.—S. and but rarely dip otherwise than 45°—90° towards E. Their vein-stones are brown spar, calc. spar and quartz. What is very curious is the occurrence, in addition to specular iron, and red hematite, of all sorts of selenium minerals, especially clausthalite, lehrbachite, and tilkerodite, also auriferous palladium: according to Credner, also spathic iron, which is changed at the outcrop into limonite.

The iron deposits occurring at Elbingerode, Lehrbach, and Zorge, are very similar.

On the Krokenstein a contact-lode of hematite occurs at the junction of limestone and clay-slate; it appears to have no connection with the greenstones.

MANGANESE DEPOSITS.[1]

§ 101. These are almost entirely confined to the porphyry district of the Hartz around Ilfeld. For although many of the iron lodes spoken of contain some ores of manganese, this is a very subordinate occurrence, while the manganese ores are the principal objects of exploitation at Ilfeld.

They form lodes in porphyry, at times 3 feet broad, principally in that free from quartz, which is often termed melaphyr.

While pyrolusite and psilomelane predominate in the manganese lodes of the Thuringian Forest, manganite is here the principal ore, combined with hausmannite, heavy spar, and calc. spar.

In places these lodes consist almost entirely of manganite, while again the same is composed almost wholly of horses. As the lodes essentially occur only in the quartzless porphyry; they are probably to be regarded mostly as secretions from the same, but naturally secretions in fissures. The same rock also contains at times manganese ores in its vesicular cavities.

In addition to the above occur pockets of manganese ores, near Elbingerode, in the depressions of the surface of the siliceous slate, which is here embedded in the Devonian clay-slate.

[1] See: Kerl, in Berg- u. hüttenm. Ztg. 1853, p. 148; Holzberger, in the same, 1859, p. 283.

ANTIMONY LODES.[1]

§ 102. Near Wolfs Mountain, southerly of Harzgerode, a broad lode occurs in the Silurian district of the Eastern Hartz; consisting chiefly of quartz, with somewhat of calc. spar, and various ores of antimony, especially stibnite, zinkenite, bournonite, feather-ore (jamesonite) and tinder-ore.

LEAD AND SILVER LODES.[2]

§ 103. They occur chiefly in three districts of the Harz. In the Eastern Hartz, in the Silurian district of Harzgerode; in the Western, so-called, Upper Hartz, in the Devonian district of Andreasberg; and in the Subcarboniferous district of Clausthal and Zellerfeld. Between these districts various single lodes of a similar character occur, as at Tanne, etc. Lasius mentioned, as a characteristic of all of them, the fact that they intersect the rock strata at a very acute angle, and are only found where many strata alternate with each other.

A. District of Harzgerode and Neudorf. The lodes traverse the clay-slate of the Silurian formation, especially on the Pfaffen and Meisen Mountains, they strike SE.—NW. parallel to the principal axis of the Hartz. On the Pfaffen Mountain they attain a breadth of 14 feet. They consist of quartz, spathic iron, and calc. spar; with which are combined galena, copper pyrites, iron pyrites, tetrahedrite, bournonite, stibnite, and which is very remarkable, traces of wolfram (whether cassiterite also?). They frequently also contain fragments of the wall-rock, which are often surrounded by concentrical bands of ore, in the following order; spathic iron, massive quartz, fine granular galena, dark brown blende, coarse granular galena. Zinken has described some mineralogical details of these lodes, particularly of the Birnbaum group, and also the circumstance; that a vein, matrix, in places of porphyritic nature, in places resembling clay-slate, is traversed by numerous small veins,

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[1] See: Hausmann, die Bildung d. Harzgebirges, 1842, p. 134; Credner, geogn. Verh. Thüringens u. d. Harz, p. 126.

[2] See: Credner, Geogn. Verhältn. Thüring. u. d. Harz, p. 123; Zinken, in Von Leonhard's Jahrbuch, 1850, p. 692; and Zeits. d. deutsch. Geolo. Gesells. 1851, p. 231; Bergwerksfreund, vol. XXII. p. 331; Lasius, die Harzgebirge, 1789.

which consist of quartz in the clay-slate, but in porphyry of galena, whereby the nature of the wall-rock is shown to exert a very peculiar influence.

B. ANDREASBERG DISTRICT.[1]

§ 104. Andreasberg lies in a small clay-slate district of the Devonian formation, which is towards the South bounded by diabase, towards the West by Subcarboniferous strata; while to the North it is limited by granite, and to the East borders on Silurian slates. The predominant clay-slate is traversed by pyroxenic greenstones (diabases), by quartz, as well as lodes and barren veins, so-called *Ruscheln* and *Schlechten*, by which local terms are meant wide, or narrow, fissures filled with clay and fragments of rock. The lodes are silver lodes, galena lodes, copper pyrites and ironstone lodes. The first alone have been exploited for many centuries, and are exhausted to a considerable depth.

Ten to twelve silver lodes, with various side branches are known: they are, as a rule, only found between two great *Ruscheln*, the so-called *Neufanger* and *Edelleuter faulen Ruschel*. These *Ruscheln*, about 5 fathoms broad, consist of decomposed clay-slate; and strike with bendings, branchings, and reunions, NW. to SE. like the lodes they enclose. Where the lodes come in contact with the *Ruscheln*, they are generally cut off; they commonly become empoverished, and very narrow, for indefinite distances before such contacts. Still the lodes send out branches, or droppers, at times into the *Ruscheln*, or parallel to them; from which may be deduced, that the *Ruscheln* represent fissures, which have been repeatedly torn open, and dislocated; whose matrix, the decomposed clay-slate, already existed in them before the formation of the lodes.

Two of the most interesting cases are represented by the following wood-cuts.

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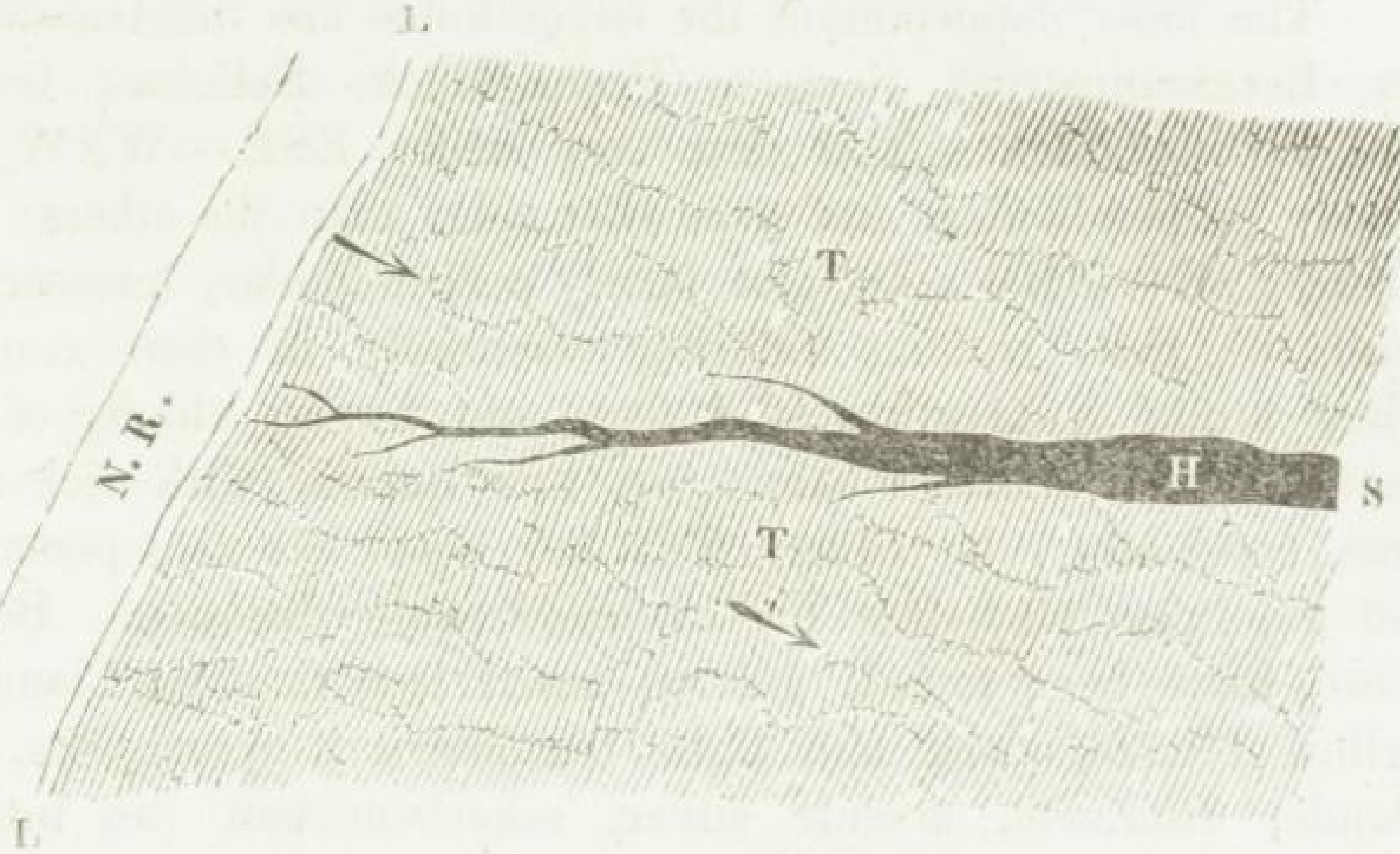
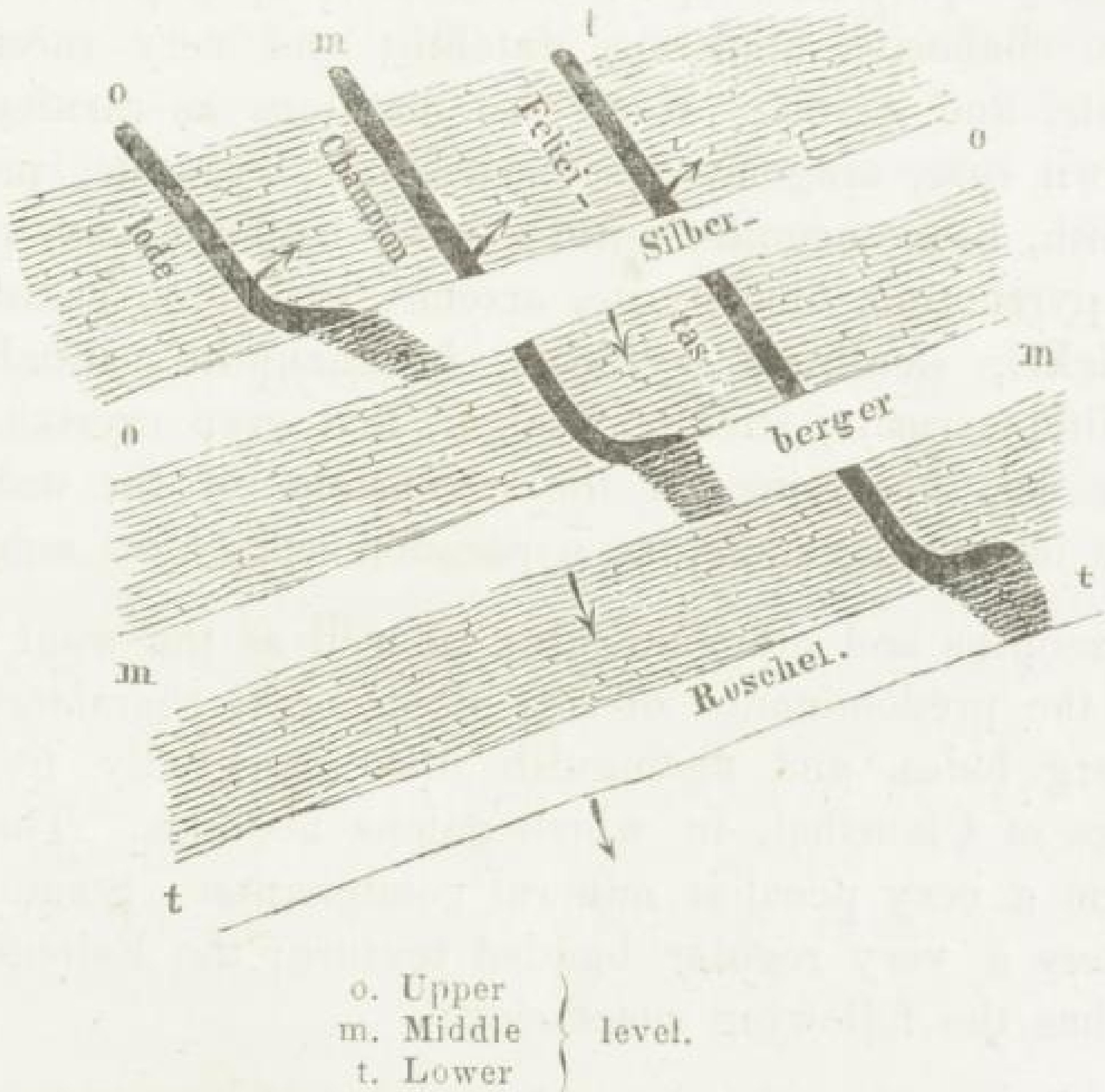
[1] See: Schultz, in Karsten's Arch. 1822, vol. V. p. 95; Hausmann, die Bildung des Harzgebirges, 1842, p. 134; Credner, Geogn. Verh. Thür. u. d. Harz: Kerl, in Berg- u. hüttenm. Zeit. 1859, p. 21; Breithaupt, in the same, 1860, p. 9; Credner, Geogn. Beschreibung des Bergwerkdistricts St. Andreasberg, 1865; in the Zeitschr. d. deutsch. geol. Gesellschaft, and as separate imprint.



S. Samson champion lode.
T. Clay-slate.
N.R. Neufanger Ruschel.
L. Clay-aselvage of the Ruschel.
H. Cath rina shaft.



o. Upper
m. Middle level.
t. Lower

The lode loses its independent character in the *Ruschel*, mixes with it, and makes it metalliferous.

The so-called *Schlechten* are merely thin clay-fissures, always intersecting both the lodes and the *Ruscheln*, and frequently also faulting them.

The most important of the silver lodes are the Gnade-Gottes, Bergmannstrost, Samson, Franz-Glück, Felicitas, Gideon, and Jacobs-Glück. The first two strike ESE.—WNW., are nearly perpendicular, and somewhat older than the others; these strike SSE.—NNW., are also nearly perpendicular, intersect and fault the first, without differing essentially in their contents. They attain a breadth of 4 feet, and consist chiefly of very beautifully crystallized calc. spar, and quartz, with rich silver ores, especially ruby silver. The calc. spar has also penetrated the adjoining clay-slate for a considerable distance. Besides these, have been found: galena (much less than at Clausthal), yellow blende, dark and light tetrahedrite, pyrargyrite, fireblende, discrasite, arsenic silver, scherbencobalt (an intimate mixture of arsenical antimony, discrasite, and ruby silver), native silver, silver glance, stephanite, kerargyrite (buttermilk ore), dark tinder ore (a mixture of jamesonite and mispickel), ganomatite (an intimate mixture of realgar, arsenic, stephanite, ruby silver, discrasite and arsenolith), native copper, bournonite, chrysocolla, heavy spar, fluor spar, harmotome, apophyllite, stilbite, heulandite, chabasite, analcime, datolith; and very rarely garnet, epidote, and axinite. Kerl also mentions as rarities, amethyst, brown spar, aragonite, witherite, talc, zygadite, prehnite, pharmacolith, hæmatoconite, anthraconite, naphtha, iron pyrites, millerite, pyrrhotine, leucopyrite, arsenic, antimony, clausthalite, copper nickel, smaltine, erythrine, breithauptite, annabergite, pharmacolith, cerusite, stibnite, realgar, and even crystals of albite, these last occurring on the greenstone of the wall-rock. Breithaupt observed galena, as a pseudomorph, after anhydrite.

The zeoliths and other silicates, as well as the want of galena, and the predominance of rich silver ores; characterise the Andreasberg lodes, and distinguish them essentially from the silver lodes of Clausthal, in which galena abounds. They evidently form a very peculiar mineral combination. Some of the lodes possess a very regular banded texture; the Felicitas, for example, has the following succession:

Salband, crystalline calc. spar with somewhat of disseminated galena.
Friable calc. spar with somewhat of tetrahedrite.
Crystalline calc. spar without ores.
Massive tetrahedrite.
Friable calc. spar with somewhat of tetrahedrite.
Tetrahedrite with galena. (Middle of the lode).

It appears that the neighboring diabases must have exerted a particular influence on the origin of these lodes. Hausmann considers them to have been formed by sublimation; and cites, in favor of this view the fact, that fine incrustations, for example of realgar, are found on the lower sides of crystals in geodes. Even could it be proven that some of the minerals of these lodes had been formed by sublimation, it would scarcely be permissible to adopt a like manner of formation for their total matrix, especially for the chief minerals composing them; viz. calc. spar, and quartz. Some of the minerals mentioned are clearly formed by the decomposition of others, and are only found in the upper workings; for example, kerargyrite, tinder ore, and ganomatite.

The diabases appear to be traversed by the lodes. The cleaving, of the fissures containing the last, was in any case more recent, than the first elevation of the Hartz, and the breaking through of the diabases.

It is worth noticing, that the Samson-lode has been exploited, and found productive, to the perpendicular depth of 2500 feet, or 600 feet below the level of the sea; while it has only been possible, on account of the *Ruscheln*, to follow it in a horizontal direction for a distance of 2100 feet. No influence of the wall-rock on the ore contents has been noticed here.

C. DISTRICT OF CLAUSTHAL.[1]

§ 105. I consider, as belonging to this, the region lying between Altenau, Grund, and Lautenthal. The same consists principally of clay-slate and sandstone of the Subcarboniferous, which are traversed, in the direction from Lehrbach to Harzburg, by nearly straight lines of diabases. These have either burst through parallel to the stratification, or have been embedded parallel to it; the Subcarboniferous is bounded, northwardly towards Goslar, by the striking-out of somewhat older Devonian deposits.

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[1] See: Zimmermann, das Harzgebirge, I. pp. 105, 320; Hausmann, Bild. d. Harzgeb. p. 133; Credner, Geogn. Verh. Thür. u. d. Harz. p. 121; Kerl, in Berg- u. hüttenm. Zeit. 1859, p. 21; Köhler, in the same, 1859, p. 198; Cotta, in the same, 1864, p. 393; Wimmer, in Bericht d. Vereins Maja, Halle, 1854, p. 14; and in Von Leonhard's Jahrbuch, 1854, p. 841; there was also used a manuscript of Mr. Heucke, written in 1854.

The strata and slates of the Subcarboniferous formation mostly strike NE.—SW. and dip toward SE. while the Devonian formation is unconformable with these. The evidently igneous embeddings of diabase, between Lehrbach and Altenau, contain curious remains of a limestone occurrence, wedged-in parallel to them, which Römer considers as belonging to the Devonian Stringocephalus limestone.

The lodes occurring in this district are interesting for two reasons; first, because of their great breadth, and secondly, on account of the manner in which they have been filled.

They all strike E.—W. with at times deviations towards WNW. and ESE.; consequently they are parallel to the chief axis of the Hartz, they thus form together a mineral belt; whose breadth however is nearly as great, as its known length. In the direction of their breadth they lie, between the localities of Lautenthal and Laubhütte, near Grund. The limits of their length are the Rösteberg near Grund, and Altenau. They have been classified into nine separate groups, each of which consists in part of but a single champion lode with several side-veins. These are called:

1. The Burgstädter Group,
2. The Zellerfelder Group,
3. The Spiegel- and Hutschenthaler Group,
4. The Bockswieser Group,
5. The Lautenthaler Group,
6. The Wittenberg- and Wolfshagner Group,
7. The Rosenhöfer Group,
8. The Silbernaaler Group, and
9. The Isakstammer and Laubhütter Group.

This classification has evidently been occasioned more by the chronology of their discovery than by the real nature of the case. If we follow the chief fissures, according to their real position, and their probable connection, from South to North, we find five principal fissures with several subordinate ones, at nearly equal distances apart, westerly of Clausthal and Zellerfeld, which, in their eastern prolongation, in part actually unite, in part, at least according to their direction, approach one another at an acute angle; so that they must collectively unite before reaching Altenau, when they continue in the same direction.

The most southerly of these fissures is the Laubhütter-Isakstammer lode; which strikes W.—E., and, if it continues in this direction, must unite with the Silbernaaler Group easterly of Clausthal.

The Silbernaaler Group is the one, which has been traced for the greatest distance, over five miles. It commences at the outer westerly limit of the Hartz, at the Hilfe-Gottes mine; and continues, with a double bending, as the Bergwerkswohlfahrt-lode, almost to Altenau. It unites with the Rosenhöfer group, under the Hirschler pond. The whole group consists essentially of but one lode, whose breadth varies from 1 to 14 fathoms. Its matrix is predominantly so-called *Gangthonschiefer*[1] (vein-clay-slate), traversed by a number of threads of heavy spar, among which are broader veins of heavy spar, whose salbands are composed of very argentiferous galena, following the direction of strike. Ring-ores also occur in the heavy spar, whose kernel consists of clay-slate surrounded by layers of heavy spar and galena; also slate-fragments not concentrically enclosed. In addition to the above mentioned minerals are found principally; tetrahedrite, copper pyrites, iron pyrites, quartz, calc. spar, and spathic iron. The lode dips about 70° towards N., which is opposed to the general inclination of the lodes in this district.

Northwardly of this is situated the Rosenhöfer group, which extends from the Innerste valley, under Clausthal, to where it unites with the Silbernaaler group. At the Alter-Seegen mine, westerly of the town, this lode consists of several branches, which apparently unite at a greater depth, but which show a decrease, rather than an encrease, in richness at their junction in the direction of strike. Besides this, the lode is frequently broken up into numerous branches, several of which have caused faults; hence it may be concluded, that they are not of exactly contemporaneous formation. Their breadth varies from 1 to 11 fathoms, and averages 6 fathoms. Their matrix is predominantly calc. spar, with which is combined galena: copper pyrites, iron pyrites, and blende, are more rare.

Before the Rosenhöfer group reaches the Silbernaaler, it unites, near the Dorothea mine, with the Burgstädter group. It is faulted about 20 feet by a so-called *taube Ruschel*. It consists of a champion lode, 20 to 40 feet wide, with numerous parallel

[1] According to a careful examination made by the Author in 1864, the *Gangthonschiefer* is nothing more than a portion of the wall-rock (clay-slate) which has been altered, and impregnated with ores.

smaller ones. These last in part fault the champion lode, and are therefore of more recent formation. At the point of contact with the Rosenhöfer group, its breadth encreases to 35 fathoms; and this acute junction appears at certain depths to have developed a special richness in galena, but at a greater depth, the blende encreases at the expense of the galena. Vein-clay-slate and calc. spar form, in this group also, the chief matrix; blende, galena, copper pyrites, iron pyrites, etc. occur to but a subordinate extent.

The Zellerfelder group forms a principal fissure between Wildemann and Zellerfeld; this divides under a considerable angle, as well eastwardly beyond Zellerfeld, as westwardly near Wildemann. The southeasterly of these intersects the Burgstädter group at the Eleonore mine, while the northwesterly does the same with the Spiegelthaler group. The *gang* is principally composed, with a breadth of 6—17 fathoms, of vein-clay-slate, calc. spar and quartz; which are traversed by so-called ribbon-ore threads (*Banderzadern*), consisting of galena, copper pyrites, and iron pyrites. These only form isolated masses of ore, principally at the junctions. In the Ring and Silberschnur mines, beautiful ring ores occur, having a fragment of clay slate as kernel, surrounded, either by quartz, with galena, and calc. spar; or, first by a layer of spathic iron, and then quartz with ores.

In a northerly direction follows the Spiegel- and Hutschenthaler group, which do not accord with one another in their strike and position. The Hutschenthal fissure strikes, like the majority of the lodes, WNW.—ESE.: the Spiegelthaler, on the contrary, has a more northerly position, and strikes E.—W.

Following this is the Bockswieser group, nearly on the boundary of the Devonian rocks, and in fact partly penetrating the Devonian strata. The same appears to consist of two parallel champion-lodes, striking WNW.—ESE., which figure under several names. They traverse Posidonomya slate, siliceous slate, Goniatite limestone, Orthoceras slate, Calceola slate, and quartz-like sandstone containing Spirifers. It is stated, that the amount of ore varies with the nature of the country-rock, and that the lodes contain the most in clay-slate, Calceola slate, and Orthoceras slate. The breadth, in places, exceeds a fathom; and the matrix consists of clay-slate, quartz, calc. spar, brown spar, and more rarely heavy spar, galena, blende, and pyrites.

The Lautenthaler group is the most northerly of all. It consists of one champion-lode, 17 to 23 fathoms broad, which splits up into numerous leaders. Its chief strike is nearly E.—W., it has been followed from the valley of the Innerste to Hahnenklee, where it passes, from the strata of the Subcarboniferous, into those of the Devonian. Its principal vein-stone is again vein-clay-slate, with chimneys and pockets of quartz, calc. spar, galena, blende, copper- and iron-pyrites. The leaders of the champion-lode at times possess a symmetrical texture, with the following succession:

Calc. spar,
Blende,
Calc. spar,
Blende; and in the middle
Galena with pyrites and blende.

GENERAL REMARKS ON THE CLAUSTHAL LODES.

§ 106. The Western Hartz is traversed, in its central portion, at nearly equal distances, by a number of broad fissures, almost parallel to the axis of the whole mountains; which obliquely intersect the strata, especially those of the Subcarboniferous formation, splitting up into branches, which in part again unite.

The fissures, often many fathoms broad, are for the most part filled with fragments of the wall-rock, especially clay-slate (which is then called in Clausthal vein-clay-slate). Perhaps it would be more correct to say; that many single fissures have cut through the rocks in zones; that these zones have been disturbed, and now appear as a kind of fissure-matrix; that the fissured slate has at the same time been altered in some degree by water, or vapors; and is distinguished, as so-called vein-clay-slate, from the common clay-slates. The other vein-stones, and the ores, which have penetrated into the fissures, are found in the intermediate fissures, of very variable width, which are frequently united.

If we consider the vein-clay-slate, as only being altered in condition, position, and coherence, and therefore not belonging to the mass of the lodes proper, which were deposited in the fissures from solutions; the predominating vein-stones, and ores, are: quartz, calc. spar, heavy spar, brown spar, spathic iron, argentiferous galena, blende, copper pyrites, and iron pyrites.

Besides these, occur in the lodes: tetrahedrite, light colored tinder-ore (a mixture of lead, silver, antimony, and sulphur), bournonite, melaconite, malachite, azurite, cerusite, pyromorphite, anglesite, and limonite; these last principally in the upper levels, as products of decomposition.

Kerl mentions in addition to these: amethyst, pearl-spar, aragonite, gypsum, glauber salt, epsom salt, strontianite, asphaltum, anthracite, stibnite, clausthalite, tiemannite, cinnabar, amalgam, mercury, manganite, limonite, and hematite.

The condition of the matrix entirely corresponds to the results of an infiltration: as favoring this view, may be mentioned the occasional combed texture, and the uncommonly frequent formation of ring-ores, as also the fact that the minerals have penetrated into all the fine clefts.

The differences in depth, of the Clausthal lodes, consist (besides the secondary decompositions near the outcroppings), principally in the champion-lodes being much broken up into small leaders near the surface; and it is stated, that the proportion of blende encreases, while that of galena decreases, with the depth. A cessation of the lodes, or their matrix, in the direction of the depth, has not yet been observed; although some of the workings are as much as 1730 feet below the surface. Zimmermann asserts, that in broad champion-lodes only the small leaders are rich. The ores are very unequally distributed.

A difference of the country-rock in general, exerting any important influence on the matrix of the lodes, has only been discovered, according to Heucke, in the case of the Bockswieser lodes. On the other hand, a strongly glancing black clay-slate having short clefts, as well as a red, very ferruginous schist, which occur as portions of the matrix, are very unfavorable for the branches traversing them. Besides which, the branches, consisting of heavy spar and calc. spar, are mostly more recent, and poorer than the others.

THE RAMMELSBERG NEAR GOSLAR.[1]

§ 107. The Rammelsberg consists of the three lowest strata of the Devonian formation; the Wissenbach slate, the Calceola slate, and the Spirifer sandstone. Some great subversion has

[1] See: Freiesleben, Bemerkung. üb. d. Harz, 1795, p. 75; Lasius, die Harzgebirge, 1789, vol. II. p. 373; Schultz, in Karsten's Arch. 1821, vol. IV.

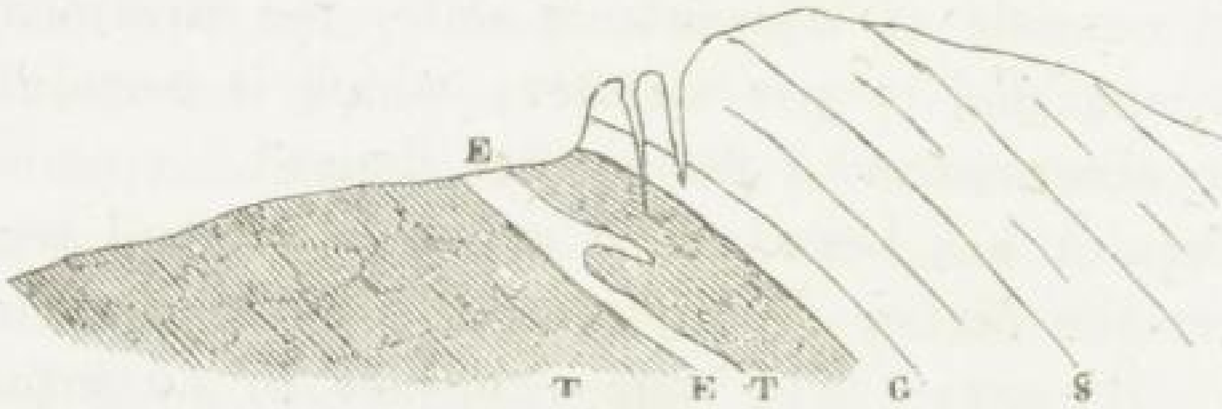
caused the above to lie in reversed order, the Wissenbach slate being the lower-, the sandstone the upper-most stratum.

The renowned pyritous deposit occurs in the Wissenbach slate, which forms the projecting lower portion of the mountain; the same consists here of real clay-slate, frequently used in the surrounding country for roofing. In the immense slate-quarries, on the left declivity of the Keppel valley above Goslar, the very distinct cleavage, as a rule, cuts the less distinct stratification at an acute angle; no such circumstance has been remarked at the Rammelsberg. Not only do the great dimensions of the pyrites deposits coincide in general with the cleavage; but a zone of Goniatites and Orthoceratites changed to pyrites in the slate, beneath the pyrites deposit, lies parallel to the cleavage; and they all lie individually with their breadth and length parallel to it. Very probably therefore in the Rammelsberg, in so far as it consists of Wissenbach slate, the stratification and cleavage are parallel to one another; which is certainly important for the observation of the pyrites deposit.

This deposit has been called a lode, bed, and segregation. Passing over the earlier descriptions, I subjoin an extract from Hausmann. He says: 'The same consists of an intimate, but not everywhere uniform, mixture of iron pyrites, copper pyrites, galena, blende, and mispickel, associated with small quantities of other ores; with which are combined massive heavy spar, and a little quartz and calc. spar. The ore-bed, which has been inserted at the contact of the clay and graywacke slate, has a general strike of ENE.—WSW. and a variable dip, in general 45° toward SSE. The extension is also variable in the direction of the strike, and diminishes with the depth: it amounts to 210 fathoms at a depth of 105 fathoms beneath the mouth of the new shaft. The breadth of the undivided bedded mass is assumed to be 40 to 45 fathoms. At a depth 72 fathoms below the mouth of the Kanekuhler shaft, the ore-mass separates into two branches; of which the hanging one wedges-out 23 fathoms deeper, the lower or principal one continues farther. The greatest thickness of the last, where it leaves the hanging branch, is

p. 229; Zimmermann, das Harzgebirge, 1834, p. 103; Hausmann, die Bildung d. Harzgeb. 1842, p. 132; Credner, Geogn. Verh. Thür. u. d. Harz, p. 121; Berg- u. hüttenm. Zeit. 1860, Nr. 2; Kerl, in same, 1853, p. 7; Cotta, in same, 1864, p. 369.

23 to 25 fathoms. It also gradually decreases, toward the West, in the line of the strike; while toward the East the bed has more the appearance of being cut off: it gradually decreases in the direction of the dip. A very firm clay-slate (so-called *Kniest*) impregnated with iron and copper pyrites, is wedged-in between the two portions of the ore-mass, forming the hanging-wall of the principal branch. The outer limits of the ore-bed are very irregular, in great part waving, here and there with cracks: it is traversed by numerous joints. The most conspicuous of these are perpendicular, and intersect the bed at right angles: others are parallel to the dip. In place of the first joints, sometimes occur small veins (so-called *Steinscheiden*), often barely a line broad; they contain copper pyrites, galena, heavy spar, and calc. spar; and extend, neither into the hanging-, nor foot-wall.'



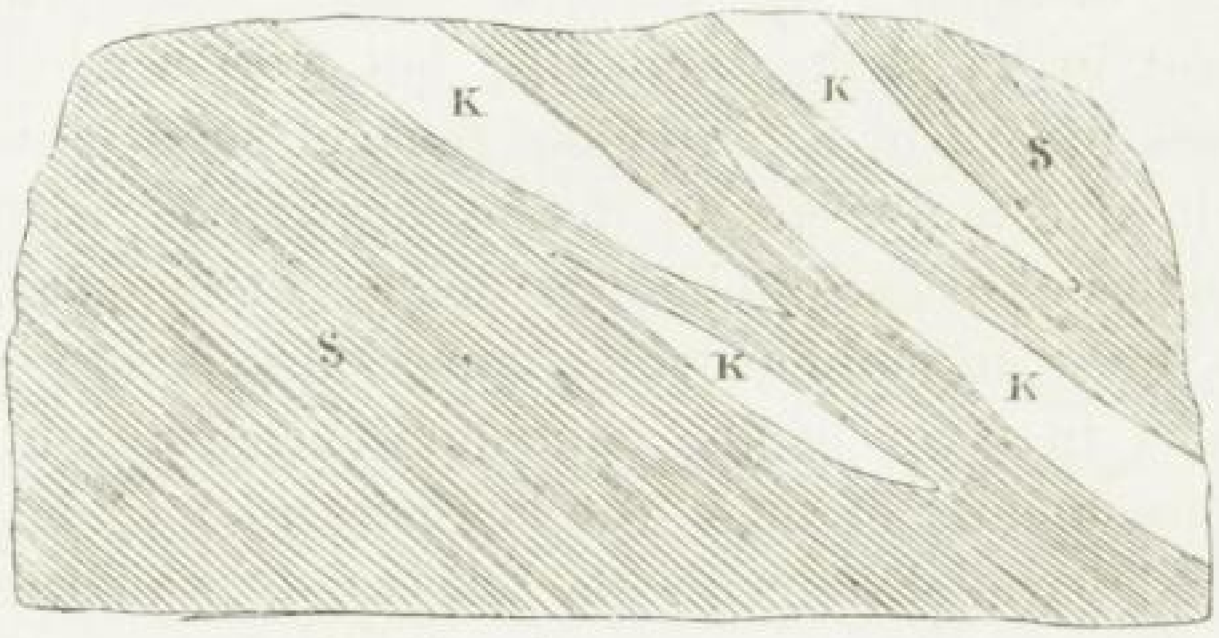
E. Ore-deposit.
F. Clay-slate (= Wissenbach slate).
G. Graywacke slate of Hausmann (= Calceola slate).
S. Graywacke of Hausmann (= Spirifer sandstone).

The wood-cut is a copy from Hausmann; it does not altogether agree with the above description, but represents the ore-deposit as being entirely in the Graywacke slate; which is more correct than at the contact of the same with clay-slate.

So far as I know, it has been since then generally described as a bed, or recumbent segregation. It is self-evident, that a mass of such a shape having a broad ramification in the roof, which indeed was the foot-wall before the subversion, is not a bed in the strict sense of the term. Even though it lies parallel to the stratification and cleavage, such an immense ramification would contradict the idea of a bed, leaving altogether out of account the great breadth proportional to the slight extension, and the entirely different nature of the mass from the enclosing strata. Should any other term be found appropriate, it will still remain difficult to explain the formation of such an entirely compact aggregation of pyrites.

Is then the coherence of the entire mass so great, as is generally assumed? From the statements of Director Lehmann, and from my own observation, I am convinced, that the common view requires some correction.

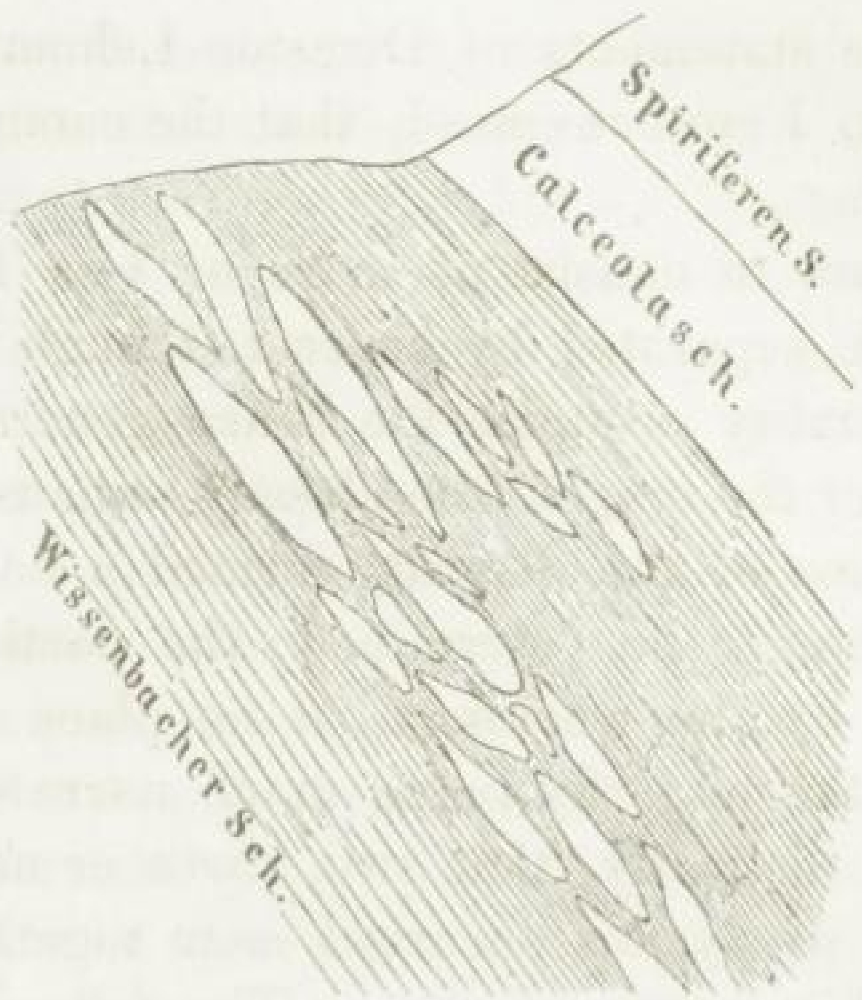
The pyritous mass appears to consist of more or less lenticular aggregations of pyrites, separated by several, though but thin layers of slate; whose totality occupies the space generally assigned to the mass. Whether the ore, in the already exhausted and partly inaccessible portions of the deposit, formed a continuous mass, or not, can no longer be determined; the portions of pyrites, at present opened by the workings, at no place exceeded a breadth of 50 feet, the majority being much narrower. In several places I saw very distinctly, that two, three or more irregular lens-shaped masses of pyrites occurred near together, but were still separated by thin layers of slate. The following wood-cut represents one of these points of observation.



S. Clay-slate.
K. Masses of pyrites.

The surveyors, who made the plans of the mine, may have found it more convenient to insert the masses lying near each other, and exploited together, as a whole. It is very possible, or rather probable, that formerly no notice was taken of these thin separations by the slate, and that the points exploited, for widths of 20, 30, or more fathoms, in reality consisted of irregular lenticular masses, separated from each other by the slate. In this manner the broad and rapidly wedging-out branch in the hanging-wall can be easily explained, as consisting only of single lenses lying somewhat outside of the principal zone. The form of the deposit, as a whole, is then nothing more than the outer contour of a combination of exploitable ore; while the form of the separate ore-masses may be very different.

The whole deposit would have about the shape in the fol-



lowing ideal section, in which the separate lenticular masses of ore are, for the sake of distinctness, represented somewhat widely apart.

The explanation of this remarkable aggregation of pyrites is rendered somewhat easier by this representation; which, though ideal, is founded on observations.

We have no longer then to deal with a single deposit of immense breadth, very peculiar shape, and proportionally small extent in its strike, and dip; but with a combination of single lenses of ore in a particular zone of slate. Still, indeed, the difficult question remains to be answered, whether these separate bodies of ore are to be regarded as contemporaneous lenticular beds, or as formations which have subsequently penetrated.

As facts in favor of the contemporaneousness of their formation, consequently of their true bed-nature; may be mentioned their general parallelism with the cleavage, which here corresponds to the stratification; also in their inner texture, since a banded arrangement can very commonly be recognised in the massive masses of pyrites; which also runs parallel to the cleavage, and consequently to the stratification. This banded texture is most distinctly seen in the so-called *melirt* ores, consisting of alternating bands of pyrites and galena.[1]

Unfavorable, for the supposition of such a contemporaneous formation, is the great breadth of some of these lenses; which, from the manner of their deposit, must have been entirely different from the mechanical sediment, of which the clay-slate was formed, which last contains distinct fossils converted to pyrites. In those places, where the sulphurets were deposited, the mechanical precipitation of clay-silt must have been inter-

[1] The large pyrites lenses of Schmöllnitz in Hungary mostly have a similar texture, and are also surrounded by impregnated slates. I am unfortunately not aware, if a similar separation into small lenses by layers of slate has been observed, or not.

rupted; and this process must have been frequently repeated in the same localities. The depositing of so many sulphurets; which contain, besides iron, copper, and lead, traces also of zinc, bismuth, mercury, cadmium, thallium, manganese, nickel, cobalt, antimony, arsenic, selenium, gold, and silver; does not altogether agree with their forming a contemporaneous formation in an otherwise entirely mechanical sediment, which they have, not merely locally impregnated, but even in places dispossessed.

This circumstance is more in favor of the view, that a subsequent penetration of the ores took place in the form of solutions. But how then could such like impregnations have formed the large spaces in which they alone predominate? Still less can it be assumed, that these spaces already existed, since from their great extent, they could not possibly have resisted the pressure of the overlying strata for the long period of time required for the formation of such large masses of pyrites.

Only a gradual replacement of the slate by the pyrites is supposable, in such a manner, that the last may have by degrees replaced the space, and in part acquired the texture of the slate, as is the case of many pseudomorphs by replacement, and fossils. This is, however, difficult to imagine; and the problem still remains unsolved in regard to the manner of formation. No event of the present time shows any thing analogous to this.

The pyritous masses of the Rammelsberg, moreover, do not form the only case of this kind: they are very similar to the deposits of Agordo, Schmöllnitz, and Fahlun; and in some degree to those of Rio-Tinto, and Domokos-Poschorita.

The chief mass of the deposit is formed of iron pyrites, which contains but little copper pyrites disseminated through it: copper pyrites, galena, and somewhat of blende, are locally frequent, in places even predominant. It appears, that the galena, with somewhat of blende, occurs most commonly, and in larger masses, in the foot-wall of the western portion; over this, and more to the East, occur the so-called *melirt* ores, consisting of alternating layers, or bands, of galena and pyrites. Over these, again, occur the purer copper ores; and finally, still more to the East, the poor iron pyrites. This is only a general law of distribution, and is subject to many exceptions. The following minerals occur at times, but are of no economic importance: heavy spar, quartz, calc. spar, tetrahedrite, red copper, erubescite, native copper, (in the places where the other minerals have been decomposed,) copperas, cyanosite, goslarite, voltaite, römerite, copiapite, botryogen (?), glockerite, and gypsum; also in the slate forming the hanging-wall, cerusite, and anglesite.

All the ores occur massive, being only more or less granular; geodes are very rare. On the other hand parallel striated friction-surfaces (schicken slides) are tolerably frequent.

The mineral composition of the deposit is a very simple one, much more so than is generally the case with lodes. The thirteen more rarely occurring metals, previously mentioned, are mineralogically unrecognizable in all the ores, with the exception of the zinc.

THE LAUTERBERG DISTRICT.[1]

§ 108. Lauterberg is situated in the Subcarboniferous formation, which is traversed in the neighborhood by porphyry. There occur here, according to Schultz, some copper lodes; the most important of which strike NNW.—SSE. and attain a breadth of 3 fathoms. Their vein-stones are heavy spar, calc. spar, and quartz; in which occur irregularly distributed pockets of copper pyrites, homichlin, iron pyrites, melaconite, malachite, chrysocolla, copper glance, erubescite, covelline, red copper, and lime-malachite. The heavy spar is frequently found in a peculiar sandy condition, similar to some of the lodes in the Black Forest. According to Hausmann, fluor spar and anhydrite also occur in the lodes.

THE COPPER SLATES IN THE HARTZ, THURINGIA, AND HESSE.[2]

§ 109. The Zechstein formation, in this portion of Germany, consists in its lower strata of the copper-slates (*Kupferschiefer*) and the white-beds (*Weissliegendes*); it rarely crops out, except in the mountainous districts; and has, during a long period, been exploited in numerous places for the ores it contains.

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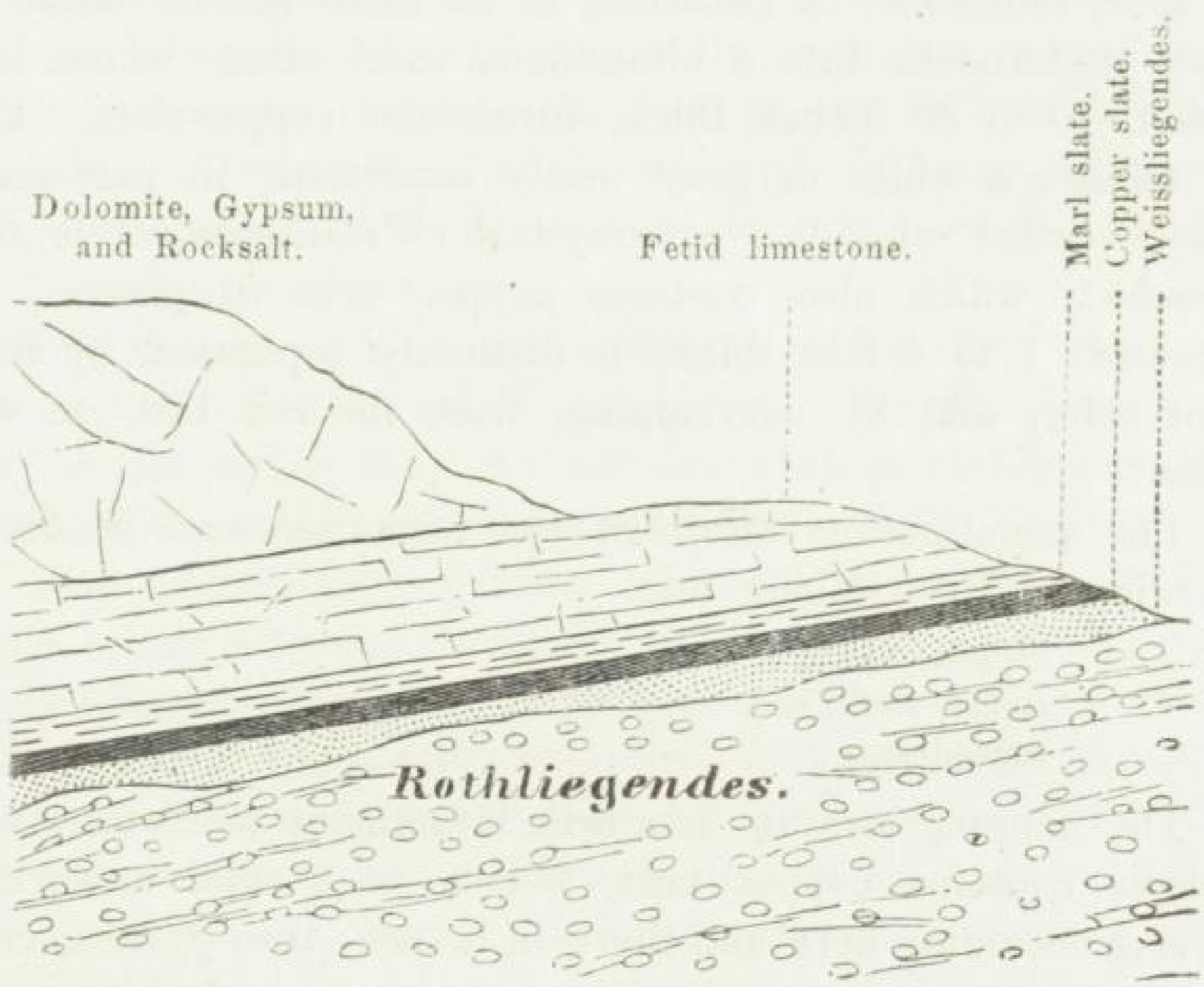
[1] See: Zimmermann, Harzgeb. p. 105; Hausmann, Bild. d. Harzgeb. p. 134; Kerl, in Berg- u. hüttenm. Zeit. 1859, p. 21; Schultz, in Karsten's Archiv, 1821, vol. IV. p. 229.

[2] See: Freiesleben, Geogn. Arbeiten, vol. III. and vol. IV. p. 15; Schmidt, in Karsten's Archiv, 1823, vol. VI. p. 73; Von Veltheim, in

The ores, occurring in this formation, are found, partly distributed in the strata above-mentioned, partly contained in fissures, so-called backs (*Rücken*), which intersect these beds; but are only metalliferous in these, while above and below them they merely contain heavy spar, or fragments of the wall-rock. Since the metalliferous lower strata of the *Zechstein* formation are most completely and characteristically developed in the region around Mansfeld, at the southeasterly base of the Hartz, I will commence with the description of the same. To this I will subjoin short remarks on the deviations in other localities.

Mansfeld. The red-beds (*Rothliegendes*), on the southeastern side of the Hartz, form a geological prolongation of its chief axis, without projecting as a mountain chain above the surrounding country. This prolongation is surrounded by a



same, 1827, vol. XV. p. 89; Tantscher, in same, 1829, vol. XIX. p. 377; 1832, vol. IV. p. 289; 1834, vol. VII. p. 606; Plümicke, in same, 1844, vol. XVIII. p. 139; Weiss, in same, 1851, vol. XXIV. p. 306; Heuser, in Von Leonhard's Taschenbuch, 1819, p. 311; Schulz, in same, 1820, p. 105; Bäumler, in Zeitschr. d. deutsch. geol. Gesellsch. 1837, p. 25; Credner, Geogn. Verh. Thür. u. d. Harz, p. 125; Buff, in Nöggerath's Rheinland-Westphalen, vol. II. p. 152; Klipstein, Versuch einer geogn. Darstellung d. Kupferschiefers d. Wetterau, 1830.

border of *Zechstein,* whose strata dip gradually toward SE., and contain exploitable ores, principally in the County of Mansfeld, and the neighborhood of Sangerhausen. As above mentioned, the ores are found in the copper-slates and white-beds. Both can be followed along the Hartz, on one side to Seesen, on the other to Ballenstädt; but the percentage of ore they contain, in these western prolongations, is so small, that they cannot be profitably exploited. In Mansfeld, on the contrary, they are worked with considerable success, owing to the uniformity of their development. The general bedding of the Zechstein formation at this locality about agrees with the wood-cut: p. 165.

The upper member in Mansfeld consists chiefly of unstratified gypsum, containing cavities; which have been washed-out (so-called 'lime-chimneys'), and soft bituminous dolomite or limestone (so-called '*Asche*'). Under this follows a regularly stratified fetid limestone, or *Zechstein* in its more narrow sense: this passes underneath into a bituminous marl slate, whose lowest portion, 10 to 20 inches thick, forms the copper-slate. Under this follows a white or gray marly sandstone, in part conglomerate, called white-bed or gray-bed (*Weissliegendes* or *Grauliegendes*); which also contains copper ores in places. This white-bed, 1 to 4 feet thick, is distinctly separated by its different color, and by overlapping, from the red bed, on which it lies.

The metalliferous strata of the formation can be divided, according to Freiesleben, into

capping stratum,
copper-slate, and
white-bed.

The capping stratum is a firm bituminous marl-slate, which at times contains copper ores, but is, as a rule, unworkable. The ores occurring here and there in it, are: iron pyrites, copper pyrites, copper glance, erubescite, red copper, malachite, azurite, very rarely also somewhat of galena. These ores are either finely disseminated, form thin plates or threads, or fill very fine clefts. The thickness of the stratum is 4—6 feet.

The copper-slate consists essentially of a dark bituminous marl-slate, 10—20 inches thick, in which copper and iron minerals are distributed in unequal quantities. Besides copper and iron, occur the metals silver, cobalt, nickel, zinc, lead, bismuth, and arsenic. Both the quantity and quality, of these ore-admixtures, are locally very different. They are in part very finely or invisibly disseminated, in part form thin layers, small pockets, nests, or the filling of fissures. The ores, which have been recognised in the copper-slate, are: copper pyrites, copper glance, erubescite, native copper, tetrahedrite, melaconite, red copper, native silver (very rare), galena (rare), iron pyrites, brown and black blende, copper nickel, earthy cobalt; cobaltine, bismuth, antimony, and arsenic (the last four very rare). Only the lower half of the slate is generally rich enough to be worth smelting.

The white-bed consists of sandstone, coarse conglomeritic sandstone, sandy or calcareous marl, of a grayish or almost white color. This is at times penetrated, in its upper layers, by streaks of ore, which is then called sand-ore. The ores, found in it, are: copper pyrites (the most common), copper glance, iron pyrites, galena, native bismuth, and blende: more rarely, native copper, azurite, malachite, copper nickel, and molybdenite. The ores are disseminated, and mixed in with the rocks, or form veins and threads: the malachite, and azurite, also small nodules. The other minerals found are: calc. spar, gypsum, heavy spar, mica, asphaltum, and coal. Almost the only petrifactions found are the remains of plants.

The members of the metalliferous strata show many modifications, when examined in detail. All the members do not every where occur, they are not every where of the same thickness, and not altogether composed alike.

The metalliferous portion is most fully developed in the region lying between Hettstädt and Gerbstädt, somewhat more simply near Eisleben and Sangerhausen. The regular bedding of these strata is frequently disturbed, both in Mansfeld and the Thuringian Forest, by so-called *backs*. By the term *back*, the Mansfeld miner understands all disturbances of the regular bedding; that is, all tiltings, basins, saddles, narrowings of the beds, and true intersecting or faulting fissures. These backs seldom contain ores, while they appear to have often exerted an influence on the metalliferous contents of the strata traversed. This influence is shown by an encrease or decrease in the amount of ores, not only in the immediate neighborhood, but at times for a considerable distance, even to the next back; it is also proved by the ores being transposed from one layer to another. But all the backs are not accompanied by such changes, many exerted no influence, especially true fissures or vein-backs; while the other disturbances of the bedding, which only caused flexures without cutting through the strata, and in consequence narrowings, breaks or divisions of the beds, are mostly injurious. It is remarkable, that the chief backs, whose fissures contain a non-metalliferous matrix, or at the most now and then somewhat of iron and copper pyrites, appear to have considerably enriched the copper-slate, and sand-ore, even to twice its general percentage. These, and the fissures branching from them, are, what enriching junctions are in vein-mining. This enrichment extends into the fetid limestone, the so-called capping rock, especially around Sangerhausen.

Bäumler states, that recognizable nickel-ores occur only in the vein-backs, while, in the copper-slate itself, they occur only in an imperceptible condition.

Kiffhäuser.—A large quantity of copper-slate was formerly removed from the base of this small mountain, which rises in the Thuringian basin.

Thuringian Forest. The *Zechstein* formation can be followed in all its strata, along the northern base of this mountain-chain. It has been found metalliferous, and been exploited, at the following places:

A. Saalfeld and Camsdorf. In this district the principal portions worked were, and still are, the so-called backs, which, as mentioned, are veins traversing the zechstein and copper-slate, and frequently causing faults. These are principally cobaltiferous in the niveau of the copper-slates; and even the copper-slate, which is itself hardly exploitable, is impregnated with cobalt ores in the neighborhood of these.

Tantscher, who described these deposits, distinguishes three so-called 'cobalt depths', or geological niveaus.

The lowest 'cobalt depth', which is that portion of the veins between decomposed clay-slate and the white-beds, contains smaltine, tetrahedrite, earthy olivenite, copper nickel, and copper pyrites. The second or middle 'cobalt depth', between the lime-stratum and the copper-slate, also immediately above this, contains brown, yellow, and green, earth-cobalt; erythrine, tetrahedrite, rarely smaltine, never copper nickel. The third or upper 'cobalt depth', between the magnesian limestone, contains only black earth-cobalt (cobaltiferous wad); which has often penetrated for a considerable distance into fissures of the limestone, and even into the mass of the same.

B. Ilmenau. Large quantities of copper-slate were formerly obtained at this locality. Recent examinations have proved, that the bed was not thick enough, being 6 to 10 inches thick, to be profitably exploited at the present condition of prices.

C. Katterfeld and Fischbach. The copper-slates were here also extensively worked; but the mines had to be abandoned on account of the encrease in the price of labor and fuel.

The *Zechstein* formation can be followed, at the south-western base of the Thuringian Forest, from Landnöden to the neighborhood of Suhl. It was formerly mined in the following localities.

D. Schweina and Glücksbrunn. At these localities the veins traversing the zechstein, were those principally exploited. They contained, in the copper-slates and white-beds; copper, nickel, cobalt, and silver ores: above and beneath these, only heavy spar and clay.

E. Alsbach. Numerous heaps of rubbish show, that the copper-slates were formerly extensively worked.

Riegelsdorf in Hesse. The *Zechstein* formation crops out here for a short distance, under the *Buntsandstein* (variegated sandstone). The copper-slate forms the lowest bed, 4 – 6 inches thick, of the bituminous marl-slate; and contains finely disseminated copper pyrites, tetrahedrite, earthy chrysocolla; more rarely red copper, melaconite, and native copper. The white-bed beneath it, 3 to 18 fathoms thick, also contains at times in its upper layer, only one inch thick, copper ores, which are then called sand-ores. The veins, or backs, strike in various directions, their breadth encreasing from the smallest dimensions to 4 fathoms. They vary considerably, as to their extent, in the direction of strike and dip; many of them forming fissures of only a few inches. Some of them, however, have produced faults of over 28 fathoms; and they must, of course, be of considerable extent in the direction of strike and dip. These lodes frequently split up into branches.

The following minerals occur: calc. spar, calc. sinter, brown spar, dolomite, pharmacolith, quartz, heavy spar, anhydrite, gypsum, iron pyrites, smaltine, copper nickel, copper pyrites, tetrahedrite, galena, ochreous limonite, hausmannite, cobaltiferous wad, erythrine, annabergite, azurite, and earthy olivenite.

Heuser has distinguished 9 different vein-formations according to the grouping of these minerals; but as these have been caused by slight differences in the manner or time of their formation, it is sufficient to mention them.

The influence of the country-rock, on the local composition of the lodes, is here very perceptible. Heuser says, that the lodes (containing cobalt ores) are the richest in the white-beds, while they decrease in the fetid limestone (*Zechstein*); and, when the lodes extend to so great a depth, are entirely barren in the red beds. This rule has been confirmed by the most varied experience. Still it has its exceptions; since the lodes have been found at times very rich in the fetid limestone. The cobalt-ores have also penetrated, at times, from the lodes into the wall-rock. The copper-slates often have their copper ores replaced by cobalt ones.

Besides the veins (or filled fissures), occur so-called 'changes': These are really nothing more than unfilled fissures, or cracks, which are frequently combined with faults of upwards of 25 fathoms. They cut through, and generally fault the veins also. They principally strike N.—S. and are parallel to the southern dip of the strata; while the richer veins mostly are parallel to the strike of these last, and are intersected by the 'changes' at right angles.

Stadtberge and Frankenberg in Hesse. The *Zechstein* formation again occurs with somewhat of copper, on the eastern edge of the Rhenish Devonian and Subcarboniferous district, under the *Buntsandstein*. According to Buff, there are many more copper-containing strata, or zones, to be recognised, than in Thuringia, without the total amount of ore being greater. Of course, this greater distribution is not advantageous to mining.

The strata, of the formation at Stadtberge, are:

cellular limestone, 7—10 feet,
cellular wacke, 21—75 feet,
fetid limestone, 35 - 40 feet.

Even the thinly stratified fetid limestone contains here and there copper-glance finely disseminated in layers, and in its fissures oxidised salts of copper. In its lower layers it alternates with 10 to 30 beds of the copper-slates, each of which is $^1/_8$ to 2 inches thick; while they occupy, with the interstratified non-metalliferous rock, a total thickness of $^1/_2$ to several fathoms. They consist partly of a crumbling, partly of a common marl-slate. The predominating ores in them are principally: earthy chrysocolla (malachite?), and azurite, which cover the cleavage-fissures. The firmer varieties appear to contain considerable quantities of very finely disseminated sulphurets. These last are probably here, as elsewhere, the original ores, the first mentioned being secondary products, during the formation of which the condition of the slate has been altered, so as to form a crumbling mass. The amount of ore is always less on saddles, and near disturbing fissures, but especially near the outcrop, than in basins and towards the depth.

This formation is also traversed by veins, or backs, which penetrate into the Devonian strata and contain a little copper ore. Their matrix is principally white clay, with nodules of copper glance, and distributed chrysocolla. By the penetration of one of the backs into the underlying siliceous slate, this was found to contain somewhat of copper in its numerous cracks.

At Frankenberg the strata of the *Zechstein* formation, commencing with the upper ones, are:

Reddish-gray limestone, at times with plates of mica, only a thin layer.
Yellowish-gray cellular limestone, about 3 feet.
Variegated clay, 21 feet.
Brownish-gray fine granular sandstone with somewhat of mica, only a thin layer.
Brownish-gray argillaceous shale, at times containing ores, about 3 feet.
Greenish-gray limestone, 3 feet.
Bluish-gray argillaceous shale, about 7 feet.
Reddish-gray limestone, 2 to 4 inches.
Ore-bed, a bluish-gray, slaty clay with darker stripes, 6 to 14 inches.
Reddish, fine granular sandstone.
Devonian.

The ore-bed proper, consisting of light crumbling clay, does not contain the ores microscopically disseminated as in the copper slate proper, but as the remains of plants converted into ores. Stalk, fruit, and leaves, are converted into tetrahedrite, copper glance, and marcasite: iron pyrites occurs but seldom, copper pyrites never. These plants are converted often into coal, and have threads of ore running through them, at times to anthracite and without ore.

Spessart. This uniform mountain-ridge consists almost entirely of variegated sandstone; but in some places, especially at the foot of the mountains, older rocks and strata crop out from beneath it, among which is also the *zechstein* formation. This is mined in several localities of the westerly edge adjoining Wetterau.

The bedding and strata of the formation in this neighborhood are, commencing with the upper ones, according to Von Klipstein, the following:

Ironstone bed.
Bituminous limestone.
Copper-clay.
Copper-slate.
White-beds.
Red-beds.
Mica-schist.

This general stratification is modified in its details at various localities, but all the beds can be referred back to the preceding normal formation. The special relations of the bedding and ore contents are best known around Bieber, on which account I will describe this locality alone.

The iron-stone bed, the upper member of the zechstein in this region, is overlaid by a limestone at Röhrig and Büchelbach, and averages 7—8 feet in thickness, but is at times even 18 feet. It consists of a very good and pure limonite, which only contains small quantities of ochreous iron and psilomelane mixed with it. The bed contains numerous geodes, whose walls are covered with stalactitic limonite, and psilomelane. There are found in the bed fibrous, massive, stalactitic, reniform, and botryoidal limonite, similar varieties of psilomelane, yellow, brown, and red, ochreous iron, specular iron, and pyrolusite.

The bituminous limestone is thinly stratified in its upper portion, but becomes massive at a greater depth.

The copper-clay is a very clayey schistose marl with slight traces of ores: in its lower portions it passes into bituminous marl-slate, several fathoms in thickness, whose lowest bed forms the copper-slate proper, and contains copper ores finely disseminated through it. Besides the copper ores are found somewhat of tetrahedrite, cobalt, and bismuth ore: these last only in the neighborhood of the intersecting veins, being probably impregnations from these. The copper-slate is vesicular in many places, and frequently contains heavy spar in its cellular cavities, on which occur small plates of silver tetrahedrite.

The white-bed contains boulders of granite, gneiss, mica-schist, and various porphyries in a conglomerate, but no ores: it gradually passes in its lower portion into the red-beds, in common with which it fills depressions in the surface of the mica-schist. It attains a thickness of $^1/_2$ to 56 feet.

All these strata are traversed by veins, which also extend into a mica-schist, causing many faults, and in some places throwing the strata 70 feet. Their matrix, 1 to 3 feet broad, contains heavy spar, and spathic iron, with copper nickel, tetrahedrite, cobalt, and bismuth ores. The ores are irregularly distributed, and remarkably enough occur principally in the mica-schist. They form in this respect a great contrast to those of the Hartz, and Thuringian Forest, in not containing the ores in the niveau of the copper slate. The impregnations from these lodes, on the other hand, are chiefly found in the bituminous marl-slate.

V. THE RHINE.

GEOLOGICAL FORMATION.

§ 110. This district is included between the following cities lying on its outer border: Bingen, Luxemburg, Sedan, Charlemont, Liege, Aix-la-Chapelle, Düren, Bonn, Duisburg, Dortmund, Waldeck, and Friedberg. It is a large extent of country, but forms a geological whole.

It is principally composed of Devonian strata, which have been tilted and upturned in a SW.—NE. direction, and form an elevated plateau, having an average height of 1100 to 1500 feet above the sea. At its southwesterly edge, in the Hundsrück and Taunus, occur quartzose unfossiliferous strata; on its northwestern edge it is overlaid by strata of the Subcarboniferous and Carboniferous formations.

The members of these formations are, commencing with the uppermost, in general the following:

	According to Von Dechen	In part, according to Sandberger.
Carboniferous age.	Upper Millstone grit. Carboniferous zone. Millstone grit.	Carboniferous shale and sandstone, with coal-beds and black-band. Millstone grit.
	Subcarboniferous strata, siliceous slate, shaly sandstone, tabular limestone, and Posidonomya slate. Mountain limestone.	Subcarboniferous strata consisting of Posidonomya slate, siliceous slate, alum shale, clay-slate, and bituminous limestone.

	According to Von Dechen.	In part, according to Sandberger.
Devonian Age.	Verenulli slate, a sandy clay rock.	
	Kramenzel, consisting of sandstone and concretions of limestone in slate.	Cypridina slate, clay-slate, and siliceous slate.
	Flinz (Goniatite slate).	Schalstein, combined with greenstone, hematite, and limonite. Not strictly confined to this niveau.
	Eifel limestone and Stringocephalus limestone.	Gray and green schists, with lime concretions (*Kramenzelstein*). Clay-slate, with thin layers of limestone (Flinz).
	Lenne slate, sandy clay rocks containing beds of limestone.	
	Wissenbach slate.	Stringocephalus limestone. Eifel limestone, and magnesian limestone, alternating with marl, slate, and sandstone.
	Older Rhenish Graywacke, (Spirifer sandstone) with beds of limestone.	Spirifer sandstone, or Rhenish Graywacke.
?	Ardennes shales, unfossiliferous and semi-crystalline.	Taunus shales, clay-slate, talc-schist, and quartzite, without organic remains.

Zechstein and *Buntsandstein* on the outer eastern edges, southerly *Rothliegendes* and tertiary deposits, overlie these older strata; while *Buntsandstein* and *Muschelkalk* occur in a depression between Luxemburg and Düren, cretaceous to the North and lignite on the heights near the Wester-Forest. These formations are frequently broken through by greenstones, basalts, and trachytes; where the Lenne slates occur, by quartz-porphyries. Granite, gneiss, and mica-schist, have never been found.

The ore-deposits of this large district are very numerous, and of a very varied character. Of course they cannot all be here described in detail, I will describe in the following order:

1. Iron deposits.
2. Manganese deposits.
3. Smithsonite deposits occurring in Devonian and Mountain limestone.
4. Copper, lead, silver, nickel, and cobalt lodes in the Devonian district.

5. Antimony lodes.
6. The lead-deposits in the *Buntsandstein* of Commern.
7. Gold deposits.

IRON ORES IN THE CARBONIFEROUS FORMATION.

§ 111. In Westphalia.[1] The Carboniferous formation of Ruhr district in Westphalia contains, especially at Essen, Bochum, and Hörde, parallel deposits of the so-called *Kohleneisenstein*, corresponding to the English blackband; it consists of an intimate mixture of spathic iron, coal, and somewhat of silicate of alumina. It was long mistaken for coal-shale, on account of its slaty texture and black color; it contains in places so much phosphorus as not to be worth smelting.

At Hörde, six to eight beds are known to exist. Lottner determined the bedding and thickness at one point to be the following:

Ironstone	56 inches.
Shale with a streak of iron-stone . .	45 "
Ironstone, locally replacing a coalbed	33 "
Ironstone	52 "
Slate	18 "
Ironstone	4 "
Ironstone	10 "

Besides the compact beds, nodular concretions are also frequent in the shales of this coal formation; while Schnabel found a bed, 24 feet thick, in the Charlottenburg mine at Bochum; which was, however, cut off in numerous places by shale. All these deposits are evidently of contemporaneous formation with the coal-formation, and were formed from fresh-water deposits, as they contain fresh-water fossils. The question has not yet been satisfactorily explained, as to how the carbonate of iron was formed.

Around Saarbrück.[2] The ironstone deposits, of the Carboniferous formation around Saarbrück, are generally richer than

[1] See: Berg- u. hüttenm. Zeit. 1852, p. 74; Herold, in Verhandl. d. naturh. Vereins d. preuss. Rheinlande, 1852, IX. p. 606; Carnall, in Zeitsch. d. deutsch. geolog. Gesell. 1851, III. p. 3; Nöggerath, in Jahrb. der geol. Reichsanst. 1852, p. 133; Schnabel (Analyses), in Poggend. Annal. vol. LXXX. p. 441; Lottner, Geogn. Skizze d. westphäl. Steinkohlengebirges, 1859, p. 114.

[2] See: Schmidt, in Nöggerath's Rheinland-Westphalen, vol. IV. p. 97; Nöggerath, in same, vol. IV. p. 382.

those of the Ruhr. The deposits are composed of brown sphero-siderite; the beds consist chiefly of lenticular concretions. These concretions frequently contain in their interior the fossil remains of plants, fish of the Genus *Amblypterus* or Saurians (*Archegosaurus*). The strata composed of the spheroids form regular beds between the coal shales, especially at Lehrbach, and Börschweiler, where they are extensively exploited and smelted.

Beds of spherosiderite are also found in the lignite near Bonn.

IRON DEPOSITS IN THE DEVONIAN.

§ 112. Many and various iron deposits occur in the Rhenish Devonian, of which only a few can be mentioned. The same occur as beds, fissure-lodes, contact-lodes, and segregations, on the edges of greenstones, basalts, and porphyries; finally also as surface-deposits.

Ironstone beds.[1] The eastern, especially the south-eastern, portion of the Rhenish Devonian contains in the neighborhood of Dillenburg, Wetzlar, etc. a large number of hematite beds mostly associated with *Schalstein.*[2] These often have a very irregular form, and might on this account be easily mistaken for segregated masses, were it not, that the fossils they at times contain, prove them to have been formed contemporaneously with the other Devonian strata. According to Sandberger, these iron ore beds are always found associated with diabase or schalstein; they are frequently bounded by these on one side, while they are surrounded by Cypridina slates on the

[1] See: Buff, in Karsten's Arch. 1833, vol. VI. p. 440; Sandberger, Uebers. d. geol. Verh. v. Nassau, 1847, p. 127; and in Leonhard's Jahrb. 1854, p. 455; Stifft, Geogn. Beschreib. d. Herzogth. Nassau, 1831, pp. 480, 485, and 486; Becher, Mineral. Beschreib. d. Nassauischen Lande; Klipstein, in Zeitsch. d. deutsch. geolog. Gesellsch. 1853, p. 523; and in Gemeinnützige Nachrichten z. Förderung d. Bergbau- u. Hüttenwesens, 1859, II.

[2] Cotta says in his Lithology: 'So many rocks have been described under the name of *Schalstein,* that we can only say in general, that by it is understood a laminated rock interspersed with small particles of calc. spar. In Nassau, the base or matrix appears to be a very fine somewhat laminated greenstone-tufa, which contains calc. spar in grains or thin layers of green, gray or variegated spotted color. In some places, however, this rock partakes of the character of breccia, or is porphyritic by reason of crystals of labradorite, or it is amygdaloidal, or is even penetrated by clay-slate and chlorite schist.' *Lawrence's Translation.*

others; they contain nearly all the fossils belonging to the Stringocephalus limestone. About 5, to 6,00 mines are worked on these beds in Nassau. Stifft says of this region: 'The hematite forms curved and faulted beds in *schalstein* and greenstone, in which fossils occasionally occurred; they were distinguished as 'Fluss' beds, with which calc. spar was combined, and siliceous beds, mixed with common and ferruginous quartz. The first often lie entirely in the *schalstein,* while greenstone or amygdaloid forms, at the most, the hanging-wall, never the footwall, of these; the last are found entirely in diorite, and peculiarly irregular in shape.' Buff found their thickness to vary between 4 and 7 feet, and their superficial area to be seldom more than a few hundred square fathoms. In addition to the hematite, limonite is also found generally associated with limestone (Allendorf, Katzenellenbogen).

Somewhat northerly of Stockhausen on the Lahn, occurs on the Lohr mountain an iron ore-bed in *schalstein* near its contact with labradorite porphyry. Von Klipstein says of it: 'On the southerly slope of the Lohr mountain, the Bernhard mine is worked on this bed, where it crops out under the labrador porphyry; the iron ore being only extracted at the outcropping of the bed, where it exhibits a peculiar character. The mass of the bed, which overlies the amygdaloid of the Lohr mountain, has not yet been opened to the hanging-wall; it is entirely broken up into branches at the outcrop, and rendered impure by fragments of schalstein. It consists of a very ferruginous red clayey mass, which encloses a number of leaders of pure hematite. At some distance from the hanging-wall, considerable brown ferruginous *schalstein* can be observed.'

Southerly of Brilon[1] in Westphalia, a chain of greenstone domes (labrador porphyry) occurs in the upper Devonian, or more specially between the Lenne slates and Kramenzel, and parallel to their strata. These domes, where they join the Kramenzel, are frequently accompanied by hematite masses, which might from their shape be termed irregular lenses, or contact-segregations; but they frequently contain Devonian fossils, and must consequently be contemporaneously formed beds of a somewhat irregular shape.

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[1] See: Castendyck, in Zeitsch. d. deutsch. geolo. Gesellsch. 1855, p. 253; Stein, in same, 1860, p. 208.

The same develop the greatest thickness (3 fathoms) on the *Eisenberg* (Iron Mountain); and here, as in the surrounding neighborhood, it appears that their thickness, as a rule, decreases, where the proportion of lime in the Kramenzel encreases, and the reverse. When the last consists of compact limestone, the iron ore bed entirely disappears; and it seems from this, that in the present case the iron ore bed and limestone mutually replace one another.

Ironstone lodes. Lodes of spathic iron, whose matrix has been partly altered to limonite, frequently occur in the Devonian district. They at times contain, as in the Saxon Voigtland, somewhat of copper pyrites; and thus form gradual transitions into copper lodes containing spathic iron, which are in turn closely related to quartzose lodes containing galena and blende. We see deposits and phenomena recurring in the Rhenish Devonian, like those with which we have already become acquainted in the Fichtelgebirge, § 90.

The Stahl Mountain near Müsen in the County of Siegen affords a good example. I am aware of but one description, that of Schulze,[1] written in 1819, of this locality; I use his description as a basis, filling it out from my recollections of a visit I made to it in 1830.

Schulze says: 'This deposit is neither a vein nor a bed, neither does it coincide with the idea of a *Stockwerk*.' It appeared to me to be a broad but irregular vein. The lode traverses the slates at an acute angle; it commences southeasterly, as a very broad but pure mass of spathic iron, and soon attains, in its strike toward NW., a breadth of 50—55 feet, while still farther in the same direction it splits up into numerous branches. The rock between these branches is clay-slate. Where the pure matrix of spathic iron begins to branch, the clay-slate is still mixed with a considerable amount of the same, which is entirely wanting at a greater distance. At a length of about 90 fathoms the clay-slate penetrates into the branches of, and through the ironstone, so that only a slate, traversed by small veins of spathic iron, can be seen; and the previously perceptible walls of the branches disappear. The branches attain

[1] See: Schulze, in Leonhard's Taschenb. 1820, p. 582; Buff, in Nöggerath's Rheinland-Westphalen, vol. II. p. 169; Schmid, in same, vol. II. p. 216; Von Dechen, in same, vol. II. p. 42.

at times a breadth of 15 feet, are innumerable, and after separating frequently again unite.

According to my recollection, somewhat of copper pyrites is at times found at the selvages of this broad and irregular lode of spathic iron. Toward SE., it is cut off and faulted by a fissure, the portion thrown has not been again discovered.

Several other lodes of spathic iron occur at the Martinshaart; those of the Schwaben mine contain argentiferous tetrahedrite and galena, while in others cerusite, anglesite, and blende, are found.

Buff has described an interesting independently occurring hematite lode, near the village of Faule Butter in the Wildewiese Mountains. The same occurs in the Devonian district, within a vein of conglomerate, 24 fathoms broad. The conglomerate vein is formed of boulders of the Devonian, cemented together by clay. The hematite lode attains a breadth of 3—7 feet, and dips 80° towards W. Small clay-dikes intersect it, and contain, like the lode itself, small boulders belonging to the Devonian slate.

Another very interesting case is that of the limonite lode at the Alte Birke mine near Siegen. The same is diagonally intersected by a perpendicular dike of wacke, which passes into spherically jointed basalt, and is enclosed by selvages of jasper. The limonite has become somewhat magnetic at the point of intersection; that is, it contains grains of magnetite, which have evidently been formed by the once igneous-fluid basalt: this latter has at the present time been partially decomposed to wacke.

IRON ORES IN THE HUNDSRUECK.[1]

§ 113. The Hundsrück, on the left bank of the Rhine, consists principally of unfossiliferous clay-slate, with subordinate beds of quartzite. It is geologically a very uniform region, in which occur tolerably frequent iron ore deposits of two different kinds. The first consist of bedlike impregnations, and of veins in clay-slate, the others of surface-deposits of limonite. The Hundsrück ore-deposits occur mostly in the Simmern and Zell circuits.

Impregnations. The soft, decomposed clay-slate is entirely penetrated, in certain zones, by hydrated peroxide of iron, as

[1] See: Nöggerath, in Karsten's Archiv, 1842, vol. XVI. p. 470.

well in its cleavage and cross fissures, as also in its mass; so that it is converted into an impure, still schistose limonite. Only in the fissures, where there was more room, has the same been formed as a massive or even fibrous limonite, which occurs at times in stalactitic shapes. The same frequently also contains somewhat of pyrolusite. It appears doubtful, whether the iron-ore was originally deposited with the clay-slate, and was subsequently concentrated in the fissures, whether it is the product of decomposed pyrites, or whether it has subsequently penetrated from without.

The limonite lodes, in the clay-slate of the same region, seem to have been originally quartz veins, into which hydrated peroxide of iron has subsequently penetrated; partly, in that it filled and widened innumerable cracks in the quartz, and thus formed a sort of breccia, adjoining fragments of which can still be seem to have once belonged to it; partly, in that it was chiefly deposited at the selvages of the quartz veins in such a manner, that the outer layers of the lode are of more recent formation than the central one. These lodes strike and dip in various directions, at times parallel to the cleavage, as bedded veins, frequently intersecting and faulting one another. They also contain manganese ores in places, which are generally found in the decomposed clay-slate (entirely penetrated by hydrated peroxide of iron). They may thus be regarded as a modification of the impregnation-fissures.

Surface-Deposits. These cover the much tilted clay-slates, and consist of variegated clay, in which the iron-ore occurs in irregular or spherical nodules, mostly collected in layers. The clay at times alternates with layers of a sharp white sand, or of small, rounded pebbles of white quartz. The nodules of limonite often contain considerable psilomelane.

Nöggerath considers these to be Tertiary deposits of the age of the lignite formation (at Bonn). Their thickness and special nature is very variable.

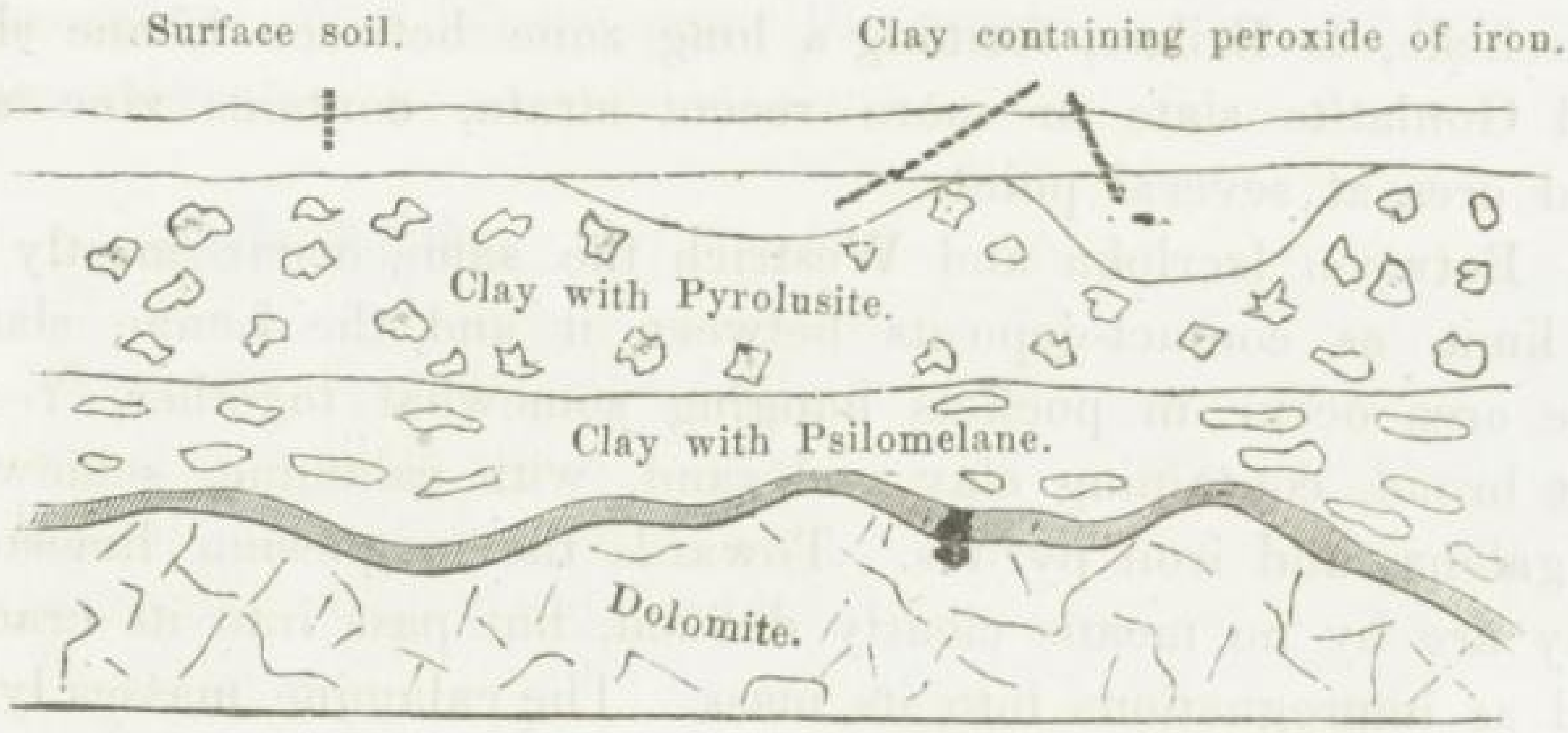
MANGANESE DEPOSITS.[1]

§ 114. These deposits are only found to any extent in the southeastern portion of the Rhenish mountainous region, and

[1] See: Von Klipstein, in Karsten's Arch. 1843, p. 265; Sandberger, Uebersicht d geol. Verhältn. d. Herzogth Nassau, 1847, p. 130; Gutberlet, in Leonhard's Jahrb. 1855, p. 317.

appear to be chiefly combined with the magnesian limestone of the Devonian formation.

Von Klipstein has fully described the interesting occurrence of Klein-Linden in the valley of the Lahn. In addition to some impregnations in the dolomite, which have partly proceeded from a vein, nodular concretions of manganese ores are found in clay on the surface of the dolomite, which are only covered by a thin stratum of earth. In the lower stratum, next to the dolomite, are found concretions of psilomelane, while in the upper stratum, on the contrary, only those of pyrolusite. This stratum contains considerable oxide of iron here and there on its surface.



I am unable to state, whether these nodules are portions of a former deposit, which have been washed away from it, and collected here; or concretions formed on the spot. They were evidently, at the time of their formation or deposit, composed of pyrolusite, which has been converted in the upper stratum into psilomelane, by the penetration of water.

Gutberlet has also described a rather peculiar occurrence of manganese ores on the Mühl Mountain near Eimerode. This mountain consists of Devonian clay-slate overlaid by strata of siliceous slate and limestone. Five fissures traverse the siliceous slate and limestone, nearly at right angles, from the hanging- to the foot-wall, where they suddenly cease. These fissures, as well as a number of isolated pockets, and nests, contain pyrolusite. These fissures vary much in breadth; and small clefts extend from them sideways. The pyrolusite is associated with calc. spar, magnesite, clay, and lithomarge. The smaller veins possess at times very distinct selvages; these consist of magnesite, then pyrolusite; and the middle is occupied by crystallized calc.

spar, and magnesite, with the clay and lithomarge. The broader lodes contain many horses of the wall-rock, by which they are split up into numerous branches.

Some other interesting occurrences of manganese ores in the Rhine district are described by List in Leonhard's Jahrbuch für Mineralogie, 1861, p. 186; Volger, in the same, 1861, p. 336; and Zerrener's 'Die Manganerzbergbaue', 1861.

ZINC AND LEAD DEPOSITS.

§ 115. In Westphalia.[1] The Devonian Eifel limestone; which extends from Elberfeld through Iserlohn, Balve, and Meschede, to Brilon; forming a long zone between Lenne slate and Goniatite slate or more recent strata, contains zinc and lead ores at several points.

Between Iserlohn and Westrich the same occur mostly on its limit, as contact-deposits between it and the Lenne slates. The ores occur in pockets hanging somewhat together, 7—14 feet broad, containing clay and sand, with calamine, somewhat of galena, and iron pyrites. Towards the magnesian limestone they are by no means clearly defined, but pass into its cracks, and as impregnations into its mass. The calamine masses lying in clay become rarer, limestone fragments take their place, until finally the limestone altogether predominates. Their limits towards the Lenne slates are, on the contrary, sharply defined. Both smithsonite and calamine occur; the first forms rounded and frequently porous masses, the last mostly compact layers. These ores are evidently of more recent formation, than the limestone.

Similar deposits exist, in the eastern prolongation of this Devonian limestone zone, near Altenbühren, Brilon, Rösenbeck, and Bleiwäsche. They consist principally of smithsonite, with somewhat of galena, free of silver, and are here found to be the richest within the limestone, while towards the Lenne slates they are too poor to be exploited. Castendyck states, that they are essentially the matrices of very irregular fissures in the limestone. Reddish sandy clay, calc. spar, cerusite, pyrites,

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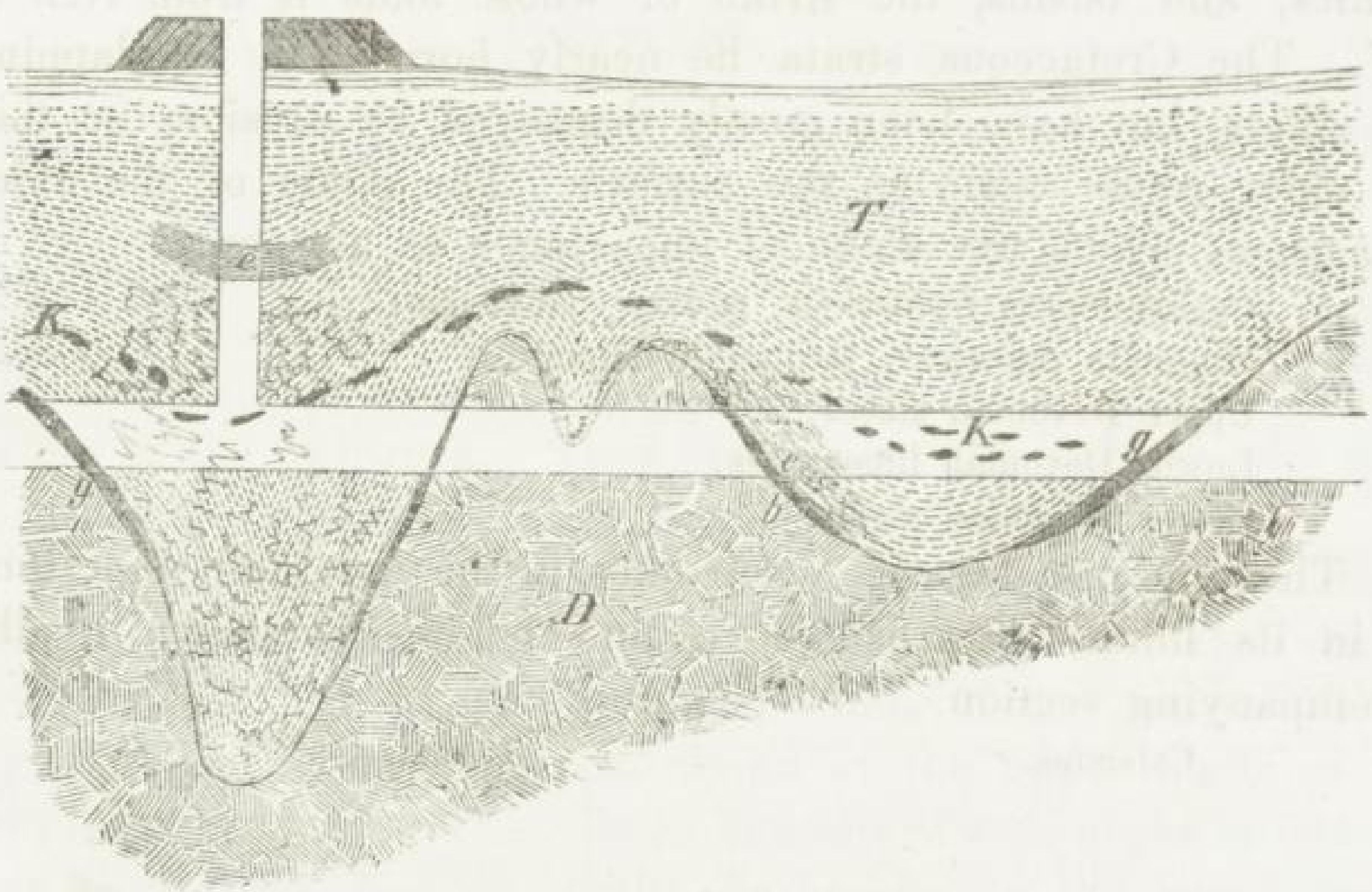
[1] See: Von Dechen, in Nöggerath's Rheinland-Westphalen, vol. II. p 37; Castendyck, in Berg- u. hüttenm. Zeit., 1850, p. 689; Huene, in Zeitsch. d. deutsch. geolo. Gesellsch. 1852, p. 575; Berggeist, 1860, p. 450.

and limonite, formed by the decomposition of the last, occur in these fissures also. The ores are distributed in pockets, or branches.

Similar deposits are found at Gladbach, easterly of Cologne, in a magnesian limestone of like Devonian age, although no longer in the same zone. Beds of lignite occur immediately over the magnesian limestone. The surface of the last is extremely irregular, and the ores occur in depressions of the same, sometimes on the steep sides, or in fissures. The ores consist of loose fragments of calamine, smithsonite, and somewhat of galena enclosed in clay. Single layers of such ore-fragments occur, even above the limits of the limestone, in the clay of the lignite formation. Von Huene gave the accompanying section of this occurrence.



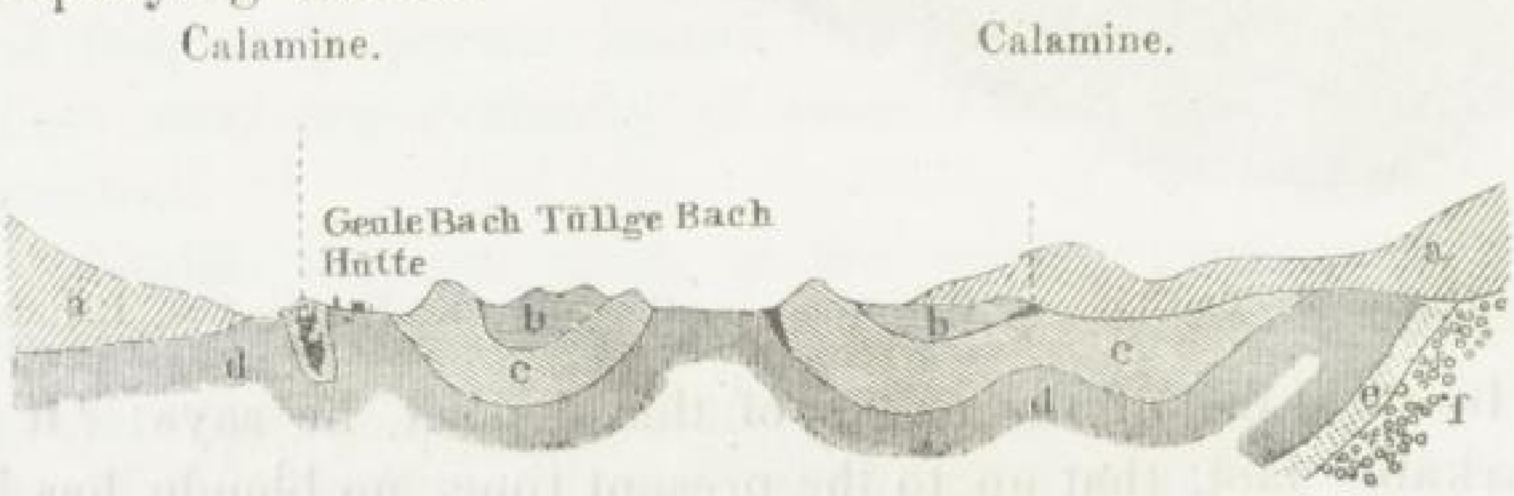
D. Dolomite; T. Clay; g. Calamine; e. Cerusite; K. Lignite; e. Blende.

In speaking of the origin of this deposit, he says: 'It is a remarkable fact, that up to the present time, no blende has been found in the calamine, which had withstood alteration. Such fragments occur very finely in the broad blende lode of the Frühling mine at Altenbrück, two miles easterly of Bensberg, where the blende has been altered into calamine at the outcropping of the deposit; and blende is still found in the centre of larger calamine fragments. The whole occurrence of ores at Gladbach and Paffrath clearly shows, that these are no longer in their original deposit, but were washed into the wavelike surface and basins of the limestone at the time the clay of the lignite formation was deposited. The edges of the fragments being mostly still sharp, tends to show that they are but a short distance from the original deposits. It is probable that the ore-fragments, deposited with the lignite formation, came from the outcrops of similar galena and blende lodes, such as occur near Bensberg, Herkenrath, Altenbrück, etc., but which are there found traversing Devonian rocks. The fact is curious, however, that the blende at present found in those lodes is for the most part coarsely laminar, while that just mentioned occurs in botryoidal form.'

In the Neighborhood of Aix-la-Chapelle and in Belgium.[1] The chains of hills in this region consist of Devonian, Carboniferous, and Cretaceous strata. The first two form saddles, and basins, the strike of whose folds is from NE. to SW. The Cretaceous strata lie nearly horizontal, overlapping the others, but have been mostly destroyed by erosion, so that the older rocks come to the surface. The strata of the older formations, which are alone of importance to us, are:

Carboniferous formations, mostly coal-shales;
Mountain limestone, frequently dolomitic;
Upper Devonian slates;
Lower Devonian limestones;
Lower Devonian slates.

The zinc ore deposits occur only in the mountain limestone or in its limits towards above and below, as shown in the accompanying section.



a. Cretaceous Deposits.
b. Carboniferous shales.
c. Mountain limestone and dolomite.
d. Upper Devonian slates.
e. Lower Devonian limestones.
f. Lower Devonian slates. Black. — Zinc Deposits.

[1] See: Braun, in Zeitschr. d. deutsch. geol. Gesellsch. 1857, p. 354; Oeynhausen, in Nöggerath's Rheinland-Westphalen. vol. III. p. 200; Berggeist, 1860, p. 452; Delanoue, in Annales des Mines, 1850, XVIII. p. 455; Piot, in same, 1844, vol. V. p. 165; Manès, in same, 1821, vol. VI. p. 499;

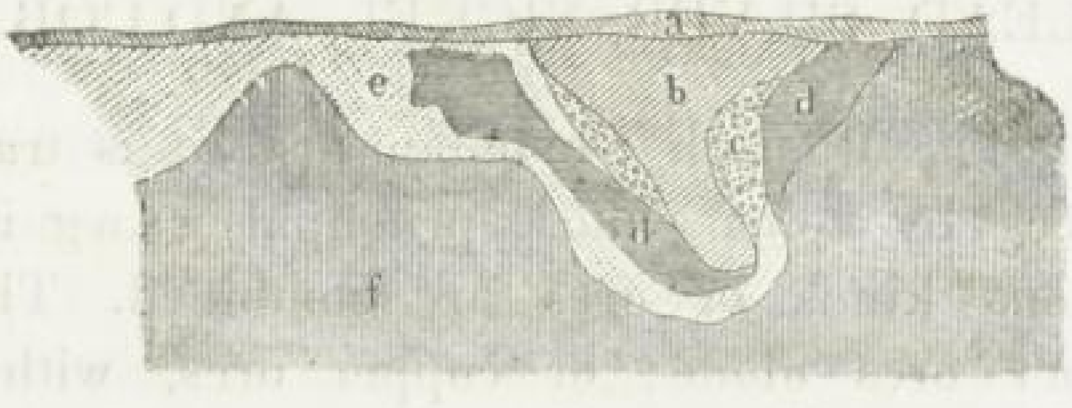
It is certainly curious; that the calamine deposits, on the left side of the Rhine, are found principally in combination with mountain-limestone; while those on the right side, occur with the older Devonian strata; as otherwise a great analogy exists in their geological formation, and they must evidently be regarded as mutual prolongations of each other, only separated by the broad valley of the Rhine. From this fact also it follows, that the ores must be of much more recent formation, than the magnesian limestones with which they occur, and which only appear from their chemical nature to have exercised a re-acting influence on the deposits, entirely independent of their own geological age.

Max Braun distinguishes in this region:

Veins,
Contact deposits,
Pockets, and
Beds;

which all principally contain zinc ores, are intimately related, and were probably formed contemporaneously. The veins fill fissures in the mountain-limestone, above and beneath which they appear to continue as barren cracks: hence their being filled with ores would seem to have been essentially caused by the nature of the wall-rock. They contain blende, galena, calc. spar, and at times quartz, in a combed arrangement.

The contact-deposits occur, resembling segregations more than beds, at the contact of the limestones with the shales, principally at the upper and lower limits of the mountain-limestone; although they are also found at the upper limits of the Devonian limestone. The contact-deposits always occur in connection with veins, fissures, faults, or breaks, in the stratification;



Bouesnel, in same, 1826, vol. XII. p. 243; Rueloux, in Annales d. travaux publiques d. Belgique, 1849, vol. VII. and 1851, vol X; Omalius d'Halloy, in Bullet. géolo. 1841; Burat, Etudes sur les gites calaminifères en Belgique, 1846.

a. Cretaceous Marl and Diluvium.
b. Carboniferous shales.
c. Slate containing galena.
d. Calamine.
e. Clay and Limonite.
f. Mountain limestone.

and appear to have penetrated from these between the original strata, extending over unequal areas. At a depth where still unaltered, they consist of blende, galena, and iron pyrites; while near their outcrop they generally contain calamine, smithsonite, galena, cerusite, limonite, clay, and sand. The accompanying two wood-cuts show two sections in the St. Paul mine at Welkenradt.

The pockets are only found in limestone and doiomite, but as well in those of the Subcarboniferous, as of the Devonian formation. They occur in connection with the veins, or the contact-deposits. They sometimes occur in rows parallel to the stratification, and contain principally calamine, galena, and cerusite.

The beds are confined to particular strata, which they accompany for a great distance. For example, a clay-slate layer of the Carboniferous formation contains a bed of blende and galena for a length of 1300 fathoms; and a layer of magnesian limestone, 5—6 feet thick, in the Devonian shales, contains near Philippeville in Belgium, considerable galena and blende, disseminated in it for an extent of two miles. These are evidently not true beds, but bedlike impregnations; and indeed all these deposits may be termed impregnations, in the broadest sense of the word, *i. e.* as infiltrations in previously existing rocks.

The adjoining zinc-deposits in Belgium are all of a similar character to these, on which account I pass them over.

COPPER, LEAD, SILVER, NICKEL, AND COBALT-LODES.

§ 116. The Rhenish Devonian district is traversed in numerous places by veins, whose principal gang is quartz, with which various kinds of ores are combined. These ores are either copper ores alone; or copper ores, with blende, and somewhat of argentiferous galena; or argentiferous galena, with blende, and small quantities of copper ores; or a modification of the preceding combinations, in which nickel and cobalt ores also occur. All these various kinds of lodes are so intimately connected by intermediate steps, that they cannot be divided into separate formations. Stifft indeed divided the veins in the Devonian of Nassau into two classes:

1. Copper ores with iron pyrites, little galena, blende, and spathic iron: these poor lodes are stated to traverse the slates at an acute angle.

2. Argentiferous lead ores with copper ores, blende, somewhat of smaltine, iron pyrites, and spathic iron: these are mostly parallel to the strata.

But since they both contain quartz, as predominating veinstone, it appears to me impossible to separate them definitely from one another.

I will describe a few cases of these widely extended formations, which do not appear to follow any general direction of strike.

HOLZAPPEL GROUP.[1]

§ 117. The group of lodes, extending from Holzappel on the Lahn to Welmich and Werlau on the Rhine, traverses the strata of clay-slate and Devonian schist: it is distinguished by its length, and the richness of several of the lodes forming it.

The strata of the intersected Devonian formation strike as a rule ENE.—WSW. and dip 30°—70° towards SE., exceptionally also towards NW. caused by saddles and basins. Their cleavage frequently varies from their stratification, and even at times forms right angles with it. Talcose clay-slates occur, combined with the common Devonian strata. It would seem as if the formation of this talcose slate had some particular connection with that of the ore-deposits, as it occurs pretty constantly near the lodes. A second kind of deposit, which traverses the Devonian clay-slate in various directions, is composed of quartz beds and veins: which last mostly intersect the strata at right angles, and are always intersected by the lodes. Basalt dikes are only found outside of the group of lodes.

These Devonian clay-slate strata contain, partly in beds, partly in lodes, iron ores, argentiferous lead, copper, and zinc ores.

The iron ores either form regular beds between the strata, or surface-deposits in the Diluvium; or else take part, as spa-

[1] See: Bauer, in Karsten's Arch. 1840, vol. XV. p. 137; Schneider, in Leonhard's Taschenb. 1813, p. 326, and Jahrb. 1836, p. 520; and in Nöggerath's Rheinland-Westphalen, vol. III. p. 216

thic iron, in the composition of the silver, lead, copper, and zinc veins.

The lodes at Holzappel form the most eastern portion of the whole group, and consist of three leaders, which probably unite at a greater depth into one lode. Their strike and dip, like those of all the lodes of this group, almost coincide with the strike and dip of the strata of the country-rock. They are consequently almost bedded veins; and many observers have supposed them to be true beds.

Two fissures have faulted these lodes, dividing them into three portions, in the most easterly of which but one of the three leaders is known, it being perhaps the niveau at which all three have united.

The matrix is principally composed of quartz and hornstone with argentiferous galena and blende. Accompanying these, as originally formed minerals, are tetrahedrite, copper pyrites, spathic iron, heavy spar, calc. spar, and dolomite. These partly alternate in ribbons with one another, partly and predominantly are combined in an irregular granular texture. Clay-slate is also occasionally found in the matrix. Iron pyrites occur only near clefts, and appear to belong more to these than to the lodes. Numerous products of decomposition, and alteration, are found in the upper workings: cerusite, pyromorphite, anglesite, and cerasine, have been formed from galena. The blende is represented by smithsonite and goslarite, the tetrahedrite and copper pyrites by azurite and malachite, the spathic iron by limonite and ochreous iron.

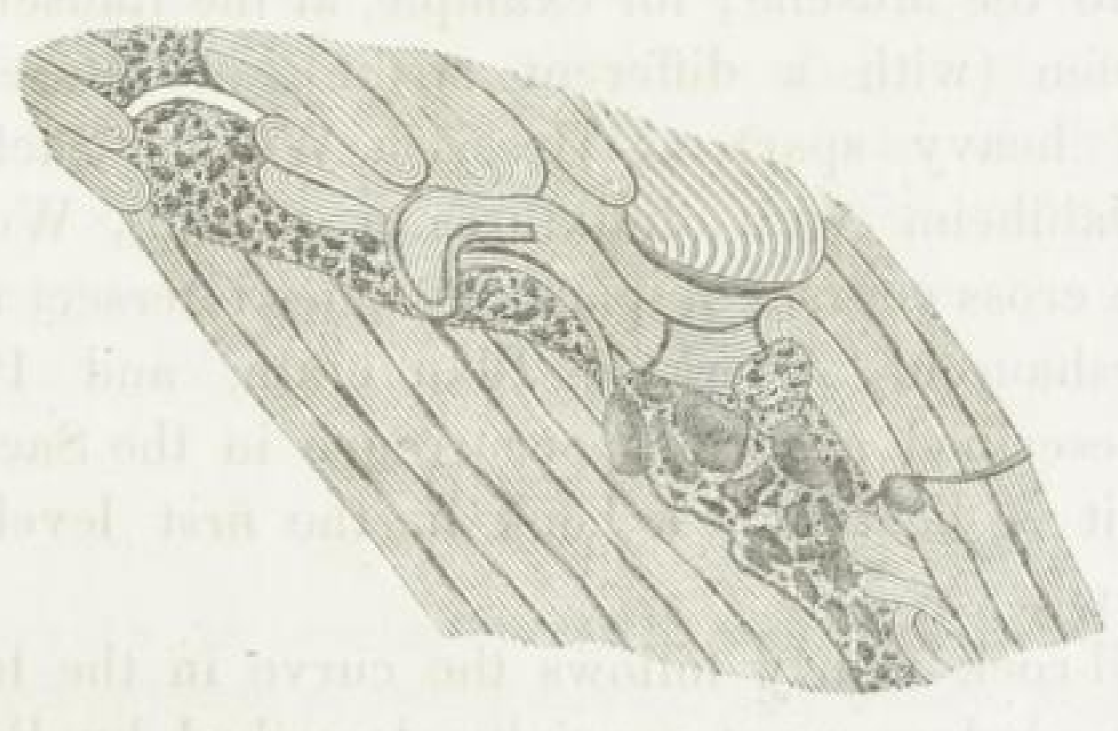
The matrix of the lode is separated from the country-rock by selvages, and at times by friction-surfaces. These friction-surfaces are generally grooved parallel to the dip of the ore-zones, hereafter mentioned, and the so-called banks. The matrix contains no geodes, but is frequently traversed by cross fissures, which do not extend into the wall-rock, and are covered by drusy crystallized layers, commonly corresponding to the crystallized minerals on which they lie: thus, the quartz is covered by quartz crystals, the galena by crystals of galena, etc.

The distribution of the ores in the lodes is by no means regular, it being easy to distinguish rich from poor or barren zones. These zones slope obliquely to the plane of the lodes at an angle of 14°—20°, they are tolerably parallel, both to one another, and to the line, which the stratification of the country-rock forms with the plane of the lode. Since the grooves of the friction-surfaces follow the same gentle inclination, the dislocation of the fissures must have been sidewards rather, than in an up and down direction.

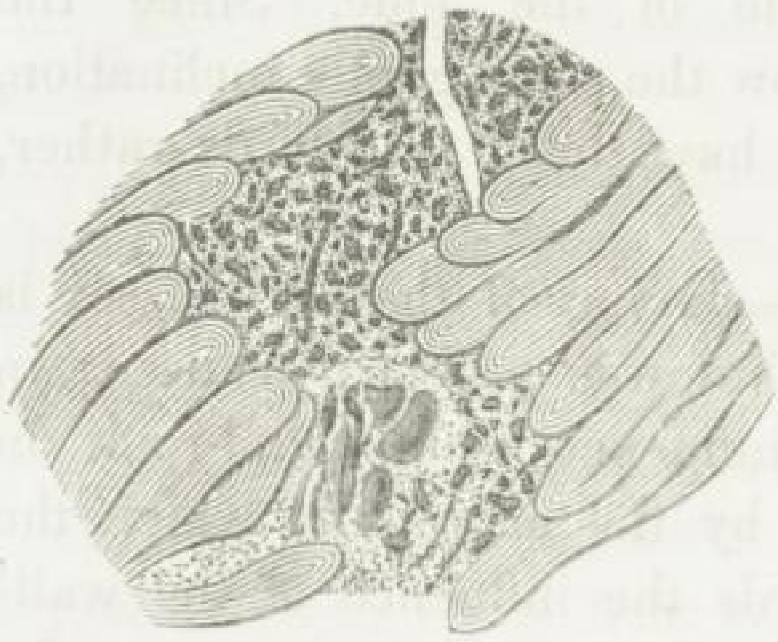
The appearance of the oblique sloping of the ore-masses is apparently not merely accidental, but was probably caused; in the first place, by the undeniable influence of the wall-rock on the deposits of ores, and secondly, by the manner in which the lode intersects the strata. As regards the influence of the wall-rock, it is true, it cannot be shown, between which strata the lode is always rich, and in which it is constantly barren. But the Holzappel miner's proverb: 'the noble (soft, crumbling) wall-rock makes an ignoble vein', deserves attention. It is, indeed, certain, that with such a wall-rock the vein is mostly narrow and much split, it only continues, as barren strings of quartz, frequently alternating with plates of slate; that in firmer rock-strata, on the contrary, it regains its former breadth and ores. This can be partially explained from the lesser capacity of a soft rock to retain a fissure within it open; but there is probably also some other reason, why the matrix contains more ores in some strata than in others, since the lode appears sometimes less rich in a hard, rough rock.

The walls of the fissures are by no means every where even and parallel to each other, they show numerous bends and disturbances, which are in part called by the miners 'banks'. These are, as it were, dams or folds of the lode which gently incline, being parallel to the stratification and plane of the lode.

Bauer has admirably delineated some of these, the two wood-cuts are copied from his drawings.



Holzappel lode in the Sophien adit, averaging 25 inches broad, in the bank, in part but 14 inches.



Holzappel lode in the Herminen level, 15—25 inches broad.

In these two cases, as in other similar ones, the fine concentrical structure of the cylindrical projections in the wall-rock are very striking. The fissures intersecting and faulting the lode are generally filled with clay, but occasionally contain spheroidal-shaped masses of ore, identical with those in the vein. The country-rock has been frequently impregnated, from these fissures, with copper and iron pyrites.

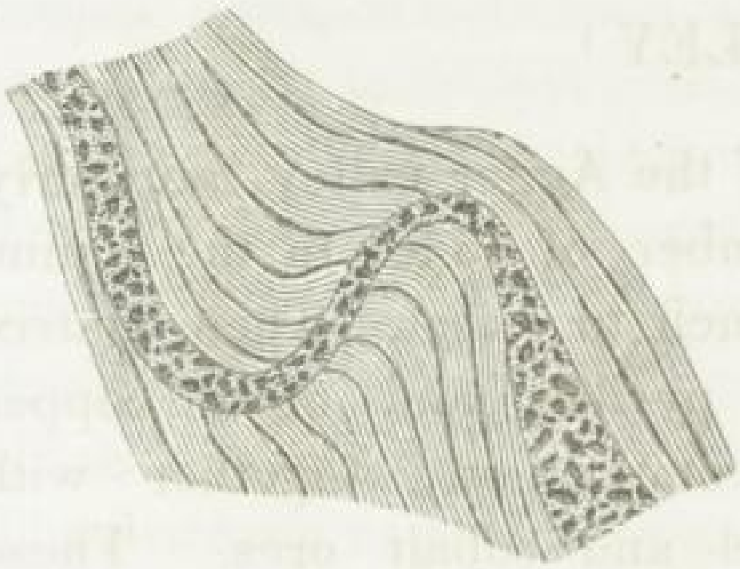
The veins of Oberhof are entirely similar to that of Holzappel, and form the western prolongation of the same; but they have a fourth leader, which contains essentially only quartz and copper pyrites.

At a distance of about 300 fathoms from and in the foot-wall of the Oberhof lodes occur the, now abandoned, Weinach lodes, containing quartz and copper pyrites. In the foot-wall of these are found the Silbach lodes, five in number. They strike ENE.—WSW. and dip 40°—45° towards SE., nearly coinciding with those of the Devonian strata. The breadth of these lodes is 7—10 inches, their gang is quartz combined with a talcose mass. The ores are galena, blende, copper pyrites, tetrahedrite, and spathic iron: in the upper workings the same secondary minerals occur, as at Holzappel.

Similar lodes, with but slight modifications, are known to extend, in large numbers, from here to the opposite side of the Rhine, and to the Moselle; for example, at the Rauschenthal mill near Sieghofen (with a different strike), at Marienfels (with veinstone of heavy spar) at Hessisch Weyer, Sachsenhausen, Ehrenthal, Dahlheim (with admixtures of stibnite), Werlau on the Rhine (where cross courses of quartz at times intersect the vein), at Niederguntershausen, Alterkülz, Blankerath, and Peterswalde. Bauer has described a curious occurrence in the Sachsenhausen lode, where it is bent like a hook in the first level, as shown in the wood-cut.

The wall-rock nearly follows the curve in the lode.

All these lodes, more specially described by Bauer, show such a similarity, that there can be no doubt, as to their rela-



tion to, and connection with each other. They lie, for the greater part, in the western prolongation of the strike of the Holzappel lode. The total length of this group, from Holzappel to Peterswalde, is 36 miles; and in the whole extent there are but few intervals, where no lodes occur. All the separate lodes of the group exhibit a great conformity in their outer and inner deportment. They are generally accompanied by a white talcose rock; but whether it exerts any influence on the ore in the lodes, has not yet been discovered.

RHEINBREITENBACH.[1]

§ 118. On the Firne Mountain at Rheinbreitenbach, a broad lode traverses the Devonian strata, tolerably parallel to the stratification or cleavage, so that it has, on this account, sometimes been regarded as a bed. The same contains quartz and hornstone as the chief veinstones; the ores originally formed in the lode are a mixture of copper glance, and erubescite, with a little copper pyrites, homichlin, iron pyrites, galena, blende, and spathic iron. In the upper portions of the lode, and to a considerable depth below the outcrop, a number of minerals have been formed by the decomposition of the preceding; viz. native copper, red copper, ehlite, melaconite, azurite, malachite, chrysocolla, libethenite, sulphat of copper, cerusite, and limonite. The mass of the lode, in the undecomposed portion, is solid, without crystals, or geodes. The lode frequently comes in contact with a basaltic dike, which is altogether decomposed near the lode, resembling a greenish gray lode, in the clefts of which are found thin dendritic leaves of native copper. From this it would appear that the dike is older than the lode; or, at least, its decomposition has continued after the formation of the latter.

[1] See: Nöggerath, in Leonhard's Jahrb. 1846, p. 457; Stifft, Geogn. Beschr. d. Herzogth. Nassau, p. 460; Sandberger, Uebers. d. geolo. Verh. d. Herzogth. Nassau, 1847, p. 124; Odernheimer, das Berg- u. Hüttenwesen im Herzogthum Nassau, 1863.

AGGER VALLEY.[1]

§ 119. In the neighborhood of the Agger valley, northerly of Siegburg, I observed a large number of lodes in the Lenne slates, whose breadth varies from 1 inch to 7 feet. Their matrix is principally quartz, with copper pyrites, and other copper ores (partly the products of decomposition), together with blende, and galena, or even nickel and cobalt ores. These ores occur, partly associated, in part singly. The direction and distribution of the veins cannot be referred back to any law. The Walpot mine has been worked, at intervals, for centuries, on one of the most important of them. Quartz with copper pyrites, somewhat of pyrites, and very little blende and galena, occur mingled with one another in an irregular granular texture; frequently forming a sort of breccia with fragments of the wall-rock.

Rivière mentions over 100 blende and galena lodes, as occurring in the same neighborhood, on the right bank of the Rhine, between Coblentz and Düsseldorf, which have a common strike from ENE. to WSW. He takes this opportunity of expressing the opinion; as it appears to me not confirmed by facts; that the mass, direction, and period, at which the fissures were filled by the matrix, all stand in the most intimate mutual connection; that the Rhenish blende-lodes were formed before the mountain limestone, and that their partial erosion afforded the material for the calamine deposits combined with the latter. He thinks, that the copper lodes, on the contrary, are of more recent formation, on which the products caused by their partial destruction are found only in later strata than those of the mountain-limestone.

DILLENBURG.[2]

§ 120. The Devonian formation in the Principality of Dillenburg, containing *schalstein*, is also traversed by numerous

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[1] See: Rivière, in Bullet de la soc. géol. de France, 1848—49, vol. VI. p 171.

[2] See: Stifft, Geogn. Beschr. d Herzogt. Nassau, p. 486; Sandberger, Uebers. d. geolo. Verh. d. Herzogth. Nassau, p. 125; Klipstein, in Gemeinnützige Blätter zur Beförderung d. Bergbau u. Hüttenwesens, 1849, vol. I.

copper lodes, which bend so much, as to vary in their strike from N.—S. to WNW.—ESE. They have a considerable dip, frequently send out droppers, possess a breadth of 1 inch to 6 feet, but at times are entirely compressed. Their vein-stones are quartz, calc. spar, brown spar, heavy spar, and clay; while the ores found are: copper pyrites (predominating), copper glance, red copper, tile ore, malachite, azurite, and chrysocolla. The pockets of ore have an oblique dip. Stifft found the dissimilar influence of the different kinds of wall-rock to be very striking. In greenstone the principal vein-stone is quartz; the ores are rich, but few; and clay selvages are wanting. In the *schalstein*, calc. spar (brown spar and heavy spar) forms the chief gang, and serves as a support for the quartz; which succession is reversed in the greenstone. The ores are more frequent, but not of so rich a character; and contain considerable iron pyrites, which is almost entirely wanting in the greenstone. The lodes are accompanied by clay selvages. The most favorable rock for ores is the ferruginous variety of *schalstein*. Considerable impregnations of copper pyrites occur in the *schalstein*, alongside of the lodes; while the rock is here traversed only by copper and iron lodes, and veins of heavy spar free of ores. In the common Devonian strata but little ore occurs in the lodes, and the predominating quartz is intimately combined with the wall-rock.

Von Klipstein has also described the lodes around Dillenburg, in which quicksilver ores occasionally occur. He states that the tetrahedrite lodes of the Aurora, Isabella, and other mines, stand in most intimate connection with the greenstones, which appear to be the ore-carriers. A group extends from Rossbach to Roth, which contains tetrahedrite holding mercury and silver. Cinnobar also occurs in a copper pyrites lode of the Neuermuth mine at Nanzenbach, while traces of the same are found in the hematite occurring in the *schalstein* of the neighborhood.

Twenty five lodes have, up to the present time, been discovered at Donsbach near Dillenburg, which contain, in a gang of quartz and calc. spar; copper pyrites, erubescite, copper

pp. 19, 44, 58, 87; and 1859, vol. II; for other deposits, see also, von Dechen, in Leonhard's Jahrb. 1856, p. 81; and, Cauchy, in Bullet. de la soc. géolo. de France, vol. III. p. 321.

glance, covelline, azurite, malachite, tile ore, and somewhat of iron pyrites. They vary from 3 inches to 5 fathoms in breadth, strike NNE.—SSW., dip 60°—80° in SE., but seldom the reverse; and traverse clay-slate, *schalstein*, and hematite beds. The calcareous hematites evidently exert the most favorable influence, somewhat less favorable the ferruginous *schalsteins*, and the siliceous iron-stones; while the common *schalsteins*, and clay-slates, are in this connection much less favorable.

The Devonian strata in the neighborhood of Dillenburg[1] are traversed by greenstones and pyritous dikes of serpentine. About 20 veins, resembling one another, have been opened by the Hilfe-Gottes mine at Nanzenbach, having different directions of strike; one of these contains nickel ores in sufficient quantities to be exploited. While all the fissures contain a matrix of calc. spar, and a mineral resembling calc. spar, this one vein contains an ore-matrix 5 inches broad, consisting of copper pyrites, nicolliferous iron pyrites, a mineral substance resembling chrysotile. The amout of nickel is 3 per-cent, that of copper 12—15 per-cent. Arsenic and cobalt have not been found in the preceding minerals, but occur at the junction of the lode with one of the non-metalliferous veins. The junction contains copper nickel, chloanthite, smaltine, and cobaltine; similar minerals recur at the junction with another vein.

The ores appear to be confined to that portion of the lode, which traverses a glauconitic rock resembling greenstone, while they are wanting in the common sandy micaceous slate. This favorable influence appears to be confined to this single lode, since the other veins also traverse such rocks without containing any ores.

ANTIMONY ORE-DEPOSITS.

§ 121. The Rhenish Devonian contains in several localities, deposits of antimony ores, which occur independently of all other ore-deposits. I will here describe two cases.

1. Between Wintrop[2] and Uentrop, a few miles from

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[1] See: Von Klipstein, Gemeinn. Blätter z. Beförd. d. Bergb. u. Hüttenw. 1849, vol. I. pp. 18, 104; Koch, in Cotta's Gangstudien, vol. III. p. 246; Sandberger, Uebers. d. geol. Verh. d. Herzogth. Nassau, p. 126.

[2] See: Buff, in Karsten's Arch. 1827, vol. VI. p. 54, and 1833, 2nd. series, vol. VI. p. 439; Arndts, in the same, 1824, vol. VIII. p. 272.

Arnsberg, strata of tabular limestone, $^1/_2$—$1^1/_2$ feet thick, alternate with clay-slate, alum shale, and siliceous slate. They are overlaid by the millstone grit of the Carboniferous formation, and belong to the Subcarboniferous formation. These strata are, some of them, penetrated by stibnite, as well the bituminous limestone, as some of the slate layers. The penetration, 2—6 inches thick, occupies chiefly the middle of the strata, and disappears towards the hanging- and foot-walls, as decreasing dissemination. The rocks are less compact, and of a darker color, so far as the penetration reaches. The massive portions of ore, in the middle of the strata, enclose at times small fragments of rock, and the ores penetrate into cracks in the strata. Antimony ochre is found near the surface, as a product of decomposition. The rock also occasionally contains somewhat of iron pyrites, blende, calc. spar, and fluor spar. The Caspari mine had in 1827 opened up 7 of the metalliferous strata; in 1833 already 11. Near these, but without any apparent connection with them, occur veins of heavy spar, containing copper pyrites, and bismuth ores; while near Meschede there is a vein containing heavy spar, and calc. spar, with galena, copper pyrites, and tetrahedrite.

I am not able to decide, from Buff's description, which I have borrowed, whether this occurrence of antimony ores should be termed a bed or veins. In the one case, it would be only a bedlike impregnation; in the other bedded veins; which latter view indeed is favored by the fragments of wall-rock surrounded by ores, and the occurrence in limestone and slate.

2. The Hoffnung[1] antimony mine occurs near Brück on the Ahr, in the Circle of Adenau. The Devonian slates strike nearly N.—S. and dip 45° in W. The antimony ores form a zone in these 80—120 feet broad, coursing N.—S. which had been opened up, as being metalliferous, for a length of 560 feet, in 1827. This zone is only distinguished, besides its containing ores, from the common Devonian slate, by being somewhat more fissured.

The ores, consisting of stibnite, with somewhat of iron pyrites, quartz and brown spar; are found partly in true veins, partly as impregnations between the planes of stratification, or the fine cleavage-fissures.

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[1] See: Erbreich, in Karsten's Arch. 1827, vol. VI. p. 44.

The lodes, 6 inches broad, form among themselves a parallel group, striking ENE.—WSW. and dip 40°—50° in South.

The impregnation-fissures contain only quartz with the ore, but no iron pyrites.

Erbreich says of the occurrence; that veins occur so near each other (at distances of 1—7 feet), that the formation of the fissures at the same time lifted the strata so, that a portion of the matrix of the lodes penetrated between the layers.

LEAD ORE DEPOSIT NEAR COMMERN.[1]

§ 122. The remarkable lead ore deposit of the Bleiberg (Lead Mountain), near Commern in the Prussian Rhenish Province, belongs to the Variegated Sandstone formation, which there immediately overlies the Devonian. The strata of the former have a gentle dip towards N.; the lowest, immediately over the Devonian, consists of a coarse conglomerate of completely rounded Devonian boulders, with a gray quartzose binding medium. Over this follows a fine, metalliferous sandstone, white or yellowish, loosely united, and having pretty thick strata. These sandstones often contain some irregular layers of conglomerate, which soon wedge-out.

The sandstones contain ores, for a distance of about 2 miles, but are less rich towards their outer limits; the same commence near the surface, and extend with the strata to a depth as yet unknown; it is stated, that the metalliferous strata are at times more than 45 fathoms thick. The sandstone is filled, throughout its whole mass, with grains of galena, varying in size from a pinhead to that of an apple, the coarser grains being the most rare, which are distributed with most surprizing regularity. Larger grains are extremely rare: more commonly they decrease in size, so as to be barely visible. The interior of these grains nearly always contains fine sand, cemented together by the galena. From which it appears to me clear, that the grains are not found in secondary deposits, which, like a kind

[1] See: Von Carnall, in Zeitschr. d. deutsch. geol. Gesellsch. 1853, p. 242; Dartiques, in Journal des mines, 1807, vol. XXII. p. 341; Breithaupt, in Berg- u. hüttenm. Zeit. 1856, p. 7; C. Haber, in Berggeist. 1866, No. 66; and 1867, Nos. 19, 20, and 22.

of alluvial deposit, have been only accidentally washed together with the sand; but that the ore was either formed contemporaneously with the sandstone, or penetrated it subsequently by a process of impregnation. From the form of the occurrence, it would appear to be an impregnation. The grains are here and there changed into cerusite; and Dartiques states, that they frequently also contain somewhat of blende, or are colored green or blue by small amounts of copper. The percentage of silver they contain, is $^1/_{23000}$ to $^1/_{3200}$.

Ore also occurs, though in smaller quantities, in the layers of conglomerate, within the sandstone, as small threads of pure galena, without admixtures of sand, evidently deposited in small cracks, or cavities; consequently, of secondary origin.

The friction-surfaces of the sandstone are curious, the more so, since the rock is so friable, and since the dislocations, which have taken place, can only have been for very short distances.

C. Haber has very recently described this lead ore deposit. He explains its formation by impregnations, which have penetrated from numerous fissures traversing the sandstone. These fissures appear to be connected with true veins of galena, occurring in the Devonian strata beneath the sandstone.

GOLD-DEPOSITS.

§. 123. The oldest account of the occurrence of gold, on the Eisenberg (Iron Mountain) near Corbach,[1] is to be found in Agricola: he speaks of gold veins. Brückmann states, that gold was obtained from veins only so recently as 1560; but that Charlemagne opened the first gold-mine near Frankenberg. Von Eschwege has lately attempted to wash-out the gold in the river alluvium of the Edder. He obtained the gold in scales, without finding any particles of rock, to which the same was attached; proving the existence of gold, but that it was in such small quantities, as to render its extraction unprofitable.

Dieffenbach was the first, who satisfactorily proved the

[1] See: Nöggerath, in Karsten's Arch. vol. VII. p. 149; Dreves, in Leonhard's Jahrb. 1841, p. 553; Gutberlet, in same, 1854, p. 15; and 1857, pp. 513, and 672; v. Dechen, in same, 1856, p. 81; Dieffenbach, in same, 1854, p. 324.

original occurrence of the gold; while Gutberlet has attempted to give a very singular explanation. As Dieffenbach's description is very interesting, at least scientifically, I extract from it the following abridgment.

The Eisenberg near Goldhausen is formed of siliceous and clay-slates. The first is thinly stratified, much folded, fissured, and dislocated. Earthy or stalagmitic copper ores occur in its fissures, especially malachite, azurite, chrysocolla, and earthy red copper (tile ore). The siliceous slate is much decomposed around these ores, is soft, and impregnated with carbonate of lime; the clefts are often covered with incrustations of calc. spar, dolomite, or spathic iron; which are at times crystallized. The brown fragments of the siliceous slate, which are in many places covered with earthy copper ores, almost have the appearance of a cellular limestone, and effervesce in acid, although a kernel of siliceous slate remains. Such fragments are the richest in the percentage of metal. In other places the siliceous slate forms quartz or hornstone-like ferruginous masses, of a reddish, yellowish, or even grayish color; which are traversed by quartz veins. Thin clay strata of a ferruginous red or brown color occur, here and there, between the strata of siliceous slate. In other places large cavities in the slate are filled with melaconite, which can be obtained in large quantities. The siliceous slate has a very cellular appearance, especially near the deposits of melaconite; from which it is probable, that the latter, as well as the copper salts, and the peroxide of iron, were formed by the decomposition of iron and copper pyrites. The gold occurs partly in the clefts of the quartzose siliceous slate in thin dendritic incrustations; or, (and this is the most common occurrence,) it encrusts the very small rhombohedrons of spathic iron, which are found on the limestone incrustations of the clefts; these consequently have the appearance of gold crystals. The gold is here evidently of more recent formation. Over these occasionally occur small rhombohedrons of calc. spar with rounded edges. The incrustation of gold is at times so thin, that the crystals have a dull brownish-red color. From attempts at amalgamating, it has been found, that the entire rock, especially the red clay, contains gold.

This gold-occurrence tends to show, that the copper ores are of secondary formation, during which process the gold was separated. Dieffenbach was unable to find any traces of veins in the siliceous slate, although greenstones occur at a distance of about two miles. As Dieffenbach was not permitted to make a more careful examination of the Eisenberg, he was unable to determine, whether the siliceous slate was at a former period covered by the copper slates, which are still found in place on the sides of the mountain, and whose metalliferous stratum surrounds the mines at Goddelsheim; and, whether similar relations exist, as at Stadtberg, where siliceous slates, fissured in a precisely similar manner, are still covered by the Zechstein formation. It is at least not improbable; and perhaps the large amount of lime in the siliceous slate comes from the rocks of the Zechstein. Here and there, perhaps, in the fissures of the slate, occur fragments of the more recent formation, which have, in cabinet specimens, a very striking resemblance to the metalliferous magnesian limestone.

The siliceous slates, of the Subcarboniferous formations, are frequently metalliferous at the localities mentioned, containing pyrolusite, iron- and copper-pyrites. Widely extended strata of the same are indeed nothing else than white or reddish rhodonite, which when exposed to the air turns as black as coal, since it becomes encrusted by a very thin layer of manganite. A portion of these strata is altered into manganite and pyrolusite, while a larger portion has been converted into psilomelane. In other cases the pyrolusite has been more purely concentrated in the planes of stratification, or it fills fissures obliquely traversing the siliceous, or even the clay-slate. But these rocks every where contain traces of iron and copper pyrites, so that it is in the highest degree probable, that the siliceous slates will prove to be the original locality, where the gold of this region was deposited.

In the sands of the Goldbach,[1] a branch of the Moselle, gold has only been found, which originated from quartzveins in the clay-slate of this region. The amount of gold is so small, as to render its exploitation unprofitable.

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[1] See: Nöggerath's Rheinland-Westphalen, vol. I. p. 141.

VI. THE PALATINATE.

QUICKSILVER-DEPOSITS.[1]

§ 124. Ores of mercury are found, in the eastern portion of the Saarbrück coal-basin, in lodes, and as impregnations; in the rocks of the Carboniferous formation, in porphyry, melaphyr, and amygdaloid.

Von Dechen has given such an excellent synopsis of his description of these deposits on the Potz Mountain, at Rathsweiler, Erzweiler, Baumholder, Wolfstein, Katzenbach, Obermoschel, Bingart, Kreuznach, Weinsheim, Münsterappel, Mörsfeld, Nack, Spitzenberg, and Kirchheim-Bolanden, that I shall confine myself to extracts from the same.

The quicksilver ores of this district occur in lodes, and as impregnations which have penetrated from these, in the strata of the Carboniferous formation, and such igneous rocks as traverse them. These lodes are found, at the Potz Mountain, in Carboniferous sandstone, and argillaceous shale; at Mörsfeld, in melaphyre-conglomerate, claystone-conglomerate, and claystone; at Rathsweiler, Erzweiler, and Baumholder, in melaphyre and amygdaloid, frequently much split up into leaders; on the Königsberg (Kings Mountain) near Wolfsberg, in quartz porphyry; on the Lemberg (Lem Mountain), as irregular branches, and fissures, in quartz porphyry. They are at times accompanied by claystones and hornstones of the carboniferous formation, not found in this region; thus, at Landsberg, Rosswald, Stahlberg, and Kellerberg. These horn- and clay-stones pass into common argillaceous shale, and sandstone. Since they only retain their peculiar character near the lodes, they may have been transformed by some peculiar process, which came from the veins; still fragments of the shale and sandstone are occasionally found in them.

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[1] See: v. Oeynhausen, in Nöggerath's Rheinland-Westphalen, vol. I. p. 256; Burkart, in same, vol. IV. p. 185; v. Dechen, in Karsten's Arch. 1848, vol. XXII. p. 375; Gümbel, die Quecksilbererze in dem Kohlengebirge der Pfalz.

No particular connection has yet been discovered between the veins and melaphyres, although they frequently come in contact.

The lodes traversing the claystones and hornstones are metalliferous, only where these form the country-rock, being destitute of ores in the shales and sandstones they penetrate. The lodes, which traverse the common rocks of the Carboniferous formation, contain ores only in sandstone and conglomerate, and are destitute of the same in the shales. The veins are accompanied by numerous branches, and leaders, which also contain ores, as well in the common rocks of the Carboniferous, as in the claystones and hornstones (Potz Mountain, Stahlberg, Landsberg).

When the sandstone (in part conglomerate), claystone, and hornstone, form the walls of the veins, they are impregnated for some distance; while the common argillaceous is not thus impregnated. A single exception to this last is at Münsterappel, where somewhat of cinnabar occurs on impressions of fish in the shales.

This impregnation occurs in both walls of the fissures, appearing to be controled by the rock-fissures, and cracks: it extends to a distance of several fathoms from the lodes. Sandstone-strata, impregnated with ores, have even been found, which have no apparent connection with any veins; thus, on the (Forstberg) Forest-Mountain near Münsterappel, and at Waldgrehweiler. Quicksilver ores have also been found, in the jointings of porphyries, without any apparent connection with true veins; thus on the Lem Mountain.

The quicksilver lodes of this district form groups, but not distinctly separable, several lodes occurring at times alongside of and behind one another, and having a common direction of strike.

The majority of the ores, both in the veins and country-rock, are only found to a moderate depth; they have not been followed to a greater depth than 120 fathoms, but the decrease with the depth is very perceptible. This decrease is at times combined with a more gentle dip of the lodes.

The gang of the veins is principally clay, in which the ores occur disseminated. By far the most frequent of these is cinnabar in small threads, branches, or geodes, more rarely in bands, or combs; also, native mercury, amalgam, and calomel.

Mercuriferous tetrahedrite is only found in the Schwarz lode on the Landsberg. Of other ores are found, although mostly rare; iron pyrites (in part argentiferous), limonite, compact hematite, specular iron, psilomelane, galena, native silver, tetrahedrite, copper pyrites, malachite, azurite, chrysocolla, stibnite, pyrolusite, spathic iron, calc. spar, heavy spar, quartz, hornstone, red and yellow ferruginous quartz, chalcedony, and asphaltum. These vein-stones generally form only threads, or crystalline incrustations of geodes and the sides of clefts. Gümbel observed the following successions:

1. Hornstone—heavy spar—iron pyrites—cinnabar—native mercury.
2. Hornstone—semi-opal—quartz—cinnabar—asphaltum.
3. Hornstone—fluor spar—calc. spar—quartz—iron pyrites.
4. Iron pyrites—cinnabar—heavy spar—quartz.

In the district, containing quicksilver lodes, but few others are found. Copper lodes occur northerly of Baumholder; near Berschweiler, Reichenbach, Frauenberg, and Hammerstein; containing copper pyrites, native copper, copper glance, and malachite. Similar ones occur, in melaphyre, on the Lem Mountain, and the Hedder Mountain near Niederhausen. The occurrence of tetrahedrite, copper pyrites, and galena, on the Landsberg, appears to stand in intimate connection with the quicksilver ores.

The general character of these quicksilver lodes, and the fact that the ores are almost only found at a moderate depth, distributed in the numerous fissures of the rock; would seem to prove, that most of the ores, especially those of mercury, have penetrated into the fissures by a process of sublimation; and that a tolerably extended district was subjected for a considerable period to these sublimations, in such a manner, that the same penetrated, wherever a possibility existed for their doing so, and were deposited at a certain level (by a certain temperature), having some choice as to the rocks which they selected.

VII. THE BLACK FOREST.

GEOLOGICAL FORMATION.

§ 125. The Black Forest rises somewhat steeply, above the plane of the Rhine valley, to a height of about 2000 feet (being 3000 above the sea, on the Feldberg 4600 feet). Towards the East it gradually descends to the plateau of the Swabian sedimentary formations. It consists principally of granite, and gneiss; which frequently alternate with, and at times pass into one another, so that a line can hardly be drawn between the two. For although the granite forms at times distinct and clearly defined dikes in the gneiss, exactly similar granite dikes occur in the granite itself. Both of these rocks are comparatively seldom traversed by quartz porphyries, and still more rarely by greenstones and serpentines. Daub states, that the quartz porphyries lie nearly parallel to two belts of lodes, which, commencing in the southerly mountainous region, cross each other near Baden-Baden, at least according to their directions.

A small region of clay-slate, probably belonging to the Silurian Age, comes into such intimate connection with the gneiss near Todtenau, that at their contact they often imperceptibly pass into each other. Only slight remains of the Carboniferous formation occur, in part with unconformable strata, in the Black Forest; thus, at Schramberg, and at Offenburg, where seams of anthracite are also found. The *Rothliegendes* (red beds) is only extensively developed in the northern portion of the district, in the neighborhood of Baden-Baden, where it lies in thick strata directly over the crystalline rocks, but has been partially again destroyed; it gradually disappears towards the South. In the southern portion the *Buntsandstein* (variegated sandstone) coming from the East, extends, with its thick strata, on to the granite heights of the Black Forest, and covers these, in the form of isolated caps, between the indentations of the valleys, having its strata slightly tilted towards East. On the western edge of the mountains, which descend steeply towards the Rhine Valley, whole successions of sedimentary rocks occur tilted on end; they belong to the Jurassic and Triassic periods.

Lodes containing silver, lead, copper, cobalt, nickel, and antimony ores in heavy spar, with somewhat of fluor spar, quartz, and carbonates of lime, are frequent; but the majority are very poor, only containing rich pockets, or streaks, at wide intervals; and hence cannot be worked with profit. Daub states, that the percentage of silver in the galena, which averages 4 oz. to the hundredweight, decreases, the more recent the age of the country-rock traversed; the veins themselves belong to the age of the Jurassic formation. These lodes are also said to owe their origin to the porphyries, which they always intersect, when they come in contact with them; but in these they are narrower, and poorer in ores, than in granite or gneiss. In spite of their supposed division into two belts, their directions of strike are very variable: of 100 lodes, 31 strike N.—S., 46 SE.—NW., 12 E.—W., and 11 SW.—NE. These lodes somewhat resemble the argentiferous barytic veins of the Erzgebirge, and to a great degree those of the Rhine district, containing only quartz and copper ores.

A second, less extensive, group are the limonite lodes, at times containing manganese ores, and frequently considerable heavy spar; I pass them over as unimportant.

Very important and interesting deposits of pea iron ore are found on the western, outer edge of the mountains, especially in the neighborhood of Kandern.

I must also take this opportunity of mentioning the smithsonite deposits of Wiesloch in Baden, and the gold alluvium of the Valley of the Rhine.

LODES OF THE KINZIG VALLEY.[1]

§ 126. The Kinzig Valley, with its ramifications, is mostly formed of granite, and gneiss; while Buntsandstein lies only on the mountain-tops. The granite and gneiss are but rarely traversed by porphyries, which last do not here have any direct connection with the lodes.

The granite and gneiss in this valley are traversed by numerous lodes; whose vein-stones are heavy spar, brown spar,

[1] See: Braun, in Annal. d. mines, 1843, vol. XVIII. p. 115; Marignac, in same, 1840, vol. XV. p. 153; Leonhard. Beiträge z. mineral. u geognost. Kenntniss d. Grossherzogth. Baden, 1854, III. p. 98; Sandberger, in Leonhard's Jahrb. f. Mineralog. 1865, p. 584; also Sandberger, Beiträge zur Statistik u. innere Verwaltung d. Grossherzogthums Baden, 1862.

calc. spar, and quartz; while the predominating ores alternately contain silver and lead, or else cobalt, nickel or copper. They occur in such a manner, that the various kinds of lodes cannot well be separated into distinct groups, and in fact form transitions one into another; while at times all the various kinds of ores occur in a single vein. Notwithstanding the large number of lodes, that have gradually been discovered, only a small number, and even these but locally, can be advantageously exploited. Mining has consequently never prospered in this region, although very rich ores have occasionally been found. It appears, that a sufficient quantity of ore was always wanting, even though of a poorer quality, to give a sufficient guarantee for the future. Rich ores, occurring at considerable intervals, can but seldom sustain vein-mining for any length of time. A few cases will farther illustrate the general remarks.

The Wenzel mine, in the Wolfbach district, gave large dividends for a long succession of years in the preceding century. The Wenzel lode, which descended in a zigzag form, contained, with a breadth of 6 inches to 2 feet; heavy spar, brown spar, calc. spar, and fluor spar with galena, copper pyrites, spathic iron, argentiferous tetrahedrite, ruby silver, dyscrasite, silver glance, and native silver. The dyscrasite occurred, in masses, by the hundredweight; and Selb saw, in 1787, a mass of native silver, weighing 75 pounds, and surrounded by silver glance, and ruby silver.

The Alter St. Joseph mine, in the Wittich district, was mined, in the commencement of the preceding century, for native silver, silver glance, and smaltine: the rare wittichite also occurred here.

The Sophie mine, in the same district, was one of the most celebrated in the whole Kinzig Valley, and also deserves especial notice from a geological point of view. The lode itself consisted of heavy spar (predominating), fluor spar and brown spar (spathic iron?) with smaltine, silver glance, ruby silver, native silver, and native bismuth, bismuthine (partly cupriferous), realgar, and copper nickel. By oxidation of these, there were formed near the surface; earthy cobalt, erythrine, annabergite, pharmacolith, and uranite. Most curious were the great and extended impregnations in the granite forming the wall-rock. Kapf has described an interesting case. About 35 fathoms below the surface a branch of heavy spar, but a few inches broad, containing native silver, was followed in the hanging-wall of the, otherwise barren, lode. After it had been followed for a few inches, the branch wedged-out, and the formerly white and very firm granite was found changed to a reddish-brown and less firm condition, in which threads of native silver could be seen. On this account the work was prosecuted in the reddish-brown granite in a neighboring hollow, and discovered, after digging for a few fathoms, a broad leader of silver, which continued so long as the granite retained this color and softness. In addition to this leader, the entire wedge of granite was so impregnated with silver, that it was removed and dressed. A hundredweight of dressed ore gave 10—13 pounds of silver. This is a very decided case of the influence of the country-rock; which here consists both in the favorable character of the matrix of the lodes, and in impregnations.

Other similar lodes are known in this district, in some of which copper ores occurred. Braun states, that these lodes also penetrate into the *Buntsandstein*, and mentions one belonging to the Gute-Gottes mine, which had granite as foot-wall, and *Buntsandstein* as the hanging-wall.

The Friedrich-Christian mine in the Schapbach district exploited until recently a lode, 1—14 feet broad, in dark, fine granular gneiss. The lode consists principally of fluor spar and heavy spar, the last at times forming pockets in the first, and occurring in a sandy condition. In this lode are found, in pockets or indistinctly combed; quartz, calc. spar, brown spar, galena, copper pyrites, and bismuthic silver (Schapbachite). Numerous decomposed fragments of the country-rock occur in the lode. At the Leopold, formerly Prosper, mine occur native silver, native copper, red copper, and copper glance, in quartz and heavy spar.

Many mines occur scattered, on similar lodes, in the Kinzig Valley. Daub, as before mentioned, states that similar lodes, only with a less percentage of ores, which decrease in proportion to the more recent formation of the rocks traversed, occur in the formations overlying the gneiss and granite; namely, clay-slate, Carboniferous sandstone, *Buntsandstein*, *Muschelkalk*; and even into the Jura, but in the last their only matrix is heavy spar.

LODES IN THE SOUTHERLY PORTION[1] OF THE BLACK FOREST.

§ 127. Granite and gneiss predominate here also, and are accompanied by rocks of the Silurian age, gradually passing into gneiss, which are traversed by lodes of the same character, as those in the Kinzig Valley. Remains of the *Buntsandstein* formation occur in the heights.

The neighborhood of Sulzburg appears to be especially rich in lodes. The Riester mine was exploited on a lode 1½ feet broad, containing argentiferous galena in heavy spar and quartz. At the Himmelslehre, tetrahedrite and blende were found in addition to the preceding. A cobalt mine furnished cobalt ores, galena, iron pyrites, and mispickel, together with heavy spar and hornstone. At the Amalia, quartz occurred with copper ores; at the Lambertsweg, galena and copper pyrites; in the Schweizergrund (clay-slate district), stibnite, blende, and spathic iron. The most interesting mine of all is the Haus Baden (and Carl) mine near Badenweiler; the lode here exploited, at times 2 fathoms broad, is a contact-vein between granite and *Buntsandstein*; but Selb states, it is separated from the granite by a porphyry mass, 7—8 fathoms thick, itself containing galena, heavy spar, and fluor spar. The gang of the lode is heavy spar (predominant), fluor spar, and quartz; which contain argentiferous galena, copper pyrites, and copper glance; these are frequently altered near the outcrop into cerusite, pyromorphite, mimetene, wulfenite, malachite, and azurite.

The lodes of the Münster Valley are very similar to those around Sulzburg. They traverse the gneiss, occurring here in four different varieties, as also the dikes of quartz porphyry occurring in it.

The Schindler lode strikes nearly N.—S. and dips 70°—90° East or West, being but seldom as slight as 50°. Its width encreases from 5 inches to, exceptionally, 5 feet. The predomi-

[1] See: Selb, in Leonhard's Taschenbuch, 1815, p. 320; Leonhard, Beiträge z. mineral. u. geogn. Kenntniss d. Grossh. Baden, 1854, III. p. 105; Daub, in same, 1853, I. p. 115, and II. p. 106, as extracts from Leonhard's Jahrb. 1851, and Karsten's Arch. 1846; Fournet, in same, II. p. 94 (on the formation of crystals in the geodes of Teufelsgrund lode).

nating vein-stones are heavy spar, and fluor spar; towards the selvages also quartz, calc. spar, and brown spar; the ores occurring are argentiferous galena (chiefly occurring with the fluor spar, less frequently with the heavy spar), blende, and pyrites. The arrangement of these minerals is but indistinctly symmetrical. At times numerous horses of gneiss occur. Geodes, frequently 15 feet long, occur mostly in the middle of the lode, while fissures traverse it in an oblique direction. The Teufelsgrund lode strikes WNW.—ESE., dips 80°—90°, but seldom only 45°, in NW. Its medium breadth is 15 inches, its extreme breadth 45 inches. Its matrix is the same, as that of the Schindler lode; but there occur additionally, arsenic, native silver, ruby silver, and cerusite. It also contains horses, and geodes, and is traversed obliquely by fissures. Other lodes in the neighborhood also contain copper ores.

Similar lodes recur in the Hofsgrund, on the Erzkasten, and in the neighborhood of Todtenau. At St. Blasien nickel-ores have been found in serpentine.

Daub has attempted to group the most of the lodes here mentioned into two zones; of which the one (the Schindler zone) has a length of 75 miles, extending from Wiesenthal near Hofen, through St. Ulrich, Prinzenbach, Baths of Sulzbach, to Neuweiler near Steinbach; while the second (the Bernhard zone) is quite as long, commencing at Görwil in the lower portion of the Alb Valley, and passing through St. Blasien, Hornberg, Hausach, and Petersthal, to Baden-Baden.

The southerly and higher portions of both these groups contain, according to Daub, ores and vein-stones, while the northerly and lower portions have on the contrary given rise to thermal springs. He also supposes the existence of a near relation between the quartz porphyries and the lodes of the Black Forest.

THE PISOLITHIC IRON DEPOSIT[1] AT KANDERN.

§ 128. Extensive deposits of pisolithic iron ore are found in the Jura formation around Kandern, Stockach, Möhringen, and Jestetten. Similar ones occur somewhat northerly in the *Muschelkalk* also, at Dietlingen, Stein, and Gondelsheim near Pforzheim, also in the Baier Valley near Schatthausen.

[1] See: Hug, in Leonhard's Beiträge z. mineral. u. geogn. Kenntniss d. Grossh. Baden, I. p. 19; Walchner, in same, p. 104 (from the 2nd edit. of

The most important, and longest worked of these is that of Kandern. The ore occurs here in a clayey sandy deposit, its thickness varies from one to one hundred feet; which mostly occurs over the coral rag of the Jura formation. This deposit, the so-called 'Ore-Mountain', crops partly out to the surface, is partly covered by Diluvial deposits (*Loess*), but is principally overlaid by a tertiary limestone conglomerate, the so-called '*Steingang*'. About forty mines are worked around Kandern, and thirty eight in the Kleingau; this district has been exploited for about 1000 years. Walchner describes the deposit of Mösskirch nearly as follows. It lies on the upper Jura limestone, resting against the base of a hill. The single layers of the deposit, from the top to the bottom, are the following:

1. Arable soil;
2. Sand, several inches thick;
3. Pisolithic ore, several inches thick, mixed with sand, boulders, and sharks' teeth;
4. Sand, 2 inches thick;
5. Chief ore-deposit, $3\frac{1}{2}$ feet thick, mixed with boulders, snail-shells, sharks' teeth, bones of tertiary animals, and fossils of the Jura formation;
6. Fissile sandstone, with somewhat of ore, and a little limestone, 4 inches thick;
7. Sand, 2 feet;
8. Fissile sandstone, tolerably firm, 4 inches;
9. Sand, a few inches;
10. Limestone conglomerate, with disseminated ores;
11. Pebbles, varying in size, from that of an apple to that of a man's head, mostly consisting of white upper Jura limestone, mingled with sand, flints, and hornstones.

The boulders, particles of ore, and animal remains, are firmly cemented together by the hydrated peroxide of iron. The boulders are principally quartz, accompanied by white mica Concretions of flints occur at times, similar to those so frequently found in the pisolithic iron deposits of the Jura; while angular or rounded fragments, of Molasse sandstone, and granite, are by no means rare. The fossils belong partly to the Jura, partly to the Molasse formation.

Hug, who has described these deposits very completely, is

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his Geology, p. 843), and in Leonhard's Jahrb. 1832, p. 433; Leonhard, in same, III. p. 118; Merian, in same, I. p. 96. He considers the iron deposit to belong to the Jura formation. (This may have belonged to such, but through partial erosion tertiary strata were formed.)

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unfortunately not always clear, owing perhaps to the complex condition of the matter.

The miners in this region distinguish two kinds of ore, so-called '*Reinerz*' (pure ore) and '*Bohnerz*' (pisolithic, or pea-ore). The *Reinerz* is a lamellar, compact, or fibrous ironstone; which occurs, either disseminated, or in nodular concretions. The nodules and globules occur, either scattered or together, in nests, beds, or segregations. These nodules but seldom attain a diameter of 2 feet, they have an earthy, yellow, or brownish-red incrustation. When broken open, they are found to be either composed of concentric layers, or radially fibrous, or compact, or even porous. Their interior is nearly always hollow, or filled with a kernel of clay and sand. The hollow interior contains incrustations of hematite, fibrous limonite, or crystallizations of calc. spar, brown spar or spathic iron. Even fossils of the upper strata of the Jura formation are occasionally found in these nodules of clay ironstone, viz. spines of the Cidaris family.

The *Bohnerz* also forms connected nests, or beds; but occurs also occasionally with the *Reinerz*. The single globules, or grains, varying in size from that of a pea to that of a walnut, are always formed of concentric layers, more or less firmly cemented together by ferruginous clay. Those found at Alting mostly have an olive-green color, while those from Augen are yellowish or reddish-brown.

Jasper occurs with both varieties of ore. It is always gray in the nests of *Reinerz*, gray or red with the *Bohnerz*. The jasper occurs in the most varied forms; globiferous, elliptical, wound in spirals, etc. varying from an inch to a foot in diameter. The surface of these nodules is always covered by a thin white or greenish crust. In the interior they generally possess variegated, gray, yellow, brown and red colors, arranged in concentric layers parallel to the outer surface. They often contain cavities, which are covered with crystals of calc. spar, gypsum, or quartz. They frequently also contain fossils of the Jura and, according to Hug, even Nummulites (?).

This deposit is one, whose separate members; *Reinerz* nodules, *Bohnerz*, and jasper; evidently belong to the Jurassic period, but were deposited in their present position during the Tertiary age, as shown by the bones, sharks' teeth, and boulders of Molasse sandstone, occurring with them. The nodules of ore, and jasper, cannot be boulders; as otherwise their inner structure would not coincide so strikingly with their outer rounded form. The problem is certainly a difficult one to solve.

SMITHSONITE DEPOSITS [1] AT WIESLOCH IN BADEN.

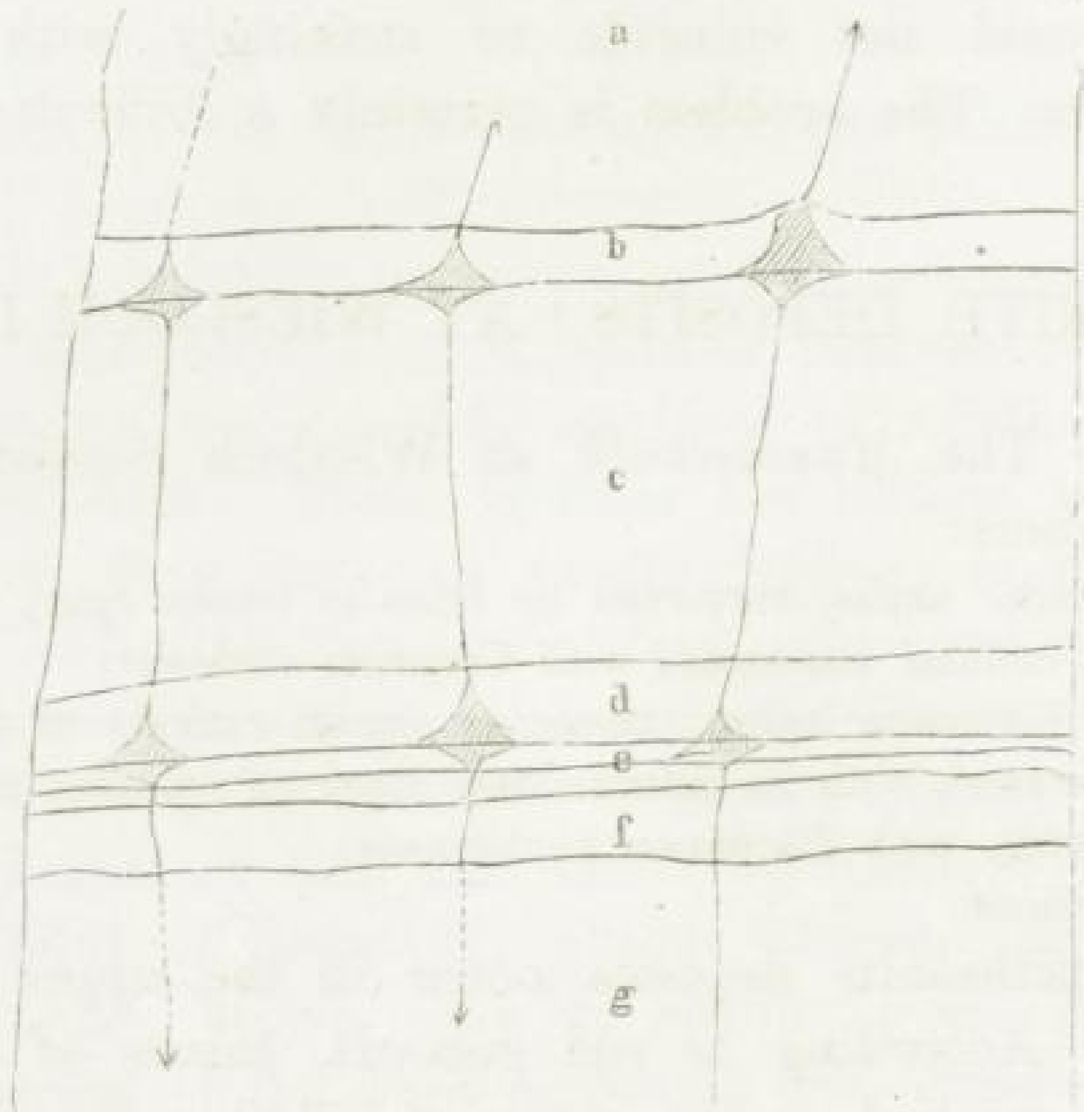
§ 129. The *Muschelkalk* at Wiesloch consists of the following members:

1. Dolomitic banks, traversed by veins of brown spar;
2. Gray cellular limestone, with *Ceratites nodosus*;
3. Two Encrinite layers, consisting almost entirely of stems of *Encrinus*, with an intermediate layer of compact limestone;
4. Dolomite, with *Buccinum turbilinum*;
5. Limestone.

The Smithsonite deposits occur in the upper members of this series. According to old records, mines of argentiferous galena were worked, in the range of hills between Nussloch and Wiesloch, as early as the 11th century, numerous remains of which still exist. The smithsonite, combined with the galena, was at that time partly won, but not being recognised as an ore, was used to fill up exhausted workings, and thrown away at the mouths of the shafts. Its existence has been but recently known, and has given rise to important mining operations. The ores are principally found in two layers, where the Encrinite layers join the compact limestone. They fill irregular enlargements of vertical fissures, which intersect the strata, as shown in the following ideal wood-cut.

The smithsonite is mostly gray, crystalline, and compact, colored red and brown by iron and manganese; no calamine occurs here. Hoffinger says: 'An impregnation by exchange of bases may have essentially contributed to the formation of these deposits; which is confirmed by the occurrence of numerous fossils converted into smithsonite, and pseudomorphs of the same for crystals of calc. spar. The compact fossiliferous limestone

[1] See: Leonhard's Beiträge z. mineralog. u. geognos. Kenntn. des Grossh. Baden, I. p. 70 (Holzmann,), p. 75 (Hoffinger), II. p. 111 (Rohatzsch), III. p. 122 (Leonhard); Holzmann, in Leonhard's Jahrb. 1852, p. 907; Carnall, in Zeitschr. d. deutsch. geol. Gesellsch. 1853, vol. V. p. 5; Walchner, in same, 1851, p. 359; Clauss, in Berg- u. hüttenm. Zeit. 1860, p. 495; and in 26th Jahresbericht d. Mannheimer Vereins f. Naturkunde, 1860 p. 36; also Ludwig, in his 'Journey through the Urals', 1862.



a. Grayish-blue limestone, 14 feet;
b. Encrinite bed, 3 feet;
c. Compact, dark blue, non-fossiliferous limestone, 12 to 25 feet;
d. Encrinite bed, 3 feet;
e. Compact limestone, 4 feet;
f. Blue, fissile limestone, 3 feet;
g. Hard, gray limestone, 30 feet, beneath which is dolomite, 34 feet, also containing traces of smithsonite in pockets.

The shaded portions represent the pockets of ore connected by vertical fissures.

has offered more resistance to this transformation, than the porous Encrinite limestone.'

The vertical fissures, but a few lines broad, are filled with ferruginous clay. Limonite and galena occur, irregularly combined with the smithsonite, as in Belgium, and Upper Silesia.

Similar deposits occur at Bruchsal, Durlach, and Grötzingen; in which places galena was also formerly exploited.

GOLD DEPOSITS [1] IN THE RHINE VALLEY.

§ 130. In all probability the ancient Gauls washed-out gold from the sands of the Rhine. In the Middle Ages a

[1] See: Daubrée, in Bullet. de la société géol. 1846, vol. III. p. 458, and in Compte rendu, vol. XXII. p. 639; Dufrenoy, in Compt. rend. 1849, p. 193; Leonhard, in his Beiträge z. miner. u. geogn. Kenntn. d. Grossh. Baden, III. p. 129.

very active gold-washing was carried on, between Mannheim and Bâle. At the present time about 400 persons are occasionally engaged in gold-washing in the Grand-duchy of Baden.

The gold is found in the masses of boulders and débris of the Rhine Valley, chiefly where the bed and banks of the stream consist of a mixture of boulders, pebbles, and sand. Grains of ilmenite, and rose-colored quartz, are the chief minerals accompanying it. The percentage of ilmenite in the sand is said to be about equal to that of the gold. The gold does not occur in nuggets, and grains, as elsewhere; but always in very fine rounded, massive scales, never exceeding a millimeter in diameter. The scales are larger, between Bâle and Breisach, than farther down the stream. The gold of the Rhine contains 93,4 per cent of gold and 6,6 per cent of silver. The entire bed of the river is auriferous, but the sand is, only in certain localities, rich enough to be washed with profit. Such are generally found, where the river has washed away the banks, or islands, and consequently subjected the sand to a repeated concentration. The sand washed-away is re-deposited, as a sandbank, at some distance, that portion richest in gold lying up stream. The richest sand generally occurs between larger boulders and at slight depths. The gold localities are worked, after every flood, and are found so much the richer, the more gradually the water has fallen.

The gold-washings commence below Bâle, near Istein and Altbreisach; but the richest localities are between Kehl and Dachslanden, especially opposite the village of Helmlingen. Some washings also occur below Philippsburg, but their productiveness is exceedingly small. The separate localities do not, according to Daubrée, extend over an area of more than 200 to 300 square metres, and are not more than 20 centimeters thick. The average percentage of gold in the sands of the Rhine, in Siberia, and in Chili, appear to be in the ratio of 1 : 20 : 74. In Siberia a sand cannot be profitably washed, containing less than 0,00001 gold, while on the Rhine a sand 7 times poorer than this is washed to advantage. One cubic meter of Rhine-sand contains about 0,0146 grammes of gold.

Rengger states, that the gold of the Rhine appears to come from the Aar, the Reuss, the great and little Emmen, and the Lutter. These rivers evidently obtain the same from the Molasse strata, and not from the original deposits. These last are probably to be looked for among the crystalline rocks of the Alps. In this way the Rhine-gold has been subjected to a repeated concentration; which, commencing with the period when the Molasse strata were deposited, has continued to the present time.

Dufrenoy has made the following comparison between the different gold alluvium deposits. According to which, are found, in the gold sands of

California.	South America	Urals.	Rhine.	
60	34	23	2	Magnetite;
16	15	50	3	Ilmenite, specular iron and [manganese;
9	20	3	?	Zircon;
14	25	14	90	Quartz;
1	1	—	—	Corundum;
—	—	10	—	Chrysoberyl;
0,3	5	0,00001	traces.	Gold (in part with quartz and iron pyrites).

VIII. THE SUABIAN AND FRANCONIAN JURA.

GEOLOGICAL FORMATION.

§ 131. I consider, as belonging to this district, the broad chain, which commences by Schaffhausen on the Rhine, and continues through Würtemberg, and Bavaria, to the neighborhood of Staffelstein. Its highest point is called the Suabian Alp: this gradually rises from the South to a height of 4000 feet above the sea, while its eastern and northern continuation, the Franconian Jura, forms a broad plateau, only about 1000 feet high, here and there intersected by river-valleys.

This chain is principally composed of members of the Jura group, overlying one another in regular succession. Igneous rocks (basalts and phonoliths) occur but to a very subordinate degree, and have no essential part either in its exterior or interior formation.

The members of the Jura group in this district, commencing with the upper strata, are the following:

Upper or White Jura.	1. White or light yellow, thinly stratified compact Jura limestone; that found in the County of Pappenheim is used as lithographic stone;
	2. Bluish clay, containing Pentacrinites;
	3. Limestone and dolomite, very thick, forming cliffs, and containing numerous cavities;
	4. Sponge bed;
	5. Oolithic limestone, with clay;
	6. Bluish clay, containing numerous corals, and Radiates;
	7. Impressa limestone of Quenstedt: alternating with clay, and containing numerous Terebratula, and Ammonites:
Brown Jura.	8. Ornaten Clay of Quenstedt: brown clay, and iron oolith, containing many Ammonites:
	9. Ostreen limestone of Quenstedt: marly limestone, and clay, with numerous oysters;
	10. Blue limestone;
	11. Yellow and brown sandstone, with iron ores;
	12. Opalinus clay of Quenstedt; containing many Ammonites:
Lias.	13. Jurensis marl of Quenstedt;
	14. Posidonia clay, dark bituminous marl-slate, full of Posidonias;
	15. Amaltheen clay of Quenstedt, with numerous Ammonites;
	16. Davoi limestone of Quenstedt; dark bituminous Lias limestone;
	17. Nummismalis marl of Quenstedt: with numerous Terebratels;
	18. Rarikestaten bank of Quenstedt;
	19. Stone banks of compact marl-stone;
	20. Turneri clay of Quenstedt: clay, and bituminous marl-slates;
	21. Astarten limestone of Quenstedt: dark bituminous limestone;
	22. Malmstein and Thalassiten sandstone of Quenstedt;
	23. Psilonotus bank of Quenstedt.

Below this commences the Keuper formation. The principal ore-deposits are those of iron, of which two in particular deserve mention. One consists of parallel beds of ironstone, found in the Brown Jura; the other of surface-deposits of oolithic limonite, which have often penetrated, for a considerable distance, into fissures and cavities of the White Jura. Iron-ore-deposits have also been found in lower divisions of the Jura (at Amberg and Ratisbon) on the eastern borders of the district.

THE IRON-DEPOSITS.

§ 132. The Brown Jura contains, in its whole extent in Southwestern Germany, parallel beds[1] of ironstone. These have been exploited for a long time at Aalen and Wasseralfingen, where they crop out at the northern base of the Suabian Alp. More recently the prolongations of these beds have been found extending, with but slight modifications, through the whole of Bavaria, at the northern, western, and even northeastern, limits of these strata; and have already begun to be worked. Their horizontal extent is therefore immense.

Their bedding in Würtemberg has been very accurately examined and described by Count v. Mandelsloh. It is the following:

	Thickness in feet.
1. Calcareous iron oolith	40
2. Gray, sandy limestone, with nodules of iron ore, and remains of Fucoids	35
3. Grayish-black bituminous slate	20
4. Bluish-gray limestone	8
5. Soft yellowish sandstone	4
6. Gray, sandy slate	3
7. Soft yellowish sandstone	10
8 Gray sandy slate	5
9. Granular clay ironstone	1
10. Gray sandy slate	7½
11. Clay ironstone (exploited at Wasseralfingen)	3½
12. Gray sandy slate	16
13. Soft yellow sandstone	7
14. Clay ironstone	1
15. Alternating strata of slate and sandstone, as between 4 and 9	31
16. Clay ironstone	2
17. Alternating strata of sandy slate with gray and reddish sandstone	52
18. Clay ironstone (exploited at Aalen)	6
19. Gray sandy slate	2
20. Grayish-black clayey sandstone	12
21. Lias-slate, alternating with layers of marl and limestone.	

[1] See: Count Mandelsloh, Sur la constitution géologique de l'Alpe de Würtemberg, 1834 (also, a German edition); Voith, in v. Moll's Neuen Jahrb. d. Berg- u. Hüttenkunde, 1824, vol. V. p. 1. He describes the continuation of these deposits in the Upper Palatinate.

The calcareous iron oolith (1) alternates with slaty marls, and is full of oolithic grains of limonite about the size of a millet. The bed 2 is similar, which contains larger globules; by whose destruction secondary oolithic deposits might be formed.

The ferruginous strata, at the same time, frequently contain numerous fossils changed into limonite. It is possible, that the material, forming the neighboring tertiary deposits, came from these.

The upper thick strata of limestone, or dolomite, of the Suabian Alp [1] contain, both in fissures, hollows, and funnel-shaped cavities, as also in slight depressions of the surface, a quantity of irregular deposits of oolithic iron ore. These are exploited not only in Suabia, but also in the County of Pappenheim and its neighborhood. The iron ore occurs in the fissures and cavities, partly alone, or only mixed with clay, partly with lignite, fragments of limestone, and all manner of such like additions; which all indicate that these deposits have been washed together by water.

IX. THE BOHEMIAN FOREST AND BOHEMIA.

GEOLOGICAL FORMATION.

§ 133. Under the above title I comprise the Bavarian and Bohemian Forest, the mountains between Bohemia and Moravia, and the portion of inner Bohemia which principally consists of old plutonic crystalline and Silurian rocks. That portion of Northern Bohemia adjoining the Riesengebirge will be described with it.

No where, in the whole of Germany, do the old crystalline massive and schistose rocks; granite, gneiss, and mica-schist; occur so extensively and continuously, as in this region. No

[1] See: Jäger, in Leonhard's Jahrb. 1853, p. 377.

where is, on this account, an exact, and at the same time synoptical, geological description more difficult, than here; since only the lithological condition of many rocks, passing into one another, can be used for their distinction and classification; where organic remains are entirely wanting, and the borders of the rock-masses are often very indistinct.

In a large basin-shaped depression of these crystalline rocks, whose principal axis (*i. e.* of the basin) extends from Prâg to Pilsen, occur very extensive Silurian formations, regularly stratified, and conforming to the depression. These are repeatedly broken through by greenstones, and are locally covered by strata of the Carboniferous group.

The number of ore-deposits occurring is very small, and their distribution a scattered one, in comparison with the great extent of this region, consisting almost entirely of ancient rocks, the more striking as contrasted with the neighboring Erzgebirge.

It is remarkable, that the lodes in Bohemia, occurring in several districts entirely separated from each other, have a N.—S. strike. This fact, in which I do not attempt to find any general law, does not well agree with Rivière's hypothesis, that the lodes in Europe, containing blende, have a predominant strike from ENE.—WSW.

I shall describe the principal ore-deposits occurring in this region as follows:

i. on the Bavarian side,
 1. Bodenmais;
 2. Erbendorf.

ii. in Bohemia,
 3. Schlackenwald, tin-deposits in granite and gneiss;
 4. Przibram, lead and silver lodes in Silurian rocks;
 5. Mies, lead-lodes in clay-slate;
 6. Horzowitz, ores of iron and mercury in clay-slate;
 7. Glashütte (Radnitz) iron-deposits in Silurian rocks;
 8. Adamsthal and Rudolstadt, silver-lodes in gneiss;
 9. Kuttenberg, silver-lodes in gneiss;
 10. Copper-lodes in *Rothliegendes* near Böhmischbrod.

BODENMAIS.

§ 134. The Bavarian Forest can, neither topographically, nor geologically, be separated from the Bohemian Forest; it only forms the southeastern portion of this last, belonging to the Kingdom of Bavaria.

The district is composed chiefly of granite, gneiss, and mica-schist; while granulite, hornblende rocks, diorite, serpentine, quartz rock, and granular limestone, or dolomite, occur to a more subordinate extent.

Of special geological interest in this district is a thick quartz bed, which can be followed from Bruck to Thierlstein, about 35 miles, as it overtops with its rocky pointed surface the adjoining, more destructible rocks. This rock, known under the name of Pfahl, which strikes NW.—SE. tolerably parallel to the low mountains, was long considered to be the outcrop of a broad lode. But it is stated, from recent investigations, to possess a bedlike nature.

Winneberger[1] has classified the granite of this region, as: gneissic granite, porphyritic granite, and more recent granite.

Considerable deposits of iron pyrites and pyrrhotine occur at Unterried, on the Silberberg near Bodenmais, and on the Red Koth near Zwiesel; the occurrences of ore at Klautzenbach, Lindberg, and on the Rachel, appear to be connected with these, since they lie nearly in one line of strike.

The Silberberg near Bodenmais consists principally of gneiss, which towards the South passes into granite. The ore-deposits, which Rust asserts to be true beds, have a most irregular strike and dip in gneiss. They generally strike, as this does, NW.—SE. and dip 35°—50° in NE. Two deposits are known. The lower of these is about 6 feet wide, and occasionally widens into a few larger hollows, which are upwards of 7 feet long and almost as broad. This deposit consists of iron pyrites; with which frequently occur pyrrhotine, and blende; more rarely magnetite, and somewhat of galena. Besides these, greenish feldspar generally accompanies the ore.

The second and principal bed occurs 60 feet northwesterly of the other: it varies from a few inches to 20 feet in breadth. It consists principally of pyrrhotine; associated with which are pyrites, blende, magnetite, and galena. The last contains 72 grammes silver to the kilogramme. These sulphurets are generally decomposed, and altered to limonite, at the outcroppings of both the beds.

[1] See: Winneberger, Beschreibung des bairischen Waldgebirges, 1851, pp. 62, and 97; Hausmann, in Göttinger gel. Nachrichten, 1853, p. 33, and in Leonhard's Jahrb. 1853, p. 285.

Hausmann; who considers, in common with Rust, that this is a bed in gneiss; while I am inclined to consider it to be an irregularly bedded vein; enumerates the following additional minerals as occurring; iolith, actinolith, garnet, and a pyroxene mineral. While Winneberger mentions the following minerals as occurring on the Silberberg; quartz, amethyst, chalcedony, fibrolith, red and brown garnet, iolith, heulandite, feldspar, kreittonite, serpentine, mica, pinite, talc, cyanite, actinolith, calc. spar, aragonite, gypsum, chrysocolla, copper pyrites, galena, magnetite, limonite, copperas, pyrrhotine, iron pyrites, vivianite, stilpnosiderite, spherosiderite, thraulith, blende, sordavalith, ficinite, and a sulphate of alumina.

From the descriptions it appears, that the ore-deposits of the Silberberg are very like the bedded veins occurring in the mica-schist around Schwarzenberg, already described in § 85; but that they contain less amphibole, and do not so much resemble greenstones.

Of a similar character, and in part probably continuations of these deposits, are several other ore-deposits in the neighborhood of Bodenmais and Zwiesel; which have for the most part long been abandoned, and are therefore less known. Thus at Maisried, where auriferous silver has been obtained, and at Lamm, where copper, silver, and alum were obtained, and in the rubbish at the mine-mouth, are found calc. spar, fluor spar, quartz, copper pyrites, galena, blende, chrysocolla, and ruby silver.

ERBENDORF.

§ 135. Erbendorf lies at the southwesterly base of the Bohemian Forest, where the crystalline schists of this last are overlaid by the Carboniferous and more recent formations. The lodes at Erbendorf occur in gneiss; they are five in number, of which but two are now exploited. They contain quartz, calc. spar, and heavy spar, with galena, blende, and copper pyrites.

Gümbel[1] states that a similar vein-formation, but containing hornstone and fluor spar, occurs at Schwarzenfeld, Weiding, and Altfalter. He also states, that the fluor spar veins

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[1] See: Gümbel, im Correspondenz-Blatt des zoolog. mineralogischen Vereins, at Ratisbon, 1854, p. 20.

of Welsenberg, which continue, in the form of hornstone-veins, through the Freuden Mountain to Hirschau, the fluor spar and heavy spar in the porphyry of Pingarten and Bodenwöhr, and that of Bach, known for its beautiful crystals of fluor spar, all belong to this formation.

SCHLACKENWALD NEAR CARLSBAD.

§ 136. The district around Schlackenwald[1] consists of gneiss, which is traversed by granite. Numerous dikes branch out, from the principal mass of the Hohenstein granite, into the gneiss, which have a peculiar composition. Jantsch distinguishes a fine granular, quartzose, stanniferous granite, containing but little mica, from the common variety. He says, that the tin ore occurs principally at the contact of the granite and gneiss, as can best be seen in the large Klinger Stockwerk-cavity, on the edge of the Hohenstein granite, and in the Kaspar-Pflugen mine.

He found the granite dikes in the gneiss, consisting of coarse granular quartz, and feldspar with steatite, fluor spar, apatite, wolfram, molybdenite, cassiterite, iron pyrites, copper pyrites, and mispickel. According to Sternberger, the tin-ore is principally found at the selvages of these veins; which consist of quartz, and are 2—12 inches broad. The same minerals, as occur in the veins, are also found in the fine granular stanniferous granite, only more finely and rarely distributed. A stanniferous greisen, consisting of a talcose micaceous quartz-rock, sometimes occurs alongside of the veins: Sternberger found the ores concentrated in pockets.

The regular lodes of tin ore, of which the best is worked at Schönfeld in the hanging-wall of the granite, strike ENE.—WSW. and dip in NW. They cut the strata of gneiss very distinctly, and are intersected and faulted by cross fissures, striking near N.—S., which contain traces of silver and cobalt ores.

Glückselig describes the following minerals, as having occurred in the tin-ore deposits of Schlackenwald:

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[1] Jantsch, in Zeitschr. des montanistischen Vereins im Erzgebirge, 1856, Nos. 7, 8, 9; Sternberger, in österreichischen Zeitschr. f. Berg- u. Hüttenwesen, 1857, p. 62; Glückselig, im amtlichen Bericht d. Versammlung deutscher Naturforscher u. Aerzte zu Wien: Vienna, 1858, p. 66.

1. Cassiterite, always in twin forms;
2. Quartz, at times as cap quartz;
3. Topaz, in greisen;
4. Physalite, quite common;
5. Beryl, rare;
6. Fluor spar, always crystallized in geodes;
7. Apatite, crystallized;
8. Phosphorite, reddish, not rare;
9. Gypsum, sitting on phosphorite;
10. Calc. spar, granular, rare;
11. Scheelite, in fine crystals;
12. Spathic iron, in rhombohedrons;
13. Orthoclase, rare in greisen;
14. Lithomarge, probably a product of decomposition of the orthoclase;
15. Carpholith;
16. Triplite;
17. Mica, several varieties, in part lepidolith;
18. Wolfram, common in small crystals, also tungstite;
19. Iron pyrites, rare;
20. Mispickel, common;
21. Scorodite, rare;
22. Blende, in fine large crystals near Schönfeld;
23. Molybdenite, common;
24. Bismuthine;
25. Emplectite;
26. Copper pyrites, very common;
27. Erubescite, rare;
28. Digenite;
29. Azurite, malachite, euchroite, olivenite, tile-ore and native copper, probably from the decomposition of the preceding minerals;
30. Lampadite, formerly found;
31. Pitchblende, found but once;
32. Chalcolith;
33. Smaltine,
34. Erythrine,
35. Millerite,
36. Silver and lead ores,

} rare, and probably found only in the cross-fissures.

PRZIBRAM.

§. 137. The neighborhood of Przibram[1] consists of Silurian strata, bounded by granite, and traversed by dikes of green-

[1] See: Vogelgesang, in Cotta's Gangstudien, vol. I. p. 305; Lilienbach, in Berg- u. hüttenm. Zeit. 1858, p. 184; Reuss, in Leonhard's Jahrb. 1860, pp. 578, and 712; Babaneck, in Sitzungsber. d. geolog. Reichsanst. 1864, p. 6; and in österreich. Zeitsch. f. Berg- u. Hüttenwesen, 1864, pp. 194, and 205; Faller, Uebersicht des Silber- u. Bleibergbaues bei Przibram, in Berg- u. hüttenm. Jahrb. d. k. k. Bergacademien, 1864, vol. XIII; Grimm, in same, 1865, vol. XV.

stone. The Silurian rocks consist of sandstone, quartzite, and slate. The last is separated from the two first by a clay-fissure, which is nearly parallel to the strike of the strata; it seems to have been caused by a large fault. The lodes were for a long time supposed to exist only in the sandstone and quartzite, where they are constantly accompanied by greenstone dikes, which are also cut off by the clay-fissure.

It was long supposed, that the clay-slates contain only traces of veins and ores; but Babaneck discovered in 1864, that the lodes continued in the slates, preserving the same mineral character, and were as rich in ores, as in the other rocks.

The lodes form, in common with the greenstones, a large belt, striking N.—S., which obliquely intersects the Silurian strata. The majority of the lodes dip in West, from which there are four exceptions.

In the Anna mine thirteen lodes have been found, in the Adalberti eight, and in the Dokolnow four; but some of these may really be but different portions of one vein. Their breadth is very changeable, varying between 1 inch and 14 feet; besides which the lodes are much bent in their course. Their matrix resembles much that of the *pyritous lead-formation* in Freiberg, but differs in containing no mispickel, in whose place are found considerable spathic iron and antimony ores. The vein-stones are principally; spathic iron, calc. spar (in the geodes in the middle of the vein), brown spar, quartz, and rarely heavy spar. The ores that occur are; iron pyrites, brown, and more rarely red, blende (containing up to 400 grammes of silver in a kilogramme), galena (containing 165 to 800 grammes of silver), tetrahedrite (partly very rich in silver), ruby silver, native silver, limonite, göthite, stibnite, and very rarely copper pyrites, stephanite, polybasite, and greenockite. The ores are much decomposed, from the surface to a depth of 60–70 fathoms; they have a gossan distinguished by the predominating limonite, with which are mixed much decomposed wall-rock, calc. spar, quartz, little galena, and more pyromorphite and cerusite. Pitchblende and vanadinite (?) occur as great rarities in the gossan. The amount of iron in the upper workings is at times so great, that they can be worked as iron veins; and it would appear, as if a larger percentage of iron, perhaps as spathic iron, had originally existed in the upper portions of the veins, than at greater depths.

The texture of the lodes is an irregular granular one; and they are firmly attached to the wall-rock; still the selvages are often characterized by threads of galena or blende. The Schefczin lode is the only one which shows a distinct symmetry of the layers; at the selvages occur spathic iron, and brown spar; next to these galena, copper pyrites, blende, and tetrahedrite; in the middle and generally crystallized in geodes, quartz, calc. spar, and heavy spar.

The ores are generally, at least in the sandstone and quartzite, quite equally distributed.

The relationship of the Przibram lodes to the greenstone dikes is very interesting. As a rule, they not only coincide in their extension and direction, but the lodes often occur for considerable distances as true contact-lodes between the greenstones and Silurian rocks. They are then frequently much narrower, being compressed by the greenstones, but they remain qualitatively the same. They also send leaders into the greenstones, or traverse these. A considerable influence, in the formation of the lodes, must be ascribed to the somewhat older greenstones; since they were the direct cause of the fissures, and have thus given the first impulse to the formation of the veins.

MIES.

§ 138. The district around Mies [1] is composed of Silurian clay-slate, which in a more southerly direction, near Kladrau, is limited, and even broken through, by granite. This clay-slate is traversed by numerous lead-veins striking N.—S., the number discovered already exceeds 60. A small number of the lodes strike NE.—SW. The most important of these, the Frischglückauf lode, averages a fathom in breadth, but splits into numerous branches, which at times again unite, and then attain a breadth, with the horses they enclose, of seven fathoms. These branches are generally the richest, and at times contain masses of compact galena 1—3 feet broad.

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[1] See: Hellmich, in oesterr. Zeitschr. f. Berg- u. Hüttenw. 1855, p. 267; Von Hauer and Fötterle, Uebersicht der Bergbaue, 1855, p. 23; Röcker, 'The ore-deposits of Mies', in Sitzungsbericht der geolog. Reichsanstalt, 1867, No. 7. p. 137.

The general matrix of the lodes is composed of quartz, fragments of slate, galena, a little blende, iron pyrites, and heavy spar. From the decomposition of these have been formed considerable quantities of cerusite and pyromorphite. Large geodes have been found in the lodes, at times exceeding three cubic fathoms in area. Their walls are incrustated with crystals of galena, over which occur crystals of quartz or crystalline cerusite; and in them are found fragments of galena encrusted with quartz. It is curious, that these lodes are often intersected, and split up, by so-called alum-slate beds, $^1/_2$ inch to 2 fathoms broad; which must themselves of course be the matrices of fissures. These, as well as the lodes, are also intersected by fissures 1—2 fathoms broad, containing fragments of rock, sand, clay, limestone, and calc. spar.

HORZOWITZ.

§ 139. The neighborhood of Horzowitz [1] (Hořowicz), northerly of Przibram and westerly of Beraun, belongs to the Silurian epoch. Oolithic hematite beds, 1—4 fathoms thick, and containing upwards of 50 per cent of iron, occur in the quartzose clay, and siliceous slates. The same are exploited in numerous localities, and several of them are remarkable for being traversed in various directions by numerous perpendicular fissures containing cinnabar. Rosenbaum states, that these fissures extend, only 14 to 35 feet beyond the beds, into the clay-slate. These fissures occasionally attain a breadth of one foot; their matrix is chiefly heavy spar, in which cinnabar occurs disseminated, and in dendritic forms, with iron pyrites. Only traces of cinnobar are found in the iron bed itself; massive iron pyrites is frequently its precursor.

MAGNETITE IN THE LORDSHIP OF RADNITZ.

§ 140. A perpendicular vein of magnetite, 30 feet broad, crops almost out to the surface, at the junction of the Silurian

[1] See: Nöggerath, Ausflug nach Böhmen, 1839, p. 384; Lipold, in Jahrb. d. geolog. Reichsanstalt, 1863, p. 147; Rosenbaum, Bergbaukunde, 1789, vol. II. p. 200.

and Azoic slates, northerly of the village of Glashütten [1] in the Lordship of Radnitz.

The magnetic iron-ore is enclosed, towards the surface, by limonite, and hematite, with layers of slate; and is generally so intimately combined with the clay-slate, that it might be called a clay-magnetite. It is a very remarkable fact, that this ore, near the surface, attracts and is polar; at a depth of 14 feet, it only repels; and at a depth of 30 feet, is no longer magnetic. From this it would appear, as if the magnetic force had first been excited by the influence of the atmosphere.

ADAMSTADT AND RUDOLSTADT [2] IN SOUTHERN BOHEMIA, NORTHEASTERLY OF BUDWEIS.

§ 141. Gneiss is the predominant rock in this region, which passes into mica-schist, hornblende-schist, and granulite; it is also traversed by granite dikes. A group of lodes traverses these rocks in the direction N.—S., the separate members of which are partly lodes, partly only quartz and clay veins or fissures. The principal lodes are the Lazar and Widersinnige.

The Lazar lode is 1—4 feet broad, strikes nearly N.—S. and dips 75° in West. Its matrix consists of a quartzose magnesian limestone; which is compact, in the most quartzose portions; and crystalline granular, where it contains less silica. This mass is frequently much decomposed, and penetrated, by a kaolin substance at the selvages, occasionally in the middle. This principal gang contains, in layers, or irregularly distributed, argentiferous blende, argentiferous galena, and iron pyrites. Blende and galena are intimately combined; the last frequently enclosing the first. Such combinations frequently occur as angular fragments in the matrix. Crystallizations also of galena, quartz, brown spar, and filiform native silver, are found in geodes. The veinstone next to the ores is the richest in silica, being often composed almost entirely of quartz.

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[1] See: Micksch, in Corresp. Blatt d. zool. mineral. Verein of Ratisbon, 1847, p. 39.

[2] See: Jokély, in Jahrb. d. geol. Reichsanstalt, 1854, p. 107, and in Leonhard's Jahrb. 1856, p. 717.

The Widersinnige lode averages three fathoms in breadth, strikes also nearly N.—S. and dips 45° in E. It traverses and faults the Lazar. Its matrix is chiefly quartz with fragments of the wall-rock (gneiss, and granite, often much decomposed). It thus varies from the matrix of the Lazar, and much resembles the Bräunsdorf lodes near Freiberg. In the veinstone occur argentiferous galena, argentiferous blende, and iron pyrites, the last partly altered to limonite.

The succession of minerals in both the lodes is:

1. The principal matrix,
2. blende and galena,
3. iron pyrites,
4. quartz in geodes,
5. brown spar in geodes.

The unequal influence of the country-rock on the distribution of the ores is here very perceptible. The lodes are the richest, where the gneiss contains only subordinate strata of mica-schist; while the same are much poorer, where the gneiss and mica-schist alternate regularly with one another, or where the latter predominates.

KUTTENBERG.

§ 142. The gneiss, which is the principal rock at Kuttenberg,[1] passes into garnetiferous granulite towards Petschkau. Diorite occurs to a subordinate degree, not being distinctly defined at its limits; in the neighborhood of which the gneiss is altered, its quartz being finely granular, its feld-spar more crystalline, and its mica darker colored. At the same time the diorite appears to pass over into a kind of aphanite. In addition to these a few serpentine veins, 5—7 fathoms broad, traverse the gneiss, which near these becomes chloritic. The gneiss itself occurs in two varieties; one of which is characterized by light gray quartz, yellowish, often compact feldspar, and white or light gray mica; which are uniformly mixed, or distributed in layers. The other, a very hard variety, has

[1] See: Grimm, in Kraus' Jahrb. f. den Berg- u. Hüttenmann, 1849, p. 58. Wysoky states, that the old mines at Kuttenberg have by no means the depth formerly ascribed to them. The deepest shaft only attained a depth of 346 fathoms.

dark crystalline quartz, dark feldspar, and brown chloritic mica passing into hornblende (?). Grimm calls this last 'dioritic gneiss'; it acts in the same manner towards the lodes, as the greenstone and serpentine.

The lodes, which traverse this region, form a network containing numerous rich points of intersection. Their veinstones are feldspar, quartz, and calc. spar, in which are found iron pyrites, copper pyrites, galena, and blende (all argentiferous), with silver ores proper.

These lodes contain ores, principally in the lighter variety of gneiss, and in granulite. They are very poor in the dioritic gneiss, greenstone, and serpentine; this unfavorable influence can be noticed to a distance of 20—30 feet from these rocks. Within the same the veins lose their distinct selvages, and the matrix is firmly joined to the wall-rock. The fissures become narrower, so that frequently but a small cleft remains. The combed texture of the lodes disappears; galena, and silver ores, no longer occur; and frequently only iron pyrites, and blende, are left; this deportment is very constant.

COPPER ORES IN THE *ROTHLIEGENDES* NEAR BOEHMISCHBROD.

§ 143. According to Reuss [1] the *Rothliegendes,* in the neighborhood of Böhmischbrod and Schwarzkosteletz, forms two subdivisions not distinctly divided from one another.

The upper, most extensive, and thickest, consists of reddish-brown, micaceous, distinctly stratified hardened clay, passing into argillaceous sandstone, alternating with greenish strata. The lower consists chiefly of coarse conglomerates, containing boulders of quartz, and gneissic granite.

Slight secretions of malachite were observed in 1851, in a reddish gray conglomeritic sandstone of the lower subdivision, at the mill of Chrast near Schwarzkosteletz. Trenches and workings, induced by this discovery, have shown, that these sandstones, with boulders of quartz, gneiss, and granite, are

[1] See: Reuss, in Jahrb. d. geol. Reichsanstalt, 1852, p. 96; in Sitzungsbericht d. Wiener Akademie d. Wissenschaften, XXV. p. 557; in Leonhard's Jahrb. 1859, p. 81; Berggeist, 1860, No. 88.

penetrated in irregular zones by copper ores. These consist of malachite, azurite (always as incrustation on the first), ferruginous and manganiferous melaconite, without any traces of pyrites. The sandstone is often entirely impregnated by these ores, they penetrate into all the fissures, even into those of the boulders, and locally form the cementing medium for the grains of quartz and feldspar composing the sandstone. In the intervals, between the zones, but traces of ores are found; while in the red clay, above the sandstone, they are entirely wanting.

Reuss has regarded the *Rothliegendes* of Böhmischbrod, Schwarzkosteletz, and other localities in Bohemia, to be an equivalent of the *Weissliegendes* of the *Zechstein* formation; since the remains of fish and plants are found in both (without any special statements as to which species), and copper ores occur. I can only remark, that at Hohenelbe (§ 145), where the *Rothliegendes* is developed in a similar manner to that of Böhmischbrod, the organic remains found entirely agree with those of the lower subdivision in other parts of Germany, and not with those of the *Zechstein* formation.

Especially the *Walchia pinnata*, which occurs here, is generally regarded as most characteristic for the lower *Rothliegendes*. It is self-evident, that the occurrence of copper-ore impregnations, consequently subsequent formations, cannot be regarded as proofs of the contemporaneous deposit of the strata. It is probable that the *Zechstein* formation is entirely wanting in Bohemia.

Numerous ore-deposits occur in Bohemia, in addition to those mentioned, but of far less importance and interest than those mentioned. I would refer those persons, desirous of fuller details and historical information concerning such deposits, to Count Sternberg's 'History of Bohemian Mining'; Von Lichtenfels, 'Essay towards a History of Bohemian and Moravian Mining'; Von Hauer's and Fötterle's 'Review of Mining in the Austrian Monarchy'; and to the 'Jahrbuch der geologischen Reichsanstalt'.

X. THE RIESENGEBIRGE.

GEOLOGICAL FORMATION.

§ 144. The central portion of the Riesengebirge (Giant-Mountains) consists of a large granite district surrounded by crystalline schists, which, towards the outer portions of these mountains, pass into clay-slates. The granite forms dikes in the schists, which are otherwise but little broken through by igneous rock, and perhaps as a consequence of this, contain but few lodes.

This predominantly crystalline district is outwardly surrounded by the Carboniferous and *Rothliegendes* formations; which last is northerly overlaid by *Zechstein*, *Buntsandstein*, and *Muschelkalk*; while to the South it is covered by *Quadersandstein*.

The Riesengebirge, whose highest peak, of mica-schist, attains a height of 4900 feet above the sea, is joined to the East by the Waldenburg-Glatz coal-basin; which is broken through by various porphyries and melaphyres, like the southerly *Rothliegendes*. Following this are the Sudeten Mountains, which, in the Altvater peak, attain a height of 4600 feet above the sea.

Crystalline rocks predominate in the higher portions of this last mountain-chain; namely, granite, gneiss, mica-schist, etc. Towards the East, their gentle slope consists almost entirely of Devonian strata, combined with somewhat of Mountain-limestone.

COPPER ORES IN THE *ROTHLIEGENDES* OF NORTHERN BOHEMIA,[1] AND IN THE CRYSTALLINE SCHISTS AT ROCHLITZ.

§ 145. The *Rothliegendes*, in the neighborhood of Hohenelbe and Starkenbach, where lying on the crystalline schists

[1] See: Porth, in Leonhard's Jahrb. 1857, p. 347; Herter, in same, 1858, p. 831; Zippe, in same, 1860, p. 612; Gurlt, in Berg- und hüttenm. Zeitung, 1859, p. 35; Polak, in Jahrb. d. geol. Reichsanstalt, 1858, p. 243; Herter and Porth, in same, 1859, p. 10.

(clay-slate and mica-schist) forming the base of the Riesengebirge, is tolerably steep. It consists, commencing at the top, of the following subdivisions:

1. Speckled sandstone with silicified plants;
2. Argillaceous sandstone with Calamites;
3. Bituminous shale (*Brandschiefer*) with numerous remains of plants and fish, in which is somewhat of copper ore;
4. Argillaceous shale and marl;
5. Argillaceous sandstone, like 2;
6. Red argillaceous shale with copper ores;
7. Sandstone, with copper ores, at Starkenbach;
8. Bituminous shale, with copper ores;
9. Sandstone;
10. Conglomerate with copper ores, lying on crystalline schists.

This succession is not always constant, at the various localities; and the copper ores only occur locally in the strata. Their peculiar distribution rendered it impossible to exploit them profitably. Nevertheless it is of geological interest, like that already mentioned in the interior of Bohemia.

It was found by trenching, that here, as in the *Rothliegendes* at Böhmischbrod, principally the sandstone, and also the conglomerate, the marl, and the bituminous slate, contained the ore in different localities between the Elbe and the Iser. The ores are essentially malachite, azurite, and chrysocolla; only slight traces of sulphurets are found near bituminous portions. Besides these, pockets of native copper, malachite, and copper glance, are frequent in the numerous melaphyres of this neighborhood.

According to Porth, the whole occurrence of these copper ores has the character of an infiltration, and appears to be dependent, with the single exception of the pockets in conglomerate and melaphyre, on the presence of organic substances. The sandstone No. 7, which is quite rich in the carbonised remains of plants, contains the largest quantity of ores. The most of these occur surrounding the threads of coal, and trunks of trees, whose bark is carbonised. The bituminous shales, and the marls immediately adjoining these, appear to be next richest in ores. All the other strata appear to contain merely traces of ores. The influence of organic remains was very distinctly seen in an old shaft near Starkenbach, which had caved in. Bones, probably of animals who fell into the shaft, were found beneath the rubbish entirely impregnated with malachite; while the rubbish itself contained no traces of ore.

Porth mentions the following facts, as favorable to a formation by infiltration:

1. The percentage of copper is always greater in the friable portions of the sandstone, than in the firm portions;

2. All cracks are filled with ores;

3. Traces of ore are never found in fresh cross-fractures of the shales, but only in the cleavage-fissures and fine cracks;

4. The percentage of ore is the greatest, in all these strata, at the outcrop; and diminishes with the depth; the impregnation must consequently have taken place from above;

5. The principal concentration of the ores around organic remains, in immediate contact with which copper-sulphurets have occasionally been formed.

O. Polak stated subsequently, that the coal and strata enclosing it; argillaceous shales, bituminous slates, etc. in the neighborhood of Radowenz, southeasterly of Trautenau, contain somewhat of malachite, azurite, tetrahedrite, and copper glance.

Porth states, that the original copper deposits must be looked for in the older rocks of the Riesengebirge. There are several localities in these mountains, where considerable copper-deposits exist. One of the most interesting is worked by the Ribnitz copper-mine. This mine exploits a siliceous argillaceous deposit, at times resembling hornstone, 3—4 fathoms broad, at the junction of the clay-slate and the conglomerate of the *Rothliegendes*. This deposit averages 3—5 per cent of copper. The copper is obtained, partly in the mass of the deposit as copper glance, partly as malachite and hydrous silicate filling all the fissures and cracks. This deposit occurs, as stated, at the junction of the *Rothliegendes*, but is still entirely in the clay-slate, and parallel to its cleavage.

Nests and disseminations of copper-ores occur in various places near the larger deposits. This occurrence of copper appears to be especially combined with an augitic rock (malacolith), which frequently occurs within segregations of crystalline limestone; for example, near Hüttenbach, and Ober-Rochlitz. At these localities, Gurlt states, that copper, zinc, lead and iron ores occur in banks of malacolith, which alternate with limestone.

Herter and Porth have described these curious deposits nearly as follows: 'The predominating rocks near Rochlitz are mica-schist, passing into quartz-schist containing beds of clay-slate and granular limestone. The granular limestone forms very irregular beds, having almost the appearance of segregations. In this occur, as still more subordinate layers, and also of a somewhat irregular and lenticular shape, metalliferous beds and pockets of malacolith. The, at times fibrous, malacolith forms alternate layers with talc-schist and limestone, which have the appearance of a lime-talc schist. Talc and feldspar occur implanted in the malacolith, the last also crystallized in calc. spar. Cyanite occurs as a rarity in the cracks of the malacolith.

The ores, which especially occur combined with the malacolith, are sulphurets of copper, lead, zinc, and iron. They are distributed, finely disseminated, over large areas, and form fine threads and fillings of fissures. The blende alone, occasionally forms more compact concretions. The whole occurrence resembles that of the Kongsberg Fallbands. At one locality, where the Hüttenbach flows into the Iser, a concentration of the ores was observed, and the following minerals found; copper glance, erubescite, tetrahedrite, copper pyrites, stibnite (rare), native silver (very rare), galena, blende, and iron pyrites. The majority of these ores contain silver, the blende up to 28 grammes, the galena 100 to 280 grammes, the copper-ores up to 1666 grammes, in 100 kilogrammes.'

At another locality, alongside of the road leading to Starkenbach, the metalliferous malacolith occurs in very thick beds at the limits of the limestone. From these beds extend, for a considerable distance, into the country-rock, ore-impregnations; which partly penetrate the mass of the rock, partly occur collected in fissures. The impregnating ores are mostly hydrous silicates, less frequently carbonates and oxides, very rarely sulphurets. According to Reuss, the deposits of malacolith are traversed by irregular quartz-veins, which contain considerable masses of erubescite, copper pyrites, malachite, tetrahedrite, etc. Reuss is of the opinion, that the ores in the malacolith come from such quartz veins.

Herter and Porth found altogether the following minerals in the Rochlitz ore-deposits; a hydrous silicate of copper, bol, allophane, neolith, malachite, azurite, melaconite, tile ore, a still undetermined antimony mineral, stibnite, tetrahedrite, cerusite, pyromorphite, minium, anglesite, calamine, native silver, galena, erubescite, copper pyrites, copper glance, earthy copper, quartz, calc-spar, and gypsum. Many of the copper minerals contain antimonic acid.

There is an unmistakable analogy between the ore-impregnations first described in Rothliegendes at the base of the Riesengebirge, also those at Böhmischbrod, and the copper-ore impregnations described by Murchison, in the grits of the lower Permian, at the western base of the Ural Mountains. Even the geological age of the impregnated rocks in these three localities, appears nearly coincident. But it would be rather bold, to attempt from this to infer any nearer connection between the deposits in Bohemia and Russia. We must consider, that these impregnations have occurred at places very far apart, only locally, and evidently long subsequent to the formation of the rocks. How much later, we do not know; but there is no positive ground for supposing, that the impregnations took place contemporaneously. Their contemporaneous occurrence could only be accidental, as it is an accident that they are found in parallel strata.

KUPFERBERG IN SILESIA.

§ 146. Websky states the following to be the succession of rocks, occurring around Kupferberg, [1] commencing with the lowest:

1. Granite, belonging to the principal mass of the Riesengebirge;
2. Dichroit gneiss, only at one locality (the Ochsenkopf), perhaps as contact-formation, between mica-schist and granite;
3. Lower diorite slate, frequently called hornblende schist; a mixture of hornblende and oligoclase, often with somewhat of mica, and fine particles of iron pyrites, pyrrhotine, and copper pyrites; also lenticular pockets of a mixture of quartz and oligoclase;
4. Lower Dolomite, embedded in the lower diorite slate;
5. Mica-schist, but little developed;
6. Quartz-schist, frequently containing feldspar, but little developed;
7. Upper diorite slate, exactly like 3;

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[1] See: Websky, in Zeitschr. d. deutsch. geol. Gesellsch. 1853, p. 373; Manès, in Annal. des mines, 1825, vol. XI. p. 19.

8. Green-slate, gradually passing into the upper diorite slate: this is a compact mixture of a mineral resembling asbestos, and feldspar; it is frequently accompanied by talc and fine plates of chlorite, having a silky lustre, and linear parallelism. It encloses pockets of dolomite, quartz, and oligoclase; and is traversed by numerous fissures filled with thin needles of tremolith, quartz, plates of mica, and specular iron, crystals of albite, pistacite, or dolomite: near Rohnau this slate contains a succession of talc-schist segregations, with lenticular masses of quartz, and nearly 15 per cent of iron pyrites, which are used for the manufacture of iron vitriol;

9. Clay-slate, merely a local modification of the green-slate;

10. Upper dolomite, and limestone, embedded in the green-slate; for example, on the Bleiberg.

These rocks are generally tilted on end, and stand nearly perpendicular alongside of each other. Websky even thinks, that the recurrence of similar rocks may have been caused by foldings, the upper portions of which have been removed by denudation. They are intersected by various kinds of igneous rocks: in the neighborhood of granite, by granite dikes; near Kupferberg, and at the foot of the Bleiberg, by dikes of quartz porphyry; the clay-slate, by a gray, much decomposed porphyry-dike northwardly of Buchwald, and by an uralite rock, which is very subordinate among the cliffs of the Röhrig Mountain.

The lodes of this district are found principally in the lower diorite slate near the dikes of porphyry; they are also found in the green-slate, mica-schist and clay-slate. The granite cuts them off. Their average breadth is 2—3 inches, but seldom 15 inches, and very exceptionally 7 feet. They can be classified, according to their matrices, into

1. copper lodes,
2. lead lodes, and
3. heavy spar veins

The copper lodes occur almost exclusively in the diorite slate, but can be divided into four groups according to their strike and matrix:

1. Lodes striking NW.—SE. and consequently parallel to that of the country-rock, but dipping in an opposite direction towards S. They are the oldest, being even older than the dikes of red porphyry, but more recent than those of granite: the ores occurring in the Schwarz Adler, Frohe Erwartung, Erwünschte Zukunft, and other lodes, are; copper pyrites, iron pyrites, pyrrhotine, mispickel, erubescite, tetrahedrite, and copper glance; with numerous minerals formed by the decomposition of these. Their gang consists of a frequently much decom-

posed chloritic or amphibolic rock, with friable quartz and specular iron.

The Einigkeit lode varies from this, its matrix possessing a fourfold character:

a. a compact mass of actinolith, tremolith, or hedenbergite, mixed with compact or crystallized prase or quartz, and a chloritic mineral, in which matrix occur; magnetite, pyrrhotine, iron pyrites, copper pyrites, and erubescite: it is possible, that a portion of this matrix was formed by alteration from lievrite, traces of which still occur;

b. a compact or granular mass, consisting of a dark colored mineral, in which fine particles of pyrites are disseminated;

c. a branch of yellow ferruginous quartz, with plates of specular iron;

d. Quartz firmly fastened to the wallrock, occurring only at junctions.

2. Lodes striking N.—S. They appear to contain but little ore, among others nickel and cobalt minerals: six are known to exist near Kupferberg, but have hardly been even examined; they traverse the slate, and before mentioned lodes, at a considerable angle.

3. Lodes striking NNW.—SSE. They occur scattered through the whole district; ten of them are known, the most characteristic of which is the Neue-Adler: its matrix, from the selvages towards the middle, is first a thin incrustation of drusy quartz, this is followed by massive copper pyrites with mispickel, then not rarely by a white or flesh-colored feldspar: the succession is closed by calc-spar, fluor spar, and brown spar. Consequently a symmetrical arrangement of the layers; and containing feldspar!

4. Lodes striking E.—W. They form the most developed group, especially between those of group 1. Sixteen of these are known, of which one appears at the same time to be the principal faulting fissure. Their principal vein-stone is quartz, with fragments of the country-rock. Calc-spar occurs but rarely in the geodes of quartz. Of the ores found, the older are; copper glance, erubescite, copper pyrites, and blende, occurring in pockets surrounded by quartz and hornstone; more recent are tetrahedrite, and copper pyrites in geodes.

The lead-lodes occur exclusively in the green-slates of the Bleiberg (Lead Mountain), and form a belt entirely apart from the copper-lodes: they are no longer worked; but from the remains of former mining it may be concluded, that they were nearly conformable to the strike and dip of the slates; also, that their vein-stone was quartz, in which occurred pockets of galena, and copper pyrites, with the minerals formed by their decomposition: the galena is argentiferous.

The veins of heavy spar, like those of Freiberg, are the most recent in this vein-district. They occur, as independent lodes, only in the Rudolstadt group, where they strike NW.—SE. parallel to the porphyry-dikes, traversing the diorite-slate. The heavy spar occurs sporadically in other veins, as the most recent formation. The most common matrix of these lodes is heavy spar, fluor spar, and quartz, with somewhat of galena and copper pyrites. On the other hand a variety of beautiful minerals were found combined with heavy spar (sporadical) in the Alt-Adler lode, at a depth of 125 fathoms; viz. calc-spar, native silver, copper pyrites, erubescite, silver glance, stromeyerite, argentiferous copper glance, tetrahedrite, polybasite, smaltine, proustite, chloanthite, copper nickel, harmotome, heulandite, and brown spar.

In addition to this abridgment of Websky's observations, some of his general remarks, on the lodes of the Kupferberg district, may be added:

'The copper-lodes often show slight changes in their direction of strike; and each such change appears to be connected with an apparent forking of the lodes: these forks are evidently the result of two somewhat varying directions of strike.

The lodes intersecting one another frequently produce faults, which appear to be sometimes also caused by sideward dislocations.

The ores are by no means equally distributed through the lodes, but are, as is common, locally concentrated in the veins.'

In regard to the distribution of the ores, the following were the apparent conclusions arrived at from observations:

1. In each separate group of lodes, the ore is principally concentrated in the central region.

2. The quartz-schist and mica-schist have always proved, as wall-rock, unfavorable to the deposit of ores.

3. The junctions of two groups of lodes have shown themselves, especially under the town of Kupferberg, where the copper groups Nos. 1 and 4 meet, to be generally rich points:

this however cannot be always recognised for the special junction of two lodes.

4. No certain results could be obtained, as to variations in richness at different depths, from the works now open.

5. The influences of air and water have considerably changed the original condition of the outcrop, and have given rise to numerous products of decomposition. The country-rock has been frequently much changed by the same causes. On the copper-lodes, there have been formed; tile ore, red copper, native copper, malachite, chrysocolla, covelline, azurite, phosphorochalcite, chalcophyllite, volborthite, wulfenite, etc.

EISENKOPPE NEAR ALTENBERG.

§ 147. On the Eisenkoppe[1] Mountain near Altenberg, northerly of Kupferberg, occurs a contact-lode. It is found between porphyry and clay-slate, strikes E.—W., dips towards N. and is 2—3 feet broad. The porphyry generally forms the foot-wall, and the clay-slate the hanging-wall of the same. But the lode sometimes leaves the line of contact, and is found entirely in the porphyry, or altogether in the clay-slate; it also sends leaders into these. From this it would appear, that the junction of the rocks was more easily fractured, than the rocks themselves.

The lode consists principally of quartz, in which are found iron pyrites, galena, somewhat of tetrahedrite, and stibnite. It generally possesses very distinct selvages, which sometimes disappear in the side of the porphyry.

VOIGTSDORF—QUERBACH.

§ 148. The mica-schist, which is embedded in gneiss on the northern slope of the Riesengebirge, surrounds, at Voigtsdorf near Warmbrunn, according to Manès,[2] a broad zone (or a bed) containing numerous veins of garnet, quartz, and calc. spar; and a very broad bed of tin and cobalt ores. This zone, 5—17 feet broad, which is in turn composed of several single layers, consists of quartz or mica-schist, containing iron pyrites, pyrrhotine, mispickel, specular iron, galena, blende, smaltine, and cassiterite. Cobalt and tin are the metals, which were obtained from these minerals. The cobalt-ore occurs in two

[1] See: Manès, in Annal. d. mines, 1825, vol. XI. p. 19.

[2] Manès, in Annal. des mines, 1825, vol. XI. p. 15.

ways: in part perceptibly crystallized on quartz, or impregnating this; in part imperceptible, mixed in extremely fine particles with the schist, garnet or pyrites.

The cassiterite is as a rule imperceptible, being mingled with the slate, or garnet, or even combined with the sulphuret of iron.

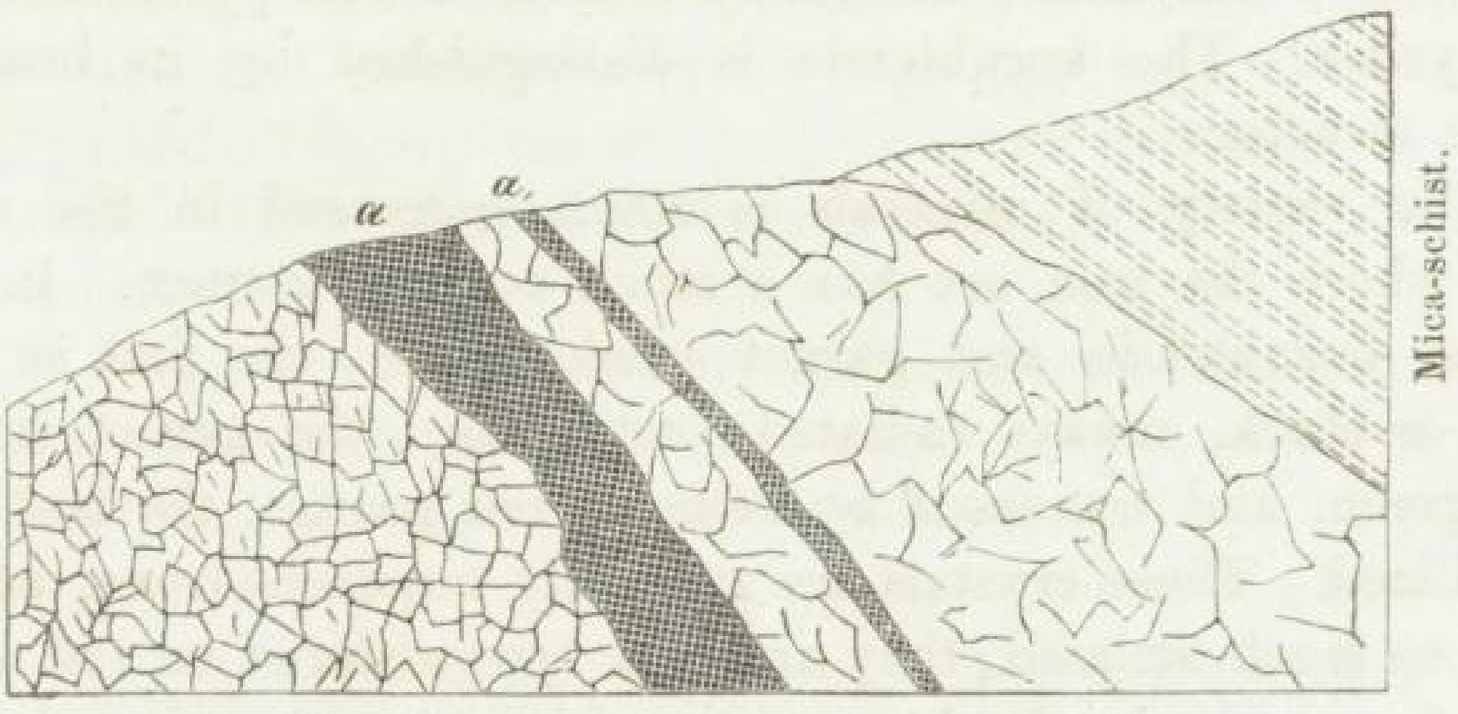
The distribution of the ores, with regard to their direction of strike, is a very unequal one. Near Giehren considerable tin, and but little cobalt was found; while at Querbach there was considerable cobalt, and but little tin.

Websky[1] states, that the principal ore was a cobaltiferous mispickel, with which were found epidote, and an automolith, resembling the Swedish variety.

IRON ORE DEPOSITS NEAR SCHMIEDEBERG.

§ 149. There occurs at Schmiedeberg[2] a small zone, between gneiss, passing into mica-schist, and granite; which is formed by the transitions of gneiss, mica-schist, and hornblende-schist; and contains numerous deposits of magnetite. These iron deposits were already worked in the 15th century, then long abandoned, and have recently again been taken up.

This metalliferous zone consists properly of rocks forming subordinate layers in the gneiss; these are hornblende-schist, garnet-rock, magnetic iron, granular limestone, quartz, serpentine, chlorite-schist, and mica-schist.



a. Greenstone, probably corresponding to the hornblende-schist of Wedding.

[1] Websky, in Zeitschr. d. deutsch. geol. Gesellsch. 1851, p. 12.
[2] See: Cordella, in Berg- und hüttenm. Zeit. 1858, p. 21; Wedding, in Zeitschr. d. deutsch. geol. Gesellschaft, 1859, p. 399.

Cordella states the bedding of the rocks to be, as shown in the preceding woodcut; which differs somewhat from the later, and here principally followed, description of Wedding.

Ten paying deposits of magnetite are known to exist, besides which there is a number of thin layers, or lenses.

The term bed is in general correct, for these magnetite deposits; since they are subordinate layers parallel to the outer rocks. But each of these beds consists of a number of larger and smaller lenses, at times 14 feet thick; which are indeed mostly joined, but frequently only by small threads of the ore. These changes occur principally, where the strata are much folded. The thickness of the beds is extremely variable. The magnetic iron occurs but seldom pure, being generally mixed with and contaminated by a number of other minerals, which at times nearly altogether supplant it. Wedding says: 'The four lower beds are distinguished by a richness in chlorite; the chlorite frequently penetrating through the entire mass of ore: it occurs in the seventh bed, principally in the floor, in considerable layers, chiefly where folds occur. This mineral also occurs, as a layer, in the garnet-rock. Innumerable crystals of iron pyrites occur in the chlorite of the seventh bed. While calc. spar is not very abundant in the lower beds, it frequently traverses the ore of the seventh bed, in veins, generally having epidote at its selvages; while garnet and tremolith occur disseminated through it. Where the ore ceases, fibrous hornblende occurs, as a substitute, intimately combined with pyrrhotine, and iron pyrites. The hornblende is distinguished by its beautiful radiate structure.

The variety of minerals is much encreased in the upper beds, where the iron ore has a much coarser texture. In one of these hornblende and garnet predominate; the first is dark green or black, always radiated (actinolith); the garnet is massive, green, and traversed by veins of red garnet, the last often crystallized. These crystals are generally trapezohedrons, having the faces much striated; they are of a brownish-red or red color, being frequently in the last case transparent.

Iron pyrites frequently occurs, massive, and in crystals. The epidote is mostly crystalline or crystallized, always having distinct cleavage-planes: its crystals are simple, and have much striated faces. The finest crystals of epidote occur in the veins of calc. spar, which repeatedly traverse the green garnet. Black mica is scarce, occurring in thin curved plates. One of the beds, which has been reached by a cross-cut, appears, in addition to similar ores, and a like quantity of garnet, to contain more hornblende than the bed just mentioned.

The upper bed contains coarse granular ore, which is at times somewhat foliaceous. Where the calc-spar veins occur, it is always more or less distinctly crystallized. The particles of iron ore have a very brilliant lustre at the selvages. Calc-spar is the principal mineral in this, and so completely supplants the ore at times, that the last frequently occurs, only as particles in the former, having a great tendency to crystallization. Iron pyrites is very common in cubes within the calc-spar, still more frequent is pyrrhotine. Chlorite occurs but rarely, in threads, or disseminated through the ore; it is more common in the calc-spar; which also contains red garnet, in veins, and as crystals. Green garnet forms veins at times in the massive ore. Actinolith is here much rarer than in the lower beds.

All the iron ores are very magnetic, but generally only possess simple magnetism. But few specimens are polar, even after being long exposed to the air. This may be explained by the numerous breaks caused by the distribution of foreign minerals. Smaller fragments, which are not polar, become so immediately, if brought, but for an instant, in contact with a magnet.'

All the rocks parallel to, and alternating with each other, are frequently traversed, and in part faulted, by fissures and dikes. The last consist partly of a granite very rich in orthoclase, partly of a very micaceous crystalline limestone containing serpentine. Their breadth is very variable. The granite veins have mostly a gentle dip.

The magnetite is frequently altered, near the surface, into hematite, and specular iron of a dark color; which were the principal minerals exploited in former times.

GABLAU[1] WESTERLY OF WALDENBURG.

§ 150. Lead and argentiferous lodes occur here in clay-slate, which has been broken through by quartz-porphyry in the neighboring Sattel Forest. Four of these have been recently

[1] See: Müller, in Berg- u. hüttenm. Zeit. 1856, p. 211.

examined, and work commenced on them. They are mostly double lodes; of which one portion consists of compact heavy spar with tetrahedrite, copper pyrites, brownish blende, and more rarely fluor spar, quartz, calc-spar, radiated marcasite, and polybasite (?). The other portion is characterised by granular quartz, with iron pyrites, galena, blende, and copper pyrites. They consequently resemble the Reinsberger-Glück lode near Freiberg.

The Fridolin lode strikes nearly N. - S. and dips 80° in E. The breadth of the double lode varies, between 1 inch and 7 feet. The two portions separate at times, and then form a quartz and a barytic lode. A junction with the Bernhard lode was found very rich in tetrahedrite.

The Bernhard lode strikes NW.—SE. and dips 70° in S. It also is a double lode, but generally only 2—8 inches broad. The barytic portion occasionally intersects the quartz portion, passing from the hanging- to the foot-wall, and the reverse. The quartz portion completely wedges-out at times, which circumstance is generally combined with an empoverishment of the barytic portion, for which it was a favorable wall-rock. The quartz portion also occasionally receives tetrahedrite by the union. The country-rock itself is frequently much impregnated with iron pyrites, and tetrahedrite. A soft and conglomerate-like nature of the same appears to have had locally a very favorable influence on the contents of the lode. Certain narrow clay-fissures, between the nearly horizontal strata, throw the lode, for distances of 4 to 22 inches. Where the Bernhard lode forms junctions with the Fridolin, it is split up into small threads containing calc-spar and tetrahedrite.

The Caroline lode was found richest in tetrahedrite near small intersecting veins of quartz and heavy spar.

ZUCKMANTEL.

§ 151. The Hackel[1] Mountain at Zuckmantel, northwesterly of Jägernhof, consists of mica-schist, passing into chlorite, and

[1] See: Oeynhausen, Geognost. Beschreibung v. Oberschlesien, 1822, p. 54; Höniger, in Jahrb. d. geolog. Reichsanst. 1856, vol. III. p. 91, and in Kraus' Jahrb. für d. Berg- u. Hüttenmann, 1849, p. 138; L. W. in same, 1852, p. 125; Glocker, in Poggendorf's Annalen, 1853, vol. 88, p. 297.

quartz-schists, with subordinate strata of limestone. The same attains a height of 2840 feet above the sea, and is covered with the rubbish from former mining operations. A large portion of the workings is open, and forms immense areas, in which sulphates frequently occur. The sides of the rocks, in the open quarries, are often covered to a thickness of half an inch with sulphates.

The deposit, which gave occasion to these mining workings, is a quartzose mica, or quartz-schist, impregnated with ores. The impregnated zone attains a breadth of 3—7 feet, strikes NW.—SE. and dips 60°—70° in NE. The disseminated ores are; auriferous pyrites (iron pyrites, marcasite, pyrrhotine, mispickel, copper pyrites), blende, auriferous and argentiferous galena; more rarely, hematite, and magnetite. Other minerals occurring with these ores are; hornblende, asbestos, actinolith, tremolith, feldspar, serpentine, epidote, garnet, calc-spar, brown spar, and somewhat of stilpnomelane. Other impregnated zones, of less breadth and extent, occur in the hanging- and foot-wall of the principal impregnation.

This deposit resembles in many respects that of Reichenstein (which is consequently omitted in the translation), but shows also considerable similarity to the Fallbands in the Scandinavian mica-schists; it is also very like the Schwarzenberg deposits in its mineral composition. Its contents do not appear to be sufficient for any extensive mining operations.

XI. THE ELEVATED PLATEAU OF UPPER SILESIA.

GEOLOGICAL FORMATION.

§ 152. This elevated, but almost level, plateau, bordering to the East on Russian Poland, is covered superficially by diluvial deposits. Under these occur the following formations, with generally but slight undulations:

1. Tertiary Strata;
2. Cretaceous Strata;
3. Jura Strata;
4. *Keuper*, with beds of clay-ironstone;
5. *Muschelkalk* (fossiliferous limestone), accompanied by deposits of zinc, lead, and iron, ores;
6. *Buntsandstein*;
7. Carboniferous formation, containing beds of spherosiderite.

Since these formations extend into Poland, in part containing similar ore-deposits, I will describe both together, without regard to political boundaries; the more so, as this portion of the Russian Empire contains otherwise no deposits worth mentioning. The large extent of country enclosed between the Carpathian Mountains, the Urals, and the Finnish Mountains, forms a remarkably sterile field for our observation; it is almost equally wanting in mountains, crystalline rocks, and ore-deposits.

The elevated plateau of Upper Silesia contains the following ore-deposits, worth noticing:

1. Ironstones in the Carboniferous formation;
2. Ironstones in the Keuper formation;
3. Smithsonite, galena, and iron-ore, deposits in the district of the *Muschelkalk*.

CLAY-IRONSTONE OF THE CARBONIFEROUS FORMATION.

§ 153. Beds of clay-ironstone (spherosiderite) are tolerably common in the Carboniferous[1] strata of Upper Silesia, and Poland; they occur principally in those localities, where numerous and thin coal seams alternate with argillaceous shales. This clay-ironstone appears to be confined to the upper strata of the Carboniferous, and near thin coal-seams. It is entirely wanting, where thick coal-beds occur. It is to be accepted, as a practical rule, that these ironstones generally occur in the foot-wall of thin seams, and in the hanging-wall of broad coal-beds. Still this rule has many exceptions.

The ironstones are either found singly, scattered as nodules and ellipsoids in the argillaceous shales; or they form regular beds, which are mostly composed of separate nodules or ellipsoids united in layers. They contain 30—35 per cent of iron, and melt easily.

[1] See: Von Oeynhausen, Geogn. Beschr. v. Oberschlesien, 1822, pp. 120, 150, and 164; Cotta, in Berg- u. hüttenm. Zeitung, 1860, p. 122.

Entirely similar spherosiderite beds recur in the adjacent portions of Poland. At Porąbka near Dombrowa I observed such a layer, 1—3 feet thick, in the hanging-wall of the principal coal-bed, 24 feet thick. The spherosiderite contains the distinct remains of plants belonging to the Carboniferous Age, and lies 19—20 feet below the surface, being covered by the following strata:

1. Soil, $1/2$ foot;
2. Red plastic clay, 3—4 feet;
3. Black carbonaceous clay, 3—4 feet;
4. Argillaceous shale, with impure seams of coal, 2 feet;
5. Gray marl, 10—12 feet;
6. Argillaceous shale, $1/2$ foot;
7. Spherosiderite, 1—3 feet;
8. Argillaceous shale.

CLAY-IRONSTONE[1] OF THE KEUPER FORMATION.

§ 154. The Keuper formation, whose strata were formerly supposed to belong to the Jura, occupies a considerable area in the northern portion of Silesia (northeasterly of Malapane), and in the adjoining portion of Poland. Its strata commencing with the upper ones are:

1. Limestone of Lublinitz;
2. Variegated clay;
3. Gray clay, and sand; in which occurs clay-ironstone, corresponding to the Keuper.

The clay, alternating with strata of sand or sandstone, contains the deposits of ironstone in a gray and unctuous variety, partly as scattered nodules, partly as coherent strata, or beds. A complete transition takes place between these two manners of occurrence. While on the one side, the ironstone-beds are traversed by clay, in such a manner separated, and altogether so intermissive, that they consist as it were of separate masses, having the most variable extent and thickness; so on the other hand, the largest nodules are combined into beds, which are united by a light gray ferruginous clay. This clay contains carbonate of iron.

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[1] See: Von Carnall, in Kalender f. d. Oberschlesischen Bergmann, 1847, p. 1; Von Oeynhausen, Geogn. Beschr. v. Oberschlesien, p. 364, and in Karsten's Arch. 1832, vol. IV. p. 350; Pusch, Geognost. Beschreibung von Polen, 1833.

These deposits consist, partly of argillaceous spherosiderite, partly of argillaceous limonite; which are both called clay-ironstone. It is possible, that the latter has been formed by alteration from the former. Argillaceous hematite, or red clay-ironstone, occurs to a subordinate degree.

The spherosiderite proper contains, on account of its impurities, only 45 per cent of iron. The largest nodules attain a diameter of $1^1/_2$ feet. These always contain a purer, more massive kernel, than their outer crust, consisting of concentric layers. Ammonites occasionally occur in the kernels, or they have a honeycombed appearance (septaria). Small crystals of spathic iron, blende, and galena, occur in the fissures. The smaller masses are less regular than the large ones, being merely rounded nodules; they are also enclosed in gray, ferruginous clay, in such a manner that they touch one another. Such nodules occur in the hanging-wall, for 3—4 fathoms beyond the bed proper.

Argillaceous spherosiderite, with 25—30 per cent of iron, forms somewhat more compact beds, 1—20 inches in thickness, but traversed by numerous cross-fissures, which attain their greatest breadth in the middle of the strata. They often wedge suddenly out, or cease very suddenly in the clay, without having been dislocated. They are also accompanied by scattered nodules of ore.

Siliceous spherosiderite is the term applied to the quartzose varieties of this ironstone. They are also compact, but somewhat harder than the others. They afford at the most 30 per cent of iron. In many, a mixture of sand can be recognised, from their decomposition; and these then pass into true spherosiderite sandstones. These beds are 15—20 inches thick.

The limonite also occurs in three modifications; as nodular, argillaceous, and sandy limonite.

The first forms concentric nodules, 3—12 inches thick, frequently hollow, and containing stalactites of limonite, or with a kernel of spherosiderite, or even with sand in their interior. They occur, commonly, scattered in the sand.

The argillaceous limonite, with 20—30 per cent of iron, forms beds a few inches to 3 feet thick; it is however often rendered impure, and unfit to smelt, from mixtures of clay and sand.

The blackish-brown sandy limonite is not smelted, there being no lack of better ores.

The red clay-ironstone, a mixture of hematite and clay, forms earthy, compact, or even somewhat slaty beds, 1 inch to 2½ fathoms thick. It is generally very poor, from the large mixtures of clay.

Similar deposits to these occur in many localities of the adjoining portion of Poland.

SMITHSONITE, GALENA, AND LIMONITE DEPOSITS IN THE *MUSCHELKALK* FORMATION.[1]

§ 155. The fossiliferous limestone formation of Upper Silesia and Poland consists, commencing with the uppermost, of the following strata:

1. Limestone of Opatowitz, but little extended, and without relation to the ore-deposits;
2. Dolomite, and magnesian limestone, widely extended, and principally connected with the ore deposits;
3. Floor limestone, corresponding to the lower Muschelkalk, or Wellenkalk, of western Germany.

The ore-deposits, which appear combined with this formation, occur in part separated from one another, but are all evidently most intimately connected, have probably one origin, and are found at times associated together for considerable distances.

The smithsonite deposits are found principally at the junction of the dolomite and the Floor limestone, but occasionally occur altogether in the dolomite.

The lead-ores occur altogether in the dolomite, or intimately combined with the smithsonite, or in pockets of the overlying tertiary strata, as if washed together.

The limonite, the most common, is combined with the smithsonite, or as large pockets embedded in depressions of the dolomite or Floor limestone.

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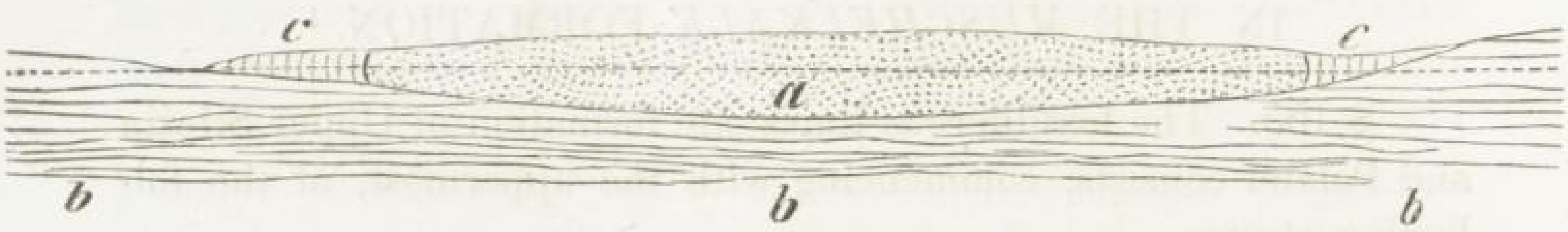
[1] See: Von Oeynhausen, Geogn. Beschr. v. Oberschlesien, pp. 203, 205; Pusch, Geogn. Beschr. v. Polen, 1833, vol. I. p. 225; Carnall, in Bergmännischen Taschenbuch f. Oberschlesien, 1844, p. 100, and Zeitschr. d. deutsch. geolog. Gesellsch., 1850, p. 177; Krug von Nidda, in same, 1850, p. 206, and postscript to same in Leonhard's Jahrb., 1851, p. 710; Rivot and Lejeune, in Annal. d. mines, 1848, vol. XIII. p. 271.

All these deposits are very common in the neighborhoods of Tarnowitz, Beuthen, 'Bendzin and Olkusz, the iron ore also near Twardowice.

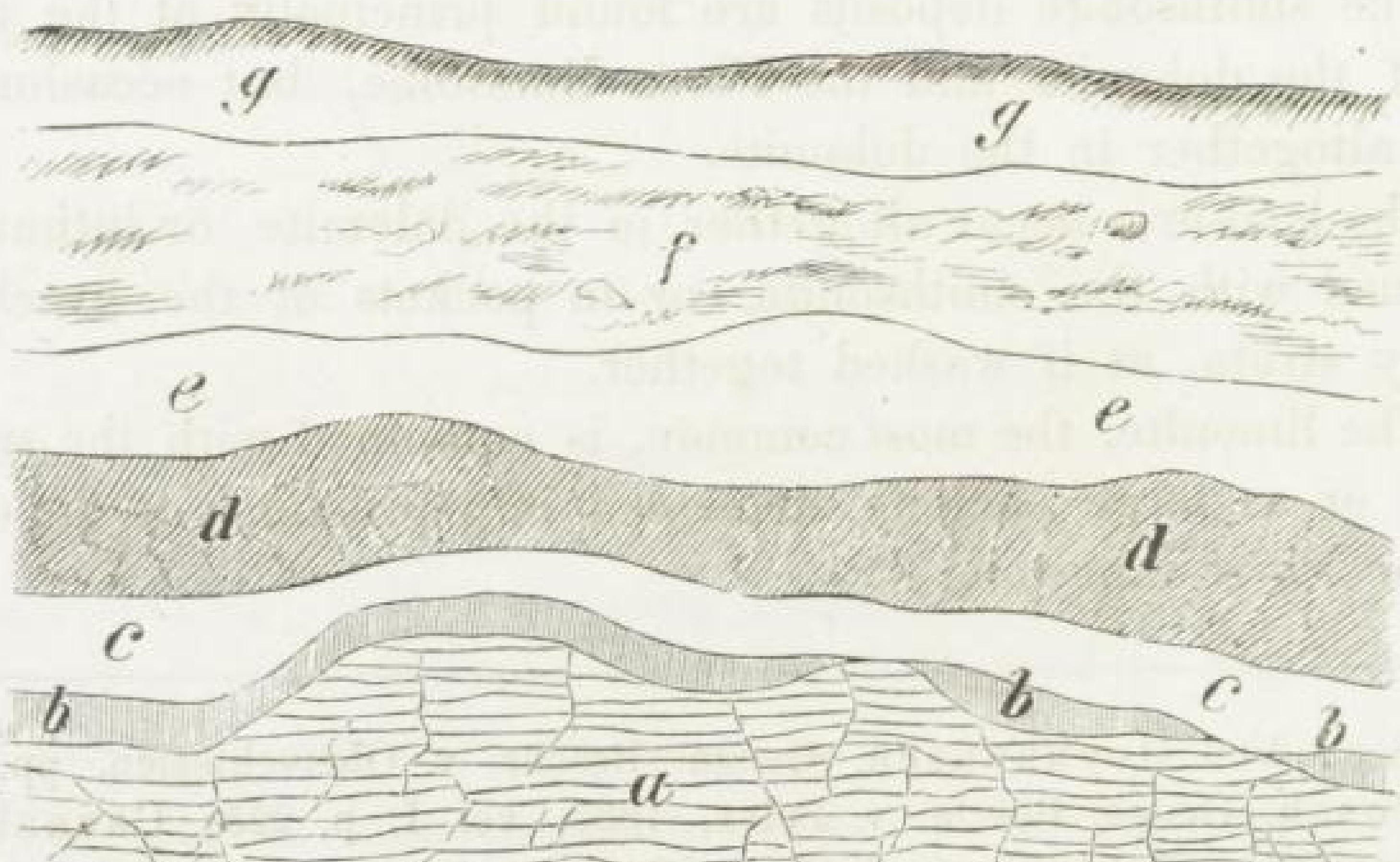
The manner of occurrence at Bendzin in Upper Silesia is the following.

The dolomite forms basin-shaped deposits in gentle depressions of the Floor limestone. Since these are the thickest in the middle of their area, their shape may generally be assumed to be lenticular. Krug von Nidda represents them as being like that in the accompanying woodcut, and says respecting them:



'The borders of the lenses, the angles (c) between the dolomite (a) and the Floor limestone (b), consist partly of the richest zinc-ore and limonite deposits, partly of tertiary strata: the ores partly penetrate the mass of the dolomite.'

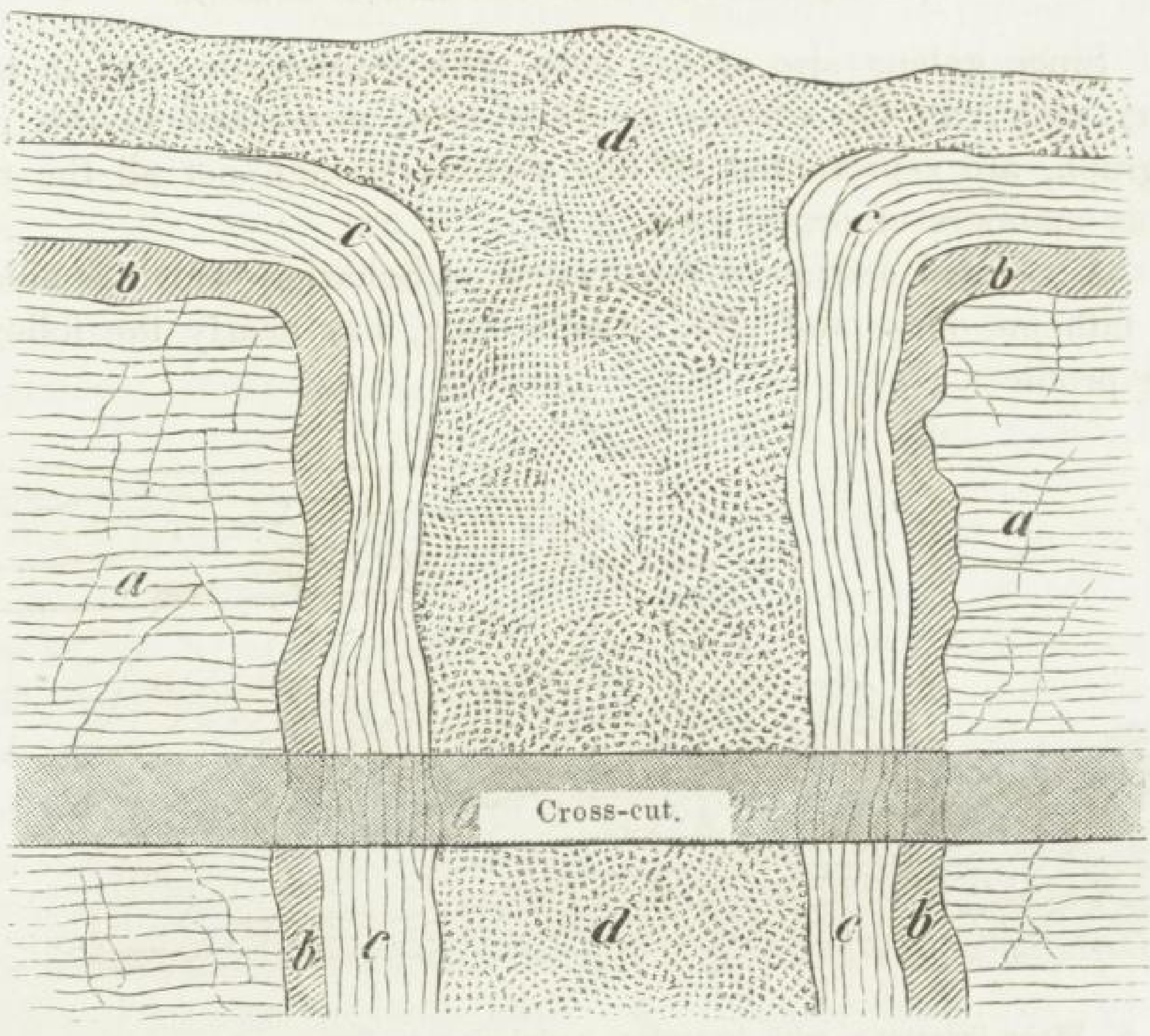
But, as already mentioned, all the ores do not occur in combination with the dolomite; and precisely those, which are not combined with it, serve as key to their comprehension. Near Radzionkau, two miles distant from the dolomite, where white smithsonite and limonite occur together, the bedding is as shown in the woodcut.



a. Floor limestone. b. Bed of white smithsonite, 30 inches to 14 feet. c. Roof of Clay. d. Limonite. e. Yellow clay. f. Tertiary sand and clay. g. Surface soil.

The strata of the Floor limestone, which generally lie horizontally, frequently have their upper surface not parallel to the strata; and it appears as if eaten by acids, so that fossils, and some harder ledges of the strata, are prominent. The separate layers *b*, *c*, are very inconstant, nearly every one of them locally disappearing, or becoming very thick; from which circumstance an irregularity in their formation arises. This irregularity becomes much more distinct from the presence of numerous cylindrical pipes filled by the same materials, and which Krug von Nidda considers to be the pipes of springs, which have had a close relation with the formation of the ores.

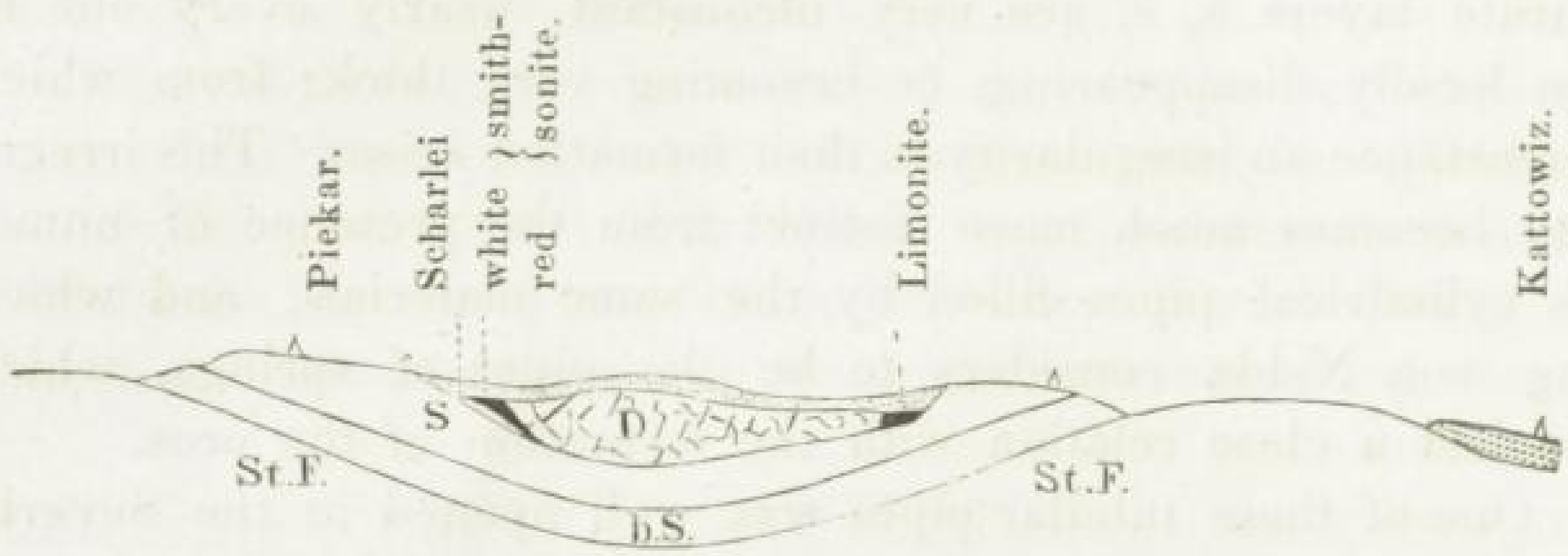
One of these tubular pipes was well opened at the Severin Zinc-mine at Bobrek, and appeared, as seen in the woodcut.



a. Floor limestone. c. Roofing clay.
b. Zinc ore. d. Sand with boulders.

Fissures occur quite frequently alongside of these pipes, which continue for quite a long way beneath the surface of the Floor limestone. The majority of limonite deposits, near Naklo and Radzionkau, occur in such fissures. The smithsonite is then generally wanting.

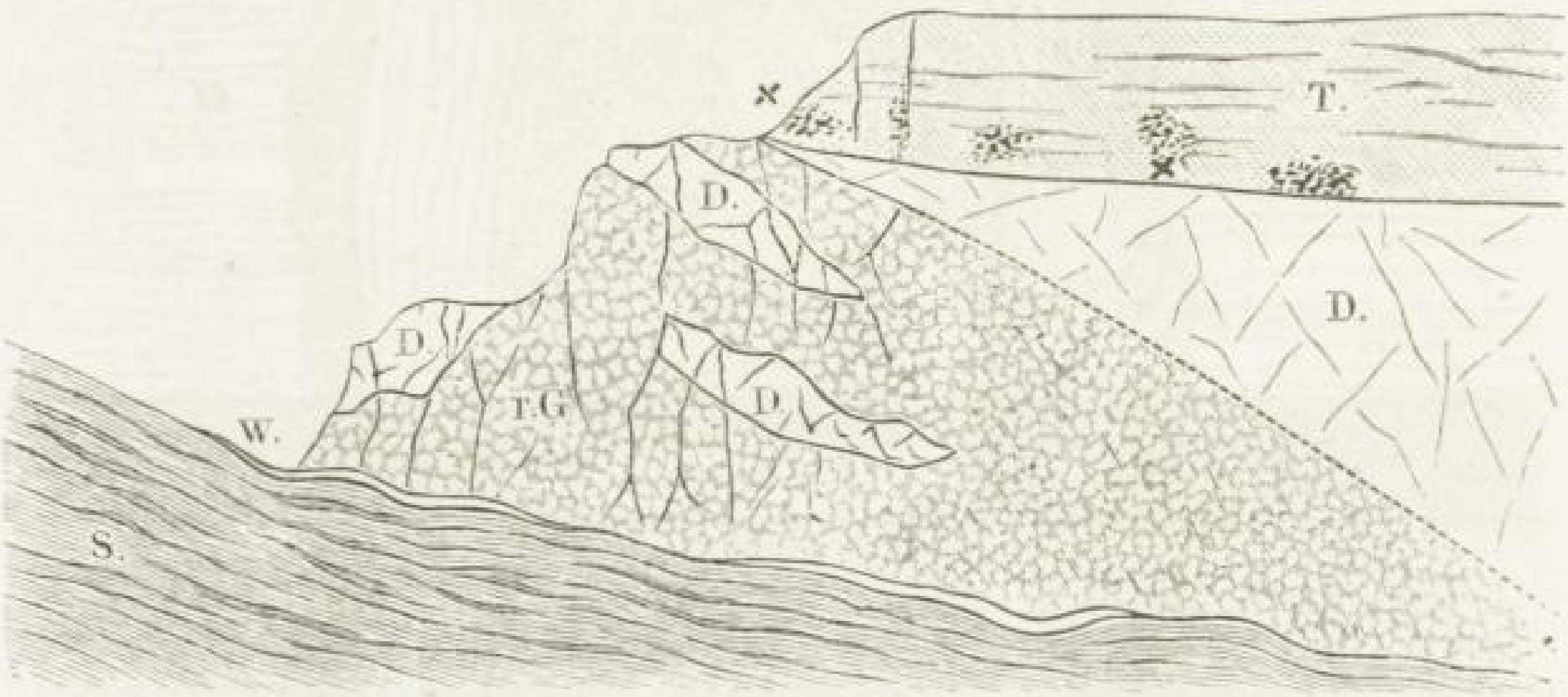
One of the most important smithsonite deposits is that of Scharlei, at present exploited by several mines and quarries. Its geological character can best be understood from the accompanying woodcut.



T. Tertiary clay and sand; D. Dolomite; S. Floor limestone; b. S. Buntsandstein; St. F. Carboniferous formation.

Since galena also occurs here, with smithsonite, and in tertiary clay; all the various kinds of ores, mentioned in this paragraph, are represented in this section, though not all the various manners of occurrence.

A vertical section of the quarry at Scharlei, which is about 18 fathoms deep, and 290 fathoms long, has nearly the following profile.



S. Floor limestone, with irregular, undulating surface.

W. Beds of white calamine, a few inches thick, which do not extend regularly, and are generally separated, by a thin layer of clay, from

r. G. the red smithsonite, which is colored, yellow or red, by much peroxide of iron, and at times encloses irregular masses of Dolomite (D); which are not sharply defined, and appear to be impregnated by considerable peroxide of iron, and smithsonite. They are also traversed, like the beds of red smithsonite, 5 to 6 fathoms thick, by irregular strings of galena a few inches broad. This deposit of smithsonite appears to extend in a wedgelike form; at least it is much thinner, in this direction, in the underground workings; and it is, therefore, supposed that it will soon wedge-out, so that then the roof

D. of Dolomite will lie immediately on the floor limestone, as shown in the preceding section. This Dolomite is much impregnated by peroxide of iron, and smithsonite, immediately over the ore-deposit, and occasionally contains strings of galena.

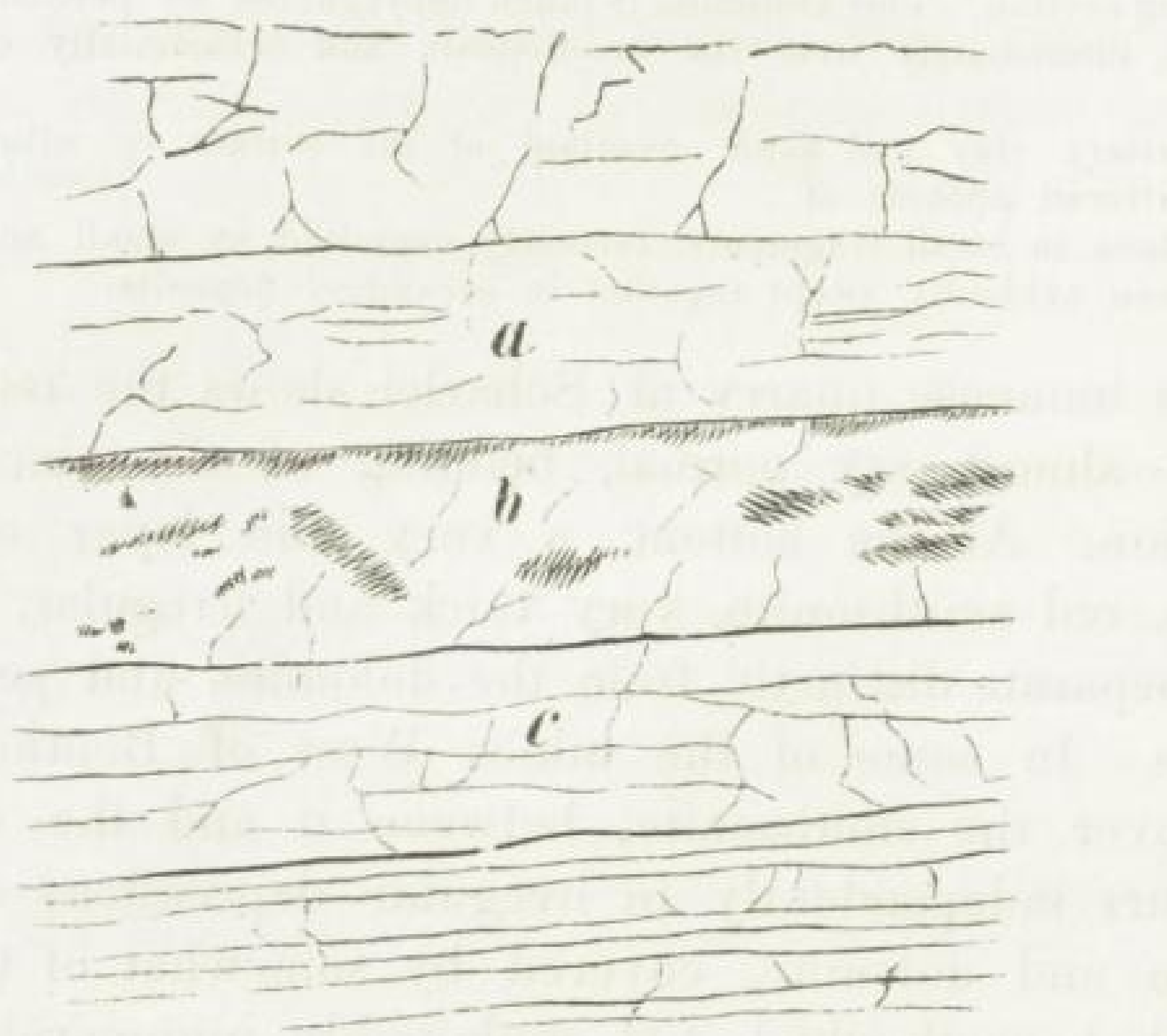
T. Tertiary clay and sand, overlaid at the surface by alluvium. In this clay lie scattered pockets of

✕ galena in small fragments, formerly exploited by small shafts. This galena has been evidently swept together in secondary deposits.

This immense quarry at Scharlei shows the most common, I might almost say normal, bedding of the zinc-deposits in this region. At the bottom, a very thin layer of calamine; over this, red smithsonite, very thick and irregular, hardly possible to separate distinctly from the dolomite, and penetrated by lead ores. In some of the mines West of Beuthen, limonite occurs over the smithsonite, between it and the dolomite; it also occurs independently in irregular depressions of the Floor limestone and dolomite, covered by somewhat of tertiary clay and sand, beneath which it is exploited in innumerable localities.

The galena-deposits occur, somewhat more apart, in the dolomite of the same district. They consist of strata of this rock locally penetrated by galena; since the strata do not contain the lead-ore throughout their whole extent, but locally alone, they cannot be regarded as beds proper, but rather as recumbent segegrations, or impregnations. Krug von Nidda says: 'The galena deposit of the Friedrich's mine, which has been exploited over a large area, occurs in one of the lower layers of the dolomite, at a height of 3—10 feet above the Floor limestone. As this layer consists of a hard or soft dolomite, or a ferruginous clay, the miners distinguish a hard-, soft-, and clay-ore layer. The hard-ore layer is undoubtedly the original one, from which the two others were formed by the action of air and water. On this account the hard-ore layers are found most frequently in the deepest, the soft- and clay-ore layers in the upper workings, which are more exposed to the action of the elements.' One of the most instructive points is the long-wall-working near the Hamster-shaft, by which three layers of the dolomite are exploited; viz. the metalliferous layer, and those immediately above and below it, in order to obtain the requisite room for working.

The upper layer (*a*) in the following woodcut consists of a rough, gray, irregularly fissured dolomite of considerable firmness; the ore-layer (*b*), of an argillaceous dolomite, colored dark gray by bitumen, which contains the galena, partly and chiefly in the



a. Dolomite.
b. Bituminous dolomite, containing galena.
c. Argillaceous dolomite.

neighborhood of the upper fissure of stratification, partly in subordinate fissures, partly disseminated. The lower layer (*c*) consists of an argillaceous, but non-bituminous dolomite, which is an admirable material for cement.

Pusch classified the occurrence of ore in the neighborhood of Olkusz in Poland, as follows:

1. A chief bed of smithsonite, and a principal galena-deposit lying immediately over it.
2. Smithsonite, and iron-ore deposits in basin- and kettle-shaped depressions of the foot-rock.
3. Very irregular smithsonite and galena-deposits, in the brown, drusy hanging-rock (dolomite).
4. Youngest lead-ore formation, in dolomite, or in the white, sandy, hanging-rock.

Pusch states, that 3, and 4, do not occur in Silesia. Since the smithsonite was formerly not worked, the same is now extracted from old mines, formerly exploited for lead, where it is found, generally 1—3 feet thick.

Similar deposits are exploited in the district around Krakau, especially at Lgota.

These examples will suffice to explain, to some extent, the still more undetermined masses, resembling segregations, of the whole district.

Krug von Nidda says: 'From the succession of the plumbiferous roofing clay and limonite, overlying the smithsonite, one might be led to arrange these ore-formations into a group corresponding to their relative Age; so that the smithsonite would be the oldest, the lead-ore in the middle, and the limonite the most recently formed. Such a succession, with regard to their age, is not, however, verified by facts; they must all be regarded as contemporaneously formed aggregations of ores, which have separated, in regard to extent, according to their nature, and under the influence of the wall-rock. Still this separation has remained so incomplete, that there is no iron-ore of these deposits, which does not contain more or less zinc and lead, and no zinc-ore which does not also contain iron and lead. With regard to the smithsonite and lead-ore, there is no doubt, that they have penetrated into the surrounding plastic clay, and have procured themselves space for the formation of geodes, crystals, and concretions. The clay, lying immediately on the floor-rock, served for the accumulation of the smithsonite; since, without a doubt, the finely distributed carbonate of lime in this marl caused the separation of the carbonate of zinc from aqueous solutions. This action is unmistakable on the original masses and strata of the Floor limestone, which are altered into smithsonite. The silicate of zinc is easily explained, by the action of dissolved silicic acid on the carbonate of zinc; that the former mineral springs, however, which have caused the ore-deposits in question, contained considerable silicic acid in solution, is proved by the formation of flints and hornstones, the frequent silicification of masses of clay, which are changed into hard rocks resembling hornstone, and the frequent occurrence of halloysite in pure, milk-white and opaline secretions, filling fissures and forming concretions. The lead-ore was dissolved in water, as chloride of lead, and altered into carbonate of lead by the action of some carbonic acid salt, probably carbonate of lead.

The hydrated peroxide of iron is, without a doubt, a deposit from springs, which like many of the still active springs rich in carbonic acid, contained carbonate of iron in solution, which was precipitated as hydrated peroxide, by the action of the atmospheric air.'

Krug von Nidda thus considers all the ore-deposits of Upper Silesia to be deposits from springs, which were precipitated by the reducing influence of the adjoining wall-rock. He says, however, that the circumstances causing their formation were, partly of a chemical, partly of a mechanical nature.

To the mechanical causes, aiding the formation of ores, are to be assigned the flat basins which are filled with dolomite, the impervious clay-strata, which occur at the contact of the dolomite and Floor limestone, and the numerous fissures in the dolomite. To the chemical causes belong the amount of carbonaceous, bituminous substances in the lower layers of the dolomite, and the chemical composition of the dolomite itself (the combination of carbonate of lime with other carbonates, principally carbonate of magnesia and iron).

An unbiased examination of the manner, in which the ores of Upper Silesia are embedded in the dolomite, can leave no doubt, that they are more recent than the dolomite itself; consequently they must have penetrated subsequently to its formation; and that they stand in undoubted connection with the above-noticed metallic deposits, which have been recognised, as productions of, and deposits from mineral springs. Such a connection may have also occurred, where it cannot be directly proved, and all traces of it subsequently destroyed by changes in the surface.

The large springs, containing salts of zinc, lead, and iron, flowed into flat basins filled with dolomite, were collected by the projecting walls of dolomite, and penetrated into the numerous fissures of the rock, without losing themselves in the Floor limestone, which is separated from the dolomite by strata impervious to water. The bituminous lower layers of the dolomite exerted a reducing influence on the metallic sulphates, carried to these by the aqueous solutions, and as a consequence galena, iron pyrites, and blende, were formed. These have been found, over 11 feet thick, at a depth of 47 fathoms, in a borehole on the Gritz Mountain near Miechowitz.

XII. THE NORTH GERMAN PLAINS.

GEOLOGICAL FORMATION.

§ 156. The surface of the North German plains is principally composed of alluvial and diluvial deposits. Older rocks and formations crop-out but rarely beneath these, and where they do so, contain no ore-deposits worth mentioning. We have, therefore, here to do with the most recent deposits of the earth's crust, which contain some deposits of bog-iron ore.

COTTBUS.

§ 157. Deposits of bog-iron ore are found in all the depressions of the surface throughout the lower Lausitz, but especially around Cottbus.[1] They never occur on the gentle, dry elevations, but only in the, mostly, moist depressions, where their formation is still going on in places. They generally form the upper stratum of the soil, or are covered by a layer of earth, which is then very barren of vegetation. More recent strata overlie them but very rarely; the thickness of these deposits varies from 10—36 inches.

They do not form continued strata, extending over large areas, but numerous, small deposits separated from one another, 300—450 feet long and 15—90 broad.

They commonly occur in peat-bogs, beneath brown, ferruginous grass-turf; more rarely in sandy soil, or beneath sandy peat. A fine moist quicksand, commonly, lies beneath the iron-ore; at times, however, a fine sandy clay; more rarely, a firm clayey bottom.

Where the bog-iron ore occurs purer and thicker, as in the Busch Meadow near Peitz, it shows a kind of stratification caused by dissimilar beds. Elsewhere it only forms scattered nodules, or loose grains; or is mixed, as sand-ore, with considerable quantities of quartz-sand; and even passes from this into a quartz conglomerate, with a cementing medium of hardened hydrate of iron. Vivianite occurs now and then.

The formation of bog-iron ore, where it is still going on, is very instructive. It is formed by deposits from water, which

[1] See: Freiesleben, Geognostische Arbeiten, vol. VI. p. 216.

frequently contains very small quantities of iron dissolved in it. The long continuation of the process of deposit, here, completely, replaces a greater energy of action; and it is probably the same in the formation of many other ore-deposits.

The iron-content of the water evidently originates in the rocks from which the springs rise, even the most sparing and finely disseminated iron-contents of the rocks are gradually dissolved and carried away by the water. When this water reaches low and marshy land, stagnating under circumstances where it is exposed to a strong evaporation, or where living or decomposing organic bodies exercise a peculiar reaction on it, the deposit of oxide of iron takes place, and with this the concentration, in a special deposit, of a formerly, perhaps widely, disseminated content of iron. A similar event may take place somewhat more rapidly, where springs arise from very ferruginous deposits, or even from certain iron ore-deposits; but, as a rule, the formation of bog-iron ore has no such special cause.

According to Ehrenberg, small living Infusia, also, occasionally take part in the formation of the hydrated peroxide of iron, since they construct their shells of it, as do many species of *Gaillonellæ*. After their death, their shells remain, as collections af a fine ochreous iron, which perhaps subsequently hardens, and becomes a firm mass.

Unquestionably a certain analogy can be recognised between the formation of bog-iron ore, and that of the limonite combined with zinc-ore deposits. Even the smithsonite deposits themselves appear, as we have seen, to have been formed by precipitation from mineral waters. The waters must then contain some salt of zinc in solution, which need not be more considerable than in the case of the bog-iron ores, provided it is only renewed for a long period. For the local deposition of the smithsonite, in addition to the nature of the surface-profile, the re-acting nature of certain dolomitic limestones have also been necessary. That is the essential difference between the two; and in consequence of this the zinc-solutions have penetrated deeper beneath the surface than the iron solutions, penetrating between strata of already existing rocks, and altering these. In addition to this, the first presuppose the destruction of not far distant rocks or strata containing zinc, which are indeed much rarer than those containing iron.

THE CARPATHIAN COUNTRIES.

XIII. THE NORTHERN CARPATHIANS.

GEOLOGICAL FORMATION.

§ 158. The Carpathian Mountains form a semi-circle around the great Hungarian basin, and send out spurs into this. We shall first only consider the northern chief-range, which separates Hungary from Galicia. It forms a crescent, open towards the South, from Teschen to the Bukowina and Moldavia, whose principal axis is from WNW. to ESE.

This mountain-chain, more than 370 miles long, is composed almost entirely of sedimentary rocks belonging to the age of the Carpathian sandstone, which is mostly a sandy deposit, replacing the Jura and Cretaceous of other regions, and probably still older strata. The subdivisions of this large deposit have only been determined in a few, small, districts; among others in the Lordship of Teschen, where they have been examined by Hohenegger. For the rest, it is only known, that sand and argillaceous clay strata alternate with calcareous ones, which last are partly designated as *Klippenkalkstein*; without its being possible to determine with any certainty, to what niveau these rocks belong. Crystalline schists and igneous rocks are found, to any considerable extent, only in the southeastern portion of the chain; with which we shall become better acquainted, when speaking of the ore-deposits found there. This long chain of mountains appears to contain but few ore-deposits, especially lodes, in its northern portion. This circumstance is most simply explained by the total want of igneous rocks in the same: where these occur farther to the South, lodes are found in greater numbers and variety.

IRONSTONE BEDS IN CARPATHIAN SANDSTONE.

§ 159. Beds of spherosiderite, probably connected together, are found along the whole extent of the Carpathians, from the Bukowina to the Lordship of Teschen: they are exploited in numerous localities.

In the Bukowina I examined them quite carefully at Kimpolung: those in the Lordship of Nadworna were described by Lipold, those near Skole by A. Schneider, and those around Teschen, by Hohenegger, [1] who also succeeded in satisfactorily determining their geological age.

I shall describe these localities in the order mentioned, merely remarking, that the same strata may very probably be associated with similar beds of iron-ore, in the almost equally large intervals of these, between the localities examined. If this is really the case, then this belt, of iron-ore-deposits, extends for a length of, at least, 370 miles, and is one of the most extensive known.

It is not here meant to be so understood, as that the single beds, or layers, which frequently wedge-out very rapidly, continue thus associated; but only strata which every where contain such beds, whose number and quality vary, just as the condition of the enclosing strata is somewhat altered. These last are much more bituminous in the western portion, than in the eastern.

Near Kimpolung in the Bukowina, the Carpathian sandstone consists principally of gray and yellow argillaceous shales, with numerous subordinate layers of a hard, gray sandstone, of magnesian and ferruginous limestone, of spherosiderite, and clay-iron-ore, as well as thin seams of coal. Impressions of Fucoids, which occur occasionally in the shale and clay-iron-ore, indicate a marine formation of this group of strata, which overlie, and are, in turn, covered by thick strata of gray sandstone.

These argillaceous strata, with their numerous subordinate layers, are several hundred feet thick, and form a large basin near Kimpolung, whose longest axis extends from SE. to NW.; its northeastern side exhibits a somewhat greater inclination of the strata, than the southwestern, while in the middle occurs a succession of overlying sandstone-caps. At least 20 layers of iron-stone are known on each side of this basin, and are some of them already worked. The separate

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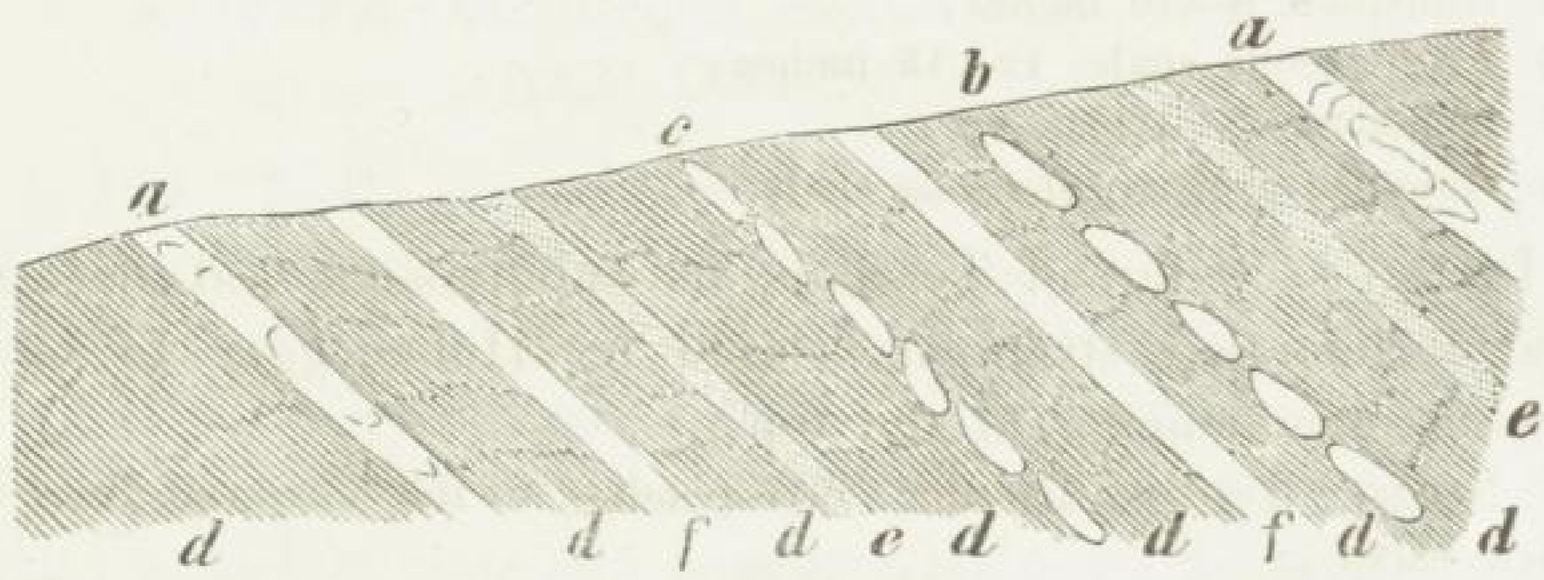
[1] See: Cotta, in Jahrb. d. geol. Reichsanst. 1855, p. 28; Hohenegger, in same, 1852, p. 140; 1855, p. 1; and in Amtliche Bericht d. 32. Versammlung deutscher Naturforscher zu Wien, 1858, p. 136; Lipold, in Haidinger's Berichten, IV. p. 99, and Leonhard's Jahrbuch, 1851, p. 721; Schneider, in Karsten's Arch. 1834, vol. VII. p. 369; Beudant, Voyage en Hongrie, 1822.

beds have a thickness of 6 inches to 3 feet, and the amount of iron they contain varies from 10 to 48 per cent. The richest consist of true spherosiderite; the poorest, of clay-iron-ore. Those which consist of spherosiderite, are frequently composed of separate lenticular masses, whose greatest diameter varies, from 1 to over 20 feet. The lenses are found, partly adjoining and touching one another, partly following each other at short intervals, within a very ferruginous, yellow, soft stratum of argillaceous shale, which serves as a guide for following them. They sometimes lie somewhat obliquely in this layer, so that like the tiles of a roof they overlap one another, or would do so, if they could be pushed nearer to one another, without altering their relative positions. This threefold manner of occurrence is represented by the following ideal sketch.



a. Bed of compact clay-ironstone;
b. Parallel lenticular masses of spherosiderite;
c. Lenticular masses of spherosiderite lying obliquely;
d. Gray argillaceous shale;
e. Gray sandstone strata;
f. Strata of limestone and dolomite, often ferruginous.

The district of the Lordship of Teschen consists, according to Lipold, almost exclusively of strata of Vienna sandstone (Carpathian sandstone), with subordinate beds of limestone, hornstone and ironstone, conglomerate, etc. *Klippenkalkstein* is only found in the neighborhood of Pasieczna in single masses, while small Tertiary deposits occur in the Bitkow Valley. The strata of the Vienna sandstone course SW.—NE. and dip in SE. The subordinate ironstone and other layers occur parallel and within these, cropping-out to the surface in small, tolerably parallel, ribbons. The iron-ores are of three kinds: First, spherosiderites: they are encrusted by a thick black shell, which becomes thicker, the longer it is open to the action of the atmosphere: Second, clay-iron-ores always form the middle bed: Third, marl-iron-ores are on the top, and generally develop the greatest thickness. The only fossils found in these are Fucoids.

Near Skole the Carpathian sandstone consists of sandstone, argillaceous shale, bituminous marl-slate, bituminous shale, clay, calcareous marl, bituminous limestone, and thin seams of coal and hornstone.

The dark argillaceous shales, bituminous marl-slates, and bituminous shales, here contain thin beds of clay-marl-iron ore, and lime-iron ore; nodules of spherosiderite, outwardly brown, also occur. Schneider observed the following succession in the mines at Skole:

1. Sandstone containing fragments of coal, outside of the mines;
2. Dark gray argillaceous shale;
3. Ironstone, 3 – 5 inches;
4. Argillaceous shale, 18 inches;
5. Ironstone, 8—10 inches;
6. Argillaceous shale, 12—15 inches;
7. Ironstone, 3 – 4 inches;
8. Greenish gray argillaceous shale.

In the Lordship of Teschen, the subdivisions and succession of the sedimentary strata are stated by Hohenegger to be the following, commencing at the top:

1. Neogene Tertiary deposits, corresponding to the Viennese *Tegel* (tile or brick earth);
2. Eocene nummulitic strata;
3. Upper Cretaceous strata, about corresponding to the *Pläner* of Saxony;
4. Sandstone of the higher North-Carpathians, probably corresponding to the Gault and Albian;
5. Wernsdorf strata (Urgonian and Aptian): black, bituminous marl-slate, which, especially in Moravia, but in the Teschen Lordship also, contain a belt of spherosiderite;
6. Upper Teschen slates, about corresponding to the Superior Neocomian and Hils-conglomerate: black, bituminous slates with a thick interbedding of sandstone, containing the principal deposits of spherosiderite above and below this sandstone;
7. Teschen limestone consisting of two subdivisions, which both about correspond to the Westphalian-Hils formation;
8. Lower Teschen slate (Hils): marl-slate of a lighter color than the upper ones, and containing no deposits of spherosiderite worth exploiting.

Hohenegger has thus fixed the geological age of the strata containing the beds of ironstone. They belong to the lower division of the Cretaceous Period, and are of marine origin. The manner, in which they were formed, is not indeed explained. Beds of iron-ore have been contemporaneously deposited by the sea over an area more than 370 miles long, between, in part, bituminous and carboniferous clay-strata: who is able to decide; whether originally as carbonate of iron, or as hydrated peroxide of iron? The concretionary form of most of these ferruginous strata, as well as the scattered occurrence of ellipsoidal concretions, appears to indicate, that changes in their form, and contractions of the similarly composed parts, have taken place subsequently to the deposition of their substance. Can this have possibly been combined with an alteration of the hydrated peroxide of iron into carbonate of iron? What has here been said of these widely distributed beds of spherosiderite, is, with the same right, equally true for all others, whatever the formation in which they occur.

COPPER-ORE-BEDS NEAR POSCHORITA, AND DOMOKOS.[1]

§ 160. In the mica-schist-district of the southern Bukowina, near its northeastern limit, which courses parallel to the general strike, occurs a layer of chloritic schist, embedded between two zones of very quartzose schist. The chloritic schist has a very variable thickness, being at times more than 100 feet, and contains a bed of iron and copper pyrites in its middle portion. The schist generally has a considerable dip, which frequently changes from NE. to SW. The ore-bed consists, partly of massive, flattened, and not sharply defined lenses of pyrites, partly of a pyritous chlorite schist only, in which the pyrites locally disappear in the prolongation of the bed. But in general this embedding can be followed continuously, for a length of 13—18 miles, and even, if Domokos is included, with some interruptions, for a length of 90 miles. The same has been opened-up by numerous mines around Poschorita and Fundul Moldowi. The amount of ore, especially that of copper, being locally distributed in unequally rich streaks, and the mass of the bed being often faulted by fissures, have given rise to numerous trial-workings, in which the chloritic schist with its quartzose walls always serves as guide. The mass of the bed consists essentially of copper and iron pyrites only, with quartz and

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[1] See: Cotta, in Jahrb. d. geol. Reichsanst. 1855, p. 17, and his Erzlagerstätten in Ungarn u. Siebenbürgen, 1862, p. 218.

chlorite schist. Other minerals, particularly such as are formed by the decomposition and alteration of those mentioned, are very rare. The compact lenticular masses of pyrites, 1 inch to 2 feet thick, lie singly, or several parallel to one another, in the chlorite schist; which then generally contains pyrites in their immediate vicinity, either in thin parallel threads, or as impregnating particles and crystals.

Similar deposits of pyrites, but of less importance, are said to occur in the common mica-schist, forming the hanging- and foot-walls of the chloritic schist zone. This occurrence somewhat resembles the Fallbands in the crystalline schists of Norway, but differs in having the pyrites somewhat more concentrated than is there the case. It is hardly conceivable, that an impregnation, taking place after the formation of the rocks, should have been confined to such a narrow belt, which is over 90 miles long. Besides which, the very simple composition would lead to the supposition that this is a true bed.

This bed of pyrites is again found in the southeastern prolongation of its strike, under similar conditions of bedding, at Balan near Domokos; the only difference being, that at Domokos, four such beds are found alongside of (originally, over) one another.

All four beds have the same strike as the enclosing schist, from SSE. to NNW. and dip 70°—75° in E. They follow one another, at the following distances, from the hanging-wall to the foot-wall:

1. Pyritous bed,
   2—4 fathoms of schist;
2. Parallel bed,
   4—5 fathoms of schist;
3. Brucks bed,
   10—12 fathoms of schist;
4. Prokopi bed:

beyond, and under this last, traces of three other, similar beds have been discovered.

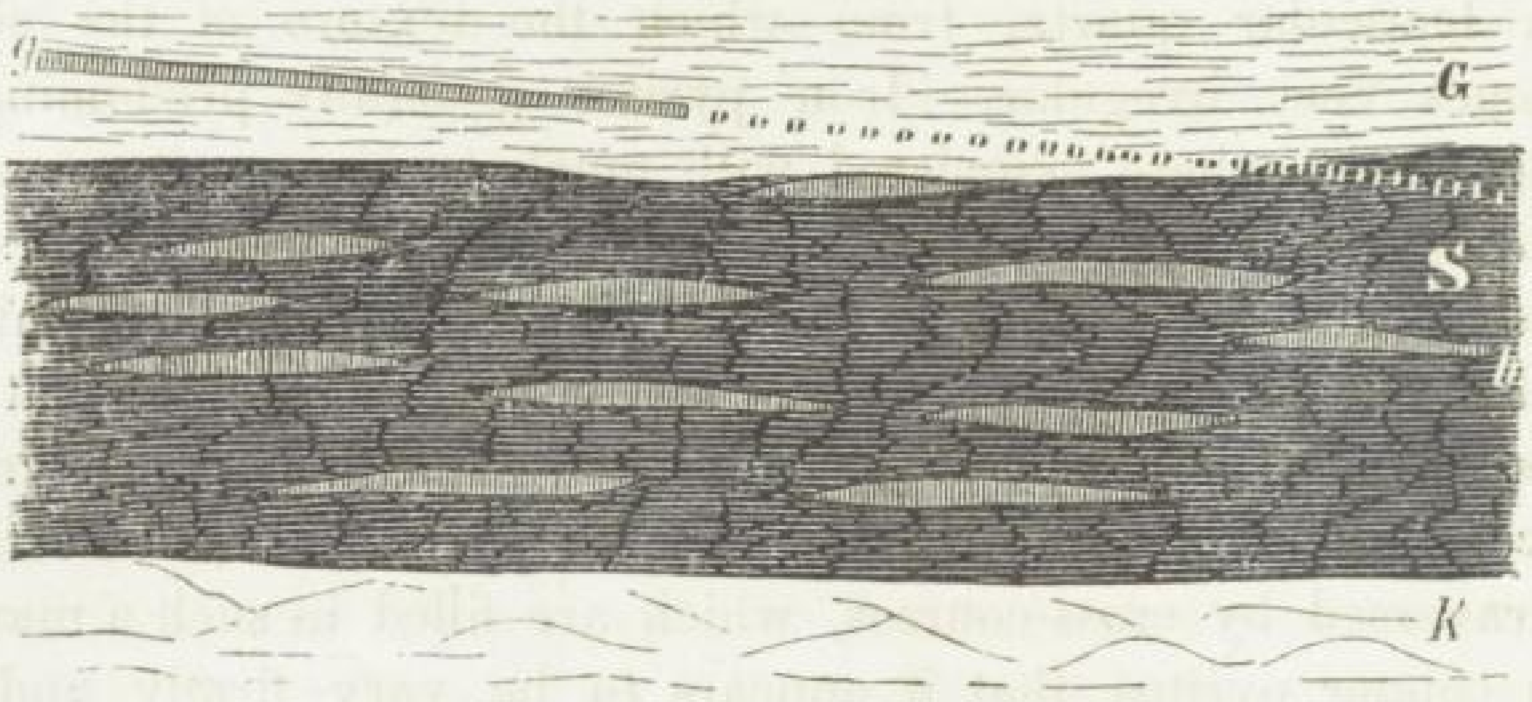
Above the pyritous bed, first lies a very dark schist, probably containing chlorite; then a very quartzose zone, with somewhat of feldspar and chlorite; over this common mica-schist, which passes, farther to the East, into gneiss.

The breadth of the single beds varies here between 1 and 8 feet. They consist chiefly of several parallel beds of pyrites of 1/4 to 6 inches thick, of impregnations of the schist, and of compact lenticular masses of pyrites, which are often combined with lenticular quartz, from which the texture of the schist becomes very irregular. Iron pyrites generally predominates, but is every where associated with much copper pyrites, which at times, especially where combined with quartz, occurs so massive, and pure, that it can be separated in large pieces by hand-sorting. It appears to me very remarkable, that the schist, which is considerably impregnated with copper pyrites, or contains very thin parallel beds of pyrites, should at times be traversed by cross-courses, which are filled in such a manner with copper pyrites, that it appears to be very firmly and intimately united with the parallel pyritous beds. Hence it would seem, as if the sulphurets had subsequently penetrated, and in consequence formed a very long zone of impregnation. There are but few other minerals accompanying those mentioned: here and there slight traces of galena and magnetite have been found, the last especially in the upper workings. The pyrites have been decomposed in a few points of the outcroppings. The relatively somewhat large proportion of quartz, in the schist immediately in contact with the beds, often causes a quartzose outcrop, which on this account projects above the common schistose surface.

LEAD AND SILVER ORE-DEPOSITS AT KIRLIBABA.

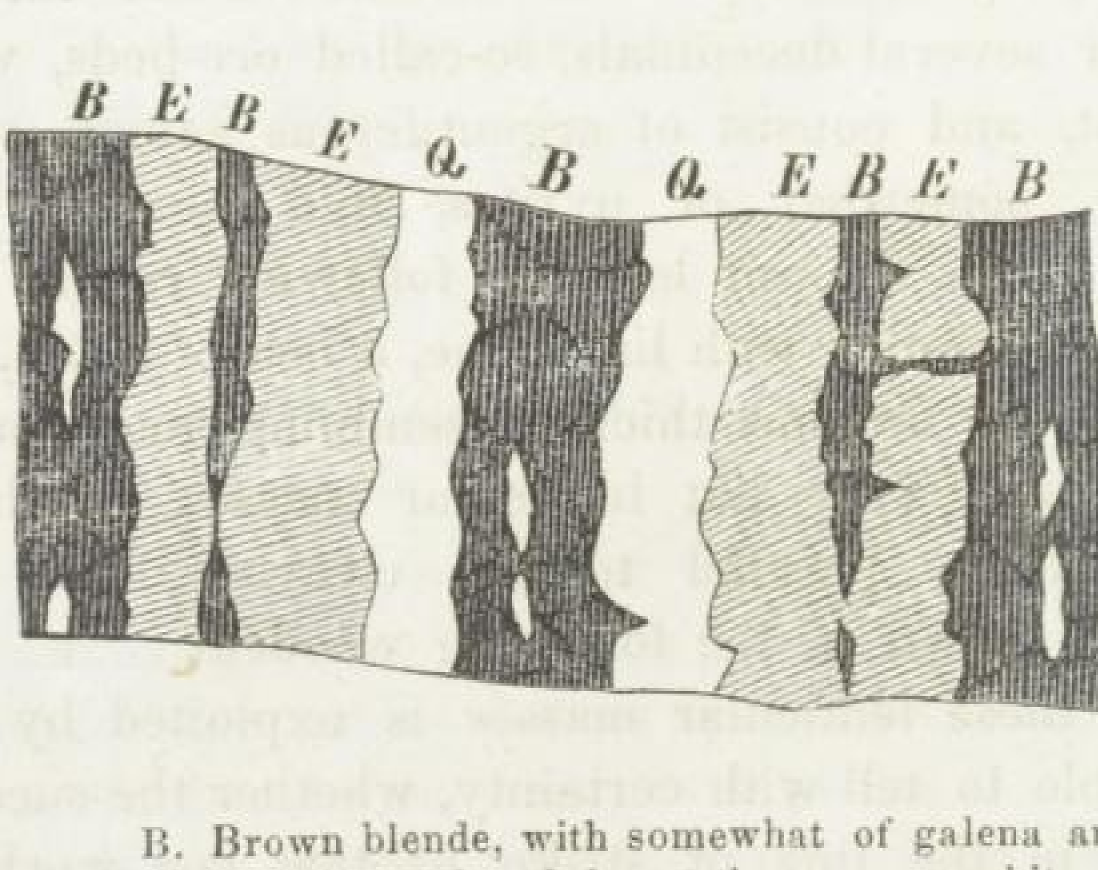
§ 161. At Kirlibaba, in the southern Bukowina, have been exploited, for several decennials, so-called ore-beds, which occur in mica-schist, and consist of argentiferous galena, with spathic iron, blende, somewhat of pyrites, and quartz. A careful examination of the deposit had the following result. The mica-schist contains, together with limestone, a bed of black, bituminous schist, nearly 50 fathoms thick, resembling many alum shales. In this are found very flat lenticular masses, or thin beds, of but slight extent, parallel to the cleavage, but irregularly distributed as shown in the following woodcut.

Each of these lenticular masses is exploited by itself; and it is impossible to tell with certainty, whether the succeeding one lies directly in the line of strike of that last worked, or not. It is therefore necessary to drive cross-courses, to open-up the black schist to its hanging- and foot-walls, and thus find all



G. Mica-schist.
S. Black-schist
K. Limestone.
g. Lode.
l. Lenticular ore-masses.

the masses, of which many indeed are not exploitable. Alongside of this black-schist occurs the so-called 'old bed' in common mica-schist, which has been opened-up by mining operations. This is, however, decidedly no bed, but a lode, which is composed of the same ores and minerals, as the lenticular masses in the black-schist; the only difference being, that the portions of the lode, as yet opened, are not so rich in lead and silver. The lode lies, according to its strike and dip, nearly parallel to the mica-schist; and might easily, from this circumstance, be mistaken for a bed. But it shows in some places a decided symmetrical arrangement of its matrix, as shown in the woodcut.



B. Brown blende, with somewhat of galena and quartz; on the clefts, at times, greenockite.
E. Spathic iron, with somewhat of pyrites.
Q. Quartz.

From the general character of the workings on this lode, it would appear, that it does not remain exactly parallel to the foliation, but approaches the black-schist, and intersects it at a very acute angle. There are probably several such lodes. From the conformity of the minerals in the lode and bed, I would suppose, that the last is really nothing else, than the consequence of an impregnation, taking place from one or more intersecting vein-fissures, whence has developed a richness in lead and silver, principally in the black, coaly schist, parallel to the texture of the same. If this hypothesis be correct, we have a very fine example of a bedlike impregnation, formed from a lode-fissure, which follows principally but one rock, and that a coaly one; like that in which the quicksilver ores of Idria occur, and also similar to that of Bräunsdorf near Freiberg, which exerts such a favorable influence on the lodes traversing it.

VEINS OF AURIFEROUS PYRITES AT BORSA.

§ 162. Borsa-Bánya[1] lies on the Viso River in the Marmaros, near the boundaries of the Bukowina. The upper portion of the Viso valley consists of a mica-schist, which is a continuation of that in the Bukowina. This is frequently covered by Carpathian sandstone and *Klippenkalkstein*, and often traversed by igneous rocks. From this circumstance the surface of the country is much more varied, than farther East, where these overlying and traversing rocks are wanting. The mountains, which are some of them quite high, are surrounded by hills, so that the broad Viso Valley has a character entirely similar to the large and broad valleys of the Alps. To the South the mountain-chains of Inien and Pietros rise to a height of 7000 feet above the variegated alternation of the fore-ground.

Those igneous rocks, which traverse the mica-schist and the overlying Carpathian sandstone, are, partly trachytes, which appear to have no connection with the auriferous veins, partly a greenstone containing labradorite (timazite) This timazite consists principally of labradorite, with somewhat of hornblende (gamsigradite); throughout which are scattered iron pyrites. It mostly possesses a granular texture, but at times

[1] See: Cotta, in Jahrb. d. geol. Reichsanst. 1855, p. 24; Strippelmann, in Oester. Zeitsch. f. Berg- u. Hüttenwesen, 1855, p. 157.

almost passes into a compact condition. It traverses, in large masses and dikes, both the mica-schist and Carpathian sandstone, of which last it contains fragments. The subordinate strata, of argillaceous shale in the Carpathian sandstone, are converted into a jaspery condition, wherever they come in contact with the greenstone.

The large mass of rock forming the Trojoka Mountains, on the right side of the Seko Valley, which opens into the Viso Valley at Borsa-Bánya, is principally composed of this timazite. On its sides, which are at least 2000 feet high, and quite steep, a number of veins crop-out tolerably parallel to one another, whose hanging- and foot-walls are formed by the greenstone. The veins are essentially composed of iron and copper pyrites, with which but little quartz occurs. The iron pyrites occurs partly in fine crystallizations; the copper pyrites is but crystallized, generally massive. Both kinds of pyrites contain gold, the copper pyrites generally the most, but in variable quantities in the different lodes. The breadth of the lodes varies from 1—12 inches. Horses frequently lie in the lodès, or the lodes branch into the rock; which is often somewhat decomposed, and particularly rich in pyrites, alongside of the veins.

Only six such lodes have been found, which all strike parallel to one another, and to the principal axis of the Seko Valley, and are nearly perpendicular. Eight barren, parallel fissures have been opened-up between these lodes; consequently there are altogether 14 fissures. The Katharina lode, cropping-out 1600 feet above the bottom of the valley, has been exploited to the greatest distance. It continues in a straight line for about $2^1/_2$ miles, extending beyond the greenstone into the mica-schist; a sufficient proof, that these lodes are true veins, and not merely gash-veins in the greenstone. It has not yet been ascertained, what amount of ore it contains in the mica-schist.

This occurrence of lodes is of considerable scientific interest: in the first place it follows, that these auriferous veins, like those of Vöröspatak, in Transylvania, are of more recent formation, than the Carpathian sandstone; since they occur in greenstone, itself traversing the sandstone. Secondly, a certain analogy can be recognised with those of Beresowsk, in the Ural Mountains, where the gold-veins traverse the so-called Beresite, likewise a feldspathic rock containing iron pyrites, as the timazite is. Finally, we shall hereafter see, that nearly all the auriferous veins of Hungary occur in rocks containing hornblende.

XIV. TRANSYLVANIA.

GEOLOGICAL FORMATION.

§ 163. Transylvania (Siebenbürgen) forms a large basin surrounded by mountains, the interior of which is filled with Tertiary deposits, and no ore-deposits worth noticing. These are found, so much the more frequently, in a portion of its mountainous walls. We have already become acquainted with the North Carpathians. These extend towards the South to the boundaries of Moldavia, forming a broad, but slightly examined, mountain-chain, here principally composed of crystalline schists and trachytic rocks. In the neighborhood of Kronstadt this chain turns completely to the West, composed in its course towards the Banat of crystalline schists and sedimentary limestones, occasionally enclosing small Tertiary basins, and, as it appears, containing but few ore-deposits. The mountain-chain, extending from the Banat to the boundaries of Hungary and Transylvania, which does not quite meet with the chain of the North Carpathians, is on the contrary quite rich in ore-deposits. It consists of granite, crystalline schists, clay-slate, greenstone, porphyry, trachyte, melaphyre, basalt, sedimentary limestone, and Carpathian sandstone. The great variety of the geological formation appears to have some relation to the great richness in ore-deposits.

Already Beudant remarked, that the great district of crystalline schists contained relatively fewer ore-deposits, than was elsewhere the case, these appearing to be chiefly combined with more recent igneous rocks. Only the most interesting, of the large number of deposits known, will be described.

SINKA NEAR KRONSTADT.

§ 164. The great district of crystalline schists; which, extending from the Banat, forms the boundary, between Transylvania and Wallachia, to the neighborhood of Kronstadt; and near Negoi reaches a height of 8000 feet above the sea; is, according to all the examinations that have been made, but rarely broken through by igneous rocks, and appears in consequence of this to contain but few metalliferous deposits. Porphyries are only known to exist in its eastern portion, in the parish of Pojana-Morului near Sinka;[1] and here alone (a fact worthy of attention) are found very remarkable deposits of argentiferous galena.

Common mica-schist, with gray mica, predominates, and passes farther East into gneiss, partly into porphyritic gneiss. A few layers, with silver white, perhaps lithion, mica, occur to a very subordinate degree within the common schist. This last is much more commonly traversed by a feldspathic, in part only, by a distinctly porphyritic rock. This rock forms over a hundred layers in the mica-schist, which are in general parallel to the foliation, with a strike from SSW. to NNE. with a considerable dip in NW. and whose breadth varies from 1—30 feet. They recur at distances of 4—100 paces, are separately not always exactly parallel to the foliation, and at times even form very distinct indentations and ramifications in their country-rock. They are consequently not beds, but bedded dikes. Their matrix every where consists of a feldspathic, compact or granular mass; occasionally as pure as quartz-porphyry, containing crystals of feldspar and quartz; at times, however, without these, but with an admixture of chlorite, from which it receives a greenish color, while the predominant color, when fresh, is brown. Hence, it may be considered as belonging to the quartz-porphyries, which are the chief causes of the occurrence of ores, or their constant companions, in the Saxon Erzgebirge.

The deposits of argentiferous galena occur between five such dikes of quartz-porphyry, which are several feet apart, they are worked from the narrow gorge of Pareu-Dracului (Devil's Gorge).

These deposits of galena form neither lodes, nor beds, nor even what are generally called segregations; although they have the greatest resemblance to the last. Consequently they do not crop-out like a lode, or bed, in a narrow belt, but only at one point, comparatively small; and have no strike.

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[1] See: Cotta, Erzlagerstätten in Ungarn u. Siebenbürgen, 1862, p. 214.

It appears, from the past exploitations, that this deposit consists of, relatively, small masses of ore, having the form of segregations; which succeed one another, although not in a perfectly straight line. These have a dip of 25°—30° in SSW. within the belt of mica-schist, which occurs, a few fathoms broad, between five neighboring bedded dikes of porphyry: in one point more nearly approaching one, again another dike of porphyry, or between two of them; and consequently having, at times, the porphyry as the hanging- or foot-wall, or separated from both the dikes by mica-schist. The perpendicular height, of the obliquely penetrating zone, in which the ore occurs, is about 120 feet, although in places much less. This somewhat curvilinear succession of ore-masses, which occur singly or several together, is here and there accompanied by impregnations of the very quartzose schist; otherwise it appears to be entirely secluded. In none of the workings, that I visited, could I perceive an extension in any direction resembling a vein. Where the ore has been entirely removed, there remains only more or less decomposed schist or porphyry, in the roof, as well as in the floor, and on all sides. It is said however, that clay-fissures quite frequently occur in the mica-schist, between the deposits of ore, but containing no traces of galena, and very rarely of iron pyrites. Every time that new ore is being sought for, drifts must be made in the direction of the inclined zone, in order to open-up new masses; since the discovery of this peculiarity, the above method has been always attended with success, though at variable distances.

I know of no deposit, of this form and manner of extension, at any other locality; the lenticular galena-deposits in the black schist of Kirlibaba, bear only a slight resemblance. But there very similarly composed lodes, and consequently fissures, are known to exist, from which the mineral matter, forming these very lenticularly shaped deposits, may have penetrated into the schist. Although the opening-up and exploitation of the Sinka mines, which penetrate the mountain-ridge, and a small portion of a declivity opposite to it, do not permit any certain conclusions on the constancy of this curious distribution of ore; still the results, already obtained, appear most remarkable, and worthy of attention.

The principal portion of these aggregations of ore generally consists of a coarse crystalline, or, also, fine granular galena, occasionally containing over 1300 grammes to the kilogramme. This galena occurs in cellular quartz, or decomposed schist, with earthy cerusite. In a few cases, fragments of galena were found entirely covered with an incrustation of cerusite. This and anglesite occur, also, in geodes of the galena. Black and greenish blende, (red is much rarer,) also rarely linarite, crocoite, copper pyrites, azurite, and calc-spar, occur with the galena; more apart, iron pyrites. A single specimen of the supersulphuretted lead, Haidinger's Johnstonite, has been found. Hence the original minerals in this deposit are; galena, blende, somewhat of copper and iron pyrites, considerable quartz, and very little calc-spar. By the decomposition of these have been formed; cerusite, anglesite, linarite, crocoite, calamine (frequent in cracks), and azurite.

I am unable to express any opinion, on the manner in which these deposits were formed; as I cannot comprehend it, so long as channels, through which the mineral solutions can have penetrated, remain undiscovered. Then the form of these deposits does not even seem like the pipe of a mineral spring, which has been filled up. In this respect, their form most nearly resembles the so-called 'badger holes', in the Devonian slate, at Ems.

WESTERN TRANSYLVANIA.

§ 165. A mountainous district rises, northwardly of the Maros, out of the horizontal Tertiary deposits, from which spring the sources of the Aranios, Samos, and Körös. Crystalline schists, as the ,oldest formations; are covered by secondary limestones and Eocene sandstones; both being frequently broken through by trachytic, basaltic, and porphyritic rocks, which often form beautiful cones.

The trachytic rocks are here of the same varieties, as around Schemnitz and Nagybánya, mostly containing hornblende, and corresponding to Breithaupt's timazite.

This mountain-district contains numerous metalliferous deposits, and among them so many auriferous ones, that the whole may be termed a gold-district. The gold-deposits occur, as veins, and impregnations from these. From the partial decomposition alluvial deposits have been formed. Here also the gold-lodes appear dependent on trachytic or feldspathic, quartzose igneous rocks, or to have been caused by their breaking out. The veins traverse, however, clay-slates and Eocene sandstones in their neighborhood; from which circumstance, as well as from the Tertiary age of the trachytic rocks, it is very evident, that their formation, like that of Schemnitz and Nagybánya, is more recent than the Eocene period.

The gold occurs in these lodes, partly, apparent to the eye, in a native state, partly, imperceptible, in sulphurets (especially iron pyrites), in what condition has not yet been determined, partly in combination with tellurium. The last-mentioned manner of occurrence is very characteristic for this region, while elsewhere it is one of the greatest rarities.

VOEROESPATAK.

§ 166. This Eldorado of Transylvania lies in a deep valley, about 5 miles northeast of Abrudbánya. The gold-deposits of Vöröspatak [1] belong to the most remarkable geological ones which exist, and are in addition very important to Austria, from the large amount of gold which is accumulated in the manifold ways of its occurrence. Although not distinguished by a great variety of minerals, it is still mineralogically interesting, from the fact, that the gold always occurs crystallized, or with a tendency to crystallization, and from the circumstance that it occurs, in some of the beds, implanted in dialogite.

No examination of the district has as yet succeeded in discovering the mutual relations between the nature of the rocks and deposits which occur together at Vöröspatak; and I am only able to add a contribution to what has previously been written on the subject.

The village of Vöröspatak (in English, *Red Brook*) lies in a tolerably deep valley on sandstone, which has been recognised by the Viennese geologists as belonging to the Eocene, consequently the oldest, of the Tertiary deposits. This valley is closed in towards the West by a crescent-shaped mountain ridge, which consists of a rock containing much hornblende, generally considered as belonging to the trachytes (Breithaupt's timazite). This rock appears to have no connection with the

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[1] See: Cotta, Erzlagerst. in Ungarn u. Siebenbürgen, 1862, p. 66; Hauer, in Jahrb. d. geol. Reichsanst. 1851, No. 4, p. 64; Grimm, in same, 1852, p. 54.

metalliferous deposits, and to be of more recent age, than the Tertiary sandstone, which it has probably broken through. Towards the South rises a bare and rocky mountain-ridge, whose mass is composed of a still doubtful, but probably igneous rock; its western peak is called Csétatye (*castle*). If Vöröspatak is approached from the North (from Offenbánya), the view from the tolerably high pass, on the western side of the trachytic or timazitic mountain, is surprising, from the very peculiar and, in a mining sense, grand prospect. The opposite declivity of the Csétatye, 600 feet high, or of the Kirnik, is covered, nearly from top to bottom, with white burrows and quarries, between which the small sheds covering the shafts can only with difficulty be recognised. When however the descent into the valley is begun, it will be remarked, that this declivity, consisting of sandstone, has been nearly every where burrowed through by miners. At a still greater descent a continuous stamping will be heard, which comes from the numerous small stamping mills; which are distributed throughout the entire valley. Over 800 such mills belong to Vöröspatak alone, and with those belonging to the neighboring valleys there are over one thousand in a district of ten square miles. Many have but three stamps, their number being a consequence of the peculiar mining regulations. There exist at Vöröspatak about 300 companies with 900 stockholders, each of which receive their dividends from the mine, not in money, but in stamping-stuff and free gold, so that each stockholder is compelled to dress and concentrate his own ore.

This peculiar relation was originally caused by the nature, and extraordinary number, of the auriferous deposits. Their number is not determinable, as there is no general mining chart of the older workings, and it is in many cases, at present, impossible to determine, what workings exist on the same veins. Over 300 clefts have been traversed, and numbered, by the deep principal-adit with its branches, which is united by a tramway with the imperial stamping-mill at Abrudbánya; the majority of these strike N.—S. but many are not worked at the present time. More to the South an E.—W. strike of the clefts is said to predominate. The lodes, as yet traversed by the adit, 800 fathoms long, occur nearly altogether in sandstone; which is frequently very indistinctly stratified; and alternates with conglomerate, and formations resembling tufa, more rarely with argillaceous shales. These fissures, or lodes, evidently encrease in number with the near approach to the Csétatye; while the first 600—1000 feet from the mouth of the adit are entirely free of them. The adit has but recently reached the igneous rock of the Csétatye.

An auriferous sandstone can thus be distinguished from the common widely extended Tertiary sandstones of the region. The auriferous sandstone surrounds the mass of the Csétatye, extending to unequal distances from it, and is distinguished from the common sandstone, in addition to its containing gold, by the greater frequency of conglomerate- or tufa-strata, which occasionally contain fragments of the Csétatye-rock, and boulders of a dark and partly schistose rock: also by more indistinct stratification, the strata being considerably tilted on the southern declivity of the Csétatye.

These lodes, or fissures, only attain a width of about a foot, have partly a vertical, partly a gentle dip; intersect, and then generally enrich one another. Their matrix is principally quartz, calc-spar, or iron pyrites. They seldom contain gold, perceptibly to the outward eye; it generally occurs very finely disseminated in iron pyrites, and together with this has penetrated from the fissures into the country-rock in certain portions, so that the gang, together with the sandstone or conglomerate, can be profitably exploited for a breadth of several feet. It is said, but I will not vouch for the fact, that the lodes are the richest between rocks of a medium degree of consistence, poorer between very firm or very soft ones. The pyritous fissures contain at times an argentiferous tetrahedrite; and in the so-called 'Silver fissure', somewhat of copper pyrites, and stalactitic pyrites-sinter have been formed, which frequently cover large areas on the sides of the fissure. These stalactitic incrustations cover both sides of thin sandstone slabs with layers of pyrites.

The fissures have been seldom followed to a greater length, than 600 feet in the direction of strike, or 150 feet in that of dip. These fissures (gash-veins), which are frequently faulted, traverse the whole sandstone around the Csétatye-rock, and northwardly to the neighborhood of the trachytic mountains.

The very quartzose rock of the Csétatye appears to be much richer in gold, than the sandstone; whose junction has been reached by the principal adit, but has never been observed sharply defined. The line of contact is covered at the surface by the tailings from the stamping-mills. Grimm has called the rock of the Csétatye, feldstone-porphyry. This term has been objected to; since the large grains of enclosed quartz have, as a rule, their edges and solid angles rounded, though generally crystallized in double pyramids. This fact would of itself be no proof against the true nature of porphyry, for quartz-crystals sometimes occur similarly rounded in distinct quartz-porphyries with very characteristic felsitic matrix; this is especially the case in the Thuringian Forest. But then the matrix of the Csétatye-rock is not compact and distinctly felsitic: it is partly very quartzose, with crystalline-granular quartz, in which particles of feldspar are sparingly scattered: partly, and predominantly felsitic, but in a somewhat decomposed condition, containing considerable quantities of small grains of quartz. It also exhibits traces of the crystalline-granular texture of the feldspar; or rather, remains of dissimilar directions of cleavage can be observed, and even of two kinds of feldspar mingled together, which have decomposed unequally. The whole mass is impregnated by a mass of small crystals of iron pyrites, pentagonal dodecahedrons, and cubes, as well as granular aggregations of the same. The quartzose varieties of the rock are frequently very drusy, or traversed by veins of quartz. The miners call the half-decomposed condition of the rock 'Drei'; the entirely decomposed, argillaceous condition, 'Klam'. It is certainly questionable, whether the rock can be rightly termed a porphyry. The compact, felsitic matrix is wanting; and on this account it resembles a granite without mica, rendered porphyritic from rounded crystals of quartz. I consider the rock to be in any case igneous, and not belonging to the sandstone formation; and will on this account for the sake of conciseness call it Csétatye-rock (pronounced Tsetatye). This at times contains fragments of a dark rock, undetermined, probably older and broken-through, similar to that already mentioned, under the conglomerate and tufa rocks.

The prominence of the Csétatye-rock, as a rocky mountain, may possibly be a consequence of its generally greater hardness. The form of its inclination beneath the surface, which has been partially opened-up by underground workings; the manner in which the sandstone surrounds it; as well as the existence of portions of the same, as fragments, or boulders, in the conglomeratic or tufalike sandstone; all go to prove that this mountain existed, before the Tertiary strata were deposited, and was overlaid by these. It seems, however, as if the rock had been subsequently raised, so as to have partly tilted, partly, fissured the neighboring sandstone strata; which perhaps occurred at the same time as the gold emanation. Whether these elevations were predecessors, or consequences, of the trachytic eruption, it is difficult to determine. The deposit of sandtsone, as already said, evidently does not belong to the mass of the Csétatye-rock; I am strongly inclined to consider it as a much altered, partly silicified, partly decomposed igneous rock, which was originally felsitic. The silicification, and decomposition, may well have been the consequences of one and the same cause; by which the gold of this region, together with its gang, reached the places of deposit. The same occurs mostly in the Csétatye-rock; and here, as in the sandstone, partly in an innumerable and altogether irregular network of fissures or veins, and passing from these, as impregnations, into the rock itself.

In ancient times large masses were obtained from quarries in the Csétatye-rock, partly by the aid of fire. On the summit of the Csétatye is a large pit, which was only excavated for the gold of the rock, probably in the time of the Roman domination.

Underneath this, in the interior of the mountain, lies the renowned network of veins, which has been called 'Katranza', from its resemblance, though very faint, to the dress of the Wallachian women. Caves have here been excavated, so colossal, that an ordinary mining-lamp does not reveal their extent, and reaching to so great a depth, that a stone thrown in, takes several seconds to reach the bottom. It is stated, that the cave is over 70 fathoms long and 20 broad: it is, any how, of much greater height, than breadth. It represents a former network of gold-veins, which were perpendicular, and irregularly columnar. An attempt is now being made to open this Katranza, at a still greater depth, by means of the chief adit.

Not far from this, and perhaps connected with it, a similar network, or a branch of this, has been opened by the Rákosi mine, also in the Csétatye-rock. Here numerous irregular veins branch out through the gray rock; which is somewhat more porphyritic than usual, and contains considerable iron pyrites, disseminated through it in crystals. These veins essentially consist of a beautiful red dialogite, with somewhat of yellow blende. These veins of dialogite, 1—2 inches broad, are here and there entirely permeated by crystalline gold; so that, when cut and polished, they have a splendid appearance.

It is remarkable, that these veins are not only irregular, but suddenly cease at times with a rotundity; and entirely enclose or surround small fragments of the porphyry.

Up to the present time I have only mentioned the ore in place. In the bed of the Vöröspatak, and of the Aranios, into which it empties, the tailings that have been swept away, and the refuse from the imperfect concentration, are washed out in many places.

From my own observations, from the views of von Hauer and Grimm, and from the communications of the mining officials, I concluded:

1. that the oldest rock, which comes to the surface, in the neighborhood of Vöröspatak, is the Csétatye-rock;

2. the Eocene sandstone was next deposited; which appears, from the tufa-layers it contains, to have had some connection with the porphyritic eruption;

3. the impregnation of gold and pyrites, and the formation of the minerals in the veins and fissures, took place after the sandstone had been formed;

4. still later occurred the upheaval of the trachytes (or timazites), and the basalts; of which the Detonata is celebrated for its beautiful columns;

5. the present valleys are of much more recent formation.

The gold, with the minerals accompanying it; pyrites, blende and tetrahedrite, quartz, dialogite, calc-spar; has penetrated into the fissures and rocks, in the interval, between the formation of the Eocene sandstone, and the eruption of the trachyte or timazite, perhaps during its eruption. It did not penetrate from above, but from below—in what form of solution?—Here as little known as elsewhere, it evidently arose principally within the limits of the Csétatye-rock, and spread itself out from this as from a centre, penetrating also into the neighboring sandstone. Was the penetration of this solution a consequence of the previous eruption of the Csétatye-rock, or a consequence of the subsequent upheaval of its mass, already hardened, occurring about the period of the trachytic eruption?

Since in the neighborhood, as in Hungary, gold-ore-beds frequently occur together with trachytic or timazitic rocks, it might be supposed, that the gold-region of Vöröspatak was in some way connected with the neighboring trachytes, or timazites; still this cannot be recognised from any outward circumstances. It is however probable, that the peculiar, partly silicified, partly decomposed, condition of the Csétatye-rock, is also a consequence of the penetration of mineral waters or vapors.

OFFENBANYA.

§ 167. Near Offenbánya[1] a mountain-chain rises out of the Tertiary sandstone district of the upper Aranios, which is principally composed of mica-schist. This schist contains, southwardly of Offenbánya, subordinate layers of granular limestone; and is traversed by a porphyritic rock, which I no where found in a fresh and distinctly recognisable condition. Bielz, who took part in the geological survey of the Viennese Reichsanstalt in this region, called it greenstone-trachyte; and thus placed it in the group of igneous rocks, which Breithaupt has called timazites. Where I was able to observe the rock, especially on the rubbish-heaps at the mouths of the shafts, it was every where in a decomposed state, frequently bleached almost white, commonly containing pyrites disseminated through it. Those portions appeared the freshest, which, curiously enough, occur in the neighboring limestone of the mica-schist, and are entirely enclosed by this; while in the workings of the mines I visited, the limestone never comes directly in contact with the greenstone-trachyte, but is separated from it by the mica-schist.

It appears to me very difficult, and from the few observations lying before me impossible, to explain these enclosures in the limestone. When the porphyritic rock, as it appears to do, traverses the mica-schist, it must necessarily be more recent than this and the embedded limestone. How then can this last contain fragments and even large masses of the same? The only explanation is, that the limestone was softened and in motion during, or after, the eruption of porphyry; so that it was able to separate and enclose fragments of the greenstone-trachyte (timazite). This is certainly a hypothesis, which

[1] See: Cotta, Erzlagerstätten in Ungarn und Siebenbürg. p. 81; Bielz, in Verhandlungen u. Mittheilungen d. Siebenbürg. Vereins f. Naturwissenschaften z. Hermannstadt, 1860, p. 167; Hauer u. Fötterle, Uebersicht der Bergbaue, 1855, p. 59.

cannot be farther confirmed by the local conditions, to which I have been led by the analogous case at Miltitz in Saxony, where granular limestone, embedded in mica and hornblende-schist, contains fragments of the granite dikes traversing the schists. At Offenbánya the analogous igneous rocks of the neighborhood are of more recent origin, than the Eocene sandstones; so that, if the igneous rock of Offenbánya belongs to the same period of formation, the limestone may first have been softened in the Miocene period. It is useless to trouble oneself with the explanation of geological relations, which are so little known as these; and for which some future more accurate examination may reveal a simple explanation. On this account I pass to the metalliferous deposits, which occur under very peculiar geological conditions. There are two kinds, which occur: telluric veins in igneous rocks, and segregated masses in granular limestone.

1. The telluric veins (called locally 'Clefts') are in reality almost only clefts. Fifteen are known, within the ground belonging to the Franzisci adit, which are tolerably parallel to one another, strike E.—W. and dip 30°—40° in N. They have an average breadth of one inch, and contain locally sylvanite, and at times somewhat of native gold. Other small veins intersect these, containing pyrites, or quartz; and which generally occasion an enrichment at the point of intersection. The telluric ores are so sparingly distributed, that their exploitation is rendered much more difficult, than it otherwise would be. According to the statement of the mining-officials, the state of decomposition of the country-rock always has a certain relation to the contents of the lodes: they are the richest in a medium-hard, and but slightly decomposed rock, less rich in a slightly, or very much decomposed, condition of the wall-rock. Both can be explained, if it be assumed that the slight decomposition comes from a re-action of the metalliferous solutions, which could no longer penetrate, where an extensive decomposition had already taken place. The principal matrix is quartz and dialogite; in which occur, as the principal ores, nagyagite, sylvanite, and native gold; associated with which are iron pyrites, galena, blende, stibnite, native silver, and pyrargyrite.

Similar telluric veins are said to occur in the neighboring property of the Barbara adit, which strike N.—S. and dip in W.

2. Segregations. The same adit, which has opened-up the tellurium veins, has also opened the neighboring granular limestone, in which two segregated masses are known to occur. Their form is very irregular, with a curious contour of surface. The so-called pyrites segregation consists predominantly of iron pyrites, with somewhat of galena, tetrahedrite, and blende; which are accompanied by quartz, and calc-spar, as vein-stones. It surrounds a large rounded mass of porphyry, on the borders of which the galena has principally collected, being at times a foot broad. On this account the mass of porphyry, several feet wide, is opened-up, and laid free, on nearly its whole circumference, at least in its upper portion.

It appears to be an entirely separated mass of porphyry, like the smaller ones, which are occasionally found here, completely surrounded by the common limestone, and then surrounded also by narrow zones of pyrites, galena, and blende.

The second, or so-called 'Old ore-segregation', consists principally of dialogite with considerable galena, containing but little silver, blende, manganblende, iron pyrites, and tetrahedrite; it occasionally also contains copper pyrites. Quartz and calc-spar occur, crystallized, in large geodes. The minerals frequently show a combed texture in such a manner that the combs form irregular ellipses; portions of which occasionally penetrate the limestone in such a manner, that small handpieces of the same might be easily mistaken for portions of a symmetrically banded vein in granular limestone, being yet in reality portions of irregular cockade ores. I observed on such a handpiece, the following entirely regular arrangement of the layers, from the exterior limestone towards the interior:

1. dialogite, with particles of manganblende;
2. three thin bands of light gray quartz, separated from each other by still thinner layers of pyrites, and blende;
3. dialogite, like 1;
4. a very thin band of pyrites and blende;
5. white calc-spar, also but a line thick;
6. Pyrites, and blende, like 4;
7. dialogite, forming the nucleus, with a little pyrites, blende, and galena.

This so peculiarly composed ore-deposit, upwards of 16 fathoms thick, which is entirely surrounded by limestone, encloses, like the previously mentioned segregration, a broad mass of porphyry; which does not, however, appear to have exerted any special influence on the distribution of ore.

The facts, about these peculiar and irregular collections of ore, are too little known, to enable me to express a definite opinion, or explanation concerning them. These segregations appear to be entirely independent of the entirely differently composed telluric veins.

NAGYAG.

§ 168. The mining town of Nagyág[1] lies in a valley-gorge on the southern edge of the great trachytic mountain-district, which is here known by the name of Csetraser Mountains. All the surrounding mountains are here, also, composed of the trachytic-greenstone, Breithaupt's timazite. These rocks, around Nagyág, were formerly called greenstone-porphyries. Baron von Hingenau separated these into several varieties and alterations of porphyry and trachyte; and also mentioned the occurrence of melaphyre, and quartz-porphyry. He states, that the greenstone-porphyries occupy the under, or inner portion of the mountains, and pass in an upward, and outward direction, into trachytes. He sought, in a more recent memoir, to maintain the trachytic nature of these rocks, against the objections of Grimm; and proposed the name, which originated with G. Rose, of diorite-trachyte, to do away with the very indefinite name of greenstone-porphyry. The cabinet-specimens, which I brought with me from Nagyág, all correspond very decidedly with Breithaupt's timazite. In my opinion the name is of little importance, it being only essential that they should be recognised as igneous rocks, composed of feldspar and amphibole, which have broken through eocene sandstones, and argillaceous shales. They recur in a similar manner, traversed by lodes, at Kapnik, Felsöbánya, Nagybánya and Schemnitz; while similar rocks are found at Vöröspatak, but having no apparent connection with the gold-veins. These rocks occur in many varieties, probably caused by the conditions under which they

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[1] See: Cotta, Erzlagerst. in Ungarn u. Sieberbürg. p. 85; Hingenau, in Jahrb. d. geol. Reichsanst. 1857, p. 82; Grimm's Geognosie f. Bergmänner, 1856, p. 72, and following; Zerrener, in Oesterreich. Zeitschr. f. Berg- und Hüttenw. 1855.

hardened; but it is not always possible to show, what these special causes were.

Red shales and yellow sandstones, most probably Eocene, crop-out beneath these rocks in the valley-gorge of Nagyág. The Franz adit has opened these up, for a long distance, under the summit of the timazitic Calvary Mountain, until they are cut off by the timazite, whose limits dip very steeply towards N.

Since the adit has not intersected any prolongation of the Calvary-Mountains timazite, which may be regarded as having been the special channel of eruption; it must therefore be presumed, that this beautiful cone, together with many other similar ones in the neighborhood, were not each formed by separate volcanic action, but are the conical denuded remains of one immense overflow of lava. The crater was opened by the adit somewhat farther to the North.

The lodes of Nagyág are only known to exist in the igneous rocks, and essentially only in the deeper varieties, called by Von Hingenau greenstone porphyries; they do not exist, at least not so as to be exploitable, in the upper, more trachytic rocks.

The lodes are auriferous tellurium ones. They strike principally N.—S. or NW.–SE., and in such a manner, that they converge somewhat in their course. Their dip is generally very great. The lodes are said to contain more gold, near the surface, than in the depth; a circumstance, which agrees with the manifold experiences on this subject, which have been made in this relation with gold-veins.[1] Their breadth is generally a few inches, exceptionally it attains 5—6 feet. They are very commonly accompanied by a breccia in their hanging- or foot-walls, very peculiar in its occurrence, which is called *'Glauch'* by the miners. It consists of a dark matrix, formed of triturated or decomposed particles of rock, containing numerous angular fragments of various kinds of clay-slate; more rarely, rounded (perhaps by friction) boulders of the wall-rock are also found in it. Whence came the fragments of clay-slate? is a question asked in vain. This breccia attains a breadth of

[1] It appears to be generally the case, but is not always so, that gold-veins decrease in richness with the depth. Exceptions are, many of the mines in the Grass-Valley-district in California. *Trans.*

over 6 feet, and branches into widely extended and irregular side-fissures, often but 1—2 inches broad; this is a very remarkable manner of occurrence, for a mechanically formed breccia, containing numerous fragments, and here and there boulders.

The matrix of the lodes proper is dialogite, or brown spar and calc-spar, or hornstone and quartz; this varies in the different lodes, and in the different portions of the same lode. Through these veinstones are scattered auriferous telluric ores: the most common after these are, manganblende, and iron pyrites; the last has frequently impregnated the country-rock for a considerable distance. The following are the chief ores exploited: nagyagite, sylvanite, native gold, auriferous iron pyrites, argentiferous tetrahedrite, native silver, and galena. Associated with these are: hessite, bournonite, jamesonite, heavy spar, blende, stibnite, arsenic, realgar, orpiment, silver glance (rare), copper pyrites, marcasite, native copper, malachite, pyrrhotine, sulphur; the following also are said to have occurred formerly, but it is not certain: aragonite, altaite, erythrine, eucairite, asbolan, pyrolusite, smaltine, and scorodite. The following secondary minerals occur: agalmatolith, kaolin, gypsum, calamine, pharmacolith, copperas; and (doubtful) cerusite, smithsonite, keramohalite, and plumbo-resinite. No combed texture can be observed; very commonly, however, small geodes, in which are found crystallized quartz, and dialogite.

The tellurium-lodes of Nagyag evidently have a considerable analogy with those of Offenbánya: they occur, in both places, as nearly parallel, narrow fissures in an igneous rock containing hornblende: the essential difference between the two is, that the gang of Nagyág consisting of dialogite, brown spar, or quartz, occurs somewhat more massively; but this quality is wanting at Offenbánya.

Von Hingenau relates, that according to a manuscript of Debreczényi, a former local official, very remarkable intersections and enrichments of the Nagyág lodes occur; which, as I, unfortunately, had no opportunity myself of seeing them, I can neither confirm nor deny. Von Hingenau himself does not seem to have observed them, although staying at Nagyág for two weeks. The officials, who accompanied me on my visits to the mines, expressed the opinion, that such appearances occurred; but could give me no particulars regarding them. If I rightly understand von Hingenau's memoir, the following are the most important phenomena he observed:

1. The country-rock, like that of Offenbánya, has exerted an unequal influence on the distribution of ores in the veins, according to its greater, or less solidity (freshness, or decomposition): the lodes appear to be much contracted between firm walls, and then consist of barren fissures; between less firm ones, they widen out and contain ores; in a soft (much decomposed) rock, they branch, contain many horses, and are poorer.

2. The intersections, and junctions, are just the contrary of those at Offenbánya, as a rule containing but little ore, even though both lodes were rich before their intersection. The curious circumstance occurs, that small side-branches connect, alongside of the junctions, the rich portions of the lodes.

3. These side-veins branch off, very rich in ores, from the champion-lode, and again unite with it, while the lode itself contains no ores for the whole extent of these side-branches.

4. When the tellurium-lodes are intersected by clay-dikes, as is often the case; they are often faulted by them, and have the peculiar relation of retaining their whole breadth, in the foot-wall of the dike, up to the point of contact; in the hanging-wall, on the contrary, they consist for several feet merely of a thin cleft, and only regain their full breadth at a considerable distance.

The clay-dikes appear to correspond to the curious breccia I observed; although I find no mention of this in von Hingenau's paper.

These phenomena of enrichment, and intersection (especially 2 to 4), mentioned by von Hingenau, are partly of such a peculiar kind, that they are, up to the present time, isolated cases, appearing even to contradict all previous experience on this subject. I would, on this account, regard them as the result of an imperfect examination, if I had any right to do so. But I have the less right, as the veins of breccia, which I observed, belong to one of the most abnormal appearances, which I have ever seen in nature; since they contain in fissures, frequently but a few inches broad, fragments of a clay-slate, which has not been observed in place, together with a few, boulder-like, rounded portions of the adjoining country-rock; although Grimm, indeed, mentions the cropping-out of clay-slate, with embedded layers of limestone and gypsum near here, at the village of Vermaga.

XV. THE BANAT, AND SERVIA.

GEOLOGICAL FORMATION.

§ 169. The geological formation of the Banat, and that portion of Servia adjoining it, is very manifold; but has not yet been sufficiently examined.

Crystalline schists, and granitic rocks, rising to high mountains, are surrounded by crystalline schists, sandstones, limestones, and argillaceous rocks of the Carboniferous, Jurassic, Cretaceous Periods. Thick Tertiary deposits are found in the broad valley-basins, partly containing lignite, partly marine fossils. The crystalline schists, and the secondary formations, are traversed by porphyries, syenites, greenstones, melaphyres, and basalts; while they contain coal-deposits of very different ages.

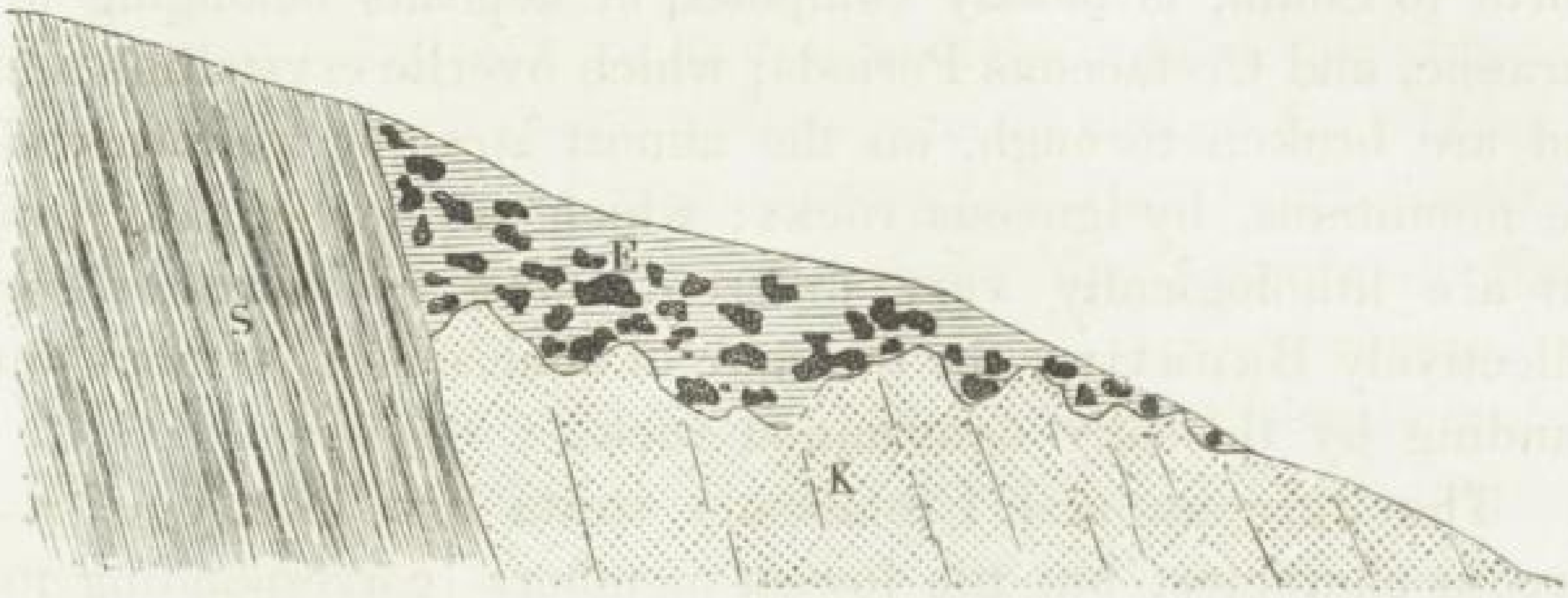
The geological formation of Servia is still less known, than that of the Banat: it is only certain, that the Danube, though a political boundary, is not here a geological one.

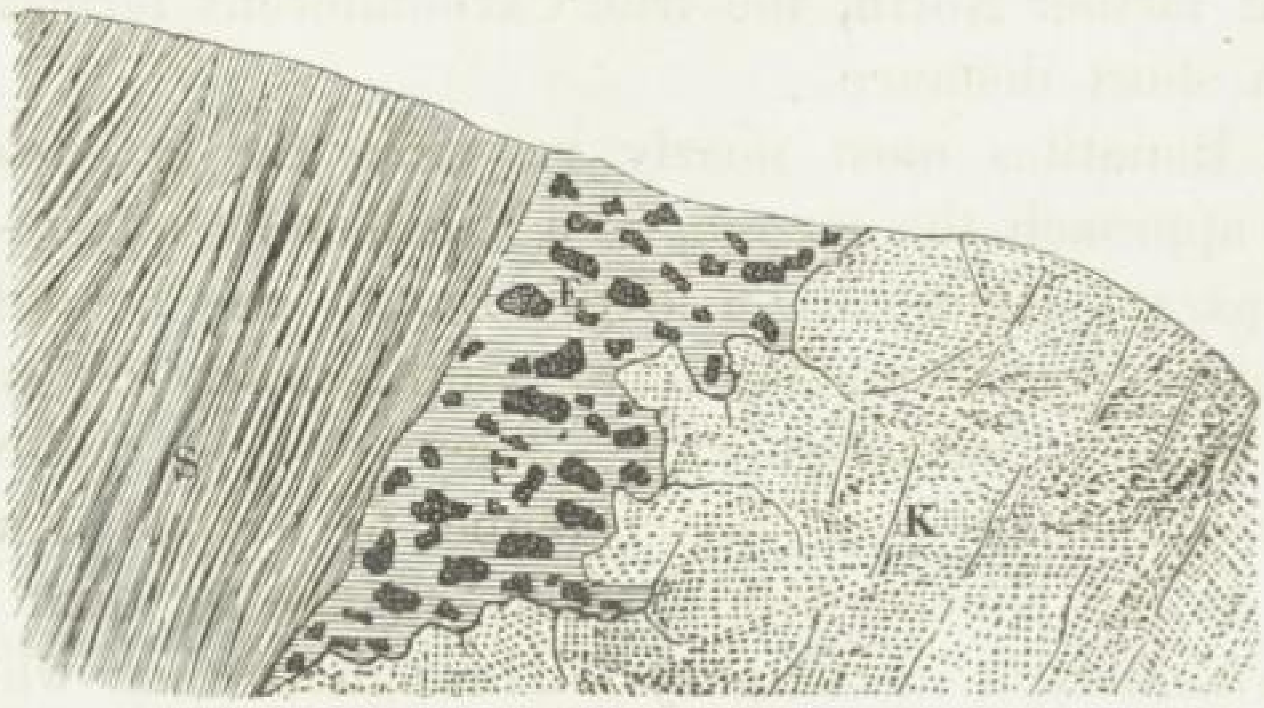
LUNKANY.

§ 170. The neighborhood of the Baths of Lunkany, in the northern Banat, consists of mica-schist passing into chlorite schist, and clay-slate; which contain numerous crystalline limestones, quartzites, and siliceous slates, embedded in them. In this district excellent hematite, and limonite, partly containing manganese, are exploited; which are principally combined in a peculiar manner with the limestones; since they form altogether irregular beds, in which they are found, as irregular nodules, or masses, in brown clay or ochreous iron.

Although in some places they only fill depressions in the surface, in others they occur, in a very analogous manner, irregularly embedded between crystalline schist and limestone. As these ore-pockets evidently fill cavities washed-out in the limestone, they must, of course, be of a more recent origin than this, and the schist enclosing it; but, of what age they are, I am unable to decide.

The two accompanying woodcuts represent two cases of this diverse manner of occurrence, which is found repeated with innumerable modifications.





S. So-called silk-slate, midway between clay-slate and mica-schist.
K. Fine-grained limestone.
E. Iron ore; a ferruginous clay containing nodular masses of limonite and hematite.

The ironstone is at times more brownish-red in the neighborhood of the schist, nearer black and containing considerable manganese near the limestone. In addition to the nodular iron, fragments of schist occasionally occur in the clay; and on the borders of the limestone the deposit frequently passes into a kind of breccia, of limestone fragments, cemented together by iron-ore and calc-spar. Some of these irregular deposits are 60—70 fathoms broad, and over 300 long. They must generally be called secondary contact-deposits; being secondary in so far, that they only fill cavities washed-out, which have been induced by the rock-limits.

THE BANAT ORE-SEGREGATIONS.

§ 171. The mountain-chain, traversing the Banat[1] from North to South, is mostly composed of deposits belonging to the Jurassic, and Cretaceous Periods; which overlie crystalline schists, and are broken through, on the almost straight western wall of the mountains, by igneous rocks; which are geologically united, but are lithologically very different. We will name them all collectively Banatite, for the sake of conciseness, without understanding by this any determined rock.

The Jurassic and Cretaceous strata are mostly of a calcareous character; but the lowest members (corresponding to the Lias) contain the coal-basin of Steierdorf; while at Reschitza, somewhat farther North, the true Carboniferous formation crops-out for a short distance.

The Banatites most nearly resemble the greenstones; but at times approach the syenite, or a hornblendic quartz-porphyry. Their separate eruptions lie in the Banat, one behind another, in a straight line from North to South, nearly 50 miles long, on the western mountain-wall. They can be followed in a southerly direction over the Danube to beyond Kuczaina in Servia; to the North, with a slight change in their direction, as far as Rezbánya in Hungary. Throughout their whole extent they are accompanied by irregular, segregated contact-ore-deposits; which consist of cupriferous pyrites, galena and blende, or magnetic iron, locally alternating, and accompanied by numerous other minerals.

Where these Banatites have broken through the Jura, or Cretaceous limestones; these last are generally converted, at the junctions, into crystalline, granular marble, with considerable admixture of garnets, at times almost entirely altered into garnet-rock. Their stratification is also partly destroyed, and the segregations of Neu Moldova, Szászka, Csiklova, Oravicza, Dognacska, Moravicza and Petris in the Banat, also that of

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[1] See: Cotta, Erzlagerstätten im Banat u. Serbien, 1864, p. 100; Schröckenstein, Geognostische Notizen aus dem Banat, 1863; Peters, Geologische u. mineralogische Studien aus dem südöstlichen Ungarn, 1861; Von Berg, Aus dem Osten der österreich. Monarchie, 1860; Von Zepharovich, Mineralogisches Lexicon, 1859, and in Oesterreich. Zeitschr. f. Berg- u. Hüttenwesen, 1857, p. 12; Breithaupt, in Berg- u. hüttenm. Zeit., 1857, p. 1.

Rezbánya in Hungary, and Kuczaina in Servia, are principally found at the limits of the metamorphosed limestone.

It would occupy too much space to describe in detail all the contact-deposits of the Banat; the translator, therefore, refers those persons, desirous of more special information, to the Author's work on the same, which was published in Vienna in 1864, under the title 'Erzlagerstätten im Banat und Serbien'; and confines himself to extracts from the chief conclusions arrived at.

1. A zone of igneous rocks, 150—200 miles long, can be followed in a N.—S. direction through the whole of the Banat, and extending into Hungary, and Servia: they do not every where reach the present surface, but still in many places.

2. The separate localities, where they occur, appear to form the fillings of an uncompleted fissuring, and consequently to represent, in common, a broad igneous dike, whose separate portions are not connected at the level of the present surface.

3. These igneous rocks are certainly of more recent origin, than the Jura formation, and probably also than the Cretaceous deposits of this region: they have broken through, and frequently much metamorphosed the same in many places.

4. The nature of these igneous rocks, which I have comprised under the common name of Banatite, is very variable. They vary, in their composition, between syenite, diorite (timazite), minette, granitic porphyry, and feldstone; in their texture, between crystalline granular, porphyritic with granular or compact matrix, and almost entirely compact. In the amount of silicic acid they contain, they form a transition from distinctly basic to acidic igneous rocks, but only attain the level of gray gneiss.

Geologically all these various kinds of rocks belong together; they are only modifications of one igneous mass.

5. It appears in the Banat, as in many other localities; that the mineralogical, like the chemical composition, and the texture, of the igneous rocks, is very independent of the period of their origin; that many rocks might be contemporaneously formed from the same mass by peculiar subordinate circumstances, which are distinguished from one another by their texture, mixture, and chemical composition; while, on the other hand, almost entirely similar igneous rocks have been formed

at similar epochs. This is a point to which I have frequently called attention in my lithology.

6. It is not improbable, that the Banatites belong geologically to the variety of diorites, or greenstones, called by Breithaupt timazite, which occurs very widely extended in Servia, Transylvania, and Hungary. It is frequently accompanied by ore-deposits; and where it comes in contact with Tertiary deposits, generally traverses them.

7. These igneous rocks (Banatites) are generally, though not always, accompanied at their limits, especially where they traverse limestone, by striking contact-phenomena, which consist in changes in their condition of aggregation, or in the formation of certain minerals (garnet-rock): besides this they are accompanied by ore-deposits of irregular form, rich in sulphurets, magnetite, and their products of metamorphosis.

8. The character of these ore-deposits is in many respects a uniform one, but dissimilar ores and minerals predominate in different localities.

9. We must separate the contact-formations proper, consisting of mixtures of garnet, calc-spar, wollastonite, vesuvianite, and amphibole (which I call garnet-rock), from the ore-deposits, which are of more recent and other origin. The ore-deposits are subdivided into original (chiefly sulphurets), and products of decomposition and metamorphosis (limonite, calamine, etc.).

10. These three categories of deposits are evidently of very dissimilar, and not contemporaneous formation; still they pass into one another. The original ores are ramified in the true contact-formations. The regions of decomposition are not distinctly limited, but have penetrated to very variable depths, and have advanced unequally, with regard to the separate minerals. They are also not the result of a simple event, but the result of a metamorphosis, now more catogene, then more anogene,[1] extending over a long period.

11. Since the numerous minerals, which occur in these three kinds of deposits, all belong together geologically, I will

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[1] *Catogene* signifies the transmutations which have taken place in the interior of the earth with exclusion of the atmospheric air (for which definition Lyell's *hypogene* has really priority); *anogene* means the transmutations, which proceed from the exterior towards the interior under the influence of air and water. *Trans.*

comprise the minerals observed at the various localities together, arranged according to the threefold nature of the deposits, in order to give a general mineralogical and, to a certain degree, also chemical view of the composition of the same.

12. The true contact-deposits contain, as original minerals, that is, probably by the contact of the Banatites with the limestone:

1. Garnet;
2. Wollastonite;
3. Malacolith, as substitute for 2;
4. Tremolith, and asbestos;
5. Actinolith;
6. Vesuvianite;
7. Mica (green);
8. Calc-spar (frequently blue):

according to G. Leonhard, also hypersthene; and, as doubtful in regard to the manner of formation, analcime, apophyllite, and stilbite.

These minerals form irregular crystalline masses, which I have called garnet-rock; they are, probably, for the most part, the results of the combination of the lime in the limestone with the silicates of the Banatites, by melting under a high pressure, and subsequent very gradual cooling-off in enclosed places. These minerals contain the following chemical elements: silicium, calcium, magnesium, aluminium, iron, carbon, and oxygen.

With the preceding, occur as secondary penetrations, or products of metamorphosis, in the true contact-deposits; epidote, quartz, agalmatolith, steatite, serpentine, chlorite, szaibelyite, magnetite, pyrites, galena, blende, and their products of decomposition.

13. The ore-deposits, which were evidently deposited, after the Banatites had solidified, from solutions in accidentally existing cavities; or such as were excavated by the solutions themselves; contain, as probably belonging to their original condition:

Minerals of the Ore-Deposits.[1]	Rezbánya.	Mora-vicza.	Dog-nacska.	Oravicza.	Csiklova.	Szaszka.	Neu Moldova.	Kuczaina.	Maidan-pek.
Gold	+	—	+	+	—	—	—	—	—
Arsenic	—	—	—	+	—	—	—	—	—
(Bismuth)	—	—	(+)	—	—	—	—	—	—
Tetradymite	+	—	—	—	—	—	—	—	—
Bismuthine	+	—	+	+	—	—	—	—	—
Silver Glance	+	—	—	—	—	—	—	—	—
Galena	+	—	+	+	—	+	+	+	+
Stromeyerite	+	—	—	—	—	—	—	—	—
Copper Glance	+	—	+	+	—	+	+	—	—
Digenite	—	—	—	—	—	+	—	—	—
Molybdenite	—	—	—	+	—	+	—	—	—
Stibnite	—	—	+	+	—	—	—	—	—
Hessite	+	—	—	—	—	—	—	—	—
Erubescite	—	—	—	—	—	+	+	—	—
Copper Pyrites	+	+	+	+	+	+	+	—	+
Iron Pyrites	+	+	+	+	+	+	+	+	+
Pyrrhotine	—	—	+	(+)	—	—	+	—	—
Blende	+	—	+	+	—	—	+	+	—
Mispickel	—	—	—	+	+	—	—	—	—
Tetrahedrite	+	+	+	—	—	(+)	+	—	+
Rezbányite	+	—	—	—	—	—	—	—	—
Realgar	—	—	—	—	—	—	+	—	—
Orpiment	—	—	—	—	—	—	+	—	—
Glaucodote	—	—	—	+	—	—	—	—	—
Copper Nickel	—	—	—	+	—	—	—	—	—
Magnetite	+	+	+	(+)	—	(+)	(+)	—	+
Hematite	—	+	+	(+)	—	(+)	(+)	—	+
Psilomelane	—	—	—	—	—	+	—	—	—
Pyrolusite	—	+	—	—	—	—	(+)	—	—
Quartz	+	+	+	+	+	+	+	+	+
Calc-spar	+	+	+	+	+	+	+	+	+
Dolomite	+	—	—	—	—	—	—	—	—
Spathic Iron	+	—	—	—	—	—	—	—	—
Heavy Spar	—	—	+	—	—	—	—	—	—
Fluor Spar	—	—	—	—	—	+	+	—	—
(Orthoclase)	—	—	—	(+)	—	—	—	—	—

The mixture of these minerals is very irregular: generally one or two, of those printed in coarser type, locally predominate, and determine the technical character of the deposits. The following, are the essential chemical elements they contain:

1. Iron, } predominant;
2. Copper, }
3. Lead, }
4. Zinc, }
5. Arsenic;
6. Silver;
7. Gold;
8. Bismuth;
9. Cobalt;
10. Nickel;
11. Tellurium;
12. Manganese;
13. Antimony;
14. Molybdenum;
15. Sulphur (considerable);
16. Selenium (traces);

[1] A + denotes the presence, a — the absence of the mineral; when in parenthesis, it signifies, only mentioned in Schröckenstein's manuscript.

17. Carbon;
18. Oxygen;
19. Hydrogen;
20. Silicium;
21. Calcium;
22. Magnesium;
23. Barium;
24. Fluorine:

Consequently, about one third of the elements known to exist. In those portions of the ore-deposits, where decomposition had taken place, were found:

Minerals in the Regions of Decomposition of the Ore-Deposits.	Rezbánya.	Moravicza	Dognacska.	Oravicza.	Csiklova.	Szaszka.	Neu Moldova.	Kuczaina.	Maidanpek.
Silver	+	—	—	+	—	—	—	—	—
Copper	+	—	+	+	—	+	+	—	—
Tile Ore	+	—	—	+	—	—	—	—	—
Red Copper	—	—	+	—	—	+	+	—	—
Covelline	—	—	—	—	—	—	—	—	+
Hematite	+	—	+	—	—	—	—	—	—
Limonite	+	+	+	+	+	+	+	+	+
Melaconite	+	—	+	—	—	—	+	—	+
Minium	+	—	—	—	—	—	—	—	—
Bismuth Ochre	+	—	—	—	—	—	—	—	—
Psilomelane	—	—	—	—	—	+	—	—	—
Pyrolusite	—	—	+	—	—	—	—	—	—
Wad	—	—	+	—	—	—	—	—	—
Quartz	+	—	+	+	+	—	—	—	—
(Chalcedony)	—	—	(+)	(+)	—	—	(+)	—	—
Bole	+	—	(+)	—	—	—	—	—	—
Calamine	+	—	+	+	+	(+)	—	+	—
Chrysocolla	+	—	—	+	—	+	+	—	—
Opal	+	—	+	—	—	—	—	—	—
Calc-spar	+	—	+	+	+	+	+	—	—
Aragonite	+	—	(+)	—	—	—	+	—	—
Smithsonite	+	—	+	—	—	—	—	+	—
Cerusite	+	—	+	—	—	+	+	—	—
Malachite	+	—	+	+	—	+	+	—	+
Azurite	+	—	+	+	—	+	+	—	—
(Plumbic Ochre)	—	—	(+)	—	—	—	—	—	—
Buratite	+	—	—	—	—	—	—	—	—
Wulfenite	+	—	—	—	—	+	—	—	—
Crocoite	+	—	—	—	—	—	—	—	—
Pyromorphite	+	—	+	+	—	—	—	—	—
Thrombolith	+	—	—	—	—	—	—	—	—
Phosphorchalcite	+	—	—	—	—	—	—	—	—
Tyrolite	+	—	—	—	—	—	—	—	—
Gypsum	+	—	—	—	—	+	+	—	—
Brochantite	+	—	—	—	—	—	+	—	—
Cyanosite	+	—	(+)	—	—	(+)	+	—	+
Copperas	—	—	—	—	—	—	+	—	+
Goslarite	—	—	—	—	—	—	+	+	—
Linarite	+	—	—	—	—	—	—	—	—
Caledonite	+	—	—	—	—	—	—	—	—
Leadhillite	+	—	—	—	—	—	—	—	—
Anglesite	+	+	—	—	—	—	—	—	—
Allophane	—	—	+	—	—	—	+	—	—
Lettsomite	+	—	—	+	—	+	+	—	—
Erythrine	—	—	—	+	—	—	—	—	—

Minerals in the Regions of Decomposition of the Ore-Deposits.	Rezbánya.	Moravicza.	Dognacska.	Oravicza.	Csiklova.	Szaszka.	Neu Moldova.	Kuczaina.	Maidanpek.
Marcasite	—	—	+	—	—	—	—	—	—
Kaolin	—	—	—	—	—	—	+	—	—
(Talc)	—	—	(+)	—	—	—	—	—	—
Lithomarge	—	—	—	—	—	+	—	—	—
Steatite	—	—	—	—	—	+	—	—	—
Chlorite	—	—	+	—	—	—	—	—	—
Epidote	+	—	—	+	—	+	—	—	—
Apophyllite	—	—	(+)	—	—	+	—	—	—
Chabazite	—	—	—	—	—	+	—	—	—
Stilbite	—	—	—	(+)	—	+	—	—	—
(Analcime)	—	—	—	—	—	—	(+)	—	—

These minerals contain, in agreement with the original ore-deposits, the following chemical elements:

1. Iron;
2. Copper;
3. Lead;
4. Zinc;
5. Silver;
6. Arsenic;
7. Bismuth;
8. Cobalt;
9. Manganese;
10. Molybdenum;
11. Sulphur (much less);
12. Carbon;
13. Oxygen (more);
14. Hydrogen (more);
15. Silicium;
16. Calcium;
17. Magnesium.

From this it appears, that gold, tellurium, selenium, nickel, barium, and fluorine, are wanting.

To these have been added:

18. Aluminium;
19. Strontium (in aragonite?);
20. Chromium;
21. Chlorine;
22. Phosphorus:

which were probably, in part, concealed in the original minerals, or in the country-rock.

14. All these ore-deposits occur, in irregular forms, on the borders, or at least near the limits, of the igneous rocks; in great part in the limestone, but also at the contact of the limestone and mica-schist. Impregnations are frequently combined with these. Regular beds and lodes are entirely wanting.

15. The irregular form was here, also, evidently caused by the predominance of peculiar circumstances. These were probably: first, irregular cavities and fissures, which were formed by mechanical forces at the period the Banatites broke through; secondly, local dissolutions and excavation of the limestone, by the same solutions from which the ores were deposited; and

thirdly, subsequent upheavals and subsidences, by which breccias were formed.

16. The solutions (in their underground courses, probably warm mineral springs) may have been subsequent effects of the same plutonic action, by which the Banatites were forced to the surface.

17. The commencement of their formation can, at the earliest, have been during the Cretaceous Period; their completion, probably, took a long period of time, and during this the alterations and decompositions had already begun in many places, from which it becomes difficult to sharply separate the original minerals from those formed by alteration.

So much the more difficult is it, when, during the period of formation, changes of level, overlyings, and erosions, continued in such a manner, that the same region was subjected, now to catogene, then to anogene transmutations; as Peters has shown to have been probably the case at Rezbánya.

18. The geological connection of all these deposits, in a zone over 150 miles long, is not without practical importance. It may be supposed from this, that the intervals, between the ore-districts of the Banat already discovered, also contain ore-deposits at some depth, and in all probability less altered, predominantly composed of sulphurets. Whether they are attainable for mining purposes is a question, that can only be answered by practical experience in the various cases.

19. The characteristics of these ore-deposits may be concisely described as follows:

a. Form: irregular (segregations and impregnations), neither beds nor veins;

b. Contents: sulphurets predominate, combined with quartz and calc-spar; heavy spar and fluor spar are very rare; near the surface numerous products of decomposition;

c. Occurrence: at the contact of dissimilar rocks, especially of the limestone;

d. Predominant direction: North-South;

e. Age: Cretaceous or Eocene Period.

20. The ore-deposits, here described, agree in their geological occurrence, their form and composition, most nearly with those of Bogoslowsk in the Urals; somewhat less exactly with those of Schwarzenberg in the Saxon Erzgebirge, Rochlitz in Bohemia, Offenbánya in Transylvania, Chessy near Lyons, Rio-

Tinto in Spain, the Apuanian Alps, Christiania in Norway, and Tunaberg in Sweden. These may properly all be considered as forming a class of contact-deposits.

XVI. HUNGARY.

GEOLOGICAL FORMATION.

§ 172. Hungary forms a large basin surrounded, to the East, North, and West, by the Carpathian Mountains, and to the South by spurs of the Alps. It is composed of the Neurader Mountains, and the Bakony Forest; and is divided by a range of heights, whose axis is from NE. to SW. into two unequal portions; the larger of these is the great Theis-basin, the smaller, the basin of Comorn. The flat bottom of both these basins, only slightly undulating towards the edges, consists of recent, Diluvial, and Tertiary strata, without ore-deposits. Numerous ones, on the contrary, are found in the northern mountainous portion, united to the North Carpathians, which has a very varied composition, consisting of crystalline schists, silurian strata, granites, greenstones, porphyries, trachytic and basaltic rocks: an unequally greater variety, than is shown by the principal chain of the Carpathians, of which this is a spur. We have already become acquainted with the Eastern edge of the basin, as belonging to Transylvania, and the Banat. The mountains rising southerly of both the basins, consist in great part of sedimentary limestones, without igneous rocks; they have only been very slightly examined, but appear to contain but few ore-deposits.

SCHEMNITZ.[1]

§ 173. The mining town of Schemnitz, which lies in the upper portion of the valley of the same name, is surrounded by

[1] See: Cotta, Erzlagerstätten in Ungarn und Siebenbürg. p 28; Breithaupt, in Berg- u. hüttenm. Zeit. 1861, p. 51; Faller, in Berg- u. Hüttenm. Jahrb. d. k. k. Schemnitzer Bergakademie, vol. VIII p. 1;

tolerably high mountains. These mountains consist of a crystalline rock, which is commonly called greenstone, and has in fact much in common with the greenstones of other regions. The Schemnitz greenstone passes, towards the North and South, so gradually into a trachytic rock containing hornblende, that a sharp line cannot be drawn between the two. On this account the Schemnitz rock is generally called a trachytic greenstone, or a trachyte resembling greenstone. This occurs repeatedly in Hungary, and Transylvania: we shall become better acquainted with similar rocks near Nagybánya, Felsöbánya, and Kapnik; at those places, as at Schemnitz, and Kremnitz, traversed by gold-veins.

Breithaupt has rather lately discovered, that the Hungarian greenstone, that of Schemnitz also, generally contains, instead of the common hornblende, a new species of black amphibole, which he has called gamsigradite, from the locality where first discovered (Gamsigrad in Servia). This hornblende occurs intimately combined with a feldspar, probably labradorite or albite; somewhat of mica, magnetite, and iron pyrites, occur as subordinate minerals. He called the rock Timazite, from the Roman name for Gamsigrad (*Timacum minus*). This timazite must be joined to the diabase, diorite, hyperite, and gabbro, which are collectively called greenstones, and whose compact varieties are generally called aphanite and melophyre. Baron Richthofen thinks, that all the more recent igneous rocks of Hungary can be most suitably divided into three groups: viz.

1. Trachytes resembling greenstone, corresponding to Breithaupt's timazite;

2. Basic trachytes, or trachytes proper, frequently containing oligoclase in place of sanidine;

3. Trachytic porphyries, containing the most silicic acid; and, according to Richthofen, the most recent of these rocks.

These distinctly crystalline greenstones, or timazites, of Schemnitz are bounded to the Southeast, according to von Pettko's map and description, by greenstone- and trachyte-tufa

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and Oesterreich. Zeitschr. f. Berg- u. Hüttenw. 1861, p. 5; Richthofen, in Jahrb. d. geol. Reichsanst. vol. X. p. 67; Pettko, in Abhandlungen d. geologisch. Reichsanst. 1853, vol. II. No. 1; Hauer and Fötterle, Uebersicht d. Bergbaue, p. 53; Rivot, and Duchanoy, in Annales des mines, 1853, vol. III. p. 68.

deposits, which contain, near Ribnik and Steplitzhof, imprints of the leaves of Dicotyledons, as well as traces of lignite; while near Eisenbach they overlie a limestone-conglomerate containing nummulites; consequently they must be more recent than the Eocene. Since the greenstones are most intimately combined with their tufa-deposits, and both are very probably of contemporaneous origin; while, also, the Schemnitz lodes traverse the greenstone (timazite); it follows, that these lodes must also be of more recent age than the Eocene. This result is more completely confirmed by the lodes at Felsöbánya, Kapnik, and Nagyág; where like greenstones, traversed by the lodes, have evidently burst through the Eocene series; near Olahlaposbánya, where a broad lode traverses Eocene sandstone; and at Vöröspatak, where a portion of the gold-veins also occurs in Eocene sandstone. All these lodes, of Hungary and Transylvania, appear therefore to belong to the Tertiary Period, and Miocene Epoch.

At Schemnitz the trachytic greenstone overlies a district consisting of granite, syenite, and gneiss; and surrounds it on nearly every side, like a ring, while it is surrounded and overlaid in turn by trachyte. The central granite-region is traversed by the Hodritsch lodes. In addition to these, sedimentary limestones, and slates, of probable Triassic age, occur in the neighborhood of Schemnitz, as well as trachytic porphyry, pumice, and tripoli; which do not come in contact with the lodes. A few caps of basalt occur scattered through the region.

Two groups of lodes occur in the Schemnitz district: viz.

1. at Schemnitz, in greenstone (timazite);
2. at Hodritsch, in gneiss—granite—syenite.

The Schemnitz lodes all strike almost parallel to one another, SW.—NE., and, with but a single exception, dip toward SE. The Hodritsch lodes have no such constancy of strike and dip.

The Schemnitz lodes are mostly quite broad, attaining in some places a breadth of 20 fathoms. When of such considerable breadth, they principally consist of more or less decomposed wall-rock, or, more correctly expressed, of a series of fissures and branches, between which the country-rock is often changed into a soft, even claylike, mass. But the separate leaders of the lodes, consisting of gangstones and ores, also, often attain a considerable breadth, being occasionally over a fathom broad. The decomposed rock between the related fissures, which are considered as forming a lode, is frequently so impregnated with ores, that it can be worked in the stamping-mills; thus justifying its being considered a portion of the vein. The matrix of the separate champion-lodes is not always the same, but in all of them the predominating vein-stone is quartz in its various forms; while the ores are principally silver glance, galena, and pyrites.

The separate lodes, following them from SE. to NW. are the following: I have filled out my personal observations with Faller's concise description.

The Grüner lode strikes NE.—SW., dips 80° in SE. and is 6 fathoms broad. Its matrix is principally an adhesive white clay, which probably originated from decomposed country-rock, and quartz. Both frequently have iron pyrites disseminated through them, which probably contain somewhat of gold. This matrix is penetrated by irregular threads of quartz, containing iron pyrites, silver glance, argentiferous galena, and somewhat of ruby silver. Fragments of the country-rock are occasionally found, surrounded by crystalline quartz; which contains, at slight distances from the fragment, and parallel to its general contour, small ribbons of ore, or impregnations, having the appearance of ring-ores. The same quartz frequently fills the smaller cracks in the fragments, and cements them together. In other places, the very irregularly distributed quartz contains silver glance, galena, and pyrites, unequally divided through it. These ore-strikes form chimneys, which are nearly perpendicular. The Grüner lode is accompanied by four small veins, which in part intersect and fault it. The same passes southwesterly, out of the greenstone, into a Tertiary coal-deposit; where, being barren, it has not been followed for any distance.

Faller has recently described an interesting occurrence of quartz-pebbles in this lode. They appear to occupy a very confined portion, from the surface to a depth of at least 155 fathoms, attain a diameter of 4 inches, and consist of quartz; in which, remarkably enough, traces of galena and blende occur. These ores are foreign to the Grüner lode, but occur in the Spitaler and Theresia veins, which crop out to the surface higher up the mountain sides. From which it appears, as if the pebbles came from a partial erosion of these veins, and have been washed from the surface into open portions of the fissures in the Grüner lode. If this be true, great changes, in the contour of the surface, must have taken place since the formation of the lodes; and the present outcroppings cannot be the original ones.

The Stephan lode, lies 150 fathoms northwesterly of the last, strikes nearly parallel to it, and is almost perpendicular. It contains clay and quartz, in which occur: polybasite, silver glance, silver, and argentiferous iron pyrites; which last has at times impregnated the country to a considerable extent.

The Johann lode is like the preceding, and contains: amethyst, calc-spar, brown spar, dialogite, polybasite, and somewhat of galena. Its mass frequently contains geodes. The galena is said to encrease towards the Southwest.

The Spitaler lode, strikes nearly parallel to the preceding lodes, but dips only 45° at the surface, at a greater depth 70° in SE. It is known to extend a distance of $4^1/_2$ miles. It attains a breadth of 18 fathoms. Within this considerable length its matrix does not remain constant. To the Northwest, reddish quartz, hornstone, amethyst, and auriferous (so-called) Zinopel, with galena, blende, iron and copper pyrites, predominate; which frequently enclose decomposed fragments of the country-rock. To the Southwest the matrix is more argillaceous, containing auriferous silver-ores. It is stated, that the quantity of gold decreases, while that of galena encreases, with the depth.

It appears, that the gold chiefly occurs in the so-called Zinopel; which is a brownish-red mass consisting principally of silicic acid and peroxide of iron, and deserves a more exact chemical examination. According to the accounts of some of the mining officials, a green auriferous substance frequently accompanies the Zinopel. Cinnabar occurs, as a rarity, in pyritous quartz. A peculiar fibrous, yellow alum has been found in the amygdaloidal cavities of the greenstone impregnated with ores.

The Theresia lode occurs in the highest mountain-ridge of the greenstone, where its outcrop is distinctly seen in old quarries. It courses parallel to the other veins, and dips 75°–90° partly in SE., partly towards NW. The lode attains a breadth of 3 fathoms, but forks and branches off. Its matrix appears to be quartzose, and frequently brecciated.

In the upper workings its three leaders, especially the foot-leader, contain auriferous stamping ore, and rich silver-ores, combined with dialogite, and quartz; these decrease with the depth, and the amount of lead-ores encrease. Beautiful ring-ores occur, whose kernel consists of galena, with somewhat of pyrites; this is surrounded by a thin drusy crust of quartz, over which follows a thin pyritous layer of Zinopel, and lastly radiated quartz. More recent cross-fissures, which traverse the quartzose vein-breccia, show, at times, a symmetrical arrangement of the layers; as outer layer, a white crystalline band of quartz, on this Zinopel with pyrites, then again white quartz, again Zinopel with pyrites, each of these layers only a line thick, and then, in the middle, crystallized white quartz with considerable iron pyrites, the last, occasionally, in pentagonal dodecahedrons. Crystallized, columnar brown spar, and dialogite, occur in the quartz geodes of the lode.

I omit here the Hodritsch lodes; as they are neither remarkable, nor interesting.

It is striking, that the Schemnitz lodes are barren; and, probably, do not perceptibly extend into the rock, that surrounds the greenstone, and which is called trachyte, although no sharp line between it and the greenstone can be drawn.

KREMNITZ.

§ 174. At Kremnitz[1] there occurs one champion-lode, 30—90 feet broad, which occurs in greenstone (timazite) surrounded by trachyte, in three leaders, besides numerous smaller branches. The matrix of the lodes consists of decomposed greenstone, and quartz; in which are disseminated, native gold, silver-ores, iron pyrites and stibnite; while the same ores have often impregnated the country-rock to such an extent, that it can be profitably extracted; the greenstones being often especially rich in gold between two fissures. Brown spar and heavy spar are, at times, found with the ores, and the crystals of stibnite are very rarely, encrusted with chalcedony.

HERRENGRUND.

§ 175. Herrengrund[2] lies in a deep ravine of the high mountain-chain, separating the district of Leptau from that of Sohler, and which reaches its highest point at Gumbir, with a

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[1] See: Hingenau's Zeitschr. f. Berg- und Hüttenwesen, 1856, p. 209; Hauer and Fötterle, Uebers. d. Bergbaue, p. 55.

[2] See: Cotta, Erzlagerstätten in Ungarn u. Siebenbürg. p. 41.

height of 6000 feet above the sea. The central axis of this chain consists, from Gumbir to Herrengrund, of Granite; at the last named place it is surrounded and covered by gneiss, mica-schist, and clay-slate; which last much resembles the Silurian slate, and, also, alternates with strata of sandstone and conglomerate. The geological age of this has not yet been determined, no fossils having been found in it. The red, and partly sandy, strata, which immediately overlie this, are also undetermined, they have been compared to the *Rothliegendes*, and, also, the *Buntsandstein*; they could not well belong to a more recent period, as limestones overlie them, which have been recognised as belonging to the Triassic. The strata of all these rocks are somewhat, though but slightly, tilted; and their strike and dip appear to be very variable.

The ores are principally found in the clay-slate, although they also occur in the gneiss and talcose mica-schist combined with it. They form deposits, containing tetrahedrite and pyrites, of indefinite form, in part decidedly veinlike, in part bedlike with veinlike branches, in part flat lenticular masses, soon wedging-out. Their distribution, and mineral composition, are almost as irregular as their form. It can only be stated, that a certain zone, in the partly crystalline, partly sedimentary slates and schists, contains ore-deposits of unlike form and composition, in which tetrahedrite is the most important ore. These deposits do not appear to extend into the red sandstones and slates, but appear to be cut off by these; which would indicate a great age. The irregularity, in the occurrence of these deposits, renders their exploitation quite difficult. Quartz is the principal gang, associated with which are occasionally; gypsum, spathic iron, calc-spar and heavy spar. The principal ores are tetrahedrite, and copper pyrites; with which are found: native copper, erythrine, liroconite, tyrolite, iron pyrites, sulphur, malachite, azurite, chrysocolla, copperas, cyanosite, aragonite, coelestine, epsomite, and steatite.

MAGURKA.

§ 176. On the northerly slope of the granite-chain of the Gumbir lies the mining village of Magurka,[1] about 2500 feet

[1] See: Cotta, Erzlagerstätten in Ungarn u. Siebenbürg. p. 45.

above the sea. The granite is here, where it occurs normal, composed of orthoclase, quartz, and dark-colored mica; on the joints of which epidote is often found. It is intersected by an auriferous antimony-lode. Near this lode, which has been opened-up at several levels by an adit, the normal lode is altered in a very remarkable manner. Reddish or greenish quartz is irregularly mingled with feldspar and a greenish-yellow, talcose, waxlike mineral. Mica occurs in it but scantily, and irregularly distributed; and is not the dark-brown variety, as in the fresh rock, but silver-white. That this change in the texture, as well as the mass of the rock, has been caused by the formation of the lode; appears probable from the fact, that pyrites and traces of antimony-ore are found in the altered rock, both of which seem to be the result of impregnation. To how great a distance in the rock this impregnation has continued, cannot be determined; but it appears to extend for a very considerable distance. The vein of antimony is frequently interrupted in its course by faults, which have at the same time altered its direction. Four chief faults, and several smaller ones, are known, by which the vein is divided into five parts. Its breadth varies, between a few inches and several feet. The matrix of the lode consists of stibnite, and quartz, with horses of granite. Combined with these is a finely distributed argentiferous gold; also, iron pyrites, yellow blende, brown spar, and fine threads of argentiferous galena; the last, chiefly in the country-rock. In the richest point, thus far reached, almost pure stibnite was found over a fathom broad; but this breadth of pure ore soon decreases; and it is mingled with much ore and country-rock, or the fissure becomes narrower. This is the finest known example in Europe of the occurrence of antimony-ores in lodes.

DOBSCHAU.

§ 177. It was formerly supposed, that all the ore-deposits around Dobschau[1] were formerly closely connected with the gabbro occurring there. This does not appear to be the case with all, but certainly is so with the ore-deposits containing nickel and cobalt. The surrounding country is composed of clay-slate and mica-schist, through which protrudes a small

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[1] See: Cotta, Erzlagerstätten in Ungarn und Siebenbürg. p. 48.

mass of greenstone, alongside of which is somewhat of garnetiferous serpentine. I only saw the greenstone in a compact condition; but, according to Kiss, it consists of a mixture of labradorite and dialoge, which last is mostly altered to chlorite. Somewhat of mica, quartz, and iron pyrites, occasionally disseminated in its mass, which is repeatedly traversed by veins of ankerite, and calc-spar, at times containing copper pyrites. Kiss has determined the rock to be gabbro. The same is traversed, northwardly of Dobschau, by several lodes, distinguished by their containing cobalt and nickel; and is overlaid by broad masses of spathic iron; whose lower portions, also, contain cobalt and nickel ores. Huss, with whose description my own observations agree, has divided the deposits into three classes. He distinguishes:

1. a champion-lode, striking E.—W., with numerous parallel leaders, near the junction of the gabbro and clay-slate;

2. several lodes, dipping in N., at the southern limits of the gabbro, near the clay-slate; principally containing nickel ores with calc-spar and spathic iron, but only attaining a slight breadth;

3. a thick deposit of spathic iron, with ankerite, lying on the gabbro; and containing, near its contact with the last, cobalt and nickel ores, with calc-spar and quartz.

This spathic iron is exploited by means of large quarries, and attains the immense thickness of 18 fathoms. It appears, that this somewhat irregular, perhaps lenticular, bed-mass shoots-in, towards the South, under the clay-slate, and that its proper position is between the gabbro and clay-slate; but this bedded relation has, in no place, been distinctly opened to view.

Since the lodes, also, contain spathic iron, and ankerite, in addition to the ores; the following conclusion may be drawn: viz. that the metalliferous solutions have penetrated through the fissures from below to the level of the irregular bed; from which the cobalt and nickel ores were principally deposited in the fissures; the spathic iron, on the contrary, principally over them. It will remain a difficult question to decide, whether the openings, through which the solutions poured out, were at the surface, or between the gabbro and clay-slate.

I became acquainted with the veinlike occurrence only in the Zenberg mine. The champion-lode varies in breadth from a few inches to one fathom; in the last case, principally consisting of horses, which are traversed and cemented together by parallel threads of ore. These threads extend into the wall-rock for a distance of 20 fathoms. The principal ore they contain is a compact mixture of nickel and cobalt ore (containing 4—14 per cent cobalt, and 4—16 per cent nickel); besides which, in separate leaders, tetrahedrite combined with spathic iron. Besides these are found (many as rarities): copper pyrites, erubescite, red copper, gersdorffite (dobschauite), copper nickel, mispickel, native copper, erythrine, annabergite, malachite, azurite, vivianite, and chrysocolla. Curiously enough, heavy spar has never been observed.

SCHMOELLNITZ.

§ 178. Schmöllnitz[1] lies in a deep valley. The mountains consist of clay-slate passing into mica-schist, in which quartz is here and there embedded. These rocks strike E.—W. and dip 60°—80° in S. They contain, eastwardly of the town, (in a belt, 182 fathoms broad, of gray clay-slate embedded in a black variety,) iron pyrites with copper pyrites; partly in bedlike impregnations, partly in lenticular segregations, which have been opened in the direction of strike for 2400 fathoms. There are three chief segregations, of lenticular shape, which gradually wedge-out in the direction both of strike and dip. They consist of a massive pyrites, so finely granular, that it is impossible to distinguish the iron from the copper pyrites. Even in these solid masses a parallelism of the more or less pure layers can be recognised, corresponding to the general strike. These segregations are accompanied by shales, more or less impregnated with pyrites. Two principal zones of impregnation are known, one of which connects two of the segregations. These considerably impregnated zones attain a greater depth than the segregations; but pass, without any sharply defined limits, into the common, less impregnated, gray slate. So that the whole may be designated, as a pyritous deposit, in which the pyrites are unequally distributed, at times forming an extremely fine granular mixture, at times somewhat more distinctly crystallized; so that the iron and copper pyrites can be distinguished, and somewhat separated, at times in considerable quantities, at times much scattered through the mass.

[1] See: Cotta, Erzlagerstätten in Ungarn u. Siebenbürg. p. 53.

Near the outcrops the pyrites are partly altered to limonite, while erubescite and native copper also occur. In the eastern portion of the zone traces of galena, blende, and cobalt ores, have been discovered.

The pyritous segregations of Schmöllnitz have a great similarity with those of the Rammelsberg in the Hartz, and Agordo in the southern slope of the Alps: also a certain resemblance to those of Rio-Tinto in Spain, and Fahlun in Sweden, cannot be denied; while, on the contrary, the deposits of Borsabánya in the North Carpathians, of Poschorita and Domokos, form more regular beds. It is very difficult to explain satisfactorily the origin of such wide local accumulations of pyrites. The continuation of traces of the cleavage, even through the most compact masses of pyrites of the three segregations at Schmöllnitz, would argue in favor of contemporaneous deposit, or subsequent impregnation. At least the supposition would be excluded, that irregular fissures, or hollows, could have been filled with pyrites. Whence came the quantity of mineral matter forming the sulphurets, during or subsequent to the deposit of the rock? How could this matter, in the one case remain unchanged during the subsequent alteration of the rock; or, in the other, find a channel and cause for such massive impregnations? These are questions, I will not attempt to answer.

NAGYBANYA, FELSOEBANYA, KAPNIK, AND OLAHLAPOSBANYA.

§ 179. In the eastern corner of the Szathmar District,[1] and the northernmost extremity of Transylvania, where both join the Marmaros, rises a magnificent mountain-district of trachyte, for the most part luxuriantly wooded. The trachytic rocks, like those of Hungary in general, are of the most various kinds. Nearly the same varieties occur, similarly combined with one another, as around Schemnitz; viz. trachytic greenstones (timazites), trachytes and trachytic porphyries. All these igneous rocks have burst through Tertiary formations, in which sandstones and argillaceous shales predominate, and according to the

[1] See: Cotta, Erzlagerstätten in Ungarn u. Siebenbürg. p. 56.

geological examination of the Viennese Reichsanstalt, belong to the Eocene Period. Beneath these, and at a greater distance from the mountains, Cretaceous strata crop-out, which have not yet been observed in the district of the ore-deposits. The ore-deposits, chiefly distinct lodes, occur almost entirely in the timazite, having but rarely been observed in the trachytes or Tertiary sandstones. From their occurrence in igneous rocks, which have broken through Tertiary strata, and even, exceptionally, between Eocene sandstones and argillaceous shales; it is certain, that they were formed subsequently to the Eocene epoch. In all these relations, they completely resemble the Schemnitz lodes, and their mineralogical composition shows much similarity with these.

I comprise together a large number of single lodes or groups, which occur in the neighborhood of Nagybánya, Felsöbánya, Kapnik, and Olahlaposbánya; though great differences between them may be recognised; because they belong to a common geological district, occur under nearly like circumstances, and appear to have been formed at about the same time. Quartz is common to them all, as predominating gang, in the form of veins, often very crystalline; it traverses the older members of the lodes in various directions, from which a repeated formation of quartz must be concluded.

Nagybánya. This mining village lies at the base of the luxuriantly wooded Kegel Mountain, which rises precipitously 7—800 feet above the surrounding country. The plains, and slightly advanced hills, consist of drift and fragments of Eocene deposits. The dome of timazite rises out of these, and is traversed by lodes. The rock is generally so much decomposed, that fragments are but seldom found, whose nature can be determined. The Kreuzberg lode traverses the mountain of the same name, from its crest to its base, and must continue to a considerable distance beneath. The matrix of the lode is principally quartz; in which the chief ores are: auriferous iron pyrites, somewhat perceptible native gold, and some silver ores. Its immediate wall-rock is a very much decomposed, white, felsitic mass, impregnated with iron pyrites; and appears to be a much altered condition of the timazite. Southerly of this occurs the Evangelist lode; whose veinstones are quartz, amethyst and hornstone, partly with cellular or drusy, partly with banded texture. This lode is more auriferous than the last, but free gold is rare.

The finest fragment I saw, was from a lode at Vivisa, somewhat to the North of Nagybánya. The following was the order of occurrence;

1. wall-rock;
2. quartz;
3. brown spar;
4. iron pyrites;
5. mixture of quartz and calc-spar.
6. impregnation of gold, in the middle of preceding;
7. mixture of quartz and calc-spar;
8. iron pyrites;
9. brown spar;
10. quartz; and
11. wall rock.

The arrangement is very symmetrical, but the central quartz appears pure only on one side, being intimately combined with calc-spar on the other. In addition to those already mentioned, the following minerals have been found at Nagybánya; ruby silver, tetrahedrite, stephanite, silver glance, galena, native silver, blende, copper pyrites, realgar, orpiment, native arsenic, stibnite, and marcasite.

Felsöbánya. But one lode is here exploited, which is traversed by numerous others. This lode entirely traverses a mountain, which it cuts through from East to West: it is of great breadth, and dips steeply in N. The breadth of the lode is very variable; it encreases from a few inches to 12 fathoms. Not only the breadth, but the mineral matter filling the vein, is extremely variable. Even the quartz, hornstone, and heavy spar, forming the chief veinstones, are most unequally distributed. Veins of crystallized quartz, or amethyst, only $^1/_2$ to 2 inches broad, traverse the lode, and the horses in the same, partly parallel to one another, partly in undetermined directions. This younger vein-formation, within an older, is very common in this district. The ores are still more unequally distributed, than the lodes. It is asserted, that the rich silver-ores are principally collected near the surface, and auriferous pyrites are characteristic of greater depths; but this distribution is not found to be constantly the case. The richest mass, I saw, when visiting the mine in Sept. 1860, was a place, three feet broad, consisting of almost pure galena, with but little pyrites, in the lowest working. The coarse granular contains here but 100 grammes in 100 kilogrammes, the fine granular in other places up to 265 grammes.

It is extremely difficult to more exactly characterize the motley mixture of cellular quartz, hornstone, banded or brecciated heavy spar, large fragments of wall-rock, large geodes, galena, blende, and various kinds of pyrites; with here and there stibnite, heteromorphite, valentinite, bournonite, realgar, orpiment, ruby silver, polybasite, native gold, silver, arsenic, miargyrite (kenngottite), freieslebenite, felsobanyite, kermesite, wad, pyrolusite, sulphur, anthracite, etc. One is inclined to say, that all lies topsy turvey, while frequently fragments of the country-rock, or some of the older portions of the lode, are radially surrounded by more recent. The quartz-veins alone, traversing the whole, have a constant character. The lode traverses a considerable mass of schist enclosed in the greenstone, in which it appears particularly to lose its breadth and ores. It is accompanied by numerous side-branches, which have been chiefly observed near the surface.

Both this, and the Kreuzberg lode at Nagybánya, traverse, as we have seen, mountains, 6—700 feet high, from the crest to the base. This fact appears to me especially important, as the mountains consist of a, relatively, recent Tertiary igneous rock. With fissures averaging so considerable a breadth, it appears impossible to assume, that the same can have been filled by solutions; since the mountain-cones stood free, and, consequently, the fissures were open at the sides. The matrix must, therefore, have been deposited at a time, when the mountains still formed a coherent plateau, not yet intersected by valleys, or they were surrounded on all sides by Tertiary strata. The formation of the valleys, or the laying free of the peaks, appears to have here taken place at a more recent date, than the filling of the fissures.

Kapnik. In this district the only fact worth noticing is, that the outer members of the metalliferous belt contain galena, and are auriferous; while the central lodes contain galena, and but little gold. They have been formed by a repeated tearing-open and filling of the fissures. The vein-stones are: quartz, calc-spar, dialogite, and heavy spar; associated with which are the following ores; tetrahedrite, galena, copper pyrites, gold, silver, silver glance, ruby silver, stephanite, polybasite, and copper glance. The following minerals have also been found: blende, iron pyrites, stibnite, bournonite, dyscrasite, realgar, orpiment, arsenic, pyromorphite, kermesite, smithsonite, hornstone, amethyst, fluor spar, gypsum, anhydrite, sulphur, and talc.

Olahlaposbánya. This small village lies in the extreme northwestern corner of Transylvania, where it borders on Hungary and the Marmaros. Near it can be seen, in a steep ravine, a reiterated alternating bedding of clay, shale, and sandstone; all frequently so firmly united, that it is easy to knock off hand-specimens consisting of several layers joined together. These very irregular strata contain subordinate deposits of magnesian limestone, and a variety of greenstone, which last, as igneous rock, must have penetrated between them; according to the Viennese geologists, they all belong to the lower Tertiary deposits of the region.

A few steps northwardly of the greenstone, occurs a broad lode, the Vorsehung-Gottes, in sandstone: it is accompanied by numerous subordinate quartzose veins, and, at times, even traversed by them: it appears to have been formerly exploited by means of quarries. The lode courses E.—W., parallel to the strata of sandstone, and dips like these in N., but at a much greater angle. Its breadth is, occasionally, as much as 6—8 fathoms, but it then contains numerous horses. The vein-stones are principally hornstone and quartz, also somewhat of heavy spar, in which are found various kinds of pyrites. Among the last, copper pyrites is the most important, often occurring of great breadth, and entirely compact. The same is locally mixed with considerable galena, and this is also found alternating in bands with the copper pyrites and heavy spar, or spathic iron. It has been stated, that the ores occur more in the foot-wall of the lode, but the ore is very irregularly distributed. Large geodes occur in the matrix, in one of which, 14 feet long and $9^1/_2$ feet broad, massive aggregations of stalactitic iron-pyrites were found. It is stated, that where the vein enters the predominating slates, it decreases in breadth and contents.

The sandstone of the country-rock is often much changed in color, and is, in places, penetrated by iron pyrites, which form small crystalline grains. The sandstone is traversed, principally in the foot-wall of the lode, by numerous quartz-veins, $^1/_4$ to 2 inches broad. The quartz, or even amethyst, is distinctly crystallized, from the selvages towards the middle of the lode; and frequently forms beautiful geodes, in which curved rhombohedrons of ankerite lie on the quartz, at times somewhat of filiform native gold is found in both of these. The netlike combination of many such veins sometimes causes a sort of breccia, whose cementing medium is quartz-veins, while the fragments consist of very quartzose sandstone, or argillaceous shale.

The copper pyrites contain 30 – 32 kilogrammes of copper, and 65 – 85 grammes of silver, to the hundred kilogrammes. The silver contains $^{133}/_{1000}$ gold; and the pyrites are said to be richer in gold, where they contain the least silver. Perhaps the fact is, that the gold is more equally distributed, than the silver; and that, therefore, in an equal amount of matrix, a small quantity of silver contains relatively more gold, than a large quantity does.

XVII. THE ALPS.

GEOLOGICAL FORMATION.

§ 180. In the eastern portion of this long and high mountain-chain, a central ridge can be distinguished from two parallel side-ridges, which are at times all three separated from one another by deep and broad valleys. The central ridge is chiefly composed of crystalline schists and granitic rocks, overlying which are Palæozoic strata, to which deposits of the Carboniferous Period are added on the southern slope.

The two parallel side-ridges are mostly composed of limestones, long called 'Alpine limestones', while their subdivisions were still undetermined, but which have been recently divided into numerous epochs, belonging to the Triassic, Jurassic, and Cretaceous Periods. The outer edges, and hills, consist of Tertiary strata; which are mostly divided into Eocene Nummulitic deposits, and Neogene Molasse deposits; these last frequently, however, penetrate into the depressions of the principal ridges.

The, thus concisely described, formation of the Alpine-chain is, as it were, only the normal or ideal one, in reality the same is frequently much disturbed, even to a subversion of all the original relations of bedding. The central ridge, in particular, is eastwardly divided into two arms; which, as they advance, become more indistinct, and farther apart from one another; while towards the West the entire mountains become broader, so that but little of the original formation can be recognised. It bends, as a high and broad mountain-belt, from its original East-west axis more and more towards the South, until it reaches the sea at Nice.

It would occupy too much space, were I to attempt a detailed description; I would, therefore, only call attention to the fact, that the Alpine chain was raised at a comparatively recent period; that is, from the Jurassic to the end of the Tertiary Period; and that but few igneous rocks have been found in it. Basalts and trachytes are entirely wanting; greenstones are not common; porphyries and melaphyres are confined to a single district on the southern flank. By far the most common igneous rocks are granite and protogine, which are often difficult to distinguish from the neighboring gneiss.

Perhaps this want of igneous rocks is one of the reasons, why so few lodes have been found in this, the most extensive mountain-chain in Europe, in comparison to many smaller mountainous districts.

In describing the separate ore-districts I shall more fully treat those portions of the chain belonging to Austria and Bavaria, those in Switzerland and France.

THE GOLD-DEPOSITS OF THE ALPS.

§ 181. The central ridge of the Alps, consisting chiefly of crystalline schists, contains, in numerous places, very poor gold-deposits, which occur as beds, impregnations or lodes, but still appearing to have a general relation to one another. To these must be added a few other, in part secondary, gold-deposits in more recent formations. From their general relation to one another, I subjoin a short table of the best known of the gold occurrences, which will be followed by more special descriptions of the more important localities.

TABLE OF THE OCCURRENCES OF GOLD IN THE ALPS.

Auriferous Beds.

1. At Walchern, southeast of Oelbarn in Styria: a quartz-bed, in argillaceous schist, contains auriferous and argentiferous pyrites and other sulphurets, especially iron and copper pyrites, mispickel, tetrahedrite, and cobalt ores;

2. Fusch, westwardly of Gastein: Chlorite-schist, containing auriferous quartz, accompanied by iron and copper pyrites, mispickel, and argentiferous

galena; it seems to be a bedlike impregnation: also near Mosen in the Rauris, occurs an auriferous quartz-bed in clay-slate;

3. On the Heinzen Mountain at Zell in the Tyrol: auriferous quartz-bed, in argillaceous mica-schist: similar beds on the Rohn Mt. at the same place;

4. At the Radlgraben, northwest of Villach: lenticular quartz-masses containing gold with somewhat of wulfenite;

5. At Untersulzbach, southwardly of Mühlbach, in the Salzburg district, occurs an auriferous bed of copper pyrites in chloritic mica-schist;

6. At Schwaig and Lengholz, northwesterly of Villach in Carinthia: auriferous pyrites, with silver ores, in chlorite schist: probably beds or bedlike impregnations;

7. Räder mine, at Weissbriach in Carinthia: gold in Palaeozoic clay-slate: it is uncertain, whether in beds, or veins;

8. The Lias limestone of Grave (hautes Alpes) contains, according to Gueymard, almost every where finely disseminated gold, perhaps combined with the iron pyrites occurring in the rock: or is it perhaps a gold-deposit formed during the Lias Period?

9. The green slates of the Jura-formation, at Felsberg in Graubünden, contain somewhat of native gold, perhaps only in veins; auriferous pyrites were also formerly exploited in the crystalline schists of Graubünden.

Auriferous Veins.

10. On the Rathhaus Mountain, in the Sieglitz, in Rauris, and in the Fusch (neighborhood of Gastein), occur numerous auriferous veins: probable continuations of the same are found at Ober-Villach in the Möll valley;

11. On the Calanda, in Graubünden, auriferous veins occur in the Jura-formation;

12. Auriferous veins of pyrites occur in the crystalline schists of Pestarena, and Macugnaca, east of Monte Rosa;

13. In the Ligurian Alps, Balddracco observed auriferous veins of quartz in the Valleys of Cella and of Tana;

14. Gold veins occur in protogine, at Gardette in the Department of the Isère:

15. Lodes containing a small percentage of gold are found in the Chalanche Mts. near Allemont (Dauphiny).

Gold Alluvium Deposits.

16. In the Salza-valley near Lend, in the valleys of the Möll and the Drau, evidently coming from the neighboring central-ridge: on the Ens, the Mur, the Isar, the Inn, and the Danube, from the same source;

17. On the Aar, and the Emme, in Switzerland: the gold here originates from the Molasse deposits, into which it was probably swept from the Central Alps during the Tertiary Period;

18. In Chéron near Chateland;

19. In the hills of Saint-Georges, near Chivas in Piedmont; also in the sands of the Po, and of the Dona Despine.

If we examine the more original of these Alpine deposits, we find that they may be divided into beds or bedlike impregnations, and into lodes in the region of the crystalline schists.

Possibly the beds, or impregnations, are the original deposits, from which the lodes have received their gold. At least it is certainly very remarkable, that the majority of the auriferous veins in the Alps, and as it seems to me in many other localities, appear to be only workable in their upper portions; from which the idea may arise, that the gold has penetrated into them either out of the wall-rocks, or from above out of other, now destroyed, rocks. Lieber[1] has expressed the same idea in regard to the gold-veins of both the Carolinas; and Genth has mentioned chlorine, as the most probable solvent of gold. In some cases even a mechanical washing into the fissures does not seem to be impossible.

Even if we may assume, the gold of the veins originated in older beds or impregnations; the problem still remains to be solved, how and when the gold came into those metamorphic strata? Was it already in them before their alteration, or did it penetrate during the same? In the first case, from whence did it come into those older sedimentary deposits, out of which the crystalline schists were formed? Probably from the erosion of still older igneous rocks, in which it was distributed with the various other elements composing the earth's crust.

The results of Gueymard's[2] careful researches are of considerable scientific interest. He found traces of gold, and platinum, in numerous veins of the western Alps, of which no one had previously had an idea. The amounts were certainly too small to allow of the deposits being worked, but the scientific worth of their discovery was not in the slightest degree affected by this.

It appears from these researches, that gold is one of the most widely distributed elements; but this must be qualified by saying, that its original distribution is so finely disseminated, that it cannot be profitably extracted. Such an extraction could only be profitable, when it had been locally concentrated by chemical or mechanical causes, as in some quartz-veins, or alluvium-deposits. Is not this the case with all the metals? The greater the advances that are made in analytical chemistry, the more widely are traces of the different elements, even the absolutely rare ones, found to be distributed in the various products of nature.

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[1] See: Cotta's Gangstudien, vol. III.

[2] See: Annales des mines, 1852, vol. I. p. 345.

GOLD-VEINS IN THE SALZBURG TAUERN CHAIN.

§ 182. The central ridge of the Alps consists, in the neighborhood of the Rathhaus Mountain,[1] near Gastein, chiefly of gneiss, which passes into mica-schist; and both contain subordinate beds of granular limestone. To the North of this gneiss and mica-schist district, occur repeated alternations of chlorite schist, mica-schist, talc schist, black schist, serpentine (more like a segregation), and slaty limestone. The gold veins occur for the most part in the gneiss and mica-schist district, but also traverse the previously mentioned alternation in the Fusch valley. Their predominant strike, on the Rathhaus Mountain, is NE.—SW., but is, in the Siglitz and on the Rauris Gold-Mountain, more NNE.—SSW. and in the Fusch valley entirely N.—S. From this it would appear, that there was a general convergence of these veins in the direction of Döllach, where however a junction has not been observed. Cross-courses, containing little or no gold, intersect the principal course of the others, on the Rathhaus Mountain, and in the Ketschach valley.

On the Rathhaus Mountain there have been distinguished lodes, which dip E., and barren argillaceous veins, dipping W. The last very rarely contain gold; frequently, however, quartz, and molybdenite.

The nature of these veins is a peculiar one: they do not have the appearance of distinctly opened fissures, which have been filled with mineral matter; but essentially consist of several clefts parallel to one another, between which lies, more or less altered, often impregnated, country-rock, whose foliated texture sometimes continues uniformly between these clefts, sometimes has assumed another direction. The clefts widen, indeed, in places, and are then predominantly filled with quartz, which also appears to have penetrated from these into the rock. Such enlargements, filled with quartz and other minerals, then resemble other lodes. But the veins of the Rathhaus Mt. are essentially only systems of parallel clefts, between which lies

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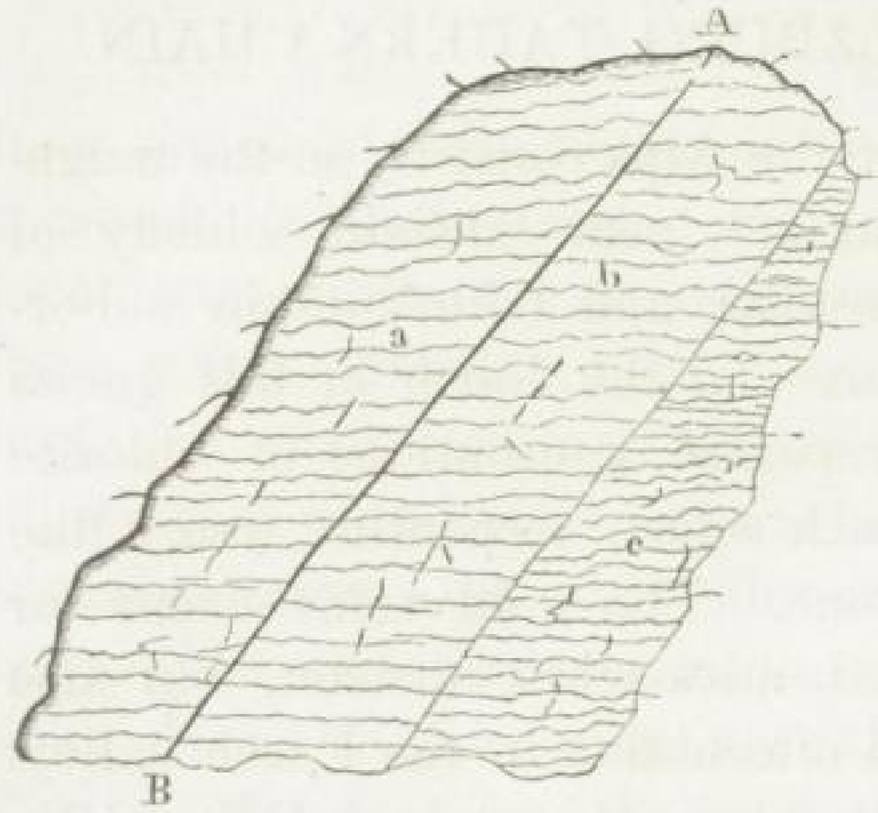
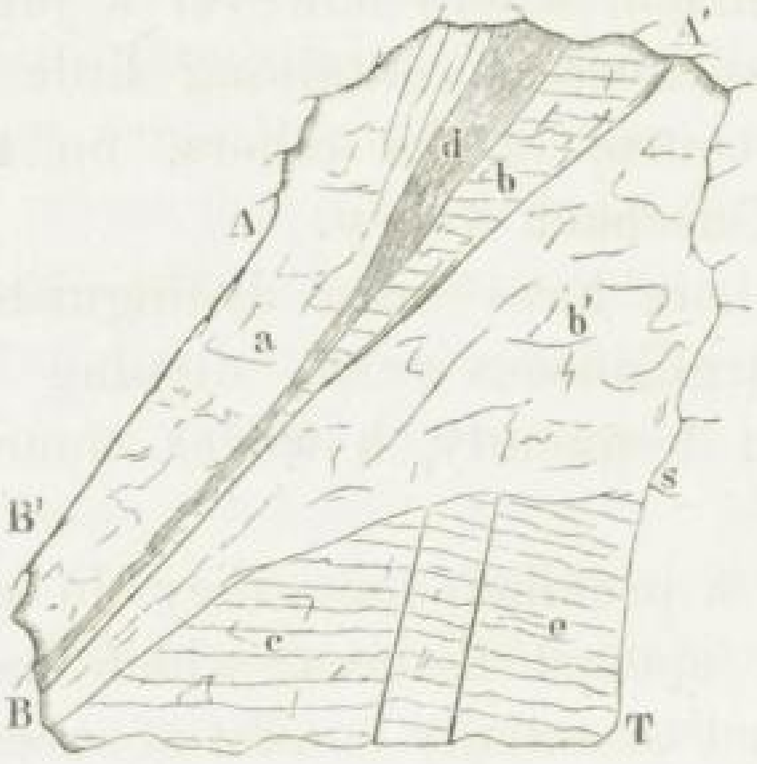
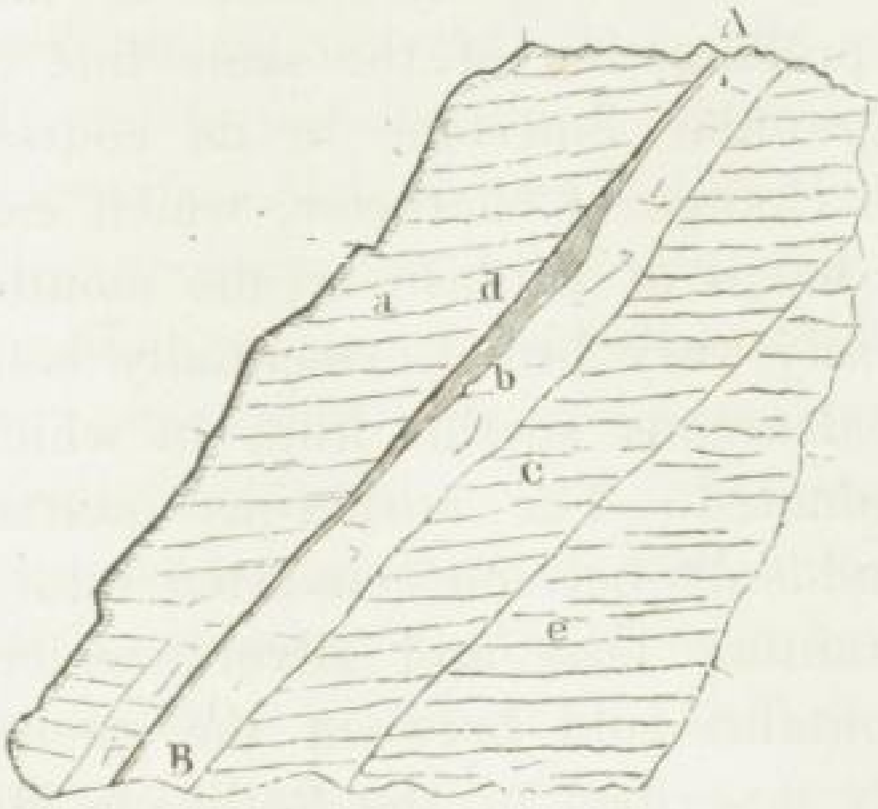
[1] See: Whitney's Metallic Wealth, 1854, p. 93; Cotta, Geol. Briefe aus den Alpen, 1850, p. 144; Ehrlich, nordöstlichen Alpen, 1850, p. 72; Reissacher, die goldführenden Gangstreichen der Salzburger Centralalpenkette, 1848; Russegger, in Leonhard's Jahrb. 1832, p. 89; 1835, pp. 182, 203, 379, 505; and 1836, p. 199; Riepl, in Bulletin géologique, 1832—33, III. p. 142, and 1835—36, VII. p. 13.



the wall-rock. Their true character can be best seen from the following four woodcuts, which are copied from Reissacher's work. They represent four consecutive sections of the Elisabeth adit. In the first *a* and *c* are gneiss, containing but little gold, *b*, on the contrary, which is separated by the principal cleft *AB* from *a*, and by a less constant one from *c*, consists of a quartzose and auriferous gneiss. The second cut represents the same adit 7 feet farther. The chief cleft *AB* has preserved the same position, containing somewhat more clay: *a* and *b* are almost entirely quartz, between which a wedge of chlorite schist has penetrated: *b* and *d* are only poor stamping-stuff, *a* and *b'* both rich enough for hand-sorting. The third figure represents the adit at a farther distance toward SW. of 36 feet. The principal cleft *AB* was here enclosed, on both sides, by auriferous, gneissic quartz *b* and *b'*, *b'* richer than *b*: the two chloritic portions *m* and *m* were particularly rich. The gneiss *a* had curved around the quartz *b*; *e* was the continuation of the barren portion of gneiss observed in the preceding figure The fourth woodcut represents the adit 83 feet farther SW. The cleft *AB* contains a soft clay *d*, alongside





of it auriferous quartz *b*, and on the other side enriched gneiss *a*; while *c* and *e* consist of barren granitic gneiss.

Frequently several parallel subordinate clefts occur, alongside of the principal one (which is chiefly followed in the exploitation). Some of these are at a considerable distance apart; and the intervals between them are then occasionally traversed in various directions by cross-fissures. Where many of these last occur, the amount of gold is said to encrease, which is easily comprehended; since each fissure acted as a channel for dissemination of the metal. The whole occurrence has some resemblance to that of Goldkronach (§ 92).

The gold penetrated from the clefts, especially the principal one, to unequal distances in the wall-rock on both sides. As a rule, its amount gradually decreased with the distances from the fissures.

Besides the native gold, which is often imperceptibly disseminated in the snow-white, compact quartz, there also occur: so-called *glaserz*, a mineral resembling tetrahedrite, containing a large percentage of auriferous silver; somewhat of copper pyrites, erubescite, iron pyrites, mispickel, galena, and blende, (according to Riepl, also stibnite, calc-spar, fluor spar, and lazulite, and, according to Russegger, dyscrasite). The copper-ores chiefly occur in the chloritic gneiss; the others, like the gold, in common gneiss and in quartz: these ores are finely disseminated. It is considered a favorable sign, when the quartz contains small particles of dialogite, and decomposed or fresh iron pyrites.

The Erzwieser champion-lode, some miles to the West of the Rathhaus Mt., can be followed 3200 fathoms in a straight line, between gneiss, chloritic gneiss, and mica-schist; it is lost sight of in the Anger valley, under a considerable quantity of Alluvium, and southwardly under the Rauris Gold-Mt. under the glacier of the high Schareck. Traces of ancient mining are found in Carinthia, on the other side of this mass of snow and ice, in the prolongation of the same line of strike. The vein intersects granular limestone in its course, in which it shows a remarkable change of character, which can be distinctly recognised in the heaps of rubbish at the mouths of old shafts. It is here evidently very broad, essentially consisting of spathic iron, and calcareous spathic iron, in which argentiferous galena is disseminated. The auriferous quartz-vein, or system of clefts has suddenly become converted into a broad spathic iron lode, containing lead and silver; which, beyond the limestone, again contains gold between the gneiss, in the same manner as already described of the Rathhaus Mt.

In Rauris, where the veins strike like those of the Rathhaus Mt., there are but two circumstances worth noticing. Firstly, the veins exhibit a concentration and enrichment near the so-called black schist, which they entirely lose, when they intersect the same, and appear to be much compressed. Secondly, certain fissures which frequently intersect the veins produce very peculiar appearances of intersection and faulting, which can however be explained by natural laws.

In the Fusch valley, where about 40 veins are known, though only 3 have been opened-up, these show an analogous relation to those on the Rathhaus Mt., although they here traverse a repeated alternation of talc-schist, mica-schist, chlorite schist and slaty limestone. The ores consist of gold, so-called *glaserz,* iron and copper pyrites, galena and blende, which occur in all the rocks but the so-called black schist. In the slaty limestone the quartz, as in the Erzwieser lode, is replaced by impure spathic iron, and the argentiferous galena is more common; but native gold is not entirely wanting, implanted on the spathic iron.

All these gold veins, in the crystalline central ridge of the Alps, which essentially coincide in their nature and strike, must have had a common origin. The fissures are the consequences of mechanical forces, caused by movements in the mountains, which can be recognised from the faults, and friction-surfaces. In what manner did the metallic and non-metallic minerals penetrate? It is highly improbable, that these, especially the last, originated from the wall-rock; while we have found this to be very probable as to some of the Hungarian and Transylvanian gold-veins in greenstone. It is the more improbable;

as, according to Reissacher, whose statements are founded on very careful experiments in the concentration-works, the amount of gold in the wall-rock decreases, and soon ceases, with the encreasing distance from the clefts, especially the chief fissure. The country-rock also contains no pyrites, which might be regarded as containing the gold. This, and the other metals have, therefore, evidently penetrated from some direction in a dissolved condition into the fissures, and have penetrated from these into a portion of their wall-rock. Of what sort the solutions, especially that of the gold, were, is still a problem. From the manner in which the gold occurs, chiefly in the upper portions of the veins, it might be supposed, that the gold penetrated from above. In this case it could only have come from the rocks, which formerly overlay those now at the surface. But there actually occur, as we have seen, auriferous beds, or belts of impregnations, in the clay-slates and chloritic schists of the Tyrol, which overlie the gneiss and mica-schist of the central ridge, whose destroyed prolongation may in reality have formerly covered the central chain at Salzburg. I will not attempt to pursue this train of thought any farther, as I merely wished to notice the same once more. The striking difference in the contents of the lodes, when within the limestone, is one of the most distinct cases of the influence of the country-rock.

GOLD-DEPOSITS ON THE HEINZEN MOUNTAIN.

§ 183. The Heinzen[1] Mt. near Zell in the Tyrol, consists of mica-schist, which dips 70° in S. The mass of the bed, in which the gold occurs disseminated, is a quartzose slate more or less impregnated with pyrites, whose thickness encreases from a few inches to 5–6 fathoms. This bed is by no means auriferous enough, throughout its whole extent, to be profitably exploited; on the contrary certain portions are very poor or barren, between which lie richer zones, 30—40 fathoms broad, which dip obliquely to the plane of the bed 30°—40° in SW. Up to the present time three such belts have been opened and exploited. In these, which occur at about equal distances apart, there appears a progressive encrease in the amount of gold from

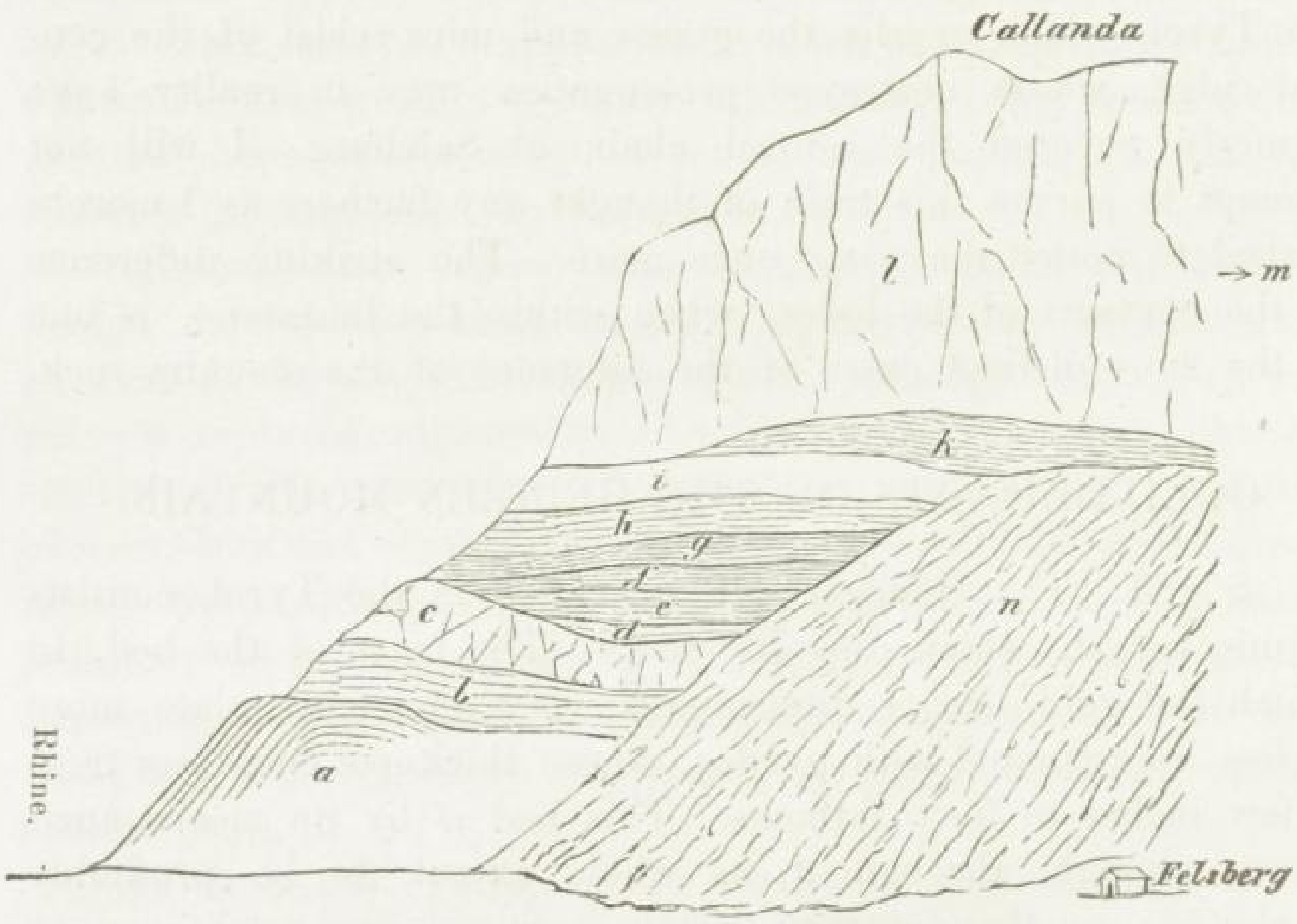
[1] See: Trinker, in Jahrb. d. geolog. Reichsanst. 1850, p. 213; Unger, Einfluss des Bodens, 1836, p. 39.

East to West; the reason of this is entirely unknown. A variation in the country-rock, as is so often the case in lodes, can here have exercised no influence, as the wall-rock remains the same. It must also be remembered that the oblique inclination of ore-chimneys can by no means always be explained. Nature sometimes resists the attempts of our interpretations; or rather our knowledge of the same is in many ways still very imperfect.

Unger states, that the Heinzen Mt. contains six similar beds to those now worked, and the Tauern Mt. four.

GOLD-VEINS ON THE CALLANDA IN GRAUBUENDEN.

§ 184. The southern slope of the Callanda[1] in Graubünden, from which the renowned landslip of Felsberg took place, consists, according to Deicke, of the following strata:

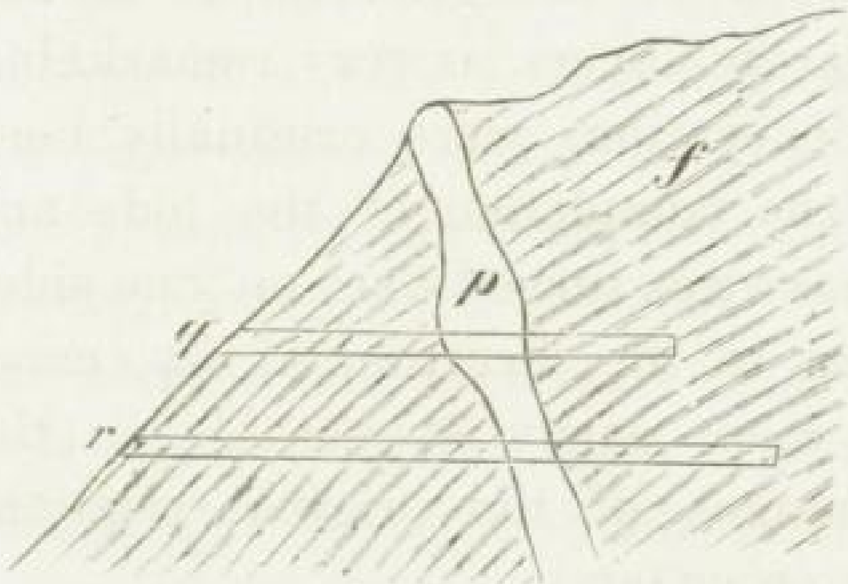


a. Red sandstone of the Alps;—Buntsandstein;
b. Yellow limestone, } Triassic;
c. Dolomite, }
d. Red schist, } Jurassic;
e. Yellowish schist,
f. Chloriticschist (containing the gold veins),
g. Schist containing magnetite,
h. Slaty limestone,
i. Limestone containing Belemites,

[1] See: Deicke, in Berg- u. hüttenm. Zeit. 1860, p. 119.

k. Slaty dolomite, } Jurassic;
l. Massive dolomite, }
m. whose eastern prolongation is the mass which formed the landslide;
n. Rubbish formed by the landslide.

In the chloritic schist *f* occur veins 1—3 inches broad, which course NE.—SW. and dip considerably in NW. The separate veins have only been followed about 20 feet in their course, the whole group about 400 feet; while a continuation is found, near Tamins, at the limits of the rock, about 8000 feet off. These veins, which appear to belong only to the Jura formation (and are therefore gash-veins), but traverse much metamorphosed chlorite schist; consist of quartz and calc-spar, in which somewhat of native gold occurs, in part imperceptibly disseminated, in part in scales and masses weighing several ounces, also auriferous iron pyrites, and iron ochre. The gold is mostly found in the hanging selvage. The wall-rock of the veins also contains considerable quantities of iron pyrites disseminated through its mass; which do not, however, contain gold. Deicke gives the following section of one of these veins, which has been opened-up by two adits.



f. Chloritic schist.
p. Gold vein.
q. and r. Adits.

He thinks, these veins must have been filled in the wet way. It is quite curious, that they only occur in the chlorite schist, and that the iron pyrites in this contains no gold.

GOLD-VEINS OF LA GARDETTE.

§ 185. At La Gardette,[1] near Bourg d'Oisans in the Isère Department, a gold-vein crops-out, in protogine, 4200 feet above the sea. The same strikes WNW.—ESE. and dips 70°—80° in S. Its breadth is 3—24 inches, and the principal vein-stone quartz, exhibiting curious phenomena. The matrix of the vein

[1] See: Graff, in Annal. des sciences phys. et naturel. Published by the Lyons' Agricultural Soc. III. p. 153.

is divided into 10 different layers; which do not occur double, and are not arranged symmetrically from the walls to the middle, but must be regarded as the result of the same number of openings and fillings of the fissure combined with dislocations. These separate layers are commonly separated from one another by distinct friction-surfaces with horizontal grooves; the last have been found to extend symmetrically for a length of 1300 feet and depth of 250 feet. The first bed, which is probably the oldest, as traces of the same are observed both on the hanging- and foot-wall, consists of quartz with somewhat of galena, tetrahedrite, iron and copper pyrites. The second layer contains in its quartz, especially in its geodes, native gold and somewhat of galena, also somewhat of calc-spar, and specular iron, occasionally even fragments of the wall-rock, or first layer, which are never larger than the breadth of this layer, and lie altogether separated from one another, at times completely enclosed in spathic iron. The remaining layers appear to consist only of quartz, the second one containing the greater part of the gold.

The nearly horizontal direction of the grooves, in all the friction-surfaces, between the separate layers, is very remarkable. Graff does not think, that the dislocations were originally horizontal, but supposes that, after the completion of the lode and the friction-surfaces, the entire mass was turned over on one side; by which the grooves, from lying in the direction of dip, came into that of strike. This is the more easily supposable in the Alps, since such mechanical changes of the original relations have been frequently proved by other facts.

COPPER AND LEAD DEPOSITS AT KLAUSEN IN THE TYROL.

§ 186. The crystalline schists, and subordinate granular limestones embedded in them, of the eastern Alps, contain beds and veins of the above ores in several localities; which are not confined to particular rocks, nor, probably, to particular geological niveaus. I shall here only mention the Pfundrer Mountain near Klausen,[1] which I have personally examined.

The predominating argillaceous mica-schist of this district is pierced on the Pfundrer Mt. by a broad mass of diorite; at whose

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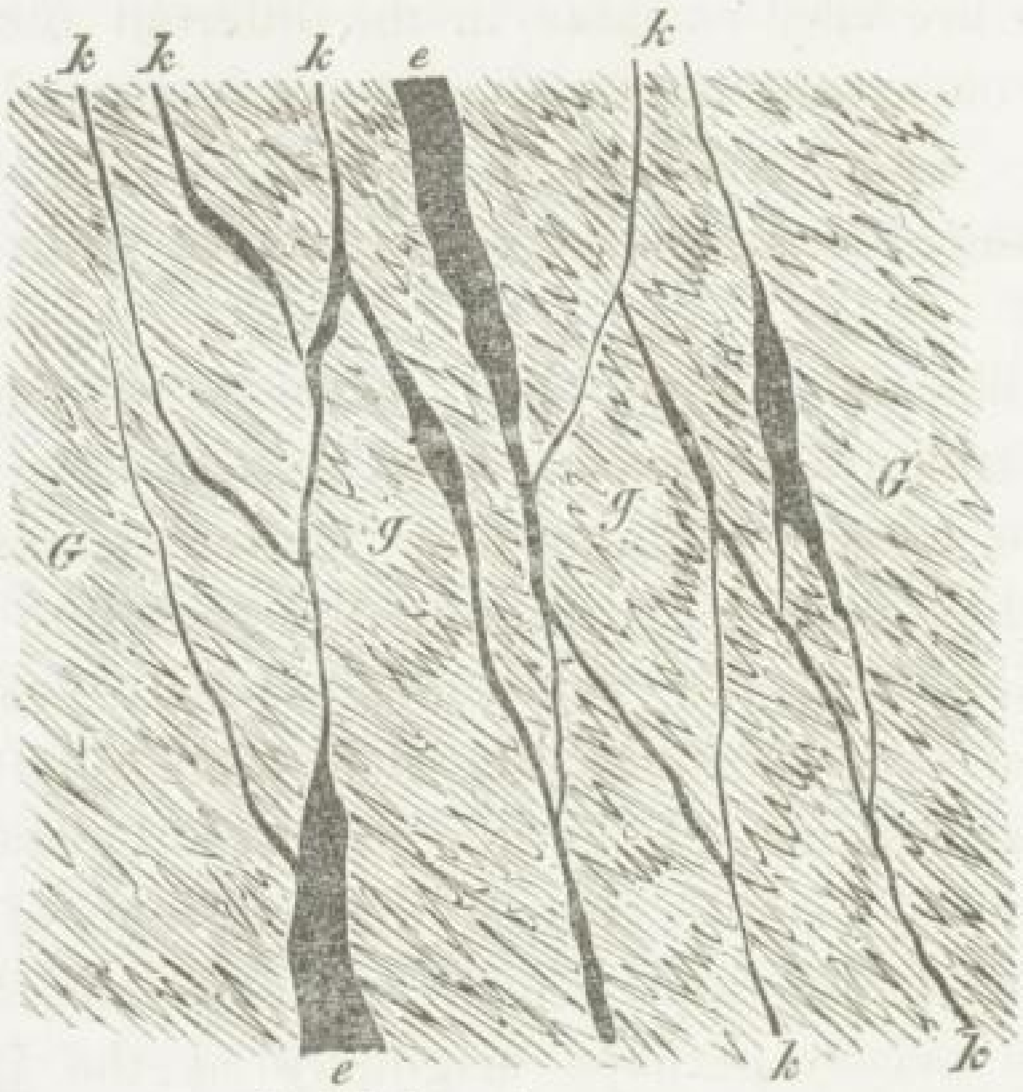
[1] See: Cotta, in Berg- u. hüttenm. Zeit. 1862, p. 377; Hauer and Fötterle, Uebers. d. Bergbaue, p. 31.

limits occurs a peculiar rock called by the miners 'Fieldstone'. All three of these rocks are traversed by lodes, which have been worked for a long time, on the steep flanks of the mountain mentioned, about 3000 feet above the sea. The contents of these lodes are very variable in the different rocks; so unlike, that the ores occurring in the diorite are separated in the mine, as containing lead, from those found in the fieldstone, or argillaceous mica-schist, only consisting of iron and copper pyrites.

The argillaceous mica-schist consists of repeated alternations of common argillaceous mica-schist, mica-schist proper, very quartzose schist containing large lenticular masses of quartz, and quartz-schist; which all frequently pass into one another. At the junction with the fieldstone, it partly passes into this, and Richthofen even considers the fieldstone to be merely schist altered by the influence of the diorite; still I observed, at one place in the mine, a quite clearly defined line of demarcation between the fieldstone and schist, while in the Vildar valley large boulders occur, perhaps originally at the junction, consisting of a very coarse breccia, in which fragments of schist, in part, indeed, resembling the fieldstone, are cemented together by a binding medium; which corresponds to the common fieldstone, and appears to consist of a reddish-yellow intimate mixture of feldspar and quartz.

The greenstone generally occurs compact in the mine, consequently aphanitic, while at the surface large masses are found very distinctly fine to middle granular, consisting of a mixture of actinolithic hornblende and oligoclase, and may therefore be called diorite. The lodes, of which three exist, strike E.—W. with a slight convergence towards W., so that they may be properly considered, as three leaders of one lode. Subordinate leaders, of a like course, occur here and there between these; and a few cross-courses of a different character, whose matrix consists of a sort of breccia, containing fragments of fieldstone, cemented together by spathic iron, somewhat of ankerite, calcspar and pyrites; also clay-fissures, which intersect obliquely, and in part produce faults. The dip of the lodes is 60°—80° in N. Their breadth encreases to several fathoms; but when so broad, they by no means entirely consist of vein-mass, but essentially of wall-rock, traversed by numerous clefts, generally following the principal direction of strike, but frequently forming a network, and then having separately a breadth of one line to two feet. These irregular fissures are then filled with ores, which are only here and there accompanied by quartz and calc-spar as vein-stones. (See woodcut.)



G. Wall-rock.
g. Wall-rock in the lode.
k. Clefts.
e. Ore.

The peculiarity of these lodes consists in the fact, already mentioned; that the ores in each of them only consist of iron and copper pyrites, when they lie in the argillaceous mica-schist and fieldstone; while in the greenstone there is found with these galena, containing 2—14 oz. of silver, and blende; also that they are generally most productive in the greenstone, somewhat less so in the fieldstone, and poorest in the schist. This difference is not confined to single streaks of ore, but to the occurrence of ore in general; that is, that there are many more and larger exploitable masses of ore, within the greenstone and fieldstone, than in the schist. Another curious, but rare ore-occurrence is that of lenticular concretions, 2—10 inches in diameter, having within a concentric structure. One of these shows an irregular amphibolic or chloritic kernel, containing cubes of iron pyrites. This is surrounded by five concentric layers, alternately composed of pyrites and galena-blende. These layers are not altogether sharply defined; so that a little blende or galena is occasionally found in the bands of pyrites, and the reverse.

From the above-described nature of these lodes is explained the intermission of the ore-masses. At times every trace of vein disappears, the wall-rock only extending, somewhat more fissured than usual, in the direction of strike, until the fissure again opens, and contains ore. It also seems to me, that the very evident influence of the peculiar character of the wall-rock on the qualitative and quantitative nature of the ore in the lodes, has been supported by its mechanical nature; a great encrease having been caused, by this means, in the surface of the rocks. The other minerals found, in addition to those already mentioned, are: chrysocolla, cyanosite, native copper, native silver, cerusite, and antimony.

COPPER DEPOSIT AT AGORDO.

§ 187. The village of Agordo[1] lies in a beautiful mountain-basin, surrounded by high peaks of limestone and dolomite; which rise perpendicularly, as precipitous peaks, to a height of 6, 7, and even 8,000 feet above the sea. In the interior of this basin, the surface consists of argillaceous mica-schist, which forms low hills and mountains with gentle slopes. This is overlaid by red sandstone (Werfner beds) corresponding to the German *Buntsandstein.* Over this follows, to the North, Guttensteiner limestone (fossiliferous limestone); southerly in the Imperina valley, on the contrary, Dachstein limestone (*Keuper*), both being considerably tilted in the beginning. At a greater distance, and farther removed from the argillaceous shale, the strata have a more gentle slope, and from the predominance of limestones and dolomites, it is not always easy to recognise the subdivisions of the Alpine Triassic: viz.

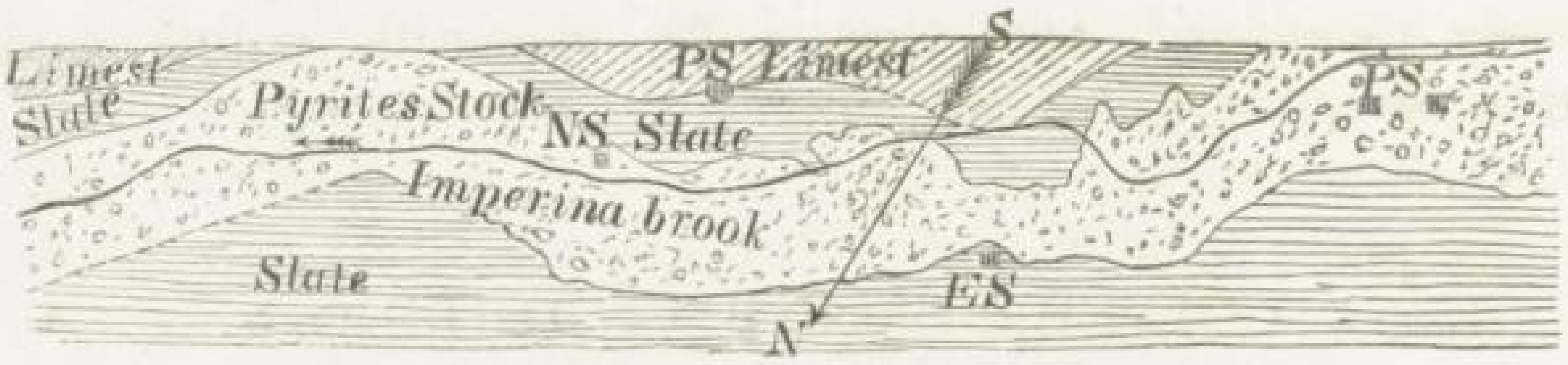
Dachstein limestone,
St. Cassian beds,
Guttensteiner limestone, and
Werfner beds (Grödner sandstone).

All these Triassic strata appear to be in no way connected

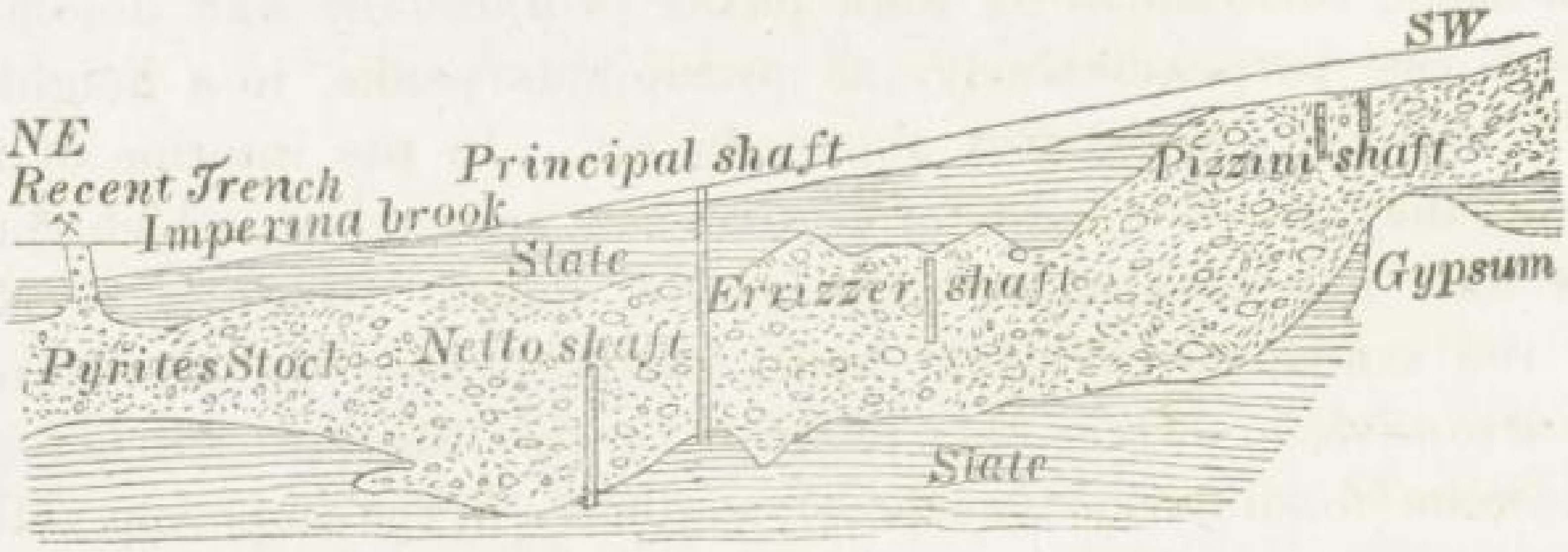
[1] See: Cotta, in Berg- u. hüttenm. Zeit. 1862, p. 425; Oesterreich. Zeitschr. f. Berg- und Hüttenwesen, 1860, p. 173; Schmidt, in Berg- und hüttenm. Zeit 1867, p. 240; Bauer, in Kraus' Jahrb. f. d. Berg- u. Hüttenmann, 1852, p. 231; Hauer and Fötterle, Uebersicht d. Bergbau. p. 37; Fuchs, Beiträge z. Lehre v. d. Erzlagerstätten, 1846, p. 14.

with the copper-ore-deposits of the Imperina vâlley, although they, at times, almost come in contact with them. These last are found altogether in the argillaceous mica-schist. They occur as large segregated masses of ore, which appear to have been formerly enclosed on all sides by the schist, and to have been partly laid free by subsequent erosions. It is, therefore, only a consequence of subsequent denudations, that the Triassic sandstones or limestones, at times, almost or quite touch the ore-deposits.

Horizontal Projection.



Vertical Section.



The principal pyrites segregation of the Imperina valley, which is said to be accompanied by some other smaller ones, has an irregular elongated form (see woodcuts). Its longest axis is almost horizontal, inclining but about 20° in NE. parallel to the narrow bed of the Imperina brook, whose bed usually follows the course of the pyrites segregation from SW. to NE., in such a manner, that it may be supposed the decomposition of the pyrites has caused the washing-out of the same, or at least aided it. Where the pyrites does not crop-out in the bed of the brook, it is only a consequence of being subsequently covered by stream-deposits. The strike, like the dip, of the two greatest dimensions of this mass, corresponds to the strike, and about to the dip, of the enclosing shales. All the dimensions of this segregation are very great, so that there is enough ore to last for several centuries. It has been opened-up for a length of 286 fathoms, a height of 45—50 fathoms, and a breadth of 11—22 fathoms; which are of course much less, near its extremities, from gradually rounding off. The mass is, however, known to have a total length of 957 fathoms. It is very difficult to observe within the mine the relations of the bedding of such a large mass, whose outer limits are so seldom distinctly opened-up by the workings. It would appear, from the plan of the mine, that there are many inequalities, irregularities, and even indentations at the limits; which appear to be generally rounded on all sides, especially in the lower portion. The mass of pyrites is almost everywhere surrounded by a light-colored talcose, at times also quartzose shale, which corresponds to the Skölars of Fahlun in Sweden; it occasionally also forms irregular ramifications in the pyrite mass, and is often penetrated by iron pyrites. Its thickness is very variable, being at times a few inches, and again several feet, or even fathoms. Beyond the white shale commences the dark argillaceous mica-schist, containing numerous masses of quartz, also containing impregnations of pyrites; it passes at a farther distance from the segregation into a more grayish-green slate.

Somewhat of gypsum has been found below the pyrites, southwest of the Pizzini-shaft and above the Barbara-adit, concerning whose relations of bedding I was, unfortunately, unable to obtain nearer particulars. According to the vertical section of the mine (Fig. 2) the gypsum must belong to the argillaceous shale. Bauer, however, considers it as belonging to the red sandstone; and says, it occasionally contains crystals of rock-salt. According to this observer, it lies between the slate and limestone, which does not agree with the map of the mine.

The mineralogical composition, of this immense mass of ore, is simple and uniform. The original ores are sulphurets, accompanied by a little quartz. Iron pyrites predominates, containing somewhat of copper, probably arising from an intimate mixture with somewhat of copper pyrites. At times, especially near the quartz, somewhat of distinct copper pyrites is added, and in a few places, also very quartzose, are mixed in argentiferous galena and blende. From older reports, argentiferous tetrahedrite has also occurred; and from the accurate analyses of the ores, and smelting products, small quantities of cobalt, arsenic, antimony, and tin, are present, whose ores it is impossible to recognise. Von Zepharowich mentions goslarite as a product of decomposition. The pyrites crop-out very distinctly at one point in the bed of the Imperina brook, and even form a waterfall.

There are numerous friction-surfaces, or slicken-sides, traversing this mass of pyrites in various directions, which mostly exhibit very distinct grooves, and are, according to Fuchs, sometimes covered with somewhat of the friction-powder. They are particularly interesting, from often exhibiting on cabinet-specimens various directions of the parallel scratches; and from the fact, that the amount of copper is frequently very different on the two sides. Fuchs has attempted to prove, in his peculiar manner, that these slicken-sides were not formed by dislocations, but are rather the result of a peculiar property of the pyrites; as reasons for this view, he states:

1. that their directions are too varied for friction-surfaces;

2. that they suddenly cease at times in the mass of the pyrites; and

3. that quartz, galena, and blende, are never found on their surfaces, but only pyrites.

With regard to the first reason, it is to be remarked, that the single separated portions, here masses of pyrites, can be moved by an immense pressure in the most different directions, as is seen in other cases of this kind; thus in serpentine, alum shale, coal, and even in argillaceous shales.

The second reason may rest on insufficient observations. Mining-captain Somariva, who accompanied me in the mine, has not observed a single case of this sudden cessation.

The same is much more true for the third reason; since the principal mass of the segregation consists of pyrites, the appearance of quartz, galena, etc. on the friction-surfaces must necessarily belong to the exceptions. Mr. Stelzner has observed such an exception, where galena occurs on a friction-surface. Not only the circumstance, that there is no other satisfactory explanation for the parallel-grooved slicken-sides, between which the powder produced by the friction is occasionally observed, is in favor of their having been formed by dislocations; but also the fact, so prominantly mentioned by Bauer, that the amount of copper in the pyrites is different on both sides, and that they intersect and cut off the laminæ of talc-schist penetrating into the pyrites. Both facts can be most simply and satisfactorily explained by faults, of which these slicken-sides were the planes of dislocation and friction.

SILVER AND COPPER DEPOSITS IN ALPINE LIMESTONE AT BRIXLEGG IN THE TYROL.

§ 188. Near Brixlegg[1] the lowest division of the Alpine limestone, the so-called Guttensteiner limestone, forms a rocky ridge on the right side of the Inn-valley. Its stratification appears to be much disturbed, since it projects to the surface between the red sandstone of the Werfner beds, properly belonging beneath it, and the crystalline clay-slate of the central ridge itself containing similar beds of limestone, often difficult to distinguish from the fine granular, and mostly magnesian, Guttensteiner limestone. Pichler recently stated, that the metalliferous limestone of Schwatz (and Brixlegg) was older than the Triassic Period. The same belt of limestone extends to beyond Schwatz, and there also contains similar deposits.

On the Kleinkogel numerous but irregular veins occur, which often contract to small clefts or form branches in the common joints, mostly striking N.—S. and dipping 55° in S. in the much fissured limestone, they at times attain a breadth of several feet. They consist of irregular mixtures of heavy spar, quartz, calc-spar, argentiferous tetrahedrite, and copper pyrites, with azurite and malachite. These last ores occur in the reddish limestone, the sulphurets chiefly in the gray limestone, which relation, with regard to the color of the limestone, may also be a consequence of the decomposition. The ores are very irregularly distributed in the veins, which often contain little or none at all. Trinker states, that the distribution of the ores follows a certain law, the so-called '*Adelsvorschub*'. This is still an enigma; and it appears to me entirely incomprehensible, that the same mysterious cause should have produced this peculiar distribution of the ore, under so very different relations, as on the Heinzen Mt. (§ 183) and on the Kleinkogel; although I by no means intend to doubt the fact of such a distribution, which I was not sufficiently able to observe.

The lodes of the other mines around Brixlegg are similar to these, except that on the Grosskogel still other, even cobalt and nickel, ores occur.

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[1] See: Stapff, in Berg- u. hüttenm. Zeit. 1862, p. 134; Cotta, in same, 1858, p. 107; Trinker, in Jahrb. d. geolog. Reichsanst. 1850, p. 213; Hauer and Fötterle, Uebersicht d. Bergbau, p. 39.

SILVER AND COPPER DEPOSITS IN ALPINE LIMESTONE AT SCHWATZ IN THE TYROL.

§ 189. In the western prolongation of the same limestone-belt, which contains the ores, mentioned in the preceding paragraph, similar ores occur at Schwatz,[1] only in a somewhat different form. They here form segregated masses, whose chief ores also occur in a so-called '*Adelsvorschub*'; that is, they lie in and alongside of a plane, which dips in W. at an angle of 27°. These curious aggregations of ore form, according to von Gumppenberg, prismatic chimneys, which are no where over 7 feet in diameter, but have been followed 60—120 fathoms in a perpendicular direction. The ore here, as at Brixlegg, predominantly tetrahedrite, containing, in part, considerable quantities of mercury, appears to be firmly united to the wall-rock. The tetrahedrite occurs, combined with calc-spar and heavy spar; while azurite, malachite, and chrysocolla, have been formed by its decomposition.

SILVER DEPOSITS OF CHALANCHES NEAR ALLEMONT, DEPT. OF ISÈRE.

§ 190. The probably Jurassic-limestone-district (according to Schreiber a crystalline schist-district) is traversed at Chalanches[2] by numerous veins, which are in part lodes. Gueymard, and Graff, distinguished five varieties of veins:

1. Diorite, or diabase dikes, partly bedded, upwards of $12^1/_2$ fathoms broad: they are the oldest;

2. Veins; striking N.—S. and dipping in W., consisting of limestone with argentiferous iron ochre;

3. Champion-lodes; partly also striking N.—S., but dipping in E.; partly striking E.—W., and dipping towards N.: their principal vein-stones are calc-spar and dolomite; which are

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[1] See: Pichler, Beiträge z. Geognosie Tyrols, 1859, p. 10; Hauer and Fötterle, Uebers. d. Bergbau, p. 49; Trinker, in Jahrb. d. geolog. Reichsanst. 1850, p. 219; Von Gumppenberg, in Leonhard's Jahrb. 1836, p. 50.

[2] See: Gueymard, and Graff, in Bullet. de la societ. de Stat. des sciences natur. du Dept. de l'Isère, I. p. 27; Schreiber, in Köhler's bergmännisch. Journal, 1788, p. 22.

accompanied by argentiferous cobalt, nickel and antimony ores, iron ochre, and some other minerals; such as, native silver, galena, blende, cinnabar, and iron pyrites: sometimes a symmetrical arrangement of the minerals can be observed, consisting, from the selvages towards the middle, of:

1 Quartz;
2. Spathic iron;
3. Dialogite, with cobalt and antimony ores;
4. Cobalt, nickel and antimony ores.

Breithaupt has observed the following successions on cabinet-specimens:

Smaltine – erythrine – ganomatite;
Copper nickel—chloanthite;
Smaltine—native silver—erythrine.

Fragments of limestone also occur in the veins and appear to have been subsequently penetrated by ores;

4. Broad fissures, upwards of $2^1/_2$ fathoms broad, filled with large fragments of rock; and between these with micaceous clay: they contain no ores: Schreiber calls them 'filons sauvages';

5. Still more recent and narrower fissures, also filled with rock-fragments and clay: they intersect the fissures No. 4, and are, therefore, of course younger.

THE LEAD AND ZINC DEPOSITS OF CARINTHIA

§ 191. Certain limestones of the Carinthian[1] Alps contain lead and zinc deposits in various localities; which, notwithstanding slight differences in detail, are so analogous to one another, and have so many common characteristics; that there can be no doubt of their being geologically united.

The principal localities, where these ores are exploited, are, going West: Bleiberg, Kreuth, Raibl, Windisch-Bleiberg, Kappel,

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[1] See: Cotta, in Berg- u. hüttenm. Zeit. 1863, pp. 9, 33, 41, 53; Peters, in same, 1863, p. 133, and in Jahrb. d. geolog. Reichsanst. 1856, p. 67; Hauer and Fötterle, Uebers. d. Bergb. p. 41; Niederrist, in Leonhard's Jahrb. 1852, p. 769; Morlot, in Jahrb. d. geolog. Reichsanst. 1850, p. 255; Melling, in Haidinger's Berichten, 1848, vol. V. p. 31; Fuchs, Beiträge z. Lehre d. Erzlagerstätten, pp. 19, 22; von Buch, in Leonhard's Taschenb. 1824, p. 408; Mohs, in Moll's Ephemeriden d. Berg- u. Hüttenkunde, 1807, vol. III. p. 201; Potiorek, in Oesterreich. Zeitsch. f. Berg- u. Hüttenw. 1863, pp. 373, 382; Phillips, in Annal. d. mines, 1845, vol. VIII. p. 239; Boué, in Mémoires de la sociét. geolog. de France, 1835.

Miss, and Schwarzenbach near Bleiburg. They occur in a belt of Alpine limestone, about 75 miles long and a few broad; in which, according to the examinations of the Viennese geologists, the Alpine Triassic is represented, from the Werfner beds upwards to the Dachstein limestone.

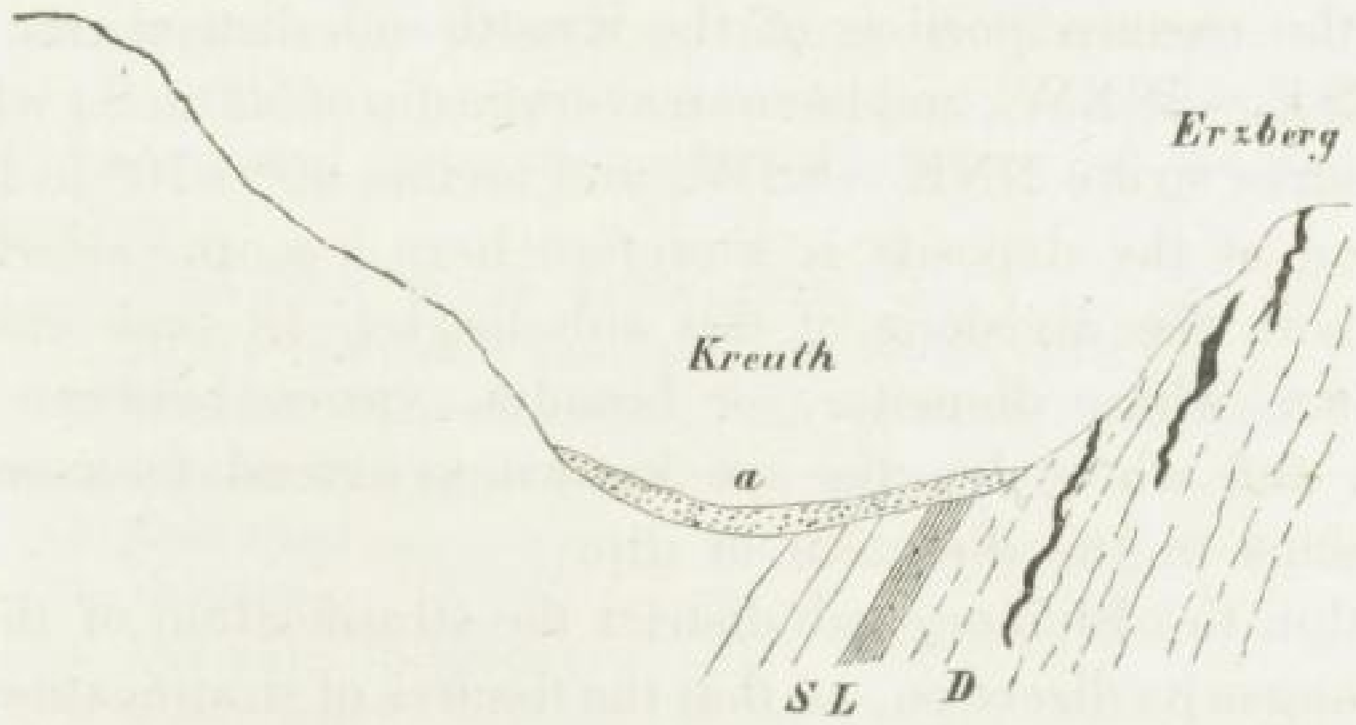
For the information of the reader, it seems proper to give the subdivisions of the Alpine Triassic strata now generally used, since its separate members will be repeatedly mentioned. I extract the subjoined table from Gumbel's 'Bayerische Alpengebirge', 1861, p. 116.

	Subdivisions.	Names.	Synonyms and parallel Strata.
Keuper.	Upper Keuper (Lias of the Viennese).	Upper Keuper limestone, or Dachstein limestone, containing *Megalodon triquater*.	Lithodendron limestone.
		Upper Muschelkeuper, containing *Avicula contorta*.	Kössener beds, upper St. Cassian beds, Gervillia beds, Bonebed.
	Middle Keuper.	Principal dolomite of the Alpine Keuper. Gypsum and cellular limestone.	Dolomite of the Dachstein limestone.
		Lower Muschelkeuper of the Alps, containing *Cardita crenata*.	Raibl beds, St. Cassian beds, Esino limestone.
	Lower Keuper.	Lower Keuper limestone, and dolomite of the Alps, containing *Monotis salinaria* and *Ammonites globrus*. Clay-Keuper of the Alps, containing *Pterophyllum longifolium* and *Halobia Lommeli*.	Hallstätter limestone, Arlberg or Wetterstein limestone, Wenger beds, St. Cassian beds, Partnach beds. Cardita beds.
Muschelkalk.	Fossiliferous limestone	containing *Encrinus liliiformis*.	Virgloria limestone, Guttensteiner limestone.
Buntsandstein.	Haselgebirgs strata	containing gypsum and rock-salt.	Röth.
	Variegated sandstone	containing *Meyophoria vulgaris* and *Myacites Fassaensis*.	Werfner beds containing rock-salt. Verrucano.

1. Bleiberg and Kreuth. The metalliferous deposits occur here in a group, coursing N.—S., and about 5 miles long, within thick beds of limestone. The separate ore-deposits, although they belong to a common group, show slight differences of form, and even of composition, in the eastern, western, and middle portion of the entire group.

The metalliferous limestone is very pure, with but slight admixtures of extremely fine crystallized quartz. It is not very distinctly stratified, but somewhat more so at the surface than in the mines.

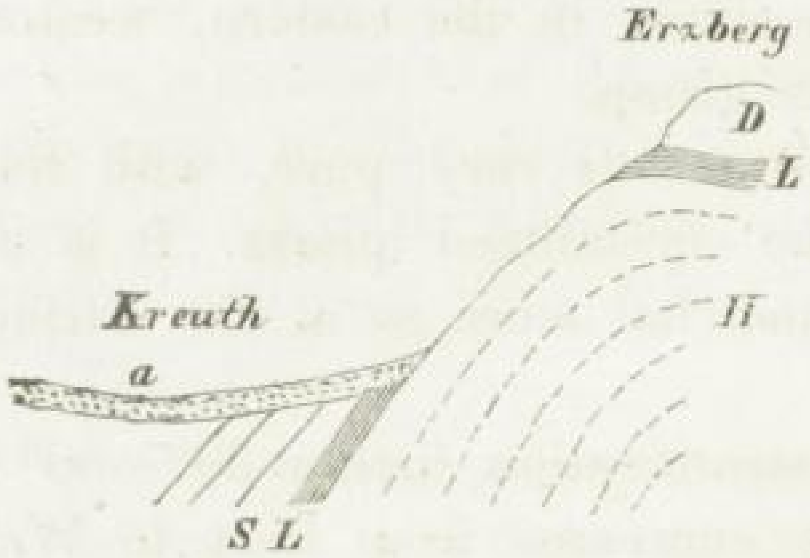
Its strata, or planes of stratification, incline 30°—80° towards S. Their tilting gradually encreases from East to West. All of the ore-deposits, worked by the mines, lie in the same limestone; while none of them have been followed out of this into another rock, although the slate and stinkstone have been pierced by numerous adits. Until recently the metalliferous limestone has been commonly supposed to belong to the Dachstein limestone, since it often contains casts of the interior of so-called Dachstein bivalves. These have been subdivided by Gümbel, in his recent examinations, into several species, of which *Megalodon triquater* and *M. columbella* have been found in the Bleiberg metalliferous limestone. Both kinds do not seem, in the southern Alps, to be exclusively confined to the Dachstein limestone, but reach down to the Hallstätter limestone; their presence cannot therefore altogether decide for the Dachstein limestone. The metalliferous limestone is overlaid by a dark bituminous, clayey marl-slate, containing comparatively few and small beds of so-called 'fossiliferous marble'; in which are found *Ammonites floridus*, *A. Jarbas* and *A. Johannis Austriæ*, causing a beautiful play of colors.



D. Dachstein limestone, containing the metalliferous deposits.
L. Black slate. — S. Bituminous limestone. — a. Alluvium.

Potiorek has represented the bedding, as seen in the preceding woodcut, the local repetitions of the black slate being omitted.

Lipold on the contrary has represented the bedding, as in the following woodcut:



D. Dachstein limestone.
L. Black slate.
S Bituminous limestone.
a. Alluvium.

The majority of the metalliferous deposits in all three of the sub-districts, Bleiberg, Kreuth, and Fuggerthal, are long-extended, irregular, and pipe-shaped, without definite limits. These ore-pipes, or chimneys, extend locally in the depth at a determined angle; their direction is dependent on the junction of certain fissures with the stratification-fissures of the limestone, the principal axes of these deposits following such lines of junction. The fissure-junctions form the ideal axes of the deposits, without the strata being themselves filled with ore.

In the Fuggerthal, and in the western portion of the Kreuth sub-district, the strata of limestone, and consequently the stratification-fissures, course SE.—NW., and dip 60°—80° in SW.; while the cross-fissures, whose lines of intersection the deposits generally follow, strike NNW.—SSE., and incline but 50° in SW. Every junction is not accompanied by a metalliferous deposit, nor is it possible to distinctly recognise the fissure-junction in every deposit; the presence of these last can sometimes only be recognised from the general conditions.

In the eastern portion of the Kreuth sub-district, the strata course ESE.—WNW., and have an average dip of 52° in S.; while the cross-fissures strike NNE.—SSW., and incline 60°—70° in E. The inclination of the deposits is therefore here a south-easterly one.

In both the divisions of this sub-district, 18 such chimneys are known, whose diameter, or breadth, varies between 1—15 fathoms, and whose lengths are known to extend for more than 200 fathoms in the direction of dip.

Within the Bleiberg sub-district the stratification of the limestone changes its direction, so that the fissures of stratification again strike NW—SE., but only dip about 30° in SW. They are traversed:

1. by veins, which strike E.—W., and have a considerable dip in N. or S.;

2. by, so-called, Dreier fissures, which strike NE.—SW.; and

3. by other fissures, which strike NNE.—SSW.

The ore-chimneys here usually follow the line of junction of the veins with the stratification-fissures, and dip in SW.; they also follow other lines of junction, and then dip in S.: they exist in greater numbers, but are smaller than in the western sub-districts. Besides these, the veins striking E.—W. also contain ores, especially galena, as true fissure-fillings, 1—6 inches broad. Seven of these larger veins are known to exist, besides several smaller ones.

The Dreier fissures fault not only the strata, but also the ore-deposits, at times upwards of 20 fathoms. Potiorek states, that the fissures coursing NNE.—SSW. encrease the richness of the deposits, where already existing.

I have thus far only attempted to describe the form of the Bleiberg-Kreuth deposits; from which it appears that they are partly irregular, but often very massive, impregnations, following certain fissure-junctions; partly true fissure-veins.

I now pass to their mineralogical composition: this is for the most part very uniform. The principal ore is every where galena, containing either very little or no silver; while only in the western subdivision, called the Fuggerthal, does enough smithsonite occur with it to render the same an object of exploitation. This zinc-ore is perhaps merely an alteration from blende, which is found in small quantities in the other subdivisions combined with the galena. Pyrites occur but in small quantities, and the gang-stones found are; calc-spar, heavy spar, fluor spar, and a very little quartz. Von Zepharowich enumerates the following minerals, as having been found at Bleiberg:

1 Anglesite, in geodes of smithsonite, accompanied by yellow ochre;

2. Asbestos (mountain leather), in fissures of the metalliferous limestone;

3. Asphaltum, in the Asling mine;

4. Heavy spar, with calc-spar and brown spar;

5. Blende, yellowish-brown, with cerusite, wulfenite, fluor spar, calc-spar, and iron pyrites;

6. Calc-spar;

7. Cerusite;

8. Dolomite, in geodes;

9. Fluor spar;

10. Galena;

11. Gypsum, in slate;
12. Calamine;
13. Zinc bloom;
14. Anhydrite; granular, blue masses; with gypsum, blende, and galena, in metalliferous limestone;
15. Naphtha (mineral oil), in bituminous shale, and limestone;
16. Iron pyrites, with galena;
17. Smithsonite; globular, reniform, botryoidal, stalactitic, concentric, and in small crystals;
18. Wulfenite, as tabular crystals, in geodes.

As a rule, the ores mentioned have penetrated in such a manner into the limestone, that they traverse it in the most irregular manner. They form irregular strings, spots, or grains; surround fragments of the limestone, but fill no regular connected fissures in it, except in the eastern subdivision. The ores occur only alongside of the fissures, or rather alongside of their lines of junction, enclosing them on one or both sides; not alongside of all fissures or junctions, but only alongside of some of them, and even of these not always constantly. Their entire occurrence gives the impression of impregnations from fissures.

It is worth noticing, that the ores, in these irregular, and by no means sharply defined metalliferous deposits, occasionally have a concentric structure, as if they had been successively deposited, one over another. This structure is often of such a kind, that an irregular kernel of galena is surrounded by a layer of brownish-yellow blende, a few inches thick; over which follows calc-spar; which last, at the same time, cements the former together.

Friction-surfaces, or slicken-sides, frequently occur in these deposits. They are also here distinctly the result of friction, and occur not only in the galena, blende, and pyrites, but very frequently also on the fissure-planes of the limestone. They even occur in the stratification-fissures; which circumstance caused Mohs to assert, that these could not be fissures of stratification; but there can be no doubt that subsequent dislocations followed the fissures of stratification, leaving friction-planes behind them.

That very considerable dislocations must have taken place in the Bleiberg district, is evident; not only from the faults observed, but also from the jagged projections, which the marl-slate has formed in the metalliferous limestone.

I would call attention to the fact, that the ores by no means occur at every junction of two fissures; but it can be only said, that these junctions are often metalliferous, and that ore-chimneys, thus far discovered, follow nearly all the recognisable lines of junction, frequently even several at the same time, or in succession; in the last case springing over from one line of junction to the other. A farther rule for this peculiar distribution of the ore cannot be given.

Mohs; who considered, in accordance with the then knowledge of the Alps, the metalliferous limestone as belonging to the transition-rocks; thought, that the ore-deposits in this originally formed a continuous bed. This bed was subsequently intersected, and faulted, by numerous, mostly parallel, fissures. He explains the true veins in the eastern portion, as fissures filled during the original formation of the bed.

Phillips explained the metalliferous limestone, as probably corresponding to the *Muschelkalk*; the ores, as distinctly of more recent formation.

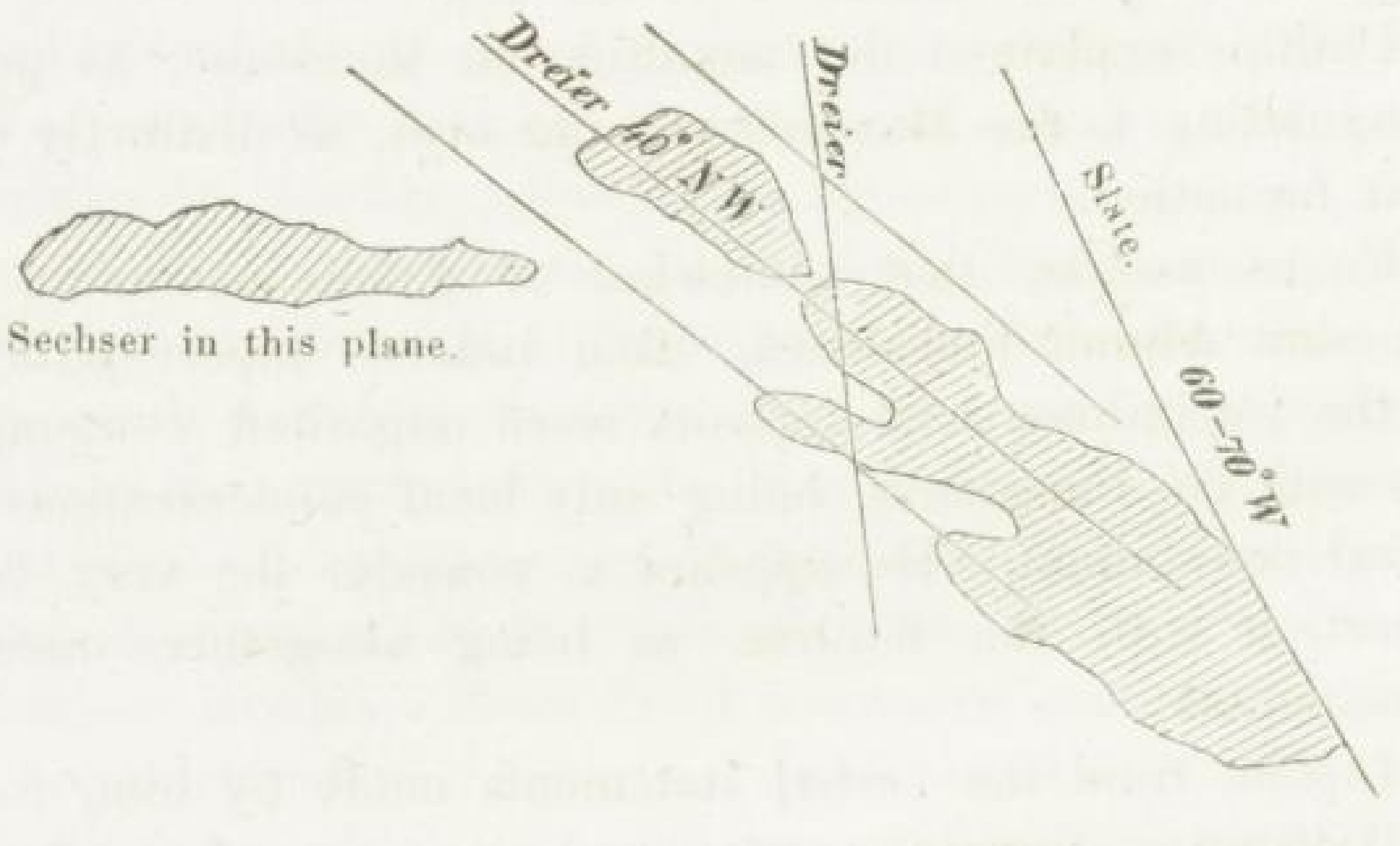
Fuchs asserts, that somewhat of galena occurs in all the magnesian Alpine limestones, often indeed imperceptibly, and that the Carinthian lead-deposits were deposited contemporaneously with the limestones, being only local concentrations of this general ore-content. He appears to consider the very constant connection with the fissures, as being altogether unessential, or accidental.

Lipold, from the verbal statements made by him, considers the Hallstätter limestone contained the ore when deposited; although locally this was unequally distributed. The exploitable deposits, he considers to be of secondary origin, from the concentration of the ore in certain points, either by chemical, or mechanical action.

With regard to myself (Von Cotta), it appears to me; the influence of the various fissures, and their junctions, on the distribution of the ores, is so evident; that I cannot but think these were deposited by solutions, which have penetrated these fissures, and their adjoining wall-rock, for a long period, in such a manner that the ore-deposits have taken place, partly in the fissures as true lodes (at Bleiberg), partly as impregnations, on a grand scale, in the wall-rock of the fissures: of course, most frequently at those points, where the means of circulation were rendered more easy by numerous fissures; which at the same time encreased the surface of rock, that could be attacked.

2. Neighborhood of Bleiburg. (Miss, Schwarzenbach, etc.) According to the examination of the Viennese geologists, the metalliferous limestone is here every where the Hallstätter; in which the separate deposits do not form a continuous group, as at Bleiberg; which may arise from the fact, that it is here much more disturbed, than there.

In the Friedrich-mine, at Miss, there are numerous so-called Dreier fissures; which are partly vertical, partly dip about 40° in NW. The last appear to be stratification-fissures, and are intersected by other fissures striking NE.—SW., E.—W., and N.—S. The ore is found, as at Bleiberg, collected at the junctions thus formed; it always ceases, where the slate in the hanging-wall commences.

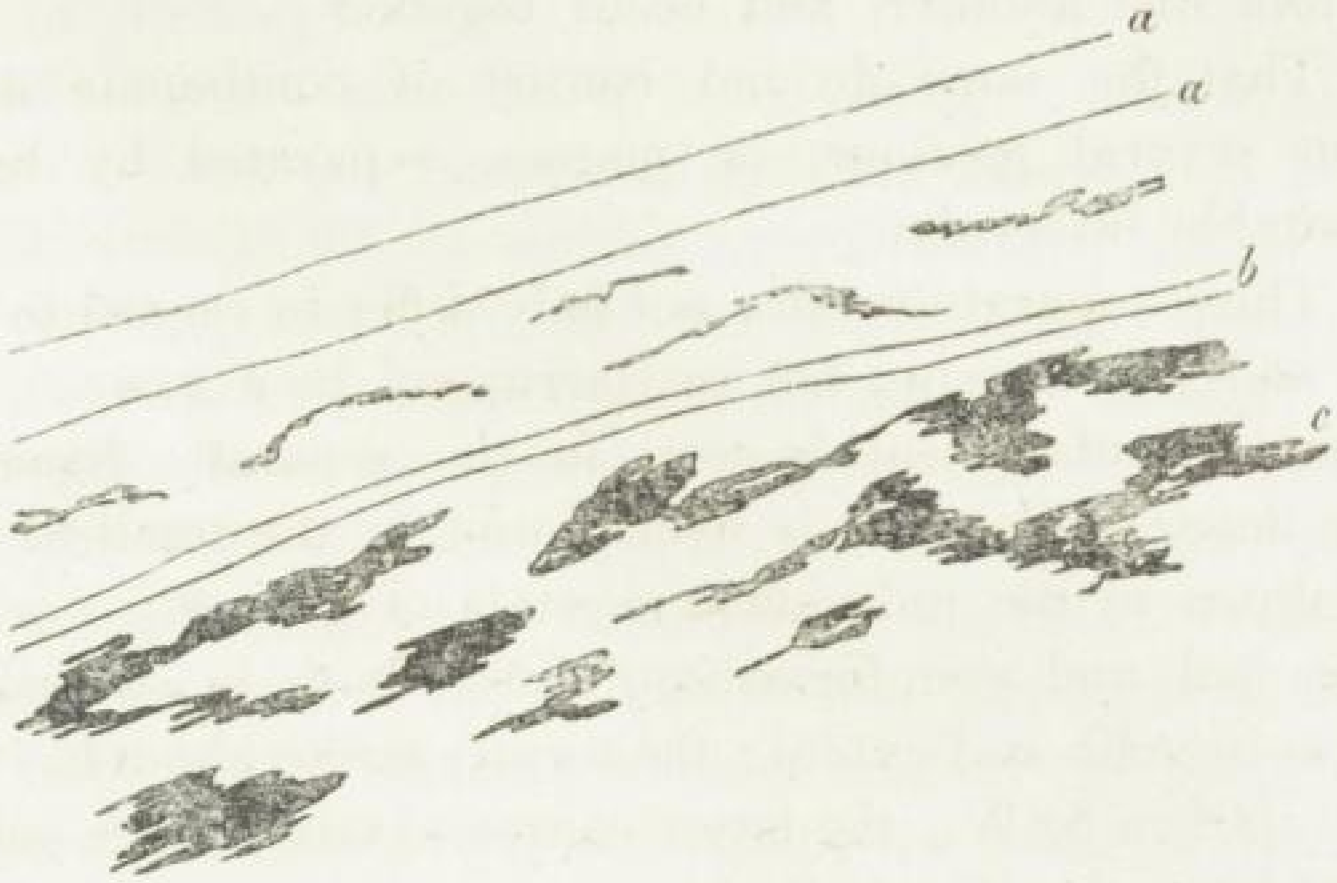


(The form of the workings is indicated by the shaded portions.)

The preceding woodcut shows the manner in which the ore-deposits are distributed in the limestone of the Friedrich-mine: the following altogether ideal representation, the manner of ore-distribution in the limestone of the deposit. In this mine, besides the ore-deposits following the lines of junction, there also occur some more horizontal ones, which have no distinct connection with the fissures.

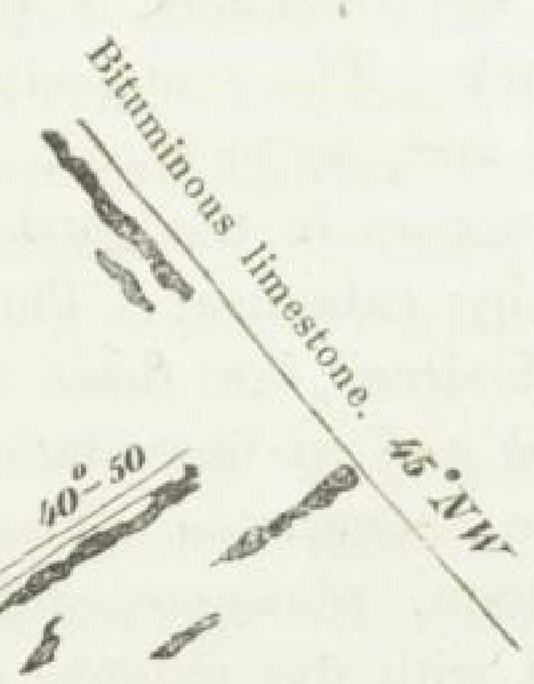
The only ore is galena, with some of the minerals already mentioned under the Bleiberg deposits.

In the Herz-Jesu mine, the intersecting fissures are wanting; and the collections of ore here follow the Dreier fissures, dipping about 40° in SE., at times having very smooth and parallel grooved friction-surfaces. The ores generally occur irregularly distributed in the limestone below these fissures, as shown in the woodcut.



a, a. Fissures frequently covered with friction-scratches.
b. A very ferruginous bed.
c. Bunches of ore.

These zones of ore do not extend into the overlying stinkstone, but suddenly stop, as shown in the woodcut.



3. Raibl. The ore-deposits of Raibl, south of Tarvis, in Carinthia, are also found in Triassic limestone; which, according to the recent examinations of the Viennese geologists, corresponds to the Hallstätter limestone, like the metalliferous limestone of Bleiburg, and perhaps also of Bleiberg. Niederrist says of these deposits: 'They occur in Alpine limestone, strike E.—W., dip in S. not altogether parallel to the strata, but are still to be regarded as beds (?), having the Alpine limestone as floor, and the slate as roof.

A peculiarity of these beds consists in their being accompanied by veinlike formations; so that the ore-occurrence appears, as a combination of veins and beds. If the ore-bed is followed from East to West, it is found:

1. That a calamine-, and a lead-belt can be recognised; which join one another, and occur together;

2. That the same do not consist of continuous masses of ore, but several portions, or masses, separated by barren or unexploitable intervals;

3. These separate masses not only differ in regard to breadth, extent, and enrichment; but are arranged in a row.

The lenticular form is seen in the separate deposits, and in their masses of ore: it is even found in the smallest portions of ore, down to the individual crystals of galena.

The bed- and vein-formations differ, both in strike and dip, as well as breadth and extent: the former strike about E.—W. and dip 10°—50° in SSW., the latter course nearly N.—S. and incline 60°—80° towards SE. or S.

The beds vary in breadth, from a few feet to several fathoms, readily splitting up in the hanging- and foot-beds: they are much more confined in the direction of length, than that of depth.

The extent of the thickness is partly occupied by ores, partly by barren rock. The composition of the ores is very simple. The proper and, so to speak, only lead-ore is galena; while cerusite only occurs in the geodes of the upper portions, already penetrated by calamine. The galena occurs crystallized, only in octahedrons, in these same geodes; otherwise massive, disseminated and as incrustation, frequently presenting a graphic or mosslike appearance. The minerals accompanying the galena are: blende, calc-spar, dolomite, heavy spar, and iron pyrites. Mixed with the galena, or separated in ribbons, they mostly appear to have a pipe-form, with a kernel of barren rock; which is a clear proof of the consistency of Nature in her formations, from the least to the greatest, even in the first stages of the structure of the elongated octahedral crystals.

The deposits, forming the belt of calamine, are clefts; which course NE.—SW., dip at decreasing angles (45°—35°) in NW. or SE. and are so arranged, in a certain zone, as to form a lenticular whole. The breadth of the fissures is very variable; they decrease from a fathom to a few inches; contractions and expansions are by no means rare; the ores occur as short masses, extending much farther in the depth than in length, like the lead-deposits: the ores are calamine, more rarely smithsonite.'

From this description, there is a certain resemblance to the deposits of Bleiberg.

4. Windisch-Bleiberg. According to von Hauer, and Fötterle, the lead-ores occur in Hallstätter limestone. A greater or less subdivision of its strata is metalliferous, and is limited, both in the roof, and floor, by barren limestone. This contains galena, disseminated in greater, and smaller masses; but the principal richness in ore occurs in the vertical veins, or fissures, striking E.—W., which traverse the metalliferous limestone without extending into the barren roof, or floor. These gash-veins are filled with a brown clay, often mixed with numerous angular fragments of limestone: they contain the galena, partly in strings about 3 inches broad, partly in nests, or pockets, at times attaining a diameter of several feet, and lying isolated in the clay. The veins but seldom extend through the entire thickness of the metalliferous limestone without any break. The ore is argentiferous galena.

The metalliferous rock is again the Hallstätter limestone, in which a zone of ore occurs together with gash-veins.

5. Similar Deposits in the northern Alpine limestone. The most important localities are, the lead mines in the Höllen valley near Garmisch, the calamine mines on the Silberleithan near Bieberwirr, and the lead-zinc mines on the Feigenstein near Nassereit.

Gümbel says of these: 'all the localities, where the lead and zinc ores occur, so entirely agree with one another, that a description of one suffices for all; the amount of ores, and their mutual mixture, is however variable at each point, so that poor and rich spots can be distinguished.

The principal ores are galena, and calamine; nearly every where accompanied by cerusite and blende, more rarely by wulfenite (in the Höllen valley near Garmisch, as at Bleiberg). The ores, when in their original condition, occur, without gang-stones, or with calc-spar, in pockets distributed in beds of the Wetterstein limestone. By subsequent decomposition they have united, as threads and strings, in fissures and clefts of the limestone; and their occurrence then has both a veinlike and bedlike appearance.'

It is worth noticing, that the lead and zinc deposits, of the northern Alpine limestone, occur, like the southern deposits, in the Hallstätter limestone; so that, if the metalliferous limestone of Bleiberg also belongs to this subdivision, as Lipold supposes, all these Alpine deposits occur in the same subdivision of the strata: a circumstance, which must lead to the idea, that these ore-deposits must in some manner be connected with this special formation, and are not merely accidental subsequent penetrations. Such a combination can be explained in two ways: either the metallic deposits were originally deposited contemporaneously with the limestone, and have afterwards, following certain fissures, merely been re-distributed and concentrated; or the metallic solutions penetrating from without have, caused by some peculiar property of the rock, been distributed especially in the Hallstätter. This particular property of the rock must then, indeed, have been extended over the whole extent of the eastern Alps, from southern Bavaria to Carinthia, in such a manner, that wherever the metallic solutions came in contact with the limestone, they had a favorable reception. These deposits cannot have been formed originally, and in the limestone, in their present form and distribution. The form and distribution of the same are much more the result of an event subsequent to the deposit of the limestone named; whether the metalliferous solutions have penetrated from without, or have been formed by dissolution from the rock itself.

The copper and silver deposits, between Schwatz and Brixlegg, in the Tyrol, belong to Alpine deposits, of a similar form and manner of occurrence, but different composition. Here the ores are chiefly copper pyrites, and tetrahedrite; which form irregular aggregations alongside of the fissures in a limestone; commonly supposed to belong to the Guttensteiner limestone; but which, Pichler states, probably belongs to an older formation.

These deposits bear a certain resemblance to those in Muschelkalk, of Wiesloch in Baden, and of Tarnowitz-Beuthen in Upper Silesia, in the Devonian limestone of Westphalia, in the mountain-limestone of Eupen near Aix-la-Chapelle, in the Chalk of the Province of Santander in Spain; also to those of Derbyshire and Cumberland in England.

When all these analogous cases are compared; which belong to such different geological periods, and in some of which the subsequent penetration of the metallic solutions has been most clearly proved; it is found to be probable, that only the special chemical, and perhaps mechanical, properties of the magnesian limestone were the cause of this class of lead- and zinc-deposits. These also differ in a very marked manner from the lead-deposits of other regions, by the extremely small amount, or absence, of silver, in the galena they contain. Their origin evidently appears to be entirely independent of the geological age of the limestone, in which they occur. This is in favor of the view, that the solutions have penetrated the limestones subsequent to their formation, and impregnated them from fissures; depositing sulphurets, in place of the carbonate of lime dissolved, in such a manner that these deposits may be regarded as pseudomorphs by replacement on the largest scale. It is under these circumstances easily comprehensible, that such kinds of deposits chiefly followed fissures, and their lines of junction, without forming true lodes.

It is as difficult to say, whence the solutions came that formed these deposits, as in other cases. But we must not forget, that only very dilute solutions (mineral springs) were necessary to deposit particle after particle, if we suppose the period of their activity to be sufficiently great, against which there is nothing to object.

From the preceding remarks, it is evident, that these metalliferous deposits belong to a common group, or class, which are chiefly united to magnesian limestones; whose ores are, galena (containing very little silver), blende, smithsonite, or calamine; but whose forms vary according to local circumstances.

COBALT- AND NICKEL-DEPOSITS, AT SCHLADMING IN STYRIA, ON THE NOECKEL MOUNTAIN IN THE LEOGANG VALLEY, AND IN THE VAL D'ANNIVIERS IN THE CANTON OF VALAIS.

§ 192. The mica-schist in the neighborhood of Schladming[1] contains zones, upwards of 8 fathoms broad; which are impregnated with iron pyrites, in a similar manner to the Scandinavian Fallbands. These fallbands, or zones, of pyrites are intersected, on the zinkwand, and in Wettern, by veins; which contain, at

[1] See: Hauer and Fötterle, Uebers. d. Bergb. p. 34; Ehrlich, Nordöstliche Alpen, 1850, p. 84; Tunner, in his Jahrbuch, 1841, p. 220.

their junctions with these, cobalt and nickel ores, with mispickel, and tetrahedrite. Ehrlich mentions especially smaltine, and copper nickel. This occurrence offers another interesting contribution to the peculiar influence of the wall-rock on the metalliferous contents of lodes.

The Leogang[1] valley is one of the largest side-valleys of the Mitterpinzgau. The Nöckel Mt. rises on the north side of the Schwarzleo valley, one of the side-gorges of the Leogang valley, and consists of Devonian strata. The Sebastian-Michael adit has been driven into the mountain, through the black Devonian slate, to the hanging-wall of a ferruginous dolomite, at a height of 1000 feet above the bottom of the valley. This dolomite, in which greenish talcose and black graphitic schists occur, contains the ore-deposits. They are irregular threads, branches, or lenses, of ore, entirely surrounded by the dolomite; and consist of quartz or bluish-gray dolomitic ankerite, with niccoliferous, and other ores. The principal one is ullmannite, with which occur copper nickel, erythrine, iron and copper pyrites. The iron pyrites, which occurs implanted on quartz-geodes, has also penetrated into the fine cracks of the wall-rock.

Rich cobalt and nickel ores occur in chloritic mica-schist high up on the mountains in the region of perpetual snow, especially in the mountain-ridge, which separates the Val d'Anniviers[2] from the Turtmann valley. They form, according to Girard, veinlike pockets striking about ENE.—WSW. They consist of gersdorffite, with somewhat of copper-nickel, iron pyrites, and a variety of tetrahedrite, in which the antimony is partly replaced by bismuth, called annivite. A similar occurrence is repeated at the edge of the Duran glacier; while at a distance of 9 miles, a vein of mispickel with cobaltine and aikinite (?) crops out, on the slope of the Reschi valley, above the hamlet of Painsec.

QUICKSILVER DEPOSITS OF IDRIA IN CARNIOLA.

§ 193. The high mountains, in which the valley of Idria[3] lies, mostly consist of limestones, whose age has not been deter-

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[1] See: Hauer and Fötterle, Uebers. d. Bergb. p. 39; Lipold, in Jahrb. d. geolog. Reichsanst. 1854, p. 148; Ehrlich, Nordöst. Alpen, pp. 49, 79.

[2] See: Deicke, in Berg- u. hüttenm. Zeit. 1859, p. 177; Girard, in Leonhard's Jahrb. 1851, p. 332.

[3] See: Huyot, in Annal. d. mines, V. p. 7; Lipold, in Oesterreich.

mined. Still less determined, than the limestones, are the strata containing the quicksilver-ores, which crop-out in the valley. The Viennese geologists have recently considered these strata to belong to the Carboniferous, or still older period; since the Werfner beds occur in their hanging-wall, while they were formerly considered to be more recent.

The following is the descending succession of the, partly metalliferous, strata:

1. Variegated sandstone (Werfner beds);
2. Dark gray to black slates, so-called 'silver-slates', containing ores of mercury;
3. Lime-breccia, impregnated with cinnabar;
4. Black, lustrous, bituminous shales, so-called 'bed-shales', containing crystals of gypsum: these contain the greatest richness in ores of cinnabar, which are known under the names of *corallinerz, stahlerz, ziegelerz, lebererz, idrialith, hornerz, etc.*; according to Huyot, a green, partly fissile, sandstone containing pyrites, follows beneath these; then
5. Limestone, passing into a light-colored sandstone, often marly, with traces of cinnabar; and
6. Brownish-gray limestone.

All these strata are inclined 30°—50° in E. or SE., but strike and dip very irregularly; their thickness is also very variable. Both the black ones, 2 and 4; which are to be regarded as true or impregnated ore-beds, and are strata principally exploited; are very irregular; their thickness varies between 1 and 28 fathoms; Huyot states, the silver-slate even attains 47 fathoms.

Lipold states, that a similar formation of quicksilver ores occurs near St. Anna in the Laibel valley, correspondiug in age to the Carboniferous Period. All the strata here are almost tilted on end, and course E.—W. The succession begins, on the side originally on top, with Guttensteiner limestone; under this (in reality alongside of it) follow the Werfner beds, then the Gail-valley beds. The last consist of upper limestone; of black metalliferous limestone, traversed by veins of calc-spar; and of gray, brownish, ferruginous marls, and slaty limestones. The cinnabar occurs in the middle limestone; partly disseminated in the white calc-spar; partly as pockets, in the black limestone, or as fillings of its fissures of stratification; principally, however, in one fissure, hence called the metalliferous crack.

Zeitsch. f. Berg- u. Hüttenwesen, 1855, p. 364; Hauer and Fötterle, Uebers. d. Bergb. p. 38; Von Odeleben, in Leonhard's Taschenb. 1819, p. 25, and 1822, p. 235.

IRON-DEPOSITS IN THE CRYSTALLINE SCHISTS OF THE EASTERN ALPS.

§ 194. Of the numerous iron-ore-deposits [1] in the crystalline schists, Carboniferous, Triassic, Post-Triassic, Tertiary, and Post-Tertiary, strata of the eastern Alps; none are so remarkable, or interesting, as to need description. There is one exception to this, that of Pitten in Austria.

The iron ores here form a bed in gneiss, which is overlaid by limestone and mica-schist. It has a considerable dip at the outcrop, which becomes somewhat more gentle at a greater depth towards W. The deposit is subdivided into two portions separated by a bed of gneiss, 4—5 feet thick; their thickness is very variable, attaining 12 feet in the upper, but only 4 feet in the lower bed.

The upper subdivision consists of mostly decomposed spathic iron, passing into hematite; in which are found traces of magnesia, iron and copper pyrites. The lower subdivision consists of spathic iron, hematite, and magnetite; which seem to pass one into another, and are so intimately combined, that cabinet-specimens sometimes contain all three kinds of iron-stone; which indeed renders the explanation, by alteration, much more difficult. In the upper portions, hematite and specular iron predominate; at a depth of 70 fathoms below the surface, very fresh spathic iron occurs, passing into magnetite. As accessory minerals, are found: iron and copper pyrites, azurite, chrysocolla, and traces of cinnabar. The bed is frequently separated from the country-rock by thin layers of clay, and is also intersected and faulted by clay-fissures with friction-surfaces. Calcspar and quartz occur in geodes.

IRON-DEPOSITS OF THE LOWER PALÆOZOIC IN THE EASTERN ALPS.

§ 195. The strata of the lower Palæozoic Era, in the eastern Alps, which are principally Devonian, although partly

[1] For further information on the iron-deposits, in the above mentioned formations, see: Munichdorfer, in Jahrb. d. geolog. Reichsanst. 1855, p. 619; Hauer and Fötterle, Uebers d. Bergb. p. 72; Leithe, in Kraus' Jahrb. f. d. Berg- u. Hüttenmann, 1852, p. 234; Haidinger, in Leonhard's Jahrb. 1848, p. 63.

also Silurian, contain a large number of extensive iron[1] deposits. The most of these are composed of spathic iron, and form long groups of beds, locally of very variable thickness; besides these, also veins. Von Cotta then gives a list of 60 of these deposits; and states, that 52 of them lie in a zone from E. to W., whose length is about 185 miles. With one exception, they all appear to lie between the same strata, or members of the Devonian formation, near to its junction with the Werfner beds, and Alpine limestone The majority of these deposits are belonging to a certain niveau of the Devonian, as von Schouppe has proved, contrary to the former views, which considered them to be igneous segregated masses. But these beds, even when locally very thick, are often very irregular in their shape, forming as it were a number of lenticular bodies, within the level of the same strata, like the spherosiderites in the Carpathians (§ 159), the only difference being that their breadth is often much greater. These lenticular beds; which, if observed separately, wonld be often mistaken for recumbent segregations; are also accompanied by veins of spathic iron, which obliquely intersect their wall-rock.

The spathic iron, of which these beds and veins are composed, is at times, partially, or altogether altered into limonite or hematite; it is contaminated by an intermixture of limestone, or slate; and contains besides these, as accessory minerals; specular iron, iron pyrites, galena, copper, and traces of cinnabar, also quartz, and heavy spar.

The best known, and most important of all, is the Erzberg (Ore Mountain). This mountain, between Eisenerz and Vordernberg in Styria, rises, as a large cone, about 1000 feet above the Erzbach valley into which it projects. It consists, on its northwest flank, from its peak almost to its base, of more or less pure spathic iron. Still the entire mountain does not consist of ironstone, but only a thick outer shell. The depth to which the

[1] For further information, see: Kudernatsch, in Jahrb. d. geolog. Reichsanst. 1852, p. 4; Von Morlot, in same, 1850, pp. 104, 118; Von Schouppe, in same, 1854, p 369; Tunner, in Jahrb. f. d. österreich. Berg- u. Hüttenmann, 1843—1846, p. 388, and 1851, p. 91; Haidinger, in Leonhard's Jahrb. 1849, p. 209; Pichler, Beiträge z. Geognosie Tyrols (2 series). 1859, p. 7; Unger, Einfluss d. Bodens, p. 39; Von Miller considers these ironstones, as belonging to the Triassic. in Berg- u. Hüttenmänn. Jahrb. d. k. k. Bergakademien, 1864, No. 12.

ironstone penetrates the mountain is, measured horizontally, 700 feet, or the thickness of its shell 630 feet. Beneath this follows limestone, or Devonian slate. The limestone, sometimes containing the remains of Crinoids, is not sharply defined at its junction with the ironstone, but, as it were, passes into the same by an admixture of spathic iron. Limonite, or at least a brownish coloring of the spathic iron, has been formed by alteration; the mass also contains in places, quartz and calc-spar, more rarely specular iron, mispickel, iron and copper pyrites; while stibnite, and cinnabar, are extremely rare. The coralloidal aragonite, which occurs very finely in cavities, is of secondary formation.

a. Graywacke, as floor; b. Devonian limestone; c. Spathic iron (vertically shaded); d. Siliceous slate, and clay-slate; e. Devonian slate, as roof; f. Werfner beds (Buntsandstein); g. Guttensteiner limestone (Muschelkalk).

Von Schouppe, who first distinctly showed the bedded character of this deposit, has given the following profile of the Erzberg. We there see the ironstone, towards Reichenstein, embedded between two limestones; towards Eisenerz, on the contrary, where limestone is wanting, immediately between Devonian slate, over which the Werfner beds soon follow. Von Schouppe has recognised the same relations of bedding in numerous other localities of the same region, in which the ironstone, sometimes, immediately overlies limestone-breccia. From the uniformity in these relations of bedding, it follows that these masses of ironstone belong to a particular niveau of the Devonian formation, corresponding to the limestone in which the Crinoids are found; consequently, these iron-deposits must be irregular beds.

The origin of these deposits is still very enigmatical. In so far as they form true beds, the mineral matter composing them must have been deposited, during the Devonian Period, between the beds enclosing them. But in what condition?

hardly as crystalline spathic iron. It might be supposed, that they were formerly spherosiderite, and had become crystalline, through a long continuing period of pressure and warmth. Such a hypothesis would also allow the consideration, that the neighboring veins of spathic iron had been pressed in a softened condition from the veins into the fissures. But where do such thick beds of spherosiderite occur? and, in any case, the manner in which the spherosiderite was formed still remains an unsolved problem.

When spathic iron has once been formed, it is then easy to explain the formation of limonite, hematite, and even magnetite, by alteration. These occur in the eastern Alps, under similar relations of bedding. It would not be strange, if analogous ironstones were found in lower strata of the Silurian and Devonian formations, or even in the crystalline schists; since the same process of formation may have been repeated several times.

ITALY.

PRELIMINARY REMARK.

§ 196. Italy contains much fewer metalliferous deposits than Germany, and those which do occur have been much less opened up. I shall only notice the more interesting of those known.

XVIII. MOUNTAINS OF MODENA AND TUSCANY.

CINNABAR DEPOSITS AT RIPA IN MODENA.

§ 197. The mountains at Ripa,[1] near the small town of Pietra Santa, consist of crystalline schists; mica-schist, chlorite

[1] See: Russegger, in Leonhard's Jahrb. 1845. p. 565; Coquand, in Bulletin géologique, vol. VI. p. 102.

schist, and talc-schist. Within the common mica-schist, occurs a white silky variety, passing into talc-schist, containing numerous layers of quartz. In these last cinnabar is found, which penetrates the entire mass, especially the fissures of foliation.

The cinnabar has probably penetrated the rock long subsequent to its formation; so that the deposit must be regarded, as an impregnation, in the fullest sense of the term. The different character of the mica-schist containing the cinnabar, from that free of the same, is possibly a consequence of the same process by which the impregnation was formed.

LEAD AND COPPER ORES IN THE APUANIAN ALPS.

§ 198. The Tamburra,[1] a portion of the highest central ridge of the Apuanian Alps east of Carara, mostly consists of granular limestone, or white marble; and the schists, observed here and there, are probably only subordinate contemporaneous rocks. A fine lead-lode occurs close under the crest, near the so-called Campanelli di Garfagnana; it strikes NNE.—SSW., dips in SW., is several feet broad, and contains argentiferous galena.

Crystalline schists crop-out, southerly of this marble district, in which the deep valley of the Versitia is excavated. In this valley, somewhat to the south of Ruosina,[2] is a mass of chlorite schist, entirely penetrated by fine threads, and pockets, which consist of quartz with sulphurets. Argentiferous galena and blende predominate; but stibnite, iron and copper pyrites also occur. These threads of ore are, in turn, traversed by strings, and veins, of specular iron; while the same schists contain, in the neighborhood, broad veins of hematite, specular iron, and magnetite. Hoffmann states, they all appear as injections, and sublimations. The last may be true for the veins of specular iron; but those containing sulphurets, seem to be rather the results of infiltration.

The rock at Val di Castello[3] is mica-schist and limestone. The schist, near its junction with the latter, contains parallel

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[1] See: Russegger, in Leonhard's Jahrb. 1845, p. 565.

[2] See: Hoffmann, in Karsten's Archiv, 1833, vol. VI. p. 238.

[3] See: Fiedler, in Poggendorf's Annalen, 1846, vol. 67, p. 428, and in Leonhard's Jahrb. 1848, p. 600; Russegger, in Leonhard's Jahrb. 1845, p 566.

bedded-veins, essentially consisting of argentiferous galena. At times several of them unite to form a so-called *Stockwerk*; from which it would seem, that they are not beds, as Russegger thought, but bedded veins.

Not far from these deposits, at Castello on the Angina canal, occurs a limestone with indistinct organic remains. This is traversed by veins, a few inches broad, consisting of heavy spar, calc-spar and fluor spar, with tetrahedrite, and iron pyrites. Very remarkable is the fact, that the masses of the veins are at times separated by empty fissures, resembling selvages, from the wall-rock, so that it stands free. This is the same case, which Fiedler once described, and thought the cavity, traversed by the lode, had existed previous to the formation of the vein. It is evident, that the easily assailable wall-rock has been washed away on both sides of the firmer lode.

COPPER ORES IN THE SERPENTINE OF MODENA.

§ 199. The mountain masses, on both sides of the Rozzena, consist, at Ospitaletta,[1] of serpentine; which here traverses *Macigno* and *Alberese* and appears to have considerably metamorphosed them. Within the serpentine are found great irregular masses, of red and green jasper, and a talcose slaty clay; which are much decomposed, and in part reduced to argillaceous variegated masses. In these decomposed masses occur small masses, of native copper, and psilomelane; which both appear to penetrate the jasper and clay in irregular strings, but so unequally and irregularly, that no idea of working them can be entertained. Russegger thinks, the jasper-clay masses are altered portions of Cretaceous marl and Macigno slate.

The Monte Nero at Rochetta consists of serpentine, surrounded by crystalline schists. Large segregations of red and green, compact or slaty jasper, occur in the serpentine, on its northern flank. These are traversed by peculiar lenticular veins, which swell out to a breadth of 3 feet, and are united by small empty fissures. These lenticular bodies consist of manganite, with native copper, and malachite; a very peculiar combination of minerals.

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[1] See: Russegger, in Leonhard's Jahrb. 1844, pp. 771, 773, 781, 782.

THE COPPER AND LEAD DEPOSITS OF TUSCANY.

§ 200. The metalliferous mountain-districts of Tuscany[1] consist of sedimentary strata, traversed and upheaved, by serpentine, gabbro, and feldspathic rock (quartz-porphyry, etc.). The eruptions of serpentine appear to have preceded the Tertiary Period; those of the feldspathic rocks, to have followed it. These sedimentary strata, whose stratification is very frequently destroyed, consist, in descending order, of:

I. Tertiary deposits:
 1. Subapennine marl;
 2. Pliocene limestones; alternating with ophiolithic conglomerates:
II. Cretaceous (or eocene?) deposits:
 1. Macigno, thick clayey and micaceous sandstones;
 2. Alberese, thick limestones and marl shales:
III. Jurassic (and Triassic?) Deposits:
 1. Red limestones, and variegated slates;
 2. White granular limestone (marble of Carara);
 3. Verrucano, sandstones, and slates; the last partly crystalline.

The ore-deposits, which are in part very intimately combined with these rocks, form irregular veins, and segregated masses, consisting of hematite, copper pyrites, erubescite, blende, galena, cinnabar, and various argentiferous sulphurets. Some of them are intimately combined with the serpentines, others with amphibolic rocks, and still others with the metamorphic sedimentary rocks.

1. Copper Deposits associated with serpentine. They form irregular veins, in serpentine, or at the limits of the rocks it has pierced; especially on the Monte-Catini, Monte-Vaso, Monte-Castelli, and in the Rocca-Tederighi. They chiefly consist of copper pyrites, and erubescite, with somewhat of native copper, melaconite, and tetrahedrite.

The best known, and most interesting, of these occurrences, is that of Monte-Catini. The Cretaceous strata are here broken through, and much metamorphosed, by gabbro and serpentine. The champion-lode, which occurs in gabbro, courses E.—W. and is extremely narrow at its outcrop, being about an inch broad; but it constantly encreases, with the depth, to 6, 9, 12, and

[1] See: W. Paget Jervis, in Mining Mag. Jan 1861, pp. 55, 198; Burat, Traité du gisement et de l'exploit. des minéraux utiles, 1858, p. 357; Pilla, in Compte rendu, 1845, vol. XX, p. 811; Caillaux, in Berg- u. hüttenm. Zeit. 1858, pp. 372, 421; Von Rath, in Zeitschr. d. deutsch. geolog. Gesellsch. 1865, vol. XVII. p. 292.

even, exceptionally, 30 feet. Its dip is about 45°. It is mostly composed of a talcose rock, resembling serpentine, with fragments, and even great horses, of gabbro. The ores occur, scattered through the serpentine rock, consisting of erubescite, and copper pyrites, very pure and almost free of other admixtures. They form small nodular masses, or even large ones, of several cubic feet content, and encrease in number with the depth. They are frequently found collected at the foot-wall of the lode, there filling irregular depressions, and fissures in the country-rock; while the hanging-wall is much more regularly defined. Nodular masses of ore occur scattered, even in the middle of the lode; while, from irregular bends of the vein, the foot-wall occasionally becomes the hanging one, but is still chiefly accompanied by the ores, in such a manner, that the aggregation of ore appears to have essentially been a one-sided one.

Some pockets of ore, while having a less thickness, are longer and higher, being 30—100 feet; and then form a sort of continuous selvage, at the foot-wall. Other ore-sheets of this kind occur more in the middle of the lode.

The lode frequently branches, and sends out, especially at right angles to its general strike, droppers, which cannot be regarded as cross-courses.

Experience has shown, that the ore encreases, not only qualitatively, but also quantitatively, with the depth; and that those places are particularly rich, where ramifications branch into the wall-rock. At such points, native copper sometimes occurs, in clefts. As accessory minerals also, occur somewhat of mispickel, tetrahedrite, and quartz.

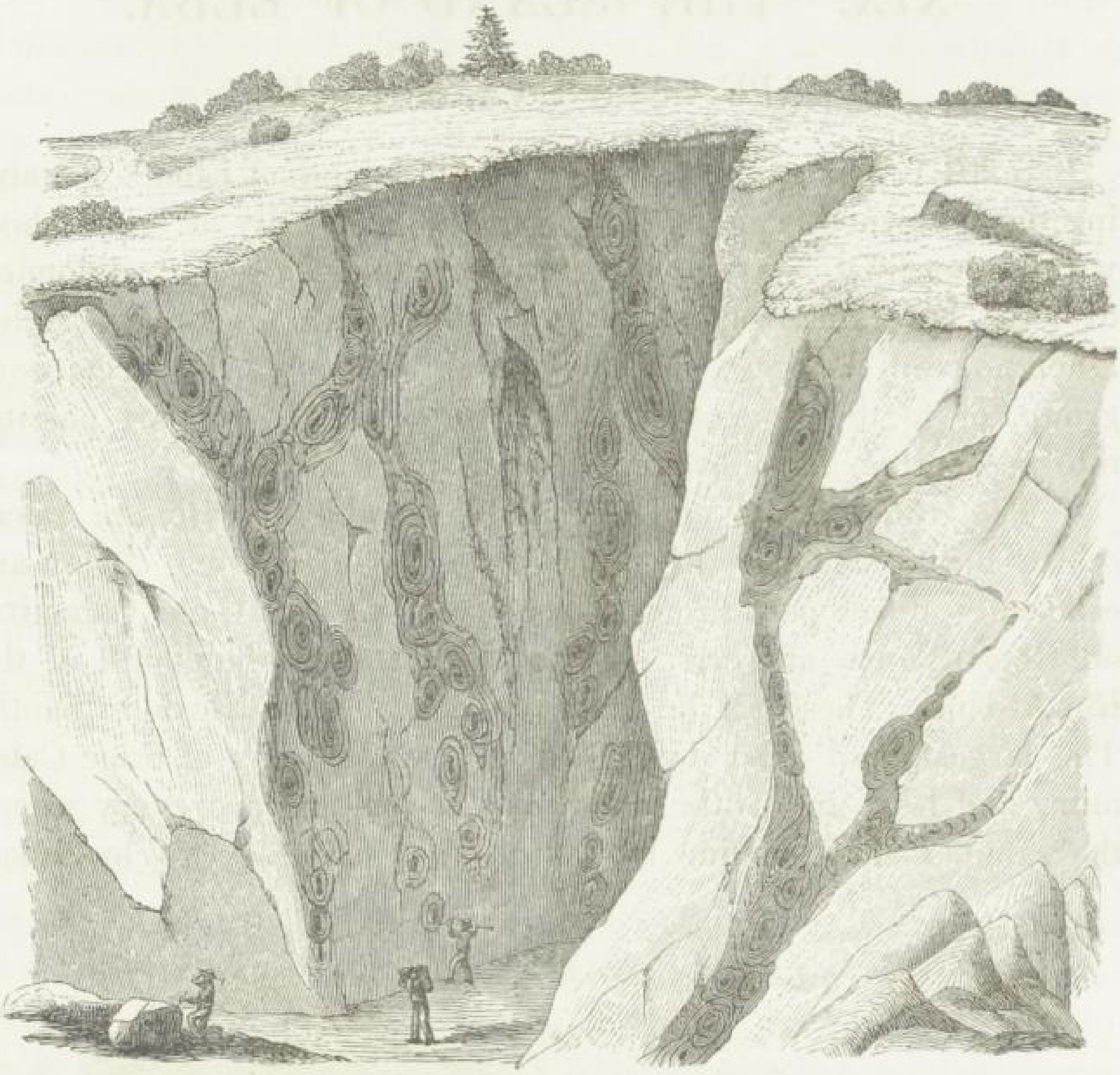
Burat is of the opinion, that the fissure in the gabbro was first filled with serpentine which received fragments of the wall-rock; and that the ores came subsequently through emanations, which were consequences of the serpentine eruption. The cavities containing the ores might have been formed by the contraction of the serpentine.

Similar lodes recur at Rocca-Tederighi, where serpentine and gabbro occur between quartz-porphyries; the veins encrease here also, in richness and breadth, with the depth. Entirely analogous are also the ore-occurrences on the Monte-Vaso and Monte-Castelli; there is likewise a considerable analogy with the ores mentioned in the preceding paragraph. Serpentine appears in numerous localities to be generally a carrier of copper-ores.

2. Ores associated with hornblende. A second very interesting group is that of Combigliese. The rock, of which the Monte-Calvi consists, is for the most part granular limestone, belonging to the Jura group, and perhaps also less metamorphosed Alberese. In these occur very irregular lodes, cropping-out with but slight breadth and extent; they ramify irregularly in the limestone, and often wedge-out very suddenly.

According to Burat, they appear to encrease, with the depth, in breadth and extent, often uniting; from which he concludes, that they represent the frequently ramified upper portions of two igneous veins. Their composition is locally different; amphibole and lievrite, with somewhat of quartz, every where form the chief mass, the amphibole sometimes forming radiated nodules: towards the outcrop, both are much decomposed, and altered to an earthy mass. In this occur, near Rocca-San-Sylvestre chiefly iron pyrites, near Temperino principally copper pyrites, at Cava del Piombo mostly blende and galena. These ores are not locally distributed in equable masses, but occur in rich streaks, 15—30 feet broad and three times as long, which appear to extend principally in the direction of depth. The mass of the lodes is often firmly joined to the wall-rock, and so intimately combined, that it is difficult to state, where the limits are: they appear to have melted together. Spheroidal secretions, with concentric structure, are often found, consisting of alternating layers of ores and vein-stone, or having kernels of pyrites, surrounded by radiated hornblende. No trace of a symmetrical arrangement, parallel to the walls, can be seen. The masses of ore are irregularly distributed, and from the manner of their dissemination, especially of the concentrical spheroids, it is evident that they were formed contemporaneously with the rest of the matrix. Burat concludes, from all the circumstances, that these are igneous dikes, formed like other similar dikes, containing no ores. He states, that where parallel zones occur, they are only consequences of an elongation caused by the upward movement. It must be conceded, that this view has much in its favor; although, from a chemical point of view, it appears very difficult to concede, that all the minerals, occurring in the veins, were formed by solidification from an igneous-fluid condition. The nature of these deposits can be very distinctly seen in a quarry in the Cava del Piombo, represented in the woodcut.

The irregular dark veins here traverse white marble; the concentrical spheroids, of which they are principally composed, at times appear in the country-rock, as if separated from the



vein. A complete penetration of the mass appears to have taken place. At this point the amphibolic rock, essentially mixed with only blende and galena, appears almost black; where only blende is mixed with it, the same appears more yellowish; and where copper pyrites predominate, of a more greenish color.

Pilla mentions a greater variety of minerals, than Burat, in the lodes just described; viz. foliated sahlite, epidosite, compact melaphyre, and lievrite, as principal ingredients, accompanied by quartz, calc-spar, aragonite, limonite, epidote, iron pyrites, marcasite, mispickel, copper pyrites, malachite, euchroite, blende, buratite, galena, and allophane, as accessory minerals. At Rocca San-Silvestre spheroidal masses occur in the veins, composed of alternating concentric layers of pyroxene, and calc-spar; and contain quartz-crystals.

XIX. THE ISLAND OF ELBA.

CAPE CALAMITA, AND RIO.

§ 201. The eastern portion of the Island of Elba,[1] containing the renowned iron-deposits, consists principally of mica-schist, with subordinate layers of granular limestone, and dolomite, overlaid by slates, sandstones and limestones, generally, called Macigno and Alberese, and belonging either to the Cretaceous group, or to the Eocene strata. Dioritic rocks, in part passing into serpentine, have broken through these strata.

The iron-deposits are essentially combined with the mica-schist, but come, also, in contact with the serpentine. They are especially developed in four localities; viz. on Cape Calamita, on Cape Bianca at Terra nera, at Rio, and at the mouth of the Rio Albano. These all lie in a line drawn from North to South. The largest, and most developed, are the deposits of Cape Calamita, and Rio; and as the conditions of bedding are every where the same, I shall confine my description to these two localities.

The woodcut represents an exterior view of the deposit at Cape Calamita (from Burat). The dark mass is specular iron,

[1] See: Krantz, in Karsten's Archiv, 1840, vol. XV. p. 347; Burat, Théorie des gites métallifères, 1845, p. 247, and Géologie appliquée, 1858, p. 354; Annales d. mines, 1852, vol. I. p. 608; von Rath, in Leonhard's Jahrb. 1865, p. 98.

and limonite; the light-colored strata over-arching it, crystalline dolomite; over which follows mica-schist.

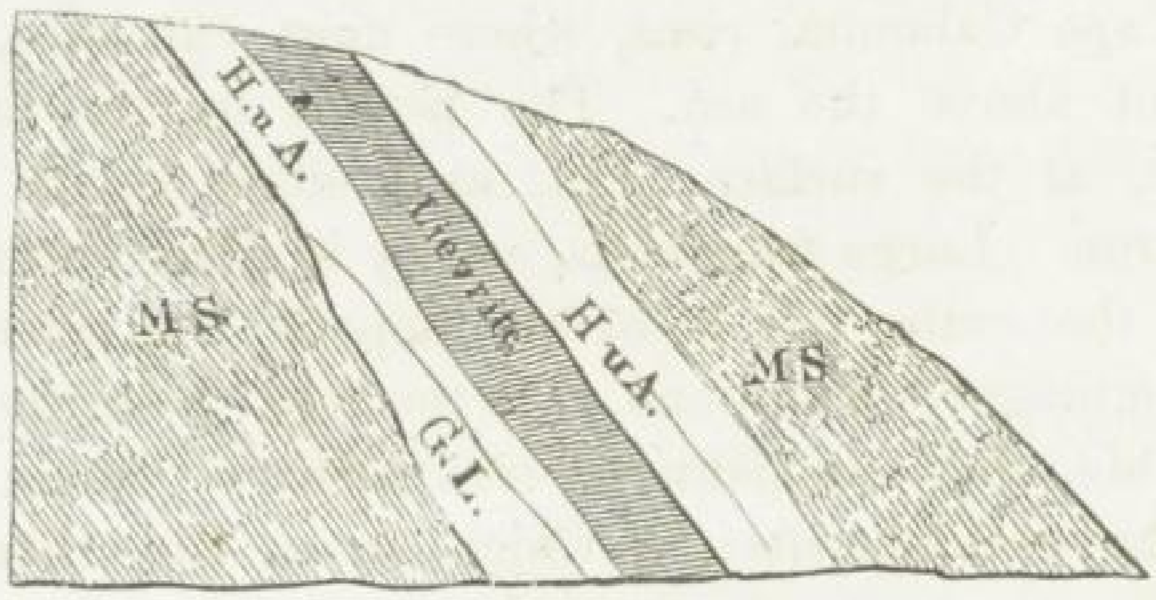
Burat describes this deposit almost as follows. The Monte Calamita rises 218 fathoms above the sea, and consists of schistose strata with calcareous beds. These strata are supposed to have been formed by the metamorphosis of Alberese and Macigno (which Naumann however doubts), and form an arch. The centre of this arch consists of hematite, and magnetite: these are accompanied, near the junction with the limestone, by green amphibole, and lievrite. The overlying strata are metamorphosed in the most different manners. Magnetite and hematite penetrate the dolomite, render it crystalline granular, and surround fragments of the same of all sizes. Burat thinks, the iron-ore must here have penetrated upwards, precisely in the same manner as igneous-fluid rocks. This supposition, he thinks, solves the whole enigma of the origin. Against which indeed many important doubts may be raised.

Krantz says, on the contrary: 'The iron-ore-deposit, occurring on Cape Calamita, rises, where most extended, to a height of 900 feet above the sea. The bed is mostly limonite, and iron-ochre, at the surface; but, at a slight depth, passes into specular iron. Large fragments, partly in place, partly detached, designate the entire extent of the deposit; on whose southeast side native magnets are found near the sea. I observed, so far as was possible, that the magnetic iron forms a bed on the eastern limit of the iron-deposits; in which, as at Rio, though less frequently, lievrite occurs having a brown incrustation. Semiopals, less frequent near the surface, but there of a brownish and reddish color, probably also owe their origin to this 'bed formation.'

Krantz says of the renowned mine at Rio: 'The rocks, altered to mica-schist, occurring immediately over the Marina di Rio, crop-out, in a much altered condition, from the influence of igneous rocks; then, while specular iron occurs higher up, the base is serpentine. This occurrence is important, as allowing the most certain conclusion (?), that the formation of the serpentine preceded that of the specular iron; then, while the elevated mica-schist contains much specular iron at its limits, the serpentine is always free from it. The following woodcut represents this occurrence.

The mica-schist occurs, at its junction with the serpentine, as a very soft, now clayey, now calcareous, fissured rock, containing quartz secretions. The nearer it approaches the specular iron penetrating it, so much the softer does it become, until it is changed to a yellow clay. It is frequently, however, very hard near the specular iron.

Finely crystallized iron pyrites, frequently occurs with the specular iron, and in its neighborhood lievrite. Krantz gives the following instructive profile of an occurrence of this last.



M. S. Mica-schist.
H. u. A. Hornblende and Actinolith.
G. L. Granular limestone.

The mica-schist here contains a widely extended bed of actinolith, full of geodes, whose walls are covered with prismatic crystals. Single crystals of lievrite occur here and there in the same, coming from the chief mass, which traverses the actinolith, as a bed, nearly in the middle. The lievrite is here black, reticulated, and stellated. It contains iron pyrites, and mispickel, in its upper portion. In the foot-wall, of the bed of amphibole, occurs a wedge of granular limestone.

Burat says, of Rio la Marina; which was the only locality, where iron was exploited in 1845; that this largest and richest iron-deposit of the island has penetrated, parallel to the stratification, between quartzose schist and limestone. The centre of the same consists of crystalline specular iron and compact limonite, the former contains concretions of iron pyrites. The limits, towards the hanging- and foot-walls, are rendered indistinct by intermixtures, and transitions. The enclosing strata have also become very crystalline near the deposits, and contain amphibole and lievrite. All the relations tend to show a sublimation, or eruption. When we call to mind, that on Vesuvius newly formed fissures have been filled, in the course of a few weeks, with specular iron by sublimation; this manner of formation becomes very probable for the iron-deposits of Elba, although the island does not belong to the truly volcanic ones. The apparently massive occurrence of the specular iron can be probably traced back to a repeated fissuring and penetration of the rocks.

Both these accounts are unfortunately so contradictory, and, in part, so incomplete, that no judgment of the reader can be founded on them.

FRANCE.

GENERAL REMARKS.

§ 202. Six mountainous districts occur on the borders and in the interior of France, consisting of older, mostly igneous or metamorphic rocks; the broad intervals between which, partly basins, are filled with Secondary and Tertiary deposits. These six mountain districts are:

1. The western portion of the Alps;
2. The Vosges;
3. The Ardennes;
4. The Central District of France;
5. Brittany;
6. The Pyrenees.

Of these, only (4, 6, 5) the Central District of France, the Pyrenees, and Brittany, will be more fully spoken of; the others having been partly already described with other districts, partly containing nothing of particular importance.

Metalliferous deposits, other than those of iron, are not found, outside of these mountainous districts, and their borders; but within these occur many veins extending from the older rocks up to the Jura.

The intervals between the mountain-districts, mostly consisting, at the surface, of recent and horizontal strata, only contain iron-deposits, partly as beds in the Jura group, partly as less regular aggregations of oolithic ore, nodular ore, and bog-ore.

I shall first mention the sedimentary iron-ore-deposits, of France and the Swiss Jura, in common; and then pass to the mountainous districts; the general character of whose metalliferous deposits, or some particularly well known cases, I shall attempt to describe.

XX. IRON-DEPOSITS OF FRANCE.

OOLITHIC ORES, AND IRON-DEPOSITS IN THE JURASSIC GROUP.

§ 203. The Jurassic strata, and, in part, also the Neocomian beds, contain, in numerous parts of France, similar deposits of ironstone to those, with which we have already become acquainted in Würtemberg, and Bavaria. From which follows, not, indeed, a general connection of the separate beds, but a great conformity in the general lithological character, throughout the whole of central Europe during the Jurassic Period, extending from the Alps to the Pyrenees, the Scottish and Scandinavian elevated plateaux.

Secondary aggregations of iron-ores occur, in the form of pebbles, nodular masses, or concentric masses (oolithic ores); together with the parallel beds of limonite, hematite, and clay ironstone; at numerous places, both in France and Germany; between the strata of the Jura group. These fill cavities, fissures, and surface-depressions, of the Jurassic and Triassic limestones; or occur in separate Tertiary beds.

These, partly at least, secondary iron-deposits are in many respects still obscure occurrences.

OOLITHIC DEPOSITS IN THE SWISS AND FRENCH JURA.

§ 204. The chain of the Jura, consisting for the most part of much tilted limestones, contains in many places oolithic iron-ores embedded in irregular cavities and fissures of the limestone; which bear a great analogy to those, with which we have already become acquainted in the Suabian Alp (§ 132).

Gressly[1] has described these deposits very completely. The ores occur in a variegated, mostly red or yellow, clay; which is at the same time mixed with earthy limonite, and contains sand and boulders. They consist of grains, nodular, and ellipsoidal masses, of very variable size; which are sometimes united in a very loose manner.

They occur, either in fissures or irregular cavities of the Jura limestone, or form very irregular deposits on the same, on older or on much more recent rocks. Fossils are rather scarce in the deposits, of these not a single specimen appears to belong to the period of their formation, but all belong to Jura, Cretaceous, or Tertiary deposits of a greater age; while the remains of mammals also occur among them, which appear to belong to a very recent period. Nevertheless they are frequently overlaid by Cretaceous and Molasse strata; from which Gressly concludes, that they are, in general, more recent than the Jura formation, but older than the Gretaceous. Which it is, indeed, difficult to reconcile with the occurrence of the more recent fossils.

The surfaces of the limestones, on which they lie, every where exhibit a certain conformable character, being uneven, as if attacked and eaten by acids. Frequently a breccia, with fragments and boulders of the Jura limestone, occurs immediately under them, also appearing as if it had been attacked by acids.

Such deposits occur in innumerable localities of the Jura-chain, principally near the great valleys, and on their bottoms, but also in fissures and cavities at the most different levels of the mountains; so that they might be regarded as the remains of a general stratum, did not other important reasons exist against this view.

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[1] See: Gressly, Sur le Jura souleurois, in the Neuen Denkschriften der allgemeinen Schweiz. Gesellschaft der Naturwissenschaften, Neufchatel, 1841, p. 251.

Gressly finally considers the oolithic ore-deposits in the Jura, to be at once contemporaneous with, and substitutes for, the Neocomian; but also local consequences of the upheaval of the chain, and in particular of hot mineral springs, which owe their origin to plutonic upheavals. When he terms them 'semi-plutonic' formations, and places other plutonic iron-lodes at their side, this is certainly a somewhat uncommon use of the term plutonic. He also speaks, in the same uncommon manner, in his memoir, of craters and elevation-craters in the Jura-chain. He thinks, that the formation of the oolithic ores has continued, from the Neocomian Period probably into the Tertiary; and that in this manner, as well as by subsequent washing-in, may be explained the tolerably rare occurrence of fossils more recent than the Jurassic or Neocomian. Nevertheless, it appears to me, that, in the Jura, as in the Black Forest and Suabian Alp, iron-ores, originally formed at some previous period, were again deposited, by repeated denudations, at various points, and under various conditions.

Gressly's work is, however, the most complete extant on the oolithic iron-deposits, and is accompanied by numerous instructive plates.

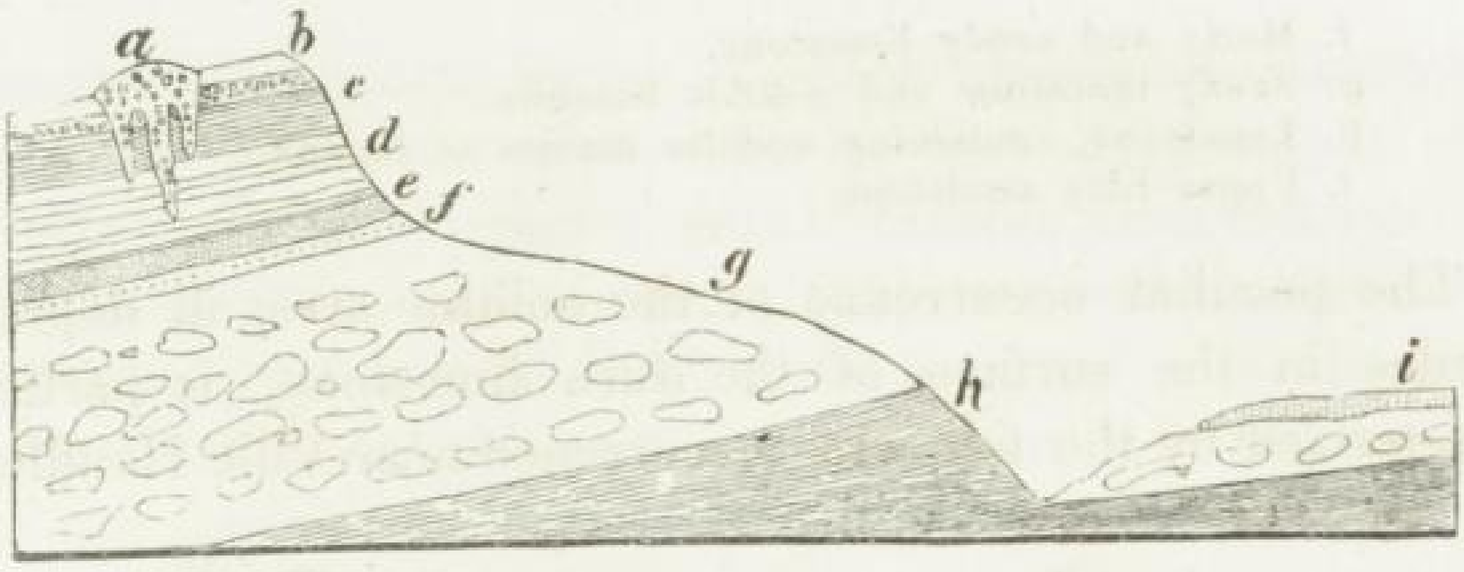
IRON-DEPOSITS NEAR THIONVILLE.

§ 205. In the Ottange valley, especially at Thionville, various iron-deposits occur in the Jura and Lias formations, which somewhat resemble those of the Suabian Alp (§ 132).

Eugène Jacquot [1] distinguished in this region the following varieties of iron deposits, whose occurrence, and bedding, will be best understood from the accompanying three woodcuts.

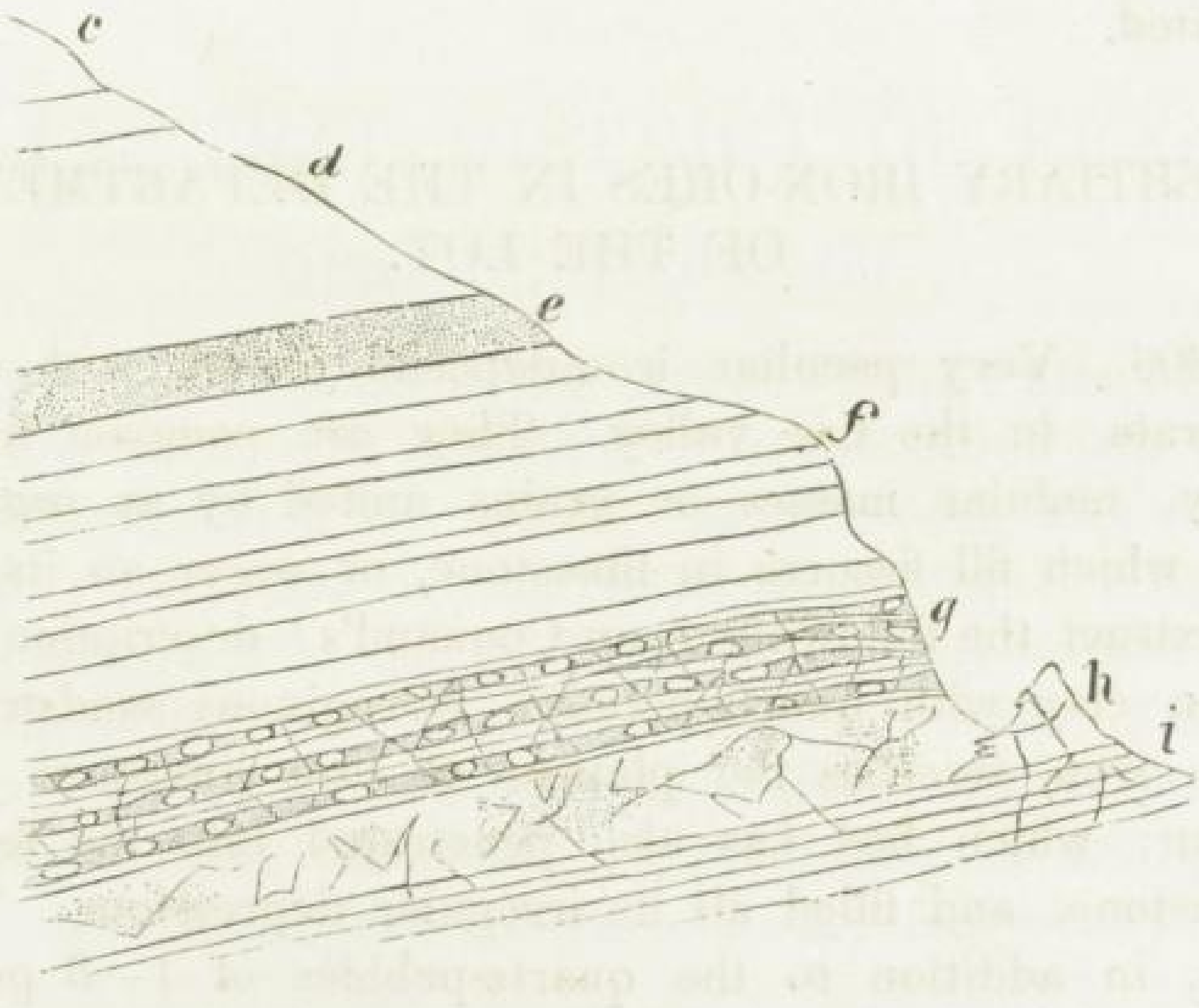
According to the profile, at least three kinds of iron-deposits occur; one parallel bed *e*, between the Jura and Lias formations, corresponding to the iron-ore-beds in the Brown Jura of the Suabian Alp; a parallel overlying deposit of oolithic iron ore *i*; and the fillings of irregular, or funnel-shaped, cavities by oolithic ore in the Jura formation, also very analogous to that mentioned in the Suabian Alp.

[1] See: Jacquot, in Annales d. mines, 1849, vol. XVI. p. 427; Langlois and Jacquot, in same, 1851, vol. XX. p. 109; Levallois, in same, 1849, p. 241; and Mémoires de la société de Nancy, 1850, p. 810.



a. Oolithic iron-ore.
b. Coral limestone, containing Ostrea Marshii.
c. and d. Slaty, sandy limestone, with interbeddings of marl, which frequently contain considerable oolithic limonite.
e. Oolithic limonite; the small grains lie in a brownish-red, clayey, calcareous, ochreous mass; the upper portion passes into gray, micaceous marl.
f. Upper Lias sandstone, brown from strings of limonite.
g. Marl, containing concretions of limestone and spherosiderite, the last surrounded by incrustations of limonite. These concretions often contain fossils. In the upper portion a more quartzose marl.
h. Fissile marl, with nodular masses of pyrites and crystals of gypsum.
i. Oolithic iron-ore.

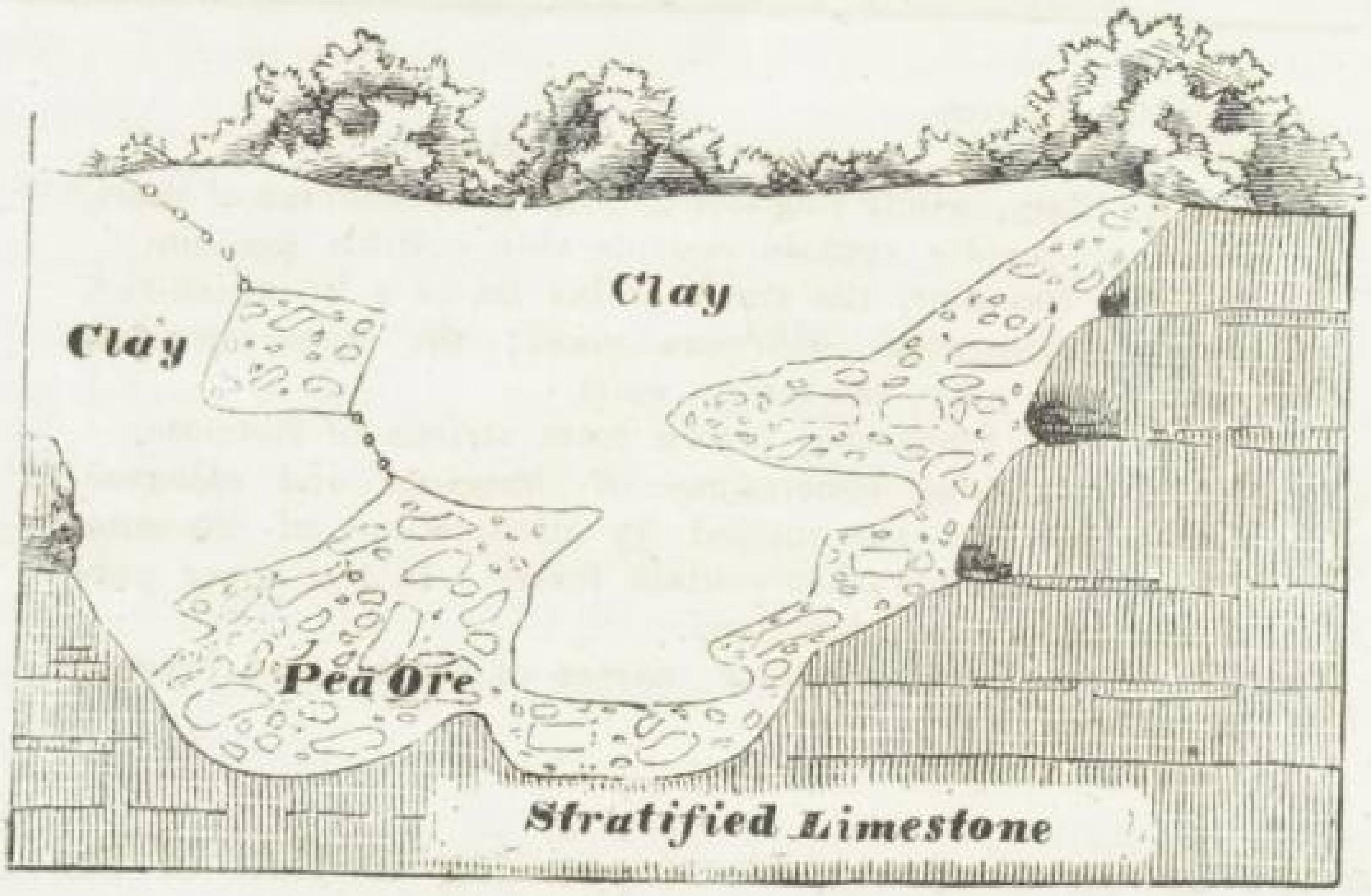
In the group of strata, corresponding to that of the Brown Jura in Suabia, several iron-ore-beds frequently occur, one above another, as can best be seen in the accompanying woodcut.



c. Limestone, like *c.* and *d.* in the preceding woodcut.
d. Gray, micaceous marl.
e. Upper, oolithic bed of limonite, like *e.* in the former woodcut.

f. Marly and sandy limestone.
g. Sandy limestone and oolithic limonite.
h. Limestone, containing nodular masses of limonite.
i. Upper Lias sandstone.

The peculiar occurrence of the oolithic ores, in depressions or holes in the surface of the Jura limestone, is particularly characterized by the following occurrence near Ville Houdlemont:



It is not improbable, that the oolithic ore-deposits of this district, like those in many other places, have been partly formed by ore being washed out of the Jurassic strata, and afterwards redeposited.

TERTIARY IRON-ORES IN THE DEPARTMENT OF THE LOT.

§ 206. Very peculiar iron-deposits occur, with the Tertiary strata, in the Lot valley. They are compact masses in red clay, nodular masses or grains united by an argillaceous cement, which fill fissures in limestone, or occur on its surface.

I extract the following from Coquand's [1] description. A bed of brown clay with quartz-pebbles, ferruginous sandstone, and ochreous iron, overlies the plateau of Jura limestone north of Montbrun; which bed has also penetrated into the fissures of the limestone, and filled all its irregular depressions. The bed contains, in addition to the quartz-pebbles of 1—3 pounds, a

[1] See: Coquand, in Bulletin de la société géologique de France, 1848 - 49, vol. VI. p. 340.

large quantity of much larger rounded masses of limonite including some of 20 pounds, which at first sight might easily be mistaken for boulders. A more careful examination soon shows, that they cannot be such. They not only at times consist of the botryoidal or reniform combination of several rounded masses, but their interior texture is also radially filiform, and has at the same time a concentric banded structure. The interior texture corresponds to the outer form, and, in the botryoidal ones, shows as many interior central points, as there are outer protuberances. This cannot possibly be the result of a process, like that by which boulders have been rounded; but the masses must have been formed, in their present positions, by the concentration of limonite. Besides these reniform masses, there are others, outwardly resembling river-boulders; they consist of compact limonite, with small cavities; and, when larger than a fist, contain near their surfaces grains of quartz, sand, and clay; while their interior is free from these impurities; which fact is also opposed to their being boulders. They are very frequent in many fissures of the Jura limestone.

XXI. CENTRAL DISTRICT OF FRANCE.

GENERAL REMARKS.

§ 207. With regard to this district, I shall first reproduce the principal portions of a memoir; in which Baron von Beust[1] mentions the results of Gruner's[2] examinations, and compares them with those made in the Saxon Erzgebirge. I reproduce the views advanced in this memoir, without any comments; but shall return to this subject at the end of the book. Baron von Beust says: 'The Central Plateau of France, with its immediate neighborhood; being the district enclosed between the Pyrenees, the Alps, the Vosges, and the Paris basin; has a very compli-

[1] Berg- u. hüttenm. Zeitung, 1860, p. 73.

[2] Essai d'une Classification des principaux filons du plateau central de la France, in Annales de la soc. impériale de Lyon, 1856, vol. VIII. p. 168.

cated geological composition. In which not only all the plutonic rocks from the oldest to the most recent, as well as the old crystalline schistose rocks, and Carboniferous formation; but also all the sedimentary strata, up to and including the Jura limestone, are represented: of the last the Lias appears to be the most developed, while the Triassic, on the contrary, is less extensive in comparison to its great development in Germany.

Gruner shows the occurrence of the following vein-formations within this district, passing from the oldest to the more recent:

1. Lenticular masses and strings of quartz in mica-schist, recognisable as having penetrated, and in so far veinlike formations, but nowhere found as true fissure-veins; containing no ores, or at the most somewhat of iron pyrites;

Period of formation: the outbreak of the igneous garnite:

2. Quartz-veins containing stibnite, also tin and wolfram;

Period of formation: eruption of the pegmatites:

3. Narrow quartz-veins, partly containing argentiferous galena, as in the Lozère Department;

Period of formation: occurrence of the granitic porphyries at the close of the Subcarboniferous Period:

4. Large vein-like and segregated masses of quartz, in immediate succession to the eruption of the quartz-porphyries;

5. Quartz-veins, containing rich argentiferous galena;

Period of formation: outbreak of the eurites.

In this classification of the older vein-formations of France, a certain analogy can, in many ways, be recognised with the positions of the older vein-formation in the Saxon Erzgebirge. Here, as there, the occurrence of lenticular quartz, barren of ores, appears, as the oldest formation, in the older schistose rocks; then follow the tin, and wolfram veins; finally the quartz-veins, with rich argentiferous galena. Especially analogous is the occurrence of large segregated quartz-masses, immediately following the outbreak of the quartz-porphyries; which in Saxony probably preceded the formation of the so numerous and manifoldly composed formations of older silver-veins.

But the principal portion of Gruner's memoir is devoted to

6. the group of the barytic veins; which occur extensively developed in central and southern France; and whose comparison with the like-named vein-formation in Saxony is interesting in more ways than one.

I (von Beust), 28 years ago, characterised the chalcedonic masses; traversed by heavy and fluor spar and galena, poor in silver; which cement the Arkose in the neighborhood of Avallon; as an equivalent of the Halsbrücke vein-formation; and am convinced, every one would have recognised this conformity at first sight, so distinctly does it occur. But what I did not know at that time, and which is so fully treated of in Gruner's memoir, is the circumstance, that this very characteristic vein-formation is extensively developed at many points in the large Central Plateau of France; which has given rise, in several localities, to a lasting and by no means unimportant exploitation. One learns in this connection; that, besides the mines which Count de Forèz exploited on such veins, the family de Blumenstein alone extracted almost 250,000 hundredweight of lead during the preceding and commencement of the present century, by the exploitation of the barytic lead-veins in the county of Forèz; partly as product from the smelting-works, partly as glazing ore.

Such a production, even though it should only be the result of a robbing of the mines for a long period, is still too considerable, for the deposits from which it came to be called other than true lodes; and there appears in this connection also to be no great difference between the likenamed formations in France, and in Saxony. When it is also considered, that this French exploitation was confined to very slight depths, without machinery, and apparently even without a washing of the ores (which is so particularly important for this class of veins); it is by no means impossible, that many, of the now abandoned French mining points of this class, might give good results by an active exploitation; although the generally dissuasive and very practical remarks of Gruner deserve full attention.

With particular regard to the similarity of this vein-formation, so widely extended in France, with that in Saxony; it is really not asserting much too, when it is said, that the same are related to one another, like the original to a very good photograph; so great is in all ways the similarity.

A partly sandy crystalline, partly chalcedonic quartz forms the gang combined with heavy and fluor spar; more rarely spathic iron, brown spar, and calc-spar; with which plumose galena (poor in silver) occurs as a characteristic, and never-failing ore; it contains but 0,0002, 0,0003 to 0,0010 per cent of silver; besides this, brown blende, at times in considerable quantities, more rarely a rich argentiferous tetrahedrite, and copper pyrites. Can a greater conformity be well found between two vein-formations, so far apart, than is here the case?

Another conformity is, that in France, as in Saxony, these barytic lead-veins occur as true, widely extending fissure-veins; and thus form a contrast to the older lodes, which do not bear so distinct a stamp of widely extended geological action. According to Gruner, some of these veins can be followed for a distance of 14,000 fathoms; and he also mentions belts full of veins, 10,500 fathoms long, and 2,300 fathoms broad.

If it can be accepted as certain; under such circumstances, and by the undoubted coincidence of the most important geological periods in both countries; that the same event has caused the same vein-formations in France and Saxony; then the proofs, which Gruner brings forward with regard to the epochs of formation of those veins in the former country also have a special interest for the latter. The Lias Period, including the lower Jura limestone, is named with great certainty, as being that within which the barytic lead-veins were formed in France. And in fact, if it be considered, that, as every where in France, where such veins occur near the Lias strata, the latter are traversed by the former, partly as true fissure-veins, partly as ore-deposits passing from the vein-fissures into the country-rock (in the arkoses of Burgundy, in the Lias of the Aveyron Department, as also in that of the Alps [Argentière near Briançon]); and, if the same veins do not extend into more recent strata, than those of the lower Jura, one must concede the determination of the age to be a very exact one.

This determination of the age attains, for the similar veins of the Saxon Erzgebirge, a so much greater importance; as a direct means for such is here wanting, since the corresponding more-recent sedimentary formations, within which such a proof were perhaps possible, do not exist. One might certainly expect to see the barytic lead-veins well developed in the Thuringian *Muschelkalk*; which might be regarded as being a favorable wall-rock, and shows besides, in many localities, distinct traces of very considerable vein-fissures. It would, however, be scarcely possible to conclude; from the circumstance, that the barytic veins are wanting; that these last are of so much greater age. On the other hand, it might well be imagined, that the broad masses of plastic clay, which every where underlie the *Muschel-*

kalk of Thuringia, as well as the clay-masses in the lowest member of the *Buntsandstein*, and even the plastic iron-clays of the *Rothliegendes*, could have been such impediments to the formation of the veins, that these last were unable to penetrate up to the *Muschelkalk*. It appears, on the contrary, to be an advantage of the conditions of bedding in France, that the Lias strata lie almost directly on the old crystalline schists, so that the continuation of the veins, from these into those, had no difficulties to contend with.

Gruner designates the upheaval of the Morvan Mountain in France, and the Thuringian Forest in Germany, as the commencement of the period, in which the barytic lead-veins were formed; and states, the certainly curious coincidence, that the axes of both these mountain systems—NW.—SE—is repeated in the general strike of the veins mentioned, both in France and Germany. He supports this assertion, with regard to France, by numerous cases; and, as regards the Saxon Erzgebirge, it must certainly be conceded to be, for the most part, fully grounded. This is especially true for those lodes of this formation, in Saxony, which occur independently; while, in those cases, where they appear as a more recent filling of older veins, deviations naturally occur.

If it be considered, in what extraordinary frequence, and at what a number of localities, in the Central French Plateau, the barytic veins occur; and if it be also remembered, how considerably this vein-formation is represented in Saxony (where the Halsbrücke vein perhaps represents the most considerable lode now known on the continent), the idea naturally presents itself, that there may still be many points in the Saxon Erzgebirge, where metalliferous and exploitable veins of this kind exist, which have not yet been discovered.

A remarkable case of this kind is the Drei-Prinzen lode, at the Churprinz-mine near Freiberg. This lode was, 40 years ago, still unknown, although the exploitation on the champion-lode of the mine, 187 fathoms off, had reached a depth of 230 fathoms. It was only with considerable trouble, that its course could be discovered at the surface. Now it has been followed to a depth of 200 fathoms, with a breadth of 2—4 fathoms, and ores worth 400,000 dollars have been extracted from it within the last 25 years. There may still be many cases of this kind.'

The writer then mentions the fact, that mining was extensively carried on in the granulite district of Saxony; and thinks, there may still be many undiscovered veins in the same. He thinks, that the occurrence of rich argentiferous tetrahedrite and fine granular galena, together with the common galena of these veins, in a mine at Schönborn, may have been caused by the favorable influence of mica and hornblende schist, at their junction with the granulite. He then continues: 'The hypothesis, that the barytic lead-veins were formed during the Lias and Lower Jurassic Epochs, is conformable, both for the older, and more recent vein-formations, in Saxony, with those which have been deduced from the actual examination of these other vein-formations. There is no sort of doubt, that the barytic lead-veins stand, in regard to age, between the numerous older vein-formations, principally containing massive quartz, and various carbonates, as gangs (pyritic lead-veins, brown-spar-veins, noble-quartz-veins), and the evidently much more recent veins of the Upper Erzgebirge, which contain cobalt, nickel, and rich silver ores, in a quartzose, hornstone matrix, resembling recent spring deposits.

Those older vein-formations are traversed by the barytic veins, which sometimes enclose fragments of the first; while the more recent age of the silver veins of the Upper Erzgebirge, distinguished by their cobalt and nickel ores, as well as that of the lodes of ironstone and psilomelane in that region, is shown by pseudomorphs, after heavy spar and fluor spar, being found, on a large scale, in those veins. So that the hypothesis seems to be confirmed, that they are altered veins of the barytic type.

But the period, of the above-mentioned older veins, hardly began before the epoch of the *Rothliegendes*; this is recognised, both from the fact, that the eurite dikes (quartz-porphyry) around Freiberg are traversed by them; as also from the circumstance, that the lodes of Erbendorf in Bavaria, stated to be analogous to the pyritous lead-veins of Freiberg, extend into the strata of the Carboniferous (according to a verbal communication of Capt. Gümbel). It is true, that the possibility, of a more recent formation of these veins, is not refuted; but it can hardly be assumed, that the period of their formation extended beyond the commencement of the Triassic Period; since at least one case is known, in the Freiberg district, of one of these lodes being traversed by a younger quartz-porphyry, and since a geological connection, of the, so very important, period of the red porphyries, with the lodes, may be regarded as very probable.

In any case, there are no facts opposed to the hypothesis, that the groups of the older Freiberg-lodes occupy the above designated geological niveau.

Müller has, with great probability, shown, that the younger lodes of the Upper Erzgebirge are closely connected with the eruption of basalt. If we must distinguish, in Saxony, three principal periods of vein-formations (the tin-lodes being left out of account, which are the oldest of interest to a miner), of which the barytic veins occupy the middle position, there is nothing against the supposition, that these last were formed in the epoch of the Lias, and consequently were formed contemporaneously with the like lodes in France.'

LEAD-LODES OF THE FORÈZ.

§ 208. The granitic chain of Forèz, and its immediate neighborhood, is traversed by numerous barytic lead-lodes, which Gruner[1] has described in the just mentioned memoir. According to the maps accompanying the same there are two vein-districts:

1. The district of St. Julien, between the Mount Pilat and the Rhone. The Mount Pilat consists of granite joined at the SE. by gneiss, traversed in several places by serpentine. About 40 veins are known, generally striking WNW.—ESE. These converge in their strike towards a point in the granite, north of St. Julien, which appears to be actually reached by but one of the lodes, that of Mizérieux. The majority of these are only known to extend for short distances, partly in granite, but a far larger number in gneiss; while those occurring in granite have been followed, in part, to its limits, but not into the gneiss. Those in the gneiss do not extend to its junction with the granite.

One of the most important of these; and the only one, which Gruner has described mineralogically, while the others appear to resemble it; is the vein of la Pause in granite. The same consists of two leaders, which at times unite, but

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[1] See: Gruner, Anciennes mines de plomb du Forèz, in Annales de la société imperiale de Lyon, 1857, vol. VIII; and Annales d. mines, 1841, vol. XIX. p. 150.

are occasionally 6 feet apart. Both consist, predominantly, of quartz, with but little heavy spar. Argentiferous galena occurs in the quartz, with somewhat of blende and pyrites, distributed in pockets or chimneys; which can be followed 30—80 meters in a horizontal or perpendicular direction. Each of these leaders is 1–8 inches broad; and when they unite, their maximum breadth is 18 inches. The, so-called, white leader consists of white, somewhat chalcedonic quartz, with very little heavy spar; the so-called red leader, of quartz, colored red by peroxide of iron.

2. The district of St. Just, and St. Germain, lies between these two places and the Bois de l'Hermitage, a granitic spar of the Forèz chain. The granite is joined, in a nearly northwest-southeast line, by granitic porphyry, mountain-limestone, and sandstone containing anthracite; which are traversed by numerous dikes of quartz-porphyry. The Tertiary deposits, and a few basaltic domes, have no connection with the lodes. These last occur especially, as contact-veins, at the junction of the granite, as well with the porphyry, as also with the limestone and sandstone. They also occur altogether in these last-mentioned rocks, much more rarely in the granite. The composition of the veins is very similar to that of the lodes in the St. Julien district.

ORE-DEPOSITS IN THE AVEYRON DISTRICT.

§ 209. The Aveyron,[1] with its branches, drains, between the Lot and the Tarn, a district of old crystalline rocks, partly overlaid by Triassic and Jurassic strata. The old crystalline rocks are partly metamorphic schists; as gneiss, mica- and talc-schist; partly igneous rocks; as granite, diorite, serpentine, eurite, and quartz-porphyry. The Carboniferous is but slightly represented; and Tertiary strata are very subordinate.

A large number of various kinds of ore-deposits occur in this region; which should, according to Fournet and Boisse, be co-ordinated, in part, with certain plutonic rocks. Boisse has separated the ore-deposits into the following classes:

[1] See: Fournet, Essai sur les filons metallif. d. Départ. de l'Aveyron; Boisse, Annales d. mines, 1852, vol. II. pp. 489, 501, 507, 519; Coquand, Bulletin de la Soc. Géol. de France, 1848—49, vol. VI. p. 328; Elie de Beaumont, Explicat. de la carte géol. de la France, 1841, p. 124.

1. Manganese lodes;
2. Magnetite lodes;
3. Veins, or segregations, of hematite;
4. Limonite lodes, usually forming merely the outcrop (gossan) of other lodes;
5. Spathic iron lodes;
6. Mispickel, iron and copper pyrites, combined with other ores and vein-stones in lodes;
7. Chronic iron, with magnétite, irregularly distributed in the serpentine;
8. Blende, and calamine, with lead-ores in lodes;
9. Lead-lodes, very common, and mostly argentiferous;
10. Copper-lodes, often argentiferous;
11. Antimony lodes;
12. Nickel-ores, only found in one lode.

Besides which, several rocks are somewhat metalliferous; and iron ores occur in beds.

I shall here confine myself to the lead, silver, and copper lodes, in the neighborhoods of Villefranche, and Najac, Asprières, Corbières and Milhau.

1. Villefranche, and Najac. The neighborhood of Villefranche consists, to the West, of granite traversed by porphyries, extending to the valley of the Aveyron. This granite-region is eastwardly bounded by gneiss and mica-schist, and is also traversed by porphyries; while, still farther east, Triassic deposits overlie these rocks. The mica-schist surrounds, in some places, masses of diorite, and serpentine; while a small fragment of the Carboniferous formation, which stands in no connection with the ore-deposits, overlies the gneiss near Najac.

The ore-deposits of this district are lodes; which, according to Fournet, are intimately related, partly to eruptions of euritic porphyry, partly to serpentines; or, in other words, which seem to owe their formation to these igneous rocks. These lodes, in the majority of cases, occur in mica-schist, and strike SE.—NW. almost at right angles to the limits of the granite, extending from NNE. to SSW., into which but few of them extend. Some of them penetrate into the Trias, and traverse its strata. A few of them appear to have a considerable deviation from the general strike, coursing N.—S.

Fournet states, that the veins, to be co-ordinated with the euritic porphyries, consist predominantly of quartz, mostly saccharoidal crystalline; partly also hyaline. The non-metallic minerals, combined with it, are heavy spar, red and yellow jasper, and traces of carbonates The ores are argentiferous galena, bournonite, mispickel, copper nickel, iron and copper pyrites. As products of decomposition, occasionally forming a gossan, occur limonite, cerusite, and anglesite. The galena, forming the principal ore, is finely disseminated in the saccharoidal quartz, and at times so intimately combined with it, that the quartz appears as if colored by the galena. The bournonite, and various pyrites, form small particles or crystals scattered through the mass; a combed texture is very rarely perceptible.

The veins, to be co-ordinated with the serpentines and diorites, occur, partly in the serpentines, partly in veined mica-schist. A characteristic example of this class is the Maillors lode, in the diorite of the Cassagne plateau. It strikes NW.—SE.; its breadth is about 7 feet; its matrix chiefly cryptocrystalline, waxlike quartz, jasper, and hornstone, traversed by strings of calc-spar, and spathic iron, which last often predominates. The original ores are copper pyrites, bournonite, and blende, with but slight traces of galena. By the decomposition of these have been formed, malachite, azurite, and limonite; which occur especially in the clefts of the calc-spar. The other veins, in the serpentine, are quite similarly composed; in such a manner, that they are all distinguished by a more waxlike quartz, more frequent occurrence of carbonates, and by the predominance of copper ores from the veins, combined with the euritic porphyry. The distribution of the ores is also a much more unequal one, both in the various lodes, and in different portions of the same lode.

2. Asprières. The numerous veins of this region have, in general, the same character as those of Villefranche, the only difference being that heavy spar is more predominant. Their principal matrix is quartz and heavy spar, frequently almost entirely the latter; in which are found galena, and pyromorphite; to a more subordinate degree, blende, cupriferous iron-pyrites, copper-pyrites, and carbonates of copper. The lodes mostly course NW.—SE. and appear to be combined with granites, feldspar-porphyries, diorites, and other amphibolic rocks. Their wall-rock is at times much impregnated with pyrites.

3. Corbières. The mountainous region of Corbières consists principally of talcose clay-schist, of the Cambrian formation, and of gneiss, in which granular limestone is embedded. These rocks are traversed by porphyritic granite, quartz-por-

phyry, euritic porphyry, basalt, and numerous lodes. Triassic strata overlie the edges, and numerous mineral springs occur in the same region.

The lodes are mostly very irregular. They consist principally of quartz, and heavy spar, with copper, lead, antimony, and iron ores; the copper ores predominate. Where the lodes traverse igneous rocks, the vein-stones are, at times, entirely wanting; in other places the quartz often predominates, and forms a wall-like, projecting outcrop, which can be readily traced. They lie, for the most part, in a belt extending from N. to S., but the strike of the separate veins is frequently very irregular and variable. The veins usually traverse calcareous slates and porphyries within these, but also penetrate into the Triassic strata.

4. Milhau on the Tarn. The Levezou Mountain rises west of Milhau, consisting of mica-schist, granite, and amphibolic rocks. Bordering on, and overlying these crystalline rocks, is first a zone of *Buntsandstein*, about 3 miles broad, whose lower subdivisions consist of black slate; this is overlaid, to the east, by *Muschelkalk*; and over this follow, still farther east, near Milhau, Lias deposits.

The lodes of this region are divided into two groups; near Minier in the black slates belonging to the *Buntsandstein*, and near Galès in the *Muschelkalk*. Fournet even thinks, they may have first been formed during the Jurassic Period; as the neighboring Lias exhibits corresponding tiltings. But the veins themselves have not, according to the same observer, been traced into these strata.

Several veins exist near Minier; of which two, however, are the champion-lodes which intersect each other. They consist of quartz with fine granular galena, often finely disseminated; more rarely of heavy spar. Fournet observed the following combed texture, without a symmetrical arrangement, in the vein of Douziliencques:

1. Quartz, galena, and pyromorphite;
2. Galena, and blende;
3. Pure quartz;
4. Galena, bournonite, and quartz.

The three principal veins, near Galès and Creissels, occur in the *Muschelkalk*, whose strikes form a triangle: viz.

The lode of Galès strikes NNW.—SSE.
The lode of Fons courses NW.—SE.

The lode of Limasette generally strikes E.—W., but, in portions of its course, often strikes WNW.—ESE.

The matrix, in all three veins, is quartz, and heavy spar; with which are combined galena, copper-pyrites, and blende. As products of alteration are here and there found cerusite, azurite, and limonite; but the ores are very unequally distributed; and only scattered bunches appear to be exploitable. Ring-ores are very common in the vein of Galès; either, a kernel of limestone is surrounded by concentric layers of quartz; or fine granular galena forms a binding medium for a limestone breccia; or finally, a quartz kernel is concentrically surrounded, first by blende, and then by quartz.

Fournet not only thinks, that these veins are more recent than the Jura formation, and have caused the local tilting of its strata; but he even supposes them to have been formed shortly previous to the Diluvial Period. It seems to me to be only certain, that they are more recent than the *Muschelkalk*.

Boisse maintains the following principles, as the results of his investigations.

The nature of the igneous rocks, and their local obtrusion, exerted an influence on the filling of the vein-fissures, and the distribution of the minerals in the same.

The veins containing copper ores appear to be principally associated with the serpentines and amphibolic rocks.

The lodes containing lead and zinc ores, with but little copper ores, accompany the euritic rocks.

The same ores occur in the igneous rocks, partly disseminated through the mass, partly as fine strings, or even as true veins, but without vein-stones.

Similar phenomena also occur in the other rocks near the igneous ones; but here the vein-stones accompany the ores, and encrease in quantity with the distance from the igneous rocks.

The breadth, continuance, and regularity, of the veins appear to depend on the firmness of the country-rock.

The ores generally occupy the middle of the lodes. They are seldom regularly distributed throughout their whole extent. The richest portions appear to form chimneys, which follow the direction of dip.

The most frequent vein-stone is quartz; it usually contains but little ore, where compactly filling the broad fissure; while a combed texture, and the occurrence of geodes, are regarded as favorable signs of an encreased abundance of ore.

It will scarcely be necessary to remark, that these veins are evidently of the same character, as the barytic and quartzose veins of the Erzgebirge, and many other localities in Germany; and that this type of lodes appears to be altogether the most common.

LODES IN THE NEIGHBORHOOD OF PONT-GIBAUD NEAR CLERMONT.

§ 210. The district around Pontgibaud consists of gneiss, and granite, traversed by porphyries and basalts; which last have also partly overflowed, as slaggy lavas.

The numerous lodes, which traverse this district, strike NE.—SW., from which there are some exceptions; and they are frequently bent and branched. They do not penetrate into the basaltic rocks, and are, therefore, probably older than these. The chief ore is argentiferous galena. Rivot and Zeppenfeld [1] distinguish two kinds of vein-formations. Only one vein is composed entirely of quartz with a little disseminated galena; this strikes almost N.—S. The rest consist of mixtures of feldspar, varying but little from the enclosing granite. This mass, as well as the enclosing granite, is much decomposed to a depth of 150 feet, being almost reduced to clay; and the rock, in each deeper gallery opened, also decomposes very rapidly. The indistinct mixture consists of quartz, and feldspar, with a little mica; in which occur argentiferous galena, somewhat of blende, iron-pyrites, tetrahedrite, and in some veins also heavy spar. The galena is generally distributed as small crystals or grains, rarely arranged in layers or strings. Iron-pyrites is principally found near the numerous intersecting veins of pyrites. Near Vernède somewhat of fluor spar also occurs in the lodes.

The ores are distributed in chimneys, extending 150—180, at the outside 450 feet in a horizontal direction, but descending in the depth like columns. The barren portions of the veins are generally more distinctly separated from the country-rock

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[1] See: Rivot and Zeppenfeld, in Annales d. mines, 1850, vol. XVIII. p. 137; Guéniveau, in Annal. d. mines, 1822, vol. VII. p. 168; Kosmann, in Berg- u. hüttenm. Zeit. 1865, p. 281.

by selvages, than those portions containing ores. All these lodes are occasionally traversed, near Pontgibaud, by clay-fissures containing but traces of galena.

The chief mines are at Pranal in the Sioule Valley, where twelve champion-lodes occur, and near Roure, where there are eight veins; both groups lie in the same direction of strike, and thus appear to belong to the same group, which has only not been exploited in the intermediate region.

The circumstance is certainly very remarkable, that the principal mass of these lodes consists of a granite-like and, therefore, possibly igneous rock. The ores and minerals accompanying them perhaps subsequently penetrated these.

MANGANESE DEPOSITS OF ROMANÈCHE IN THE DEPT. OF SAÔNE-ET-LOIRE.

§ 211. Dolomieu[1] first designated the deposits, as segregations lying on granite: they were afterwards considered to be broad veins in granite. Bonnard has described them nearly as follows:

The neighborhood of Romanèche is composed of granite, partially overlaid by a granitic arkose, probably formed by the decomposition of the former. The chief deposits occur in this arkose, they strike N.—S., dip about 45° in E., and their breadth alternates between 7—10 fathoms. Their immediate foot-wall is a more porphyritic arkose, while their direct hanging-wall is composed of a marly clay, containing nodular masses of manganese ores, and traversed by strings of such. The deposit itself consists of compact manganese ore, intimately combined with quartz, fluor and heavy spar; and surrounds numerous nodules and fragments of clay, hornstone, the hanging-rock, granite, grains of quartz, etc.; so that the entire mass represents a breccia, cemented together by manganese ore. This deposit is known to extend a length of 150—200 fathoms. To the South of, and in the prolongation of its strike, occurs a true vein of manganese in granite, one fathom broad.

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[1] See: Dolomieu, in Journal d. mines, 1796; Bonnard, in Annales d. sciences naturelles, 1829, p. 285; and Leonhard's Jahrb. 1833, p. 562.

COPPER-DEPOSITS AT CHESSY NEAR LYON.

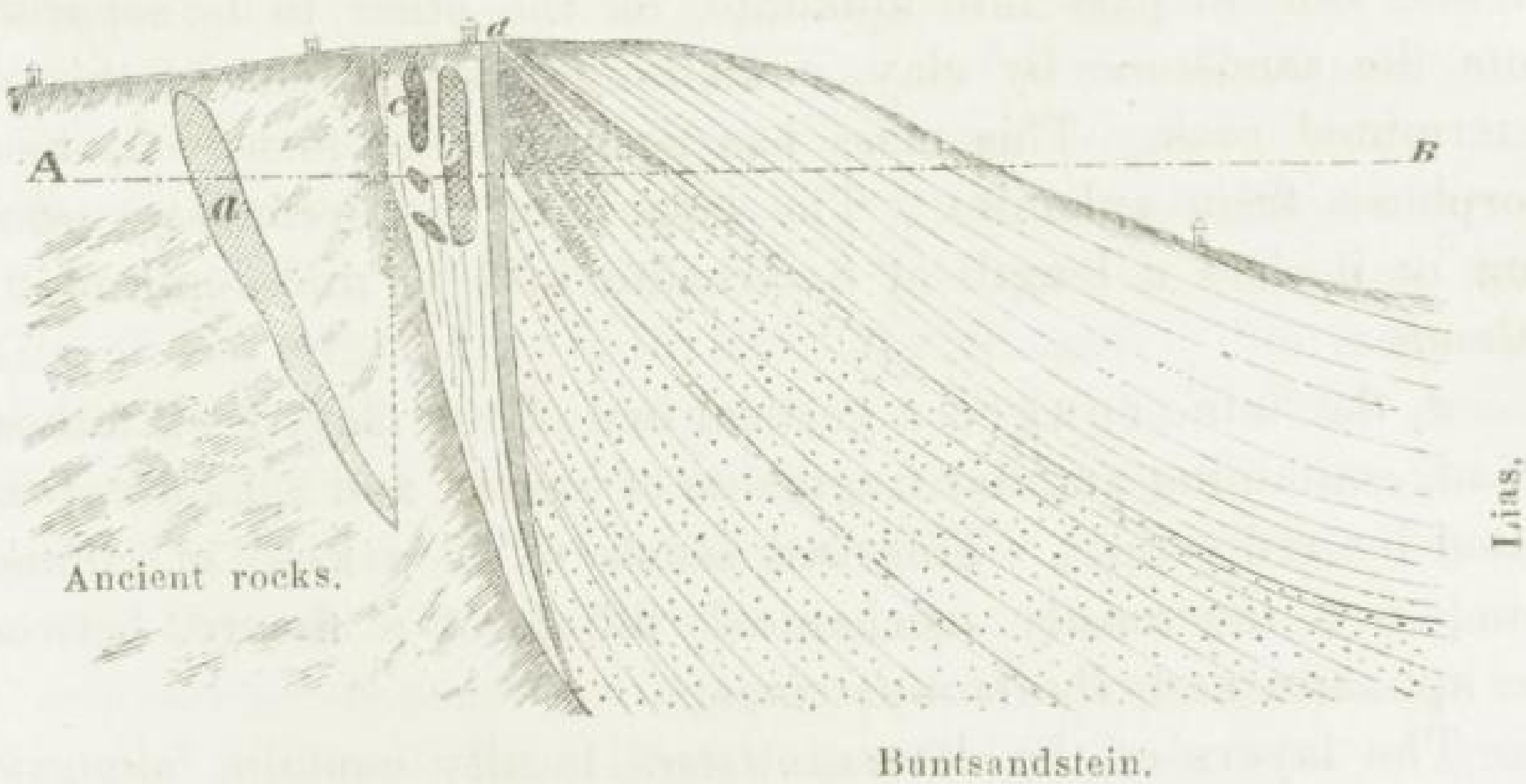
§ 212. These ore-deposits, so well known to all mineralogists, for the splendid specimens of azurite formerly obtained from them, are also very interesting in a geological point of view, and give a certain insight into the manner of the formation of a whole class of metalliferous deposits. Raby[1] has described these deposits quite completely; and the following is condensed from what he says.

Old crystalline rocks are here immediately in contact with *Buntsandstein* and more recent formations, which recline on them with a steep southeasterly dip. The crystalline rocks are; granite, gneiss, mica-schist, clay-slate, and an aphanitic rock. The last-mentioned predominates near the metalliferous deposits.

The various kinds of copper-ores occur in the following manner:

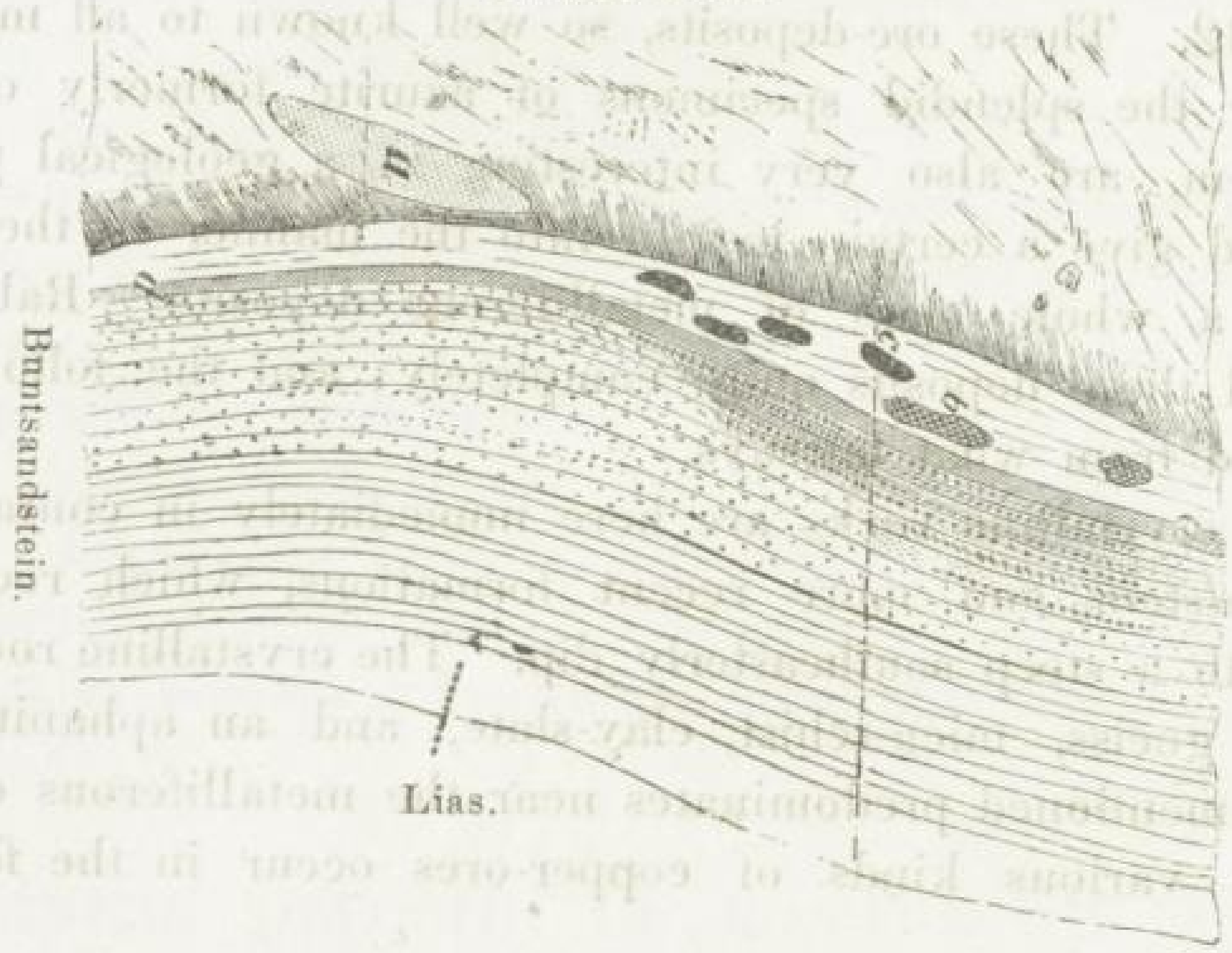
a, called 'mine jaune', represents a segregation of pyrites surrounded by aphanite: it consisted of a mixture of iron and copper pyrites, and blende; the irregular, lenticular mass dipped, tolerably parallel to the enclosing strata, about 60° in SE.; its greatest thickness, at a depth of 10 fathoms, was 7½ fathoms; its extent, in a horizontal direction, 60 fathoms, and in that of dip, about 100 fathoms. This was evidently the original manner of the ore-occurrence in this region, from which the others have been formed by alteration:

Vertical section.



[1] See: Raby, in Annales d. mines. 1833, vol. IV. p. 393; Cordier, in same, 182—, vol. VI. p. 16; Guéniveau, in Journal d. mines, 1806, No. 118; Fournet, in l'Institut 1837, p. 246.

Horizontal section.



The accompanying woodcuts represent a vertical, and a horizontal section, of the relations of bedding, in so far as they have been opened-up by the mines at Chessy:

b, and *c*, the 'mine grise', and 'mine noire', were rounded masses, consisting of intimate mixtures of iron and copper pyrites, melaconite (?), silica, and some other substances, forming a sort of contact-deposit, between the crystalline rocks and the *Buntsandstein*; or, more clearly expressed, in a wedge-shaped intermediate bed, upwards of 10 fathoms broad, consisting of a grayish-white rock of undetermined character; which appears on one side to pass into aphanite, on the other to be separated from the sandstone by clay, containing ramifications of this undetermined rock. This mass has perhaps been formed by metamorphosis from aphanite. The largest of the ore-masses occurring in it, had a length of 6, breadth of $1^1/_2$, and depth of $2^1/_2$ fathoms:

d, the 'mine rouge', a vertical bed of red clay, 1—2 fathoms broad, containing angular fragments of quartz, and aphanite, penetrated by red copper. This bed seems to be a kind of contact-vein; *i. e.* the mostly mechanical filling of a fissure, between the aphanite and *Buntsandstein*.

The layers of the *Buntsandstein* locally contain, alongside of this bed *d*, a fourth kind of ore, called 'mine bleu', represented in the woodcuts by zigzag lines. This consists of azurite with somewhat of malachite; and forms a kind of impregnation in the sandstone. The ore forms, partly parallel beds in sandstone, a few inches thick, at times containing grains of sand, and passing into sandstone cemented together by azurite; partly geodes, covered with crystals of azurite; partly round balls of azurite, hollow within. The distribution of these ores in sandstone occupies a space about 200 fathoms long in the direction of strike, 2 fathoms broad in the direction of dip, and 10 fathoms thick. Beyond this ores are barely traceable in the sandstone, and cannot, therefore, be properly regarded as having been formed contemporaneously. These blue, as well as the red, copper-ores have evidently been formed by the decomposition of pyrites, and are of much more recent formation than these, probably also than the *Buntsandstein*; since traces of them can be found in the fissures of the Lias-limestone, overlying the sandstone. The sandstone strata are also locally much impregnated by peroxide of iron; to so great an extent, that one of the beds of sandstone gave 30 per cent of iron on being smelted. It is very comprehensible, that this iron also came from the decomposition of the pyrites.

It may therefore be accepted, that in the neighborhood of Chessy a number of pyrite segregations, rich in copper, first existed in the older crystalline rocks: these have been partially decomposed with their enclosing rock, while remaining in place; from which action have been formed the black and gray masses, *b* and *c*, occurring in the problematical contact-rock. After this the *Buntsandstein* and Lias formations were deposited. The decomposition of the pyrite segregations still continued; perhaps during, and certainly after the deposit of these formations, by which the red and blue copper-ores were formed; these are found to contain fewer admixtures of pyrites, the farther removed they are from the crystalline rocks. Perhaps the upheaval and tilting of the strata were still later occurrences. The red vein-like contact-bed *d* is the most difficult to explain. The entire occurrence of these copper-ore impregnations in the sandstone somewhat resembles those of Böhmisch-Brod (§ 143) and Hohenelbe (§ 145); except that here their origin is much more evident, the original ore-deposit lies nearer, and the impregnation is locally more concentrated. Perret[1] has found 1 per cent of gold in the copper obtained from the Chessy ores.

[1] See: Compte rendu, 1849, vol. XXIX, p. 700.

The mixtures of iron and copper pyrites near Sain-Bel occur in the continuation of the same geological conditions, but here as numerous veins in a talcose schist.

XXII. BRITTANY.

GEOLOGICAL FORMATION.

§ 213. Brittany, the westernmost, mountainous portion of France, projecting into the ocean like a peninsula, consists principally of granite, crystalline schists, and Palæozoic strata; which are irregularly distributed, and do not rise to distinct mountain-chains.

Tin and lead deposits are known to occur in the old crystalline rocks of this district; of which a few will be here described. Iron ores also occur; but I pass them over, as in no way particularly interesting.

TIN-DEPOSITS.

§ 214. Durocher[1] has divided the tin-deposits into five classes: occurring in the gneiss-granite portion, or on its borders; which all lie in a belt, lying N.—S., whose northern prolongation touches the tin-district of Cornwall:

1. Stanniferous quartz-veins, which also contain white mica, beryl, tourmaline, and mispickel; on the edge of a granite district between the valleys of the Oust and Claye;

2. Stanniferous quartz-veins, with tourmaline, and mispickel, near Questembert; partly in granite, partly in mica-schist: they strike WNW.–ESE. and appear to be richest in the mica-schist, and in this, chiefly near granite dikes;

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[1] See: Durocher, in Compte rendu, 1851, vol. 32, p. 902, and 1857, vol. 45, pp. 502, 522; Mallard, in same, 1866, vol. 62. p. 223; Simonin, in same, p. 364; Elie de Beaumont, Explicat. de la carte géol. de la France, 1841, pp. 202, 204; Audibert, in Annales des mines, 1845, vol. VII. p. 181; Daubrée, in same, 1841, vol. XX. p. 96; Blavier, and Lorieux, in same, 1834, vol. VI. p. 381; Dufrenoy, in same, 1828, vol. III. p. 55.

3. Stanniferous quartz-veins, with feldspar: they traverse the granite, and mica-schist on the borders of the granite, near Piriac; and form a network of veins intersecting in various directions;

4. Tin-ore-impregnations, resembling Fallbands, in hornblende-schist, which also contains epidote and garnet: the tin-ore is distributed in strings, parallel to, or intersecting the foliation: the impregnated rock is also traversed by quartz-veins containing tourmaline;

5. Tin-placers, nearly always containing somewhat of gold; near the deposits in place.

The principal deposits are those near Piriac, at the mouth of the Loire; and near Villeder, in the Dept. of Morbihan. I have in the following description mostly followed the memoirs of Elie de Beaumont, and Blavier; which do not, however, altogether coincide with the more recent, but shorter memoir of Durocher.

The tin-deposits at Piriac are very irregular, and occur in gneiss and mica-schist near their junction with granite.

The ores occur in two ways:

1. in veins of hyaline milk-quartz;
2. as pockets in gneiss.

The cassiterite forms isolated and irregularly distributed masses in the quartz-veins; all of which veins do not contain tin-ore, but only those which are parallel to the foliation; while those at right angles do not contain any ore. The question may, therefore, arise, whether they should not be considered as ore-beds.

The pockets occur in a decomposed gneiss, whose feldspar is altered to kaolin. The cassiterite forms small concretions in this kaolin, occasionally crystallized; while no crystals occur in the quartz-veins.

Near these deposits, but only in valleys, or basins, with which the granite-gneiss district is connected, occur numerous tin-placers; in which are also found crystals, or rounded fragments, of zircon, spinel, tourmaline, beryl, and magnetite.

There is one champion-lode, in particular, in the granite near Villeder, which strikes NW.—SE. and dips 60° in NE. The same attains a breadth of 13 feet, and consists of white hyaline quartz, having a somewhat greenish color where it contains tin-ore. This quartz is generally very free from foreign admixtures, but shows, in places, the imprint of destroyed acicular crystals. Near the tin-ore, on the contrary, it contains small pockets of clay, with mispickel, and crystals of beryl, and topaz. Threads of limonite traverse it, parallel to the selvages. It is also somewhat divided into layers, which are separated from one another by thin layers of sand. The vein is only found in granite, and does not pass into the surrounding schist.

The still older description of Blavier does not altogether agree with this of Elie de Beaumont; without its being perfectly clear, whether they do not refer to two different lodes. The vein, near the mill, of Villeder, strikes, according to Blavier, NNW.—SSE., dips but 25° in NNE. aud attains a breadth of 26—33 feet. It consists of quartz with somewhat of cassiterite, mispickel, beryl, tourmaline, and limonite.

To these deposits must be added a more recent discovery, described by Audibert.

To the South of Ploërmel the granite joins the somewhat metamorphosed Silurian slates in the Oust valley, forming a projection into the slates; in which projection it is intersected, near its limits at Maupas, by 5 or 6 stanniferous quartz-veins. They strike NE.—SW. and have a considerable dip in NW.; their breadth, between 9 and 18 inches; while they frequently split up into branches, often again uniting. They can only be followed for a distance of 4 fathoms (a single case 11 fathoms) in the direction of strike, when they disappear in the granite, which is medium-grained and very micaceous. The white hyaline quartz, of which they consist, contains here and there somewhat of cassiterite, in small bunches, or isolated crystals, at times so little, that it is almost impossible to recognise it, being collected in considerable quantities at one of the selvages in but a single lode. The granite, alongside of these veins, also contains, in places, somewhat of cassiterite, porphyritically disseminated; while, contrary to the usual manner of occurrence, it is in these places particularly rich in feldspar, and contains but little quartz, as if the last had been displaced by the tin-ore. The cassiterite is accompanied by considerable mispickel, occasionally, also, by mica, beryl, and limonite. These lodes are not rich enough to be exploited, but appear to be connected with those at Villeder.

Tin-placers are found along, almost, the whole extent of coast, between the mouths of the Loire and the Vilaine, they are, also, frequent between the Oust and the Claye; finally, southward of Josselin in Morbihan, on granite and around the district it occupies. The cassiterite forms partly crystals, partly rounded pebbles. These pebbles lie in the lowest portion of the Alluvium, immediately on the granite, or crystalline schists. They originated in the veins, or impregnations, within these rocks. Curiously enough, somewhat of tin-ore is also washed out of the Miocene strata, with which it must have been contemporaneously deposited, in a similar manner to the tin-ores in the more recent placers. This is especially the case, on the coast of Pénestin, southerly of the mouth of the Vilaine. This is a similar case to that, with which we have already become acquainted in the gold of the Rhine, which has been formerly deposited in the Molasse strata of Switzerland.

The following minerals are commonly found in the tin-placers of Brittany: magnetite, ilmenite, micaceous iron, garnet, spinel, zircon, and native gold in scales; thus near Piriac, Pénestin, and Josselin. Durocher found in the Haie valley somewhat of native mercury, partly in fluid drops, partly amalgamated with gold and silver. The original deposit of these metals has not been discovered.

Tin-ore is found in three localities, in the granite, near Vaury and Puy-les-Vigner. According to De Cressac, quartz-veins, a few inches broad, occur in granite passing into greisen, which contain: tin-ore, wolfram, molybdenite, mispickel, copper-pyrites, domeykite, melaconite, native copper, fluoritic mica, and fluor spar. The country-rock is also somewhat impregnated by these minerals. This is a mode of occurrence very analogous to that of Zinnwald in the Erzgebirge.

THE LODES OF POULLAOUEN AND HUELGOAT.

§ 215. The broad and rich argentiferous lead-lodes of Morlaix[1] occur in Silurian clay-slate. In addition to several less important ones, two champion-lodes are known, those of Poullaouen, and Huelgoat.

[1] See: Daubuisson, in Journal des Mines, 1806, No. 119, p. 347; 1807, No. 122, p. 81; Elie de Beaumont, Explicat. de la Carte géolog. de la France, p. 237.

The lode of Poullaouen has been opened, for a length of more than 750 fathoms, and depth of about 100 fathoms; it forms a curve, coursing NW.—SE. and dips 45° in NE.; while the clay-slate, containing quartzite and greenstone, which forms its wall-rock, strikes ENE.—WSW. and dips 40°—50° in S.

The breadth of this lode is very variable, it widens in places to 25 fathoms, and contracts in others to a few inches, averaging about 1 fathom. Its real breadth is very difficult to determine; since distinct selvages are wanting, and it is often split into side-branches, which can be regarded *ad libitum*, as forming a portion of the lode, or not; since the matrix is mostly a sort of clay-slate, mixed with quartz; which frequently passes into siliceous slate, or black hornstone; frequently traversed, in turn, by quartz-strings.

The principal ore is argentiferous galena, combined with somewhat of blende, and iron-pyrites. The ores, like the quartz, form a network of threads, or strings, in which the galena is but rarely combined with the quartz, generally with the clay-slate; the separate threads are only a few lines to several inches broad, they often separate, and again unite. Grains of ore are sometimes found, through the slate forming the matrix; and even the wall-rock is often somewhat impregnated. The lode is considered rich, when the galena forms $^1/_{10}$ of the total mass.

The ores are by no means equally distributed; but are collected in chimneys, 40—50 fathoms long, and extending at variable angles in the depth. Whether the wall-rock, in these portions, is of a peculiar kind, is not stated. The similarity of this lode, with those of Clausthal, is very great.

The champion-lode of Huelgoat is much more regular, than that of Poullaouen. It has been developed for a length of 500 fathoms, and depth of 135 fathoms. It strikes NW.—SE. and dips 70° in SE.; its country-rock is a black clay-slate. Its breadth averages $1^1/_2$— 2 fathoms, but occasionally reaches 13 fathoms. The same contains, besides, argentiferous galena, somewhat of native silver, and kerargyrite in a kind of iron ochre. The principal matrix of the lode is quartz, besides which are found: pyrites, blende, pyromorphite, cerusite, plumbo-resinite, and laumontite; blende and quartz sometimes form ring-ores, the kernel consisting of blende. Fragments of the wall-rock, and even rounded portions, are very frequently found in the mass of the lode.

XXIII. THE PYRENEES.

GEOLOGICAL FORMATION.[1]

§ 216. Granitic rocks, combined with crystalline schists, crop-out, especially in the eastern portion of the chain; while, towards the West, they form more isolated central points, in a large district of Palæozoic rocks, extending throughout the whole mountain-chain. Triassic deposits also occur in the interior of the mountains; while strata of the Jurassic and Cretaceous Periods occur in the outer portions.

The granites, in part porphyritic from large crystals of feldspar, are frequently traversed by fine-grained, or very coarse-grained dikes of granite. Similar dikes also frequently traverse the Palæozoic strata. Certain granitic rocks have even penetrated into the limestones of the Jurassic group; and others appear, according to Durocher, to have, at least, altered the adjoining Cretaceous deposits.

The Palæozoic slates, and limestones, are every where much altered, to considerable distances from the granites. The slates contain chiastolith, and pass into mica-schist, talc-schist, etc., with numerous accessory minerals. The limestones have become crystalline, and contain numerous silicates.

Traces, of at least six successive upheavals, can be recognised. Durocher called attention to the fact, that the metalliferous deposits, like those of Brittany, are mostly found near the limits of igneous rocks. In the Pyrenees, the ore-deposits generally occur, at the junctions of the igneous with the stratified rocks; occasionally also in the granites.

Thus iron-ores, often consisting of mixtures of hematite and limonite, occur very commonly, with quartz, at the junctions of granite with Palæozoic, Jurassic, and Cretaceous limestones. They occur in these last, but owe their origin to the granite, although it is older than these ore-deposits, which were formed

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[1] See: Durocher, in Ann. des mines, 1834, vol. V. p. 307; 1844, vol. VI. p. 15(93); Dufrénoy, in Ann. des sciences naturelles, 1833, vol. 30, p. 59 Baron de Dietrich, Gites de minerai des Pyrénées, 1806; de Charpentier,; Constitution géognost. des Pyrénées, 1823.

between the Cretaceous and Tertiary Periods, and are said to be connected with the principal upheaval of the Pyrenees.

It is the same with the majority of the other ore-deposits. The veins of copper-pyrites at Fos occur between granite, and black marl-slate of the Cretaceous; into which last extend ramifications of the granite; the copper-deposit of Canavilles, between granite, Palæozoic slate, and limestone; the veins of copper-pyrites and galena at Vicdesos, at the limits of granite and granitic injections. The iron-deposits of Rancié, the lead-deposits of Argentières, Laquore, and Castelminier, as well as the copper-deposits of Escanérades in Palæozoic limestone at the limits of granite. The veins of argentiferous galena, of the Luchon-valley, in Palæozoic slate, near the granite mass of the Crabiules; the galena-lodes of the Essera-valley in Palæozoic slate and limestone traversed by granite dikes; the arsenical cobalt-deposits of the Gistain-valley in Palæozoic slate and limestone, overlying the granite; the argentiferous and cupriferous veins of iron-pyrites in the granite of the Esterry valley, etc. Besides these, numerous less regular gash-veins of iron-ores occur in the Pyrenees, as in Brittany, between sedimentary strata, only near the surface, without extending to any depth. Finally these same granite limits are characterised by the very frequent occurrence of sulphur-springs.

I shall only describe a few of the metalliferous deposits in the Pyrenees, which have been very completely examined and described.

MANGANESE DEPOSITS IN THE DEPT. OF HAUTES-PYRÉNÉES.

§ 217. The district between the valleys of the Luchon and Campan; in which the manganese deposits[1] occur, in a zone about 8200 fathoms long, lying E.—W.; consists of argillaceous, marly, and by no means metamorphic, slates; with numerous thin, embedded layers of limestone, both belonging to the Palæozoic. The strata course regularly enough, WNW.—ESE.; except that in the zone, where the manganese-ores are found, disturbances of the bedding have every where

[1] See: Gruner, in Annal. d. mines, 1850, vol. XVIII. p. 61.

taken place; so that it would appear as if this zone were the line of a dislocation of large dimensions.

The manganese-ores are not combined among themselves, but form irregular masses at the surface, or fill irregular depressions, fissures, cavities, or pockets in the strata; in the same manner as oolithic ores in many other localities. Probably these variously shaped cavities have been formed by the same causes, which have so essentially disturbed the regularity of the stratification of the zone in question. The minerals filling these cavities are, chiefly, a black, anhydrous ore of manganese; in compact, cellular, or earthy condition; mingled towards the edges with ferruginous clay, and accompanied at some depth by dialogite, which is implanted on the walls of limestone. Unaltered fragments of limestone occur in these, near Soulan, entirely surrounded by ore.

The entire manner of occurrence appears, according to Gruner, to indicate, that these ores have been deposited by mineral springs, containing bicarbonate of manganese in solution, which have penetrated to the surface, through the numerous fissures in the zone of dislocation, and deposited a portion of their metalliferous contents, under an escape of carbonic acid, either near or at the surface.

This explanation has undoubtedly a great degree of probability; and even the anhydrous condition of the ores cannot be regarded as contrary proof; although the warm springs, in other regions, generally deposit hydrated oxide of manganese. The conditions, under which the deposit took place, may have been different; or the water, at first present, may have subsequently disappeared, by one of the processes of alteration, so common in ores of manganese. Nothing definite can be stated concerning the age of the deposit.

The principal localities where the ores are exploited are: Vielle, Germ, and Soulan.

CULÉRA IN CATALONIA.

§ 218. The village of Culéra,[1] in the easternmost portion of the Pyrenees, lies on the southern slope of the spur forming the

[1] See: Müller, in Cotta's Gangstudien, vol. II. p. 321; Rosales, in Revista minera, Madrid, 1851, vol. II. p. 725.

Cap de Cerbera, between the small town of Llanza and the boundaries of France. The neighboring mountains consist of Palæozoic rocks, while granite and quartz-porphyry are the only igneous rocks occurring in the neighborhood. The Palæozoic rocks are often traversed by veins of calc-spar, and lenticular veins, and masses of quartz. These quartz-masses form, in their shape and composition, transitions into the auriferous quartz; they, also, occasionally contain traces of copper pyrites.

These rocks contain two kinds of lodes: viz. auriferous quartz-veins; and, more recent, lead-lodes. The gold-veins strike NE.—SW. and dip in SE., more rarely in NW. Their breadth varies from a few inches to one, or even two, fathoms. They are very irregular in regard to their length, and even pass into the subordinate lenticular veins above-mentioned. They consist mostly of a white to dark gray, greasy quartz, in which somewhat of mispickel, iron-pyrites, copper-pyrites, galena, brown blende, and native gold, are finely disseminated. The quartz sometimes contains, besides these, fragments of the wall-rock, and is but rarely traversed by strings of calc-spar. It is firmly attached to the wall-rock; but the line of demarcation between the two is distinctly defined, being, at times, separated by friction-surfaces: white mispickel is the most common, among the minerals above-mentioned, and contains argentiferous gold. The galena, and blende, also contain somewhat of gold and silver. The gold generally forms extremely thin incrustations, or small grains, most commonly associated with galena, blende, and mispickel. These ores are nowhere equally distributed through the gang; the dark gray, greasy quartz being the richest. No law could be recognised with regard to the distribution of the ore. Numerous veins of this kind have been found, the most important of which seems to be that in the Carolina mine. The Veta blanca, on the contrary, which protrudes as a high rock-wall, 20—30 feet high, and strikes NNW.—SSE., appears to belong to another, non-auriferous, quartz-formation, in which only traces occur of copper and iron pyrites, and spathic iron.

The lead-lodes of the same district have a very irregular strike, attain a breadth of 2 inches to 3 feet, and are, for the most part, composed of decomposed country-rock, with calc-spar, fluor spar, spathic iron, black or brown blende, galena (containing but little silver and no gold), iron and copper pyrites. The ores and vein-stones are irregularly intermingled with one another.

XXIV. SPAIN.

GENERAL SUMMARY.

§ 219. It is known, that under the dominion of the Romans, and even until the discovery of America, a profitable metal-mining existed in many parts of Spain. The discovery of America was the cause of a general decline of the mining interests of the country, nearly all the forces being turned across the ocean to the deposits, in part still richer, there discovered. It is principally since 1820, that the Spaniards have recommenced looking for the traces of the old works, and developing the natural treasures of their own country.

The iron-deposits of this land exhibit nothing either new or interesting; so that I shall confine myself to those deposits, whose description appeared reliable, in those French and German works to which I had access. Ezquerra del Bayo's map in Leonhard's *Jahrbuch für Mineralogie* for 1851, on which the most important mining localities are marked, gives a very good idea of the geological topography. Without grouping the deposits into districts, I shall describe the zinc-deposits of Santander, the silver lodes of Hiendelencia, the silver and lead lodes of the Sierra Carthagena, of the Sierra Almagrera, and of the neighborhood of Linares; the copper-deposits of the Province of Huelva, and the quicksilver-deposits of Almaden. I pass over the Kingdom of Portugal, although it is not wanting in metalliferous deposits.

CALAMINE DEPOSITS IN THE PROVINCE OF SANTANDER.

§ 220. A very considerable deposit of zinc-ores occurs in the Province of Santander,[1] on the north coast of Spain, between the western portion of the Pyrenees and the sea. They do not extend continuously and without interruption; but occur in many localities at a certain niveau, between the strata of the Upper

[1] See: Fel. Banza, in Mining Magazine, 1861, p. 73; Sullivan, and O'Reilly, in Revue de Geologie, II. p. 102; Schönichen, in Berg- und hüttenm. Zeit. 1863, p. 163; Rivière, in Compte rendu, 1858, p. 728.

Jura, in a very similar manner to the zinc-deposits of Upper Silesia, the Ruhr district, and Belgium, in older strata. The separate deposits, which are not every where rich enough to be exploited, form near Santander, partly recumbent segregations, partly bedlike impregnations; partly fill irregular fissures, even in the form of oolithic grains, in such a manner, that they cannot be termed true beds, although they resemble such in their general geological extension. They always occur at the contact of ferruginous clayey shales and dolomites; the first forming their floor, the last their roof. At times separate portions of these are altered into calamine and smithsonite, while inwardly still consisting of dolomite.

The strata, which are conformable with one another, although not every where present, consist, in descending order, of:

1. Dolomite, and magnesian limestone, very thick;
2. Ore-deposits, consisting of blende more or less altered to calamine, or galena, combined with dolomite;
3. Ochreous clay, hematite, and limonite, cupriferous clay, etc.
4. Argillaceous limestone;
5. Argillaceous, slaty limestone;
6. Sand, and sandstone;
7. Argillaceous shale, and stratified sandstone, with lignite;
8. Stratified limestone.

Above the dolomites, immediately overlying the ore-deposits, more recent ones occasionally occur, also, containing strings, and pockets, of white calamine, and zinc-bloom.

According to Rivière, distinct fossils of the Cretaceous group occur in the limestones of this group; while Schönichen and O'Reilly consider the same as belonging to the Jura formation.

It has already been remarked, that the ores were not equally distributed through the dolomite-belt, but were grouped in irregular deposits, of unequal richness, although of similar composition. The zinc-ores are generally very predominant, among these even the blende (near Cumillas), which usually occupies the lower portions in the thicker deposits. The other zinc-ores are smithsonite, calamine, and zinc-bloom. After the zinc-ores, galena is the most important; besides these ores, are also found oxides of manganese, carbonates of copper, arsenates of nickel, etc., which cause numerous changes of color.

These zinc-deposits evidently correspond, in general, with those with which we have already become acquainted, near Aix-la-

Chapelle, at Wiesloch, and in Silesia. Their manner of occurrence, combined with dolomite, is also entirely analogous, even though belonging to a much more recent formation; the only slight difference is the occurrence of blende, and the presence of zinc-bloom, copper and nickel ores. Their origin will certainly prove to be an analogous one, and not to belong to the period, during which the dolomites were formed, but a subsequent one.

THE LODES OF HIENDELENCIA IN THE PROVINCE OF GUADALAJARA.

§ 221. Hiendelencia[1] lies, 180 kilometers northeast of Madrid, on a spur of the Guadarrama mountain-chain. The rock in the neighborhood is principally gneiss, whose different varieties alternate with other crystalline schists and quartzites. These schists are traversed by two different systems of lodes, the one of which courses NE.—SW., the other N.—S. The lodes of the first are composed of heavy spar, those of the last of quartz: both contain silver ores; but the first, the most.

The best known, and, as yet, most important of the barytic lodes, is the Santa-Cecilia or Canto-Blanco. Its real breadth never exceeds 2 inches, but it sends out numerous and, in part, important branches on both sides, which frequently re-unite with the principal vein. It is generally almost perpendicular, but occasionally has but a very gentle dip. The gang of heavy spar contains silver glance, as the chief ore, distributed through it. From this last ruby silver, native silver, as well as chloride, bromide and iodide of silver, appear to have been formed by decomposition. Some portions of galena, and stibnite, both very argentiferous, also occur.

A decomposed bed-layer in mica-schist, occurs near Congostrina, only 10 kilometers distant from the just mentioned veins; which contains small masses or grains of silver-glance and ruby silver. Ezquerra del Bayo thinks, that this layer has been formed by the denudation of the above lodes, and that it is consequently a true bed, and so a sort of ancient placer. I

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[1] See: Ezquerra del Bayo, in Cotta's Gangstudien, vol. II. p. 309, Leonhard's Jahrb. 1851, p. 46; Ruyz y Leon, in l'Institut, 1845, XIII. p. 381, Bulletin géolog. 1846, III. p. 648; Breithaupt, in Berg- u hüttenm. Zeit. 1854, p. 9; De Aldama, in Revista minera, 1851, II. p. 184.

must confess, that this explanation appears to me scarcely probable; but reserve any positive opinion, with regard to a fact, of which I know so little. Bayo goes still farther, since he supposes the silver (probably in the form of silver glance) found in a Tertiary clay near Hita, 50 kilometers from Hiendelencia, to owe its origin to a similar erosion, and subsequent deposit.

LODES IN THE SIERRA DE CARTHAGENA.

§ 222. The Sierra de Carthagena[1] forms a coast-branch of the Sierra Nevada, in an East-West line. It consists of Silurian slates and limestones, traversed by trachytes and basalts, surrounded at the base by Tertiary strata.

The Silurian rocks and trachytes are traversed near Almazarron on the Monte-Rajado, east of Carthagena, by a number of lodes having a predominant N.—S. and E.—W. strike, and commonly vertical. Where they traverse the Silurian rocks they occur, according to their nature, partly as regular fissure-veins intersecting the strata obliquely to their course, partly separating into branches, which strike parallel to the strata. In the last case they often form very narrow branches, or broader lenticular masses. They often enclose fragments of slate or trachyte, and are consequently of more recent age than this last. Their matrix is, according to Fournet, of especial geological interest. It consists of an irregular mixture of a ferruginous silicate with galena, iron and copper pyrites, mispickel, magnetite, calc-spar, heavy spar, and quartz. These ingredients penetrate one another in a peculiar manner, in fine strings, threads, nodular masses, dendrites, etc., also forming small geodes.

In the broader veins, or at the broadest points of the same lode, the ferruginous siliceous mass predominates, while the narrower branches and strings are almost exclusively filled with sulphurets. Fournet thinks, that the mass of the vein has penetrated in an igneous-fluid condition, in which the siliceous and

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[1] See: Sauvage, in Annal. d. mines, 4th series, vol. IV. p. 113; Gruner, in same, 1842, vol. I. p. 712; Pernolet, in same, 1846, vol. IX. p. 42; Fournet, in Compte rendu, 1857, vol. 44, p. 1233; Lasala, in Revista minera, 1852, vol. III. p. 551; Von Hingenau, in Oesterreich. Zeitschrift f. Berg- u. Hüttenw. 1861, p. 385; Berggeist, 1862, p. 414.

earthy portions were prevented, by their viscous condition, from penetrating into the finer clefts with the more thinly fluid sulphurets. Although I cannot coincide in this view, I also refrain from expressing any positive opinion, on geological facts, which I have not had the opportunity to examine personally.

Pernolet describes two other kinds of lead-deposits. The one seem to form impregnations of galena, pyrites, and blende, in a compact green rock; the other form beds or bedded veins in limestone. In the last galena occurs, apparently unaccompanied by either pyrites or blende.

LODES IN THE SIERRA ALMAGRERA.

§ 223. The Sierra Almagrera[1] rises in the northern portion of the Province of Almeria, immediately on the coast of the Mediterranean Sea, and about 1000 feet above its surface. The Small Cordillera (the coast-chain) is, at the most, 15 miles long, and 3 broad. While rising rather precipitously out of the sea, towards the Southeast, it declines very gradually, at an angle of about 6^{o}, on its northwestern slope, towards the plains of Cuevas and Pulpi. Both slopes are intersected by deep gorges (*Barrancos*). The principal strike of its crest is NE.—SW., it consists entirely of mica-schist passing into clay-slate. An igneous rock is nowhere seen, but the schist is traversed by numerous veins, the most important of which has been called Jaroso after one of the gorges. This at times splits up into numerous branches, especially towards the N., so that at last an exploitation of the narrow droppers has to be given up; while southwardly a great fault appears to cut off the lode. The exploitable portion, between the two, is about 1800—2100 feet long. The strike of the vein is almost due N.—S., it, therefore, crosses the mountain-crest somewhat obliquely, the dip averages 60^{o} in E., near the sur-

[1] See: Rüdiger, in Berg- u. hüttenm. Zeit 1843, p. 457; Breithaupt, in same, 1852, p. 65; Ezquerra del Bayo, in Leonhard's Jahrb. 1841, p. 354, 1843, p. 787, 1851, p. 46; Pellico and Maestro, in Annal. des mines, 1841, vol. II. p. 124; Revista minera, 1851, vol. II. p. 592; Pellico, in same, vol. III. p. 1; Lambert, Proceedings of the roy. geol. soc. of London, 1840, vol. III. p. 318; Gruner, in Annal. d. mines, 1842, vol. I. p. 713; Paillette, in same, 1842, vol. II. p. 287; Pernolet, in same, 1846, vol. IX. p. 35 (71).

face somewhat more, at a greater depth somewhat less. The leaders also dip somewhat more, while the schist inclines 45° in NE. The breadth of this fine lode gradually encreases from the surface to a depth of 35 fathoms, being about $3^1/_2$ fathoms at its maximum; at a still greater depth it decreases, and only averages about 5 feet at a depth of 82 fathoms. According to Rüdinger, the contents of the lode show a similar encrease and decrease with the depth. The same is chiefly composed of limonite with argentiferous galena, an amorphous white substance called 'Molinera', and copper pyrites. Breithaupt has recognised the following minerals:

1. Spathic iron, upwards of 40 separate bands have been counted;
2. Celestine;
3. Heavy spar, mostly massive;
4. Steinmannite (antimonial galena), containing $1-1^1/_2$ per cent of silver;
5. Common galena, argentiferous, partly very fine granular;
6. Crystals of bournonite in spathic iron;
7. Brown blende, forming thin bands, or disseminated in spathic iron;
8. Copper pyrites, disseminated in spathic iron.

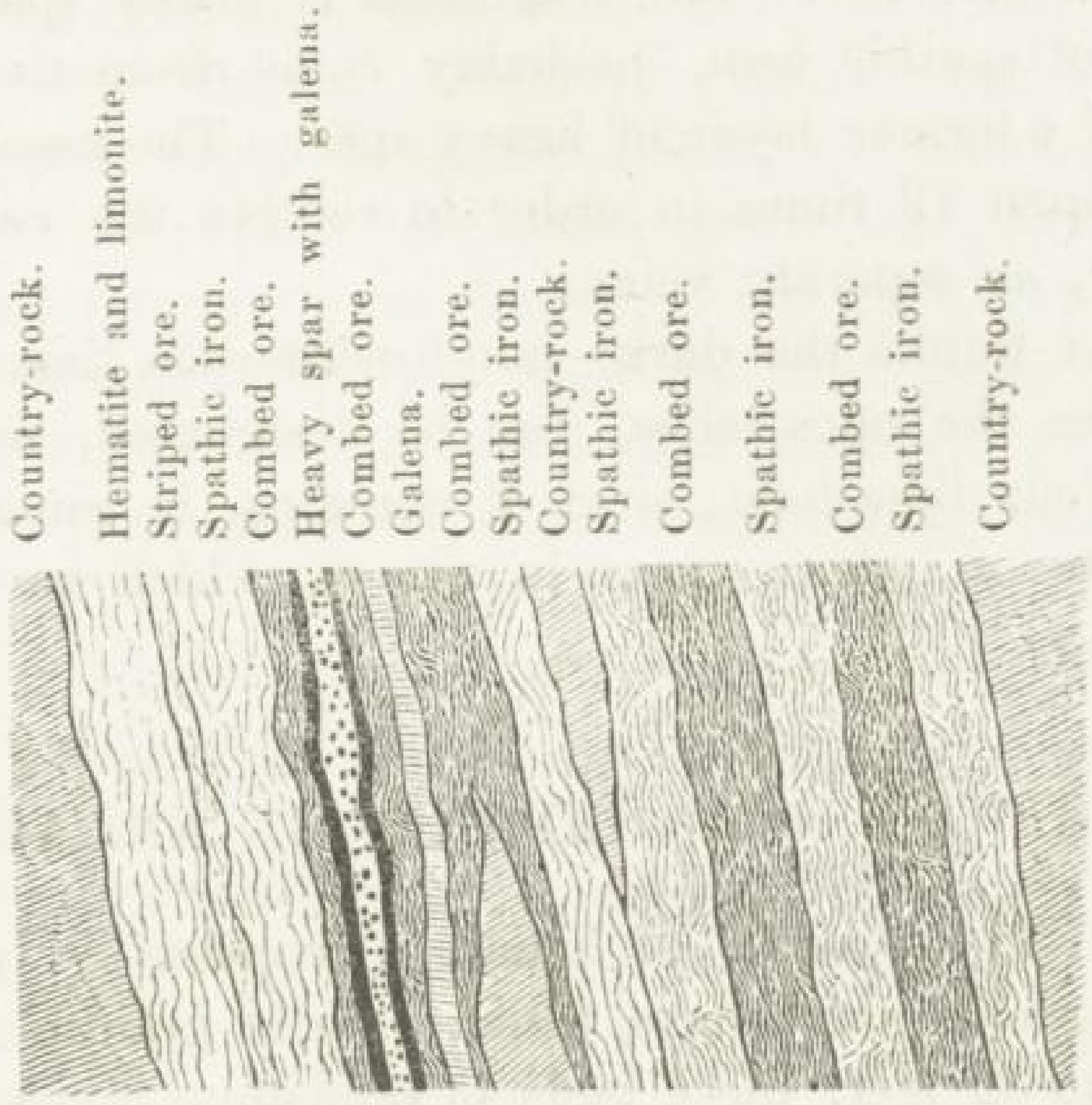
The following minerals have been formed by the decomposition of the preceding:

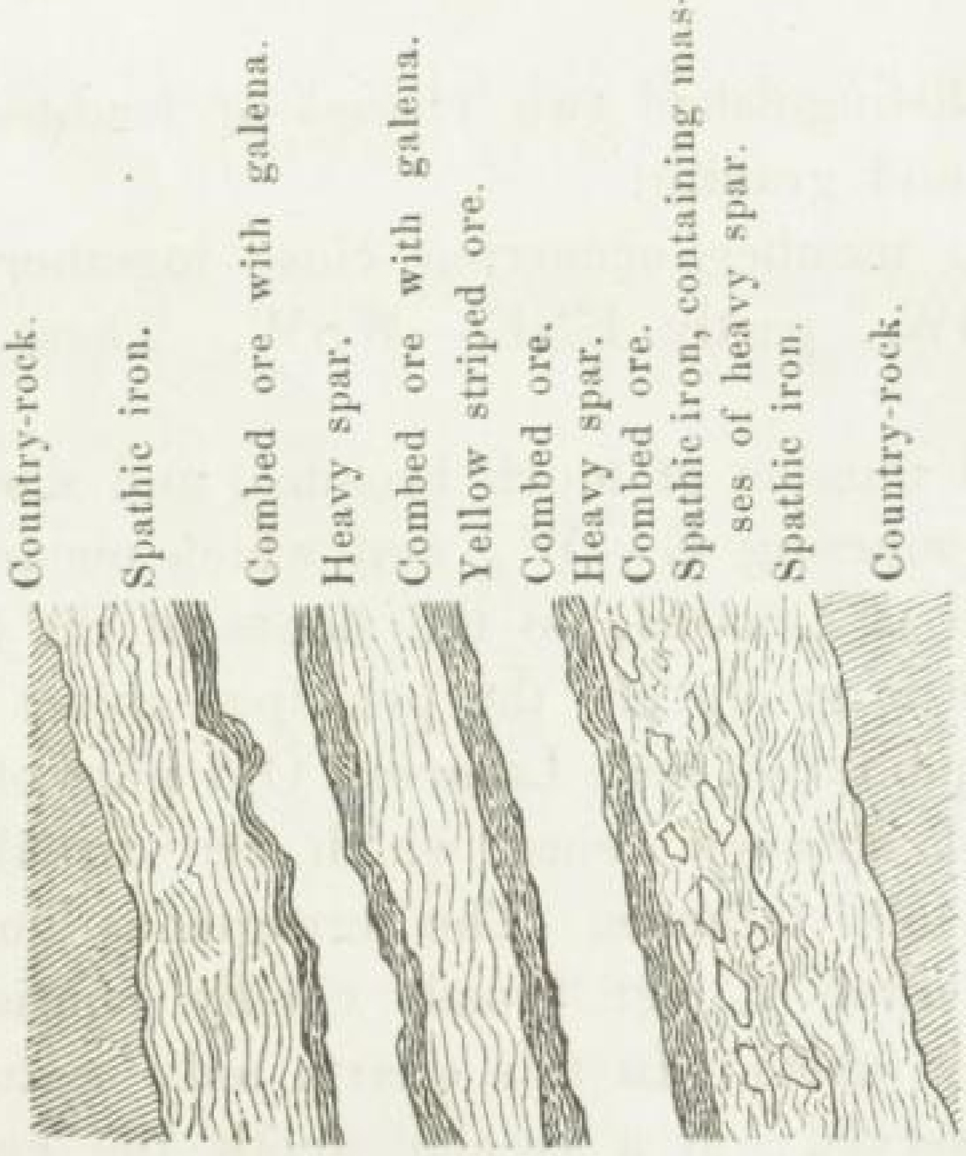
9. Hematite, from spathic iron;
10. Limonite, from spathic iron;
11. Anglesite, from galena;
12. Ochreous antimonate or antimonite of lead and copper, from bournonite;
13. Jarosite, from sulphurets;
14. Zinkosite, from blende;
15. Zinkazurite from copper pyrites and blende.

Fragments of the country-rock are not wanting. These minerals often exhibit a very fine combed texture.

As a rule, only decomposed clay-slate, heavy spar, limonite, and hematite, occur from the surface to a depth of 18 fathoms; the last probably formed by the decomposition of spathic iron and pyrites. Beneath this follows the richest zone, containing much rich argentiferous galena, also somewhat of kerargyrite in the iron ores. Below the depth of 82 fathoms, the amount of silver appears to decrease, while heavy spar and a variety of hornstone become predominant; but at the time Rüdinger wrote, the greater depths had not been sufficiently opened-up; so that it is possible the ores may again encrease both in quality and quantity. The rich zone, below the depth of 18 fathoms, might possibly be explained by the hypothesis, that the metallic portions, dissolved and washed out of the gossan, were concentrated in this zone.

The combed texture of this lode is very remarkable, in those portions which are still fresh and undecomposed. The two following woodcuts are copied from Rüdinger.





It appears, from these drawings, that the arrangement of the single layers is by no means a symmetrical one, and cannot therefore be the result of successive deposits in a fissure having the present breadth of the lode. It must, therefore, be concluded from this want of symmetry, that the fissure has been repeatedly widened, and then the repeated filling produced only one or, at the most, two layers. This can be more particularly seen from the horses in the middle of the lode, which probably formed a wall of the adjoining layer, at a certain period in the formation of the lode. The fragments of heavy spar, in one of the layers of spathic iron, probably come from the partial destruction of a former layer of heavy spar. The fissure may have been torn open 12 times in order to receive the various layers successively, as separate veins.

Pernolet thinks the dark, non-fossiliferous limestone, which here overlies the mica-schist, can be designated, in particular, as metalliferous limestone; since it contains, in numerous localities, deposits of galena (poor in silver), which rarely crop-out to the surface.

LEAD-LODES NEAR LINARES, IN ANDALUSIA.

§ 224. The plateau of Linares[1] consists of nearly horizontal ferruginous sandstones, which overlie granite for a thickness of 26 to 32 feet; these beds of sandstone appear to belong to the Trias.

Lan has distinguished two classes of lead-lodes, traversing the sandstone and granite:

1. A large number occurring close together, which strike partly NE.—SW., partly ENE.—WSW. These are the most important;

2. A small number of much broader, and more complicated veins, usually coursing E.—W., and which occur, for the most part, northward of Linares; on the slopes of the Sierra Morena. Those of the first group are the principal object of the former and present exploitation near Linares. Old piles of rubbish show the existence of 45 such veins, which are distributed over an area of 4000—4500 fathoms. The ferruginous quartz, of which their outcrop, often 2 feet broad, chiefly consists, frequently forms projecting crests. In this quartz only scattered grains of galena are observed; at a greater depth the galena becomes more frequent; and at but a slight depth, these lodes contain

[1] See: Lan, in Annal. d. mines, 1857, vol. XII. p. 623.

considerable galena (poor in silver), blende, iron and copper pyrites, carbonates of lime, iron and lead, as well as linarite, in a predominantly quartzose gang, with but little heavy spar. The cerusite sometimes extends to a depth of 40 fathoms. The blende is stated to encrease in quantity with the depth in the 'la Crux d'Arrayanes' lode. No decrease in the breadth of the veins had been observed, at the depth of about 80 fathoms, reached in 1857; the ore-chimneys extend almost vertically. The veins appear to be relatively richer, the broader they are. Narrow points are often very poor; while such as are 1—1½ fathoms broad, frequently contain pure masses of galena. Since these lodes often split up into branches and again unite, rich junctions are formed containing compact masses of galena. They are traversed by a number of barren fissures which strike E.—W. or ESE.—WNW.

The veins of the second class consist of quartz and heavy spar, with iron pyrites, copper pyrites, and galena, containing but little silver: from their firmness, the outcrops frequently project, as walls of rock above the sandstones, to a height of one or more fathoms. The ores are distributed, in these veins, in strings, and not collected in chimneys.

COPPER-DEPOSITS IN THE PROVINCE OF HUELVA, IN ANDALUSIA.

§ 225. The Province of Huelva [1] is composed, for the most part, of clay-slates belonging to the Silurian Age; which are frequently traversed by dioritic igneous rocks; while some green metamorphic, also occurring with these, might be easily mistaken for them; also by some quartz porphyries (*Eurites quartzifères*). The dioritic greenstones form irregular, lenticular masses, generally coursing parallel to the clay-slates, with a predominant E.—W. direction. Intersections of the stratification can be but rarely observed. The quartz-porphyries, which are accompanied

[1] See: Figeroa, in Revista minera, 1852, vol. III. p. 513; Ezquerra del Bayo, Memorias sobre las minas nacionales de Rio Tinto, 1852; Lan, in Annal. d. mines, 1857, vol. XII. p. 609; Hausmann, in Leonhard's Jahrb. 1859, p. 9; Schönichen, in Berg- u. hüttenm. Zeit. 1863, p. 176; Bellinger, in Odernheimer's Berg- u. Hüttenwesen v. Nassau, 1864, No. 2, p. 291.

by petrosilex, and jasper, usually form veins, and bedded veins, in the green metamorphic schists.

Lan distinguished three kinds of copper-deposits in this Province:

1. Segregated masses of iron and copper pyrites, very broad; for example, at Rio Tinto;

2. Veins united to floors (*stockwerks*), containing oxides, carbonates, and sulphurets;

3. Veins containing copper pyrites and tetrahedrite.

The segregations of pyrites principally occur in the green metamorphic schists near the quartz or diorite porphyries; at times, as contact deposits, immediately on their limits. They form irregular masses of lenticular shape, generally parallel to the stratification, and also having an inward parallel stratification, at times sending out vein-like branches.

Such segregations occur at Rio Tinto, Poyatos, Tharsis, Calañas and San-Telmo (Sant-Elmo). They are surrounded by broad selvages which are characterised by certain peculiarities; either by particular hardness and a large amount of ferruginous quartz; or by numerous interspersed grains of pyrites, causing a slight decomposition; or, finally, by decomposition of the schist into a white soft, argillaceous mass. The outcrop of the pyrites segregations is often most easily recognised from these selvages; and in some of the segregations, these can be continuously followed for a distance of 1000 fathoms.

The deposits consist of a pretty compact iron-pyrites, containing somewhat of copper, or of an intimate mixture of iron and copper pyrites, with somewhat of quartz and clay; while somewhat of blende, mispickel, and galena, occurs to a very subordinate degree, and a small percentage of silver occurs locally. They generally contain 49—50 per cent of sulphur, 43—44 per cent of iron, 3—4 per cent of copper, and 2—3 per cent of quartz, sand, and clay. Near the selvages, and in them, strings of melaconite sometimes occur, especially near Tharsis.

Some changes are found to take place, with encreasing depth; which appear to have been caused by decomposition from the surface. The upper 2—5 fathoms usually consist of an earthy ferruginous mass, or of ferruginous quartz, consequently a very characteristic gossan. Beneath this the pyrites is generally much fissured and possesses a sort of stratification parallel to the selvages; firm masses, pockets, or zones, of pyrites alternate with pulverulent varieties, which resemble a stamped ore. Still deeper, the entire mass is uniformly compact, and very hard. It is only near the selvages, exceptionally intersected, by white argillaceous veins, or masses, resembling the white variety of the selvages; also by jasper, and quartzose argillaceous shale. It has not, as yet, been determined, whether the breadth and quantity of ore decrease with the depth, or not. The former is often very great: Lan states, it is sometimes as much as 75 fathoms. Hausmann estimates the breadth of the segregation, at Rio Tinto, to average 40 fathoms, in some places even 100—150 fathoms. He found, in addition to the principal mixture of iron and copper pyrites, more rarely somewhat of galena, blende, copper glance, tetrahedrite, and mispickel; and designates the wall-rock, as clay-slate passing into talc and mica-schist; but porphyries also occur.

There is evidently a great similarity, between these segregations of pyrites, and those of Goslar in the Hartz, Agordo in the Alps, and Fahlun in Sweden; the most of which, like the Spanish ones, occur in rocks belonging to the Palæozoic era, and are surrounded by a kind of selvage.

Portions of these broad pyrites deposits have been extensively exploited by the Romans; as is seen from the large quarries and immense piles of slag. The ancient workings are especially extensive near Rio Tinto.

Less important than these broad segregrated masses, are the veins forming floors; which contain oxides, carbonates, and sulphurets, traversing, as a group, rocks of the Palæozoic era, in the northern portion of the Province; whose principal course is WSW.—ENE. The veins containing tetrahedrite are found more in the central portion of the Province; they occur singly with a predominant strike of NNE.—SSW.

In the same region occur extensive deposits of ores of manganese.

QUICKSILVER-DEPOSITS AT ALMADEN IN ESTREMADURA.

§ 226. The views, with regard to the nature of these famous quicksilver-deposits, are much divided. Willkomm[1] and Ez-

[1] See: Hawley, in American Journ. of Science, II. Series, vol. XLV. p. 9; Le Play, in Annal. d. mines, 1834, vol. VI. pp. 319, 333, 362, 369,

querra del Bayo consider them to be true veins; de Prado and Hawley, to be bedlike impregnations, comparable to those of Idria. The strata, in which the deposits occur, belong to the Upper Silurian; the immediate wall-rock is usually a black carbonaceous slate, and quartzite; with which hard, fine-grained sandstones, and slates, alternate, but contain no ores. The deposits incline, at the surface, 60^o—70^o, then dip almost vertically; they had been opened, in 1851, to a depth of 1050 feet. They strike E.—W. The two broadest of the deposits are the San Francisco and San Nicolas, each having an average breadth of 21 feet; which occur so near to one another, that they are, in places, only separated by a soft bed of slate, 3—4 feet thick. Their breadth encreases considerably, with the depth, to nearly 40 feet. At a depth of 135 fathoms the space for both, exploited in common, has a width of $67 \frac{1}{2}$ feet. These deposits consist almost entirely of quartz, and compact or earthy cinnabar; which traverses the quartz, and also forms large compact masses. At times fine geodes of calc-spar occur in the ore; or the chief mass is traversed by clefts, or cavities, containing native mercury; de Prado also found somewhat of galena in them. According to this last-mentioned observer, the deposits follow the strike and dip of the Silurian slates, on which account he calls them *beds*; but remarks, that veins of cinnabar, also, occur, to a subordinate degree, in the neighborhood; and considers, that the ores have penetrated between the slates from below with a sort of choice of way. The designation as bed, would, according to this view, hardly be a proper one. Le Play states, that the veinlike character appears, for other reasons, to be very evident; since he observed distinct quartz-selvages; which separate the veins, on both sides, from the country-rock; and contain merely a little iron-pyrites, and cinnabar. He also found fragments of ophite (a tolerably compact diorite) in the lodes; which rock occurs in the neighborhood, and with whose eruption he believes the lodes to be connected.

The uncommon breadth or massiveness of this quicksilver occurrence is very remarkable. It is not very strange to find

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489; De Prado, in Bullet. géol. 1855, b. vol XII. p. 24; Willkomm, in Bergwerksfreund, 1849, vol XIII. p. 72, Leonhard's Jahrb. 1850, p. 497; Ezquerra del Bayo, in Leonhard's Jahrb. 1851, pp. 47, 675; Nöggerath, in same. 1863, p 479: Klemm, in Berg- u. hüttenm. Zeit. 1861, p. 418, 1867, p. 13.

ores, which occur as frequently in the earth's crust, as those of iron, copper, lead, or zinc, locally aggregated in massive deposits; but in the case of a metal, such as mercury, and its ores, which relatively occur so rarely, and in so few localities; such a massive aggregation is certainly astonishing. If the localities, where ores of mercury occur, or are exploited, be enumerated and compared; it will be found, that after platinum, mercury is the rarest metal used in the arts and manufactures. It may be asked, how could it then happen, that this metal is collected in such masses at some localities; as for example, Almaden, New Almaden, and, to a certain extent, Idria; while it is generally altogether wanting in most of the geologically examined regions? Even platinum is not so unequally distributed, the least so gold and silver. Innumerable deposits, in which these metals occur, are known; but none so metalliferous, as those of quicksilver.

Tin occurs, in Spain, only in granite, and crystalline schists. It has been discovered in three localities in Galicia,[1] and two in Asturia; also in the Province of Almeria.

GREAT BRITAIN AND IRELAND.

SUMMARY.

§ 227. This kingdom contains numerous metalliferous deposits, especially in the districts composed of older sedimentary, or metamorphic rocks. In the sedimentary formations, from the Carboniferous Period upwards, only beds of iron-ore occur.

This country is richly blessed with iron-deposits of the most various kinds, whose value is in part much encreased by the immediate neighborhood of rich and excellent coal-fields. The description of these iron-deposits, in so far as they were acces-

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[1] See: Schulz, and Paillette, in Bullet. géol. vol. VII. p. 16; Revista minera, 1821, vol. I. pp. 148, 333.

sible, contained nothing either particularly important or interesting, on which account I shall pass them over. Especially important, as may well be imagined, are the iron-ores of the Carboniferous Period; which occur under like circumstances to those in Westphalia, Saarbrück, and Silesia, only thicker and richer; partly as the so-called 'black bands', partly as sphero-siderite, or clay ironstone.

While passing over many less important metalliferous deposits, especially those of Scotland, I shall mention those of Cornwall, Derbyshire, Cumberland, and Wicklow in Ireland.

XXV. CORNWALL.

GEOLOGICAL FORMATION.

§ 228. The peninsula of Cornwall[1] consists principally of so-called killas; by which the Cornish miners understand every slaty rock not belonging to either granite, or elvans; which

[1] See: Berger, in Trans. of the geol. soc. 1811, vol. I. pp. 93, 158, 161; Mc'Culloch, in same, 1814, vol. II. p. 110; J. Williams, in same, 1817, vol. IV. p. 138; E. Smith, in same, p. 404; Hawkins, in Trans. of the roy. geol. soc. of Cornwall, 1818, vol. I. 1822, vol. II. pp. 29, 223, 232, 284; 1827, vol. III. p. 115; 1832, vol. IV. pp. 1, 135; Carne, in same, 1822, vol. II. pp. 49, 290; 1827, vol. III. p. 74; 1832, vol IV. pp. 47, 95; Rashleigh, in same, 1822, vol. II. p. 282; 1832, vol. IV. pp. 47, 59; H. Boase, in same, 1827, vol. III. p. 17, vol. II. p. 383, vol IV. p. 438; Henwood (the most complete on the subject), in the same, 1843, vol. V. Philosoph. magaz. 1831, vol. X. p. 358; 1846, vol. XXIX. p. 359; Trans. roy. geol. soc. of Cornwall, vol. IV. p. 57; Proceedings of geol. soc. of London, 1832, p. 405; Colenso, in Trans. roy. geol. soc. of Cornwall, 1832, vol. IV. p. 29; Davey, in same, p. 484; Thomas, Report on a survey of the mining distr. of Cornwall, from Chasewater to Camborne, 1819; De la Beche, Report on the Geology of Cornwall, Devon, and West Somerset, 1839; Johnston, in Mining Almanac, 1852; Bonnard, in Journ. d. mines, vol. XIV. No. 84, p. 443; Combes, in Annal. d. mines, 1834, vol. V. p. 109; Dufrénoy, Elie de Beaumont, Coste, and Perdonnet, Voyage métallurgique en Angleterre, 1839, vol. II. p. 177, Annal. d. mines, vol. IX. p. 827, vol. X. p. 331, vol. XI. p. 211; Daubrée, in Annal. d. mines, 1841, vol. XX. p. 89; Moissenet, in same, XIV. p. 87, 1863, vol. III. p. 161, Compte rendu, 1862, vol. LV. p. 759; Pattison, in Quart. Journ. of the geol. soc. 1854, vol. X. p. 247.

consequently includes hornblende-schist, varieties of greenstone, etc. The age of these rocks cannot be more specially determined, than that they belong to the Palæozoic era; since only very rare and poorly preserved fossils have been found in them; from which it is indeed probable, that the majority belong to the Devonian Age.

This extensive slate-district encloses five large, and several small, masses of granite; which, without rising, in a predominant manner, above the common level, protrude as 'islands of granite out of the sea of slate'. The slate, as well as the granite, is traversed by numerous dikes of porphyry, called *elvans*; by some trap-dikes, by numerous copper and tin lodes, occasionally by veins of ferruginous quartz, and by fissures filled with clay. All these veins are, among themselves of unequal age, and most commonly near the granite, or in it. Near these, and, especially, at some distance from the granite masses, occur still other ores than those mentioned, especially those of lead.

This geological formation is very characteristic for the whole of Cornwall, and a portion of Devonshire; being, with but slight modifications, every where the same. Considerable masses of serpentine occur in the western portion; while, on the other hand, the lodes appear to be wanting in this region.

Before passing over to the delineation of the so frequently and carefully described metalliferous deposits of Cornwall, I consider it desirable to preface the same with more special remarks on the principal rocks just mentioned.

1. The *killas* is predominantly composed of greenish clay-slate, passing into many varieties of this rock, and with subordinate layers of a sandy nature. It is often more compact, near the granite masses, than elsewhere; and there contains, without any sharp line of demarcation, a number of subordinate layers of, partly crystalline, schistose rocks, whose special description would occupy a much greater space than appears adapted to this work. These schistose rocks; united by transitions with the predominant clay-slate, and found, for the most part, near the granite; are: chlorite schist, mica-schist, gneiss, tourmaline schist; felsite schist containing tourmaline, and hornblende schist, or greenstone schist, containing numerous subordinate minerals, especially garnet, actinolith, or axinite. These schists are also frequently traversed by veins, and unconnected masses of quartz, which also contain tourmaline.

The planes of slaty cleavage almost universally dip from the granite; and the various layers of slate thus irregularly mantle round the flanks of the granite hills. The dip of their lamination is seldom so rapid, as that of the line of junction with the granitic mass beneath; as it is seldom more than 30°, and is mostly less than 20°; while that of the granite usually exceeds 40°. This dip seldom, however, continues the same for considerable distances, and is even reversed within small tracts; owing, perhaps, to the irregular thickness of the laminæ in different places; as there is little or no appearance, that they have undergone mechanical displacement. The slates are not only generally altered near the granite limits; but also occasionally, as accessory minerals, thin veins or layers containing quartz, feldspar, mica, chlorite, actinolith, garnet, axinite, prehnite, epidote, topaz, and cassiterite (Crown-Rock near Cape Cornwall).

Fossils are found, but very rarely, in these rocks; and when they do occur, are so imperfect, that they were not adapted to a more accurate determination of the strata; thus near St. Austel.

2. The *granite* is, for the most part, coarse-grained, at times, however, very fine-grained, often porphyritic, containing twin-crystals of feldspar. The mica is sometimes replaced in the same by tourmaline, chlorite, or talc. These varieties alternate very irregularly with one another; one variety partly forming veins in another, or ramifications in the slates. The granite-masses enlarge, and spread out, under the slates, as they descend, and it is probable that they all unite at great depths. Their dip, as stated, is also greater than that of the slates.

That these granite-masses are more recent than the slates mantling, and obliquely overlying them; is rendered evident, by the numerous vein-like and bedded ramifications, which the granite forms in the slate, as well as from the fragments of slate it contains. These ramifications are most frequent near the lines of junction, frequently but a few inches thick, and soon wedging-out; while exceptionally broader, even bedded, ones, extend into the slate. Similar granite strings or dikes traverse the granite itself, and are then usually very fine-grained, quartzose, and containing but little mica; they not rarely contain, as accessory minerals, pinite, beryl, topaz, tourmaline, apatite, copper-pyrites, etc. The ramifications frequently also intersect the quartz-veins in the slates, and are in turn traversed by others, which contain tourmaline, topaz, mica, apatite, beryl, cassiterite, wolfram, and even somewhat of red copper (St. Michael's Mount). Veins of tourmaline; associated in some places with quartz, in others with feldspar, and often containing tin ore; traverse the granite: they are, in general, far more abundant near its junction with the slate.

3. The *Elvans* are porphyry-dikes, which vary in the number, and proportions, of their constituents; they traverse both the slates and granite. Their principal mass is always a compact felsite, like that of all quartz-porphyries, in which crystals or crystalline grains of feldspar, quartz, amphibole, mica, tourmaline, etc. are porphyritically distributed. These last are generally wanting near the selvages, the rock then consists merely of the compact matrix. Fragments of the wall-rock also occasionally occur in these elvans. Henwood states, that the mass of these elvans is somewhat different when traversing the granite, clay-slate, or greenstone-slate; in clay-slate usually composed of feldspar and quartz, in granite of feldspar and mica.

The elvans have been extensively worked, in different places, for the metallic minerals which they contain in irregular and disconnected masses, or in beds, or in small irregular veins; viz. iron and copper pyrites, and tin-ore (the last taking the place formerly occupied by crystals of feldspar). Their breadth varies between a few feet and 70 fathoms: the single veins are frequently very variable at different points. Their strike is NE.—SW., for long distances parallel to the joints of the rocks, but, in general, not parallel to the laminæ of the schistose rocks: some of them have exceptionally a different direction of strike. Their dip is, in general, 40°—60°: many more of them incline toward the North, than to the South. According to the Ordnance geological map of Cornwall, some of the elvans appear to be only ramifications of the granite-masses; thus at Blistand. They are vein-like branches of the chief granite-mass; which, perhaps from a more rapid cooling off, have hardened porphyritically with a compact matrix; while the majority of the same, indeed, extend out of the slate, through the granite, with well defined limits. These are evidently somewhat younger than the chief mass of granite: the difference in age need not have been very great; and it is possible, that they were all, like the granite-dikes, formed from a still-fluid lower granite-region, at a period when its upper portion had already solidified; while those passing into the granite are, perhaps, contemporaneous ramifications. Dufrénoy and Elie de Beaumont state, that the elvans are older than the Carboniferous formation, but more recent than a certain class of tin-lodes; since these last are intersected, and, in part faulted, by a majority of the elvans, and by all the other lodes.

The slate is often strikingly hardened, and compact, alongside of the lodes; some of which have been followed for a distance of 5 miles.

4. *Trap-dikes* are found, in general, only in the laminated rocks, which they partly traverse, like beds, parallel to the stratification.

SUMMARY OF THE ORE-DEPOSITS IN CORNWALL.

§ 229. The ore-deposits, and barren veins accompanying them, which occur in Cornwall, may be divided (according to Carne, Dufrénoy, and Elie de Beaumont), into the two great classes of tin and copper ore-deposits. A distinct line of demarcation cannot well be made between these two classes; since the former often contain copper-ores, and the latter, tin-ores; besides which veins, entirely destitute of ores, occur.

The tin-deposits may be subdivided into:

1. *Tin-floors:* these are portions of the rocks, or strata, traversed by stanniferous beds, or veins; which have been considered by some persons to have been formed contemporaneously with the enclosing rocks; but are probably, more correctly, to be regarded as, in part bedded impregnations, in part filling joints between the rocks: they can be very finely observed in the slate between St. Ives and Cape Cornwall: in the Grillsbunny mine they form a zone, about 70 feet broad, in hornblende-schist: in the Botallack-mine there is a tin-floor 18 inches broad:

2. *Tin-stockwerks:* these are combinations of numerous smaller strings, or threads, forming a network: the granite in a quarry of the Carclace mine, near St. Austel, is traversed by a large number of threads or strings, upwards of 6 inches broad, consisting of quartz, with tourmaline, and cassiterite: they all course E.—W., but are partly vertical, partly dip 70° in S.; which last intersect the first, without faulting them: crystals of tourmaline, radiating from both sides, meet in their middle portion, frequently enclosing fragments of granite near their

selvages, and are consequently true veins (gash veins?) of but slight extent: the veins in St. Michael's Mount near Penzance (already mentioned), which contain various other minerals with the tin-ore, belong to this class: such networks of veins occur still more frequently in the elvans, than in granite; thus, in the Wherry mine, between Penzance and Newlin; where an elvan, several feet broad, is intersected by numerous strings, 1—9 inches broad, consisting of quartz and cassiterite, more rarely of tourmaline: also in the Madron mine near Trewiddenball, where younger quartz-veins, containing tourmaline, and without cassiterite, traverse the stanniferous ones:

3. *Tin lodes:* these traverse the killas, granite, and elvans, especially near the limits of the granite-districts; and are most common in the neighborhood of Truro, St. Agnes, Gwennaps (Redruth and Camborne), Breage (Marazion and Gwinear), St. Just (and St. Ives): the tin-lodes vary in age among themselves: I shall describe them more fully in the next paragraph:

4. *Streamworks*, or *placers*, on the gentle slopes, and in valleys, near St. Just and St. Austel: they will be more fully described by and bye.

The copper-ores occur, in sufficient quantities to be exploited, only in veins, or networks of veins, within the elvans: other ores sometimes occur with these: with regard to their age, and course, three classes of copper-lodes can be distinguished:

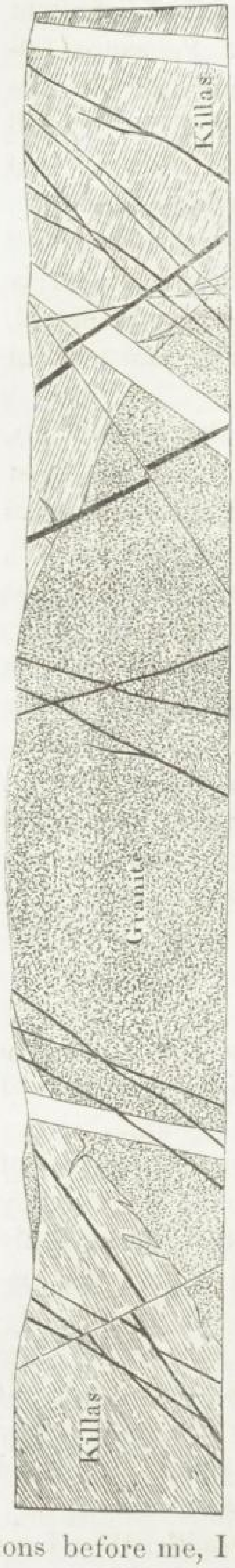
1. *Copper-lodes*, coursing E.—W.
2. *Contra-copper-lodes*, striking SE.—NW. or NE.—SW.
3. *Younger copper-lodes*:

In addition to the lodes proper, other veins often occur, in the same district, filled with clay or quartz; which have received the following names:

4. *Cross-courses:* these are for the most part composed of quartz, striking N.—S. or NW.—SE., intersecting all lodes they meet, except the youngest copper-lodes: since they occasionally contain ores, they will be more fully described in the next paragraph:

5. *Flucans*, or *cross-veins*, at times 10 feet broad, are veins almost entirely filled with clay: sometimes they are but narrow clefts, which course N.—S. and usually dip in E.; they intersect all other veins, and fissures, but the slides: Henwood considers them to be only a variety of the cross-courses:

6. *Slides:* these never exceed a foot in breadth; they have



only been observed in the slates, and only intersect schistose rocks; elvans, and other veins, intersecting these: not a single well-marked case of a slide, in the granite or the massive rocks, has been, as yet, found in Cornwall; they are entirely filled with soft clay, similar, in general composition, to the rocks which they traverse.

The relative age of all the rocks and veins here mentioned would form the following succession:

1. Killas, the oldest rocks in Cornwall;
2. Granite;
3. The majority of the elvans;
4. Some tin-lodes intersected by elvans (?);
5. Some of the elvans;
6. The majority of the tin-lodes;
7. The majority of the copper-lodes;
8. Cross-courses; which, according to De la Beche, intersect Cretaceous deposits in Devonshire;
9. Younger copper-lodes;
10. Cross-flucans (according to Carne);
11. Slides;
12. Tin streamworks, or placers.

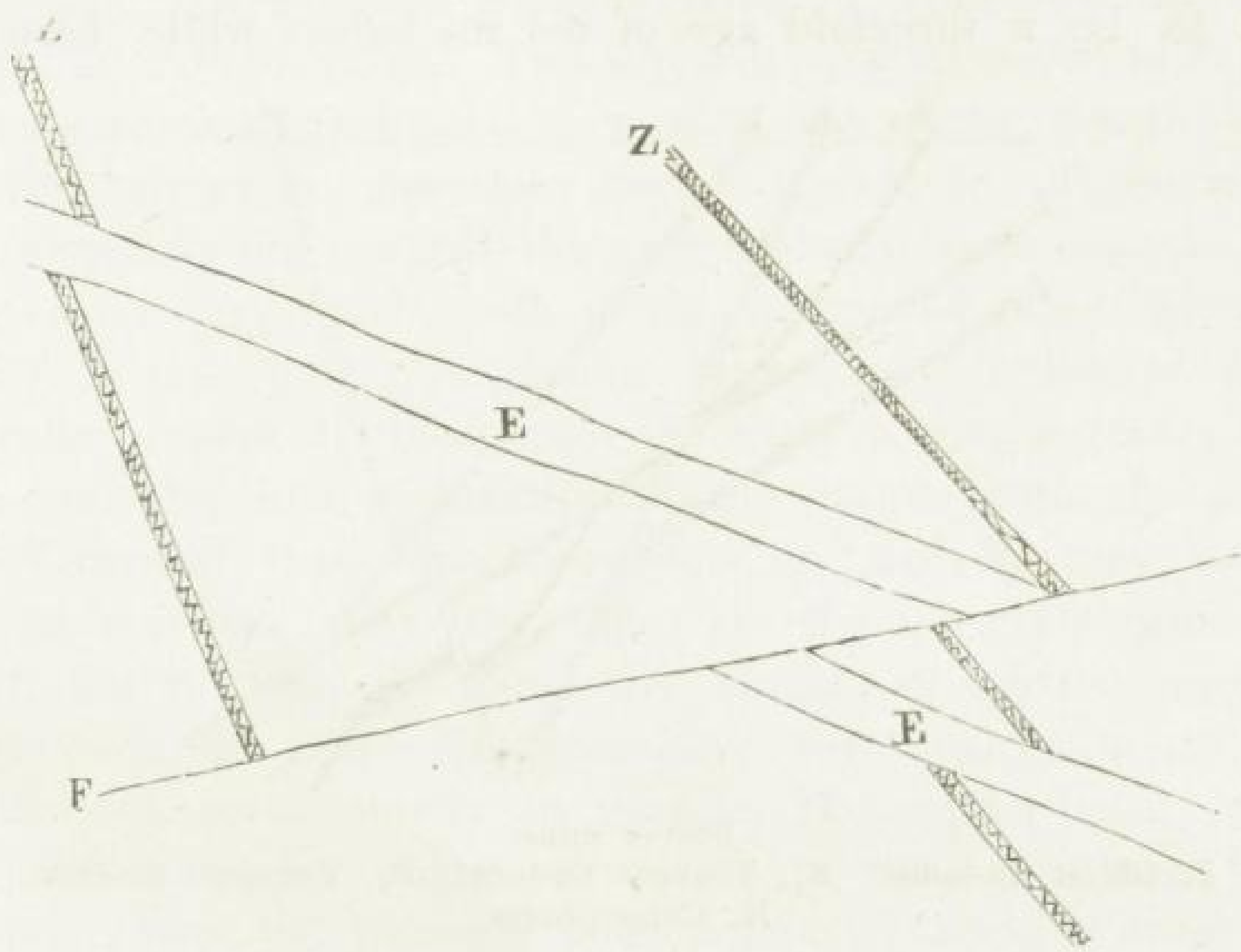
After this general review of the various rocks and ore-deposits of Cornwall, I pass over to the more special description of the kinds most important to the miner, preceding it by the accompanying ideal representation of the various relations of bedding.

THE LODES OF CORNWALL.

§ 230. There occur in Cornwall, as we have seen, in addition to the independent lodes, tin and copper ores disseminated in thin strings, or netlike veins; these deposits are, however, but rarely exploitable; on which account I confine myself, with regard to them, to what has already been said in the last paragraph; the more so as, from the descriptions before me, I could scarcely add anything essential.

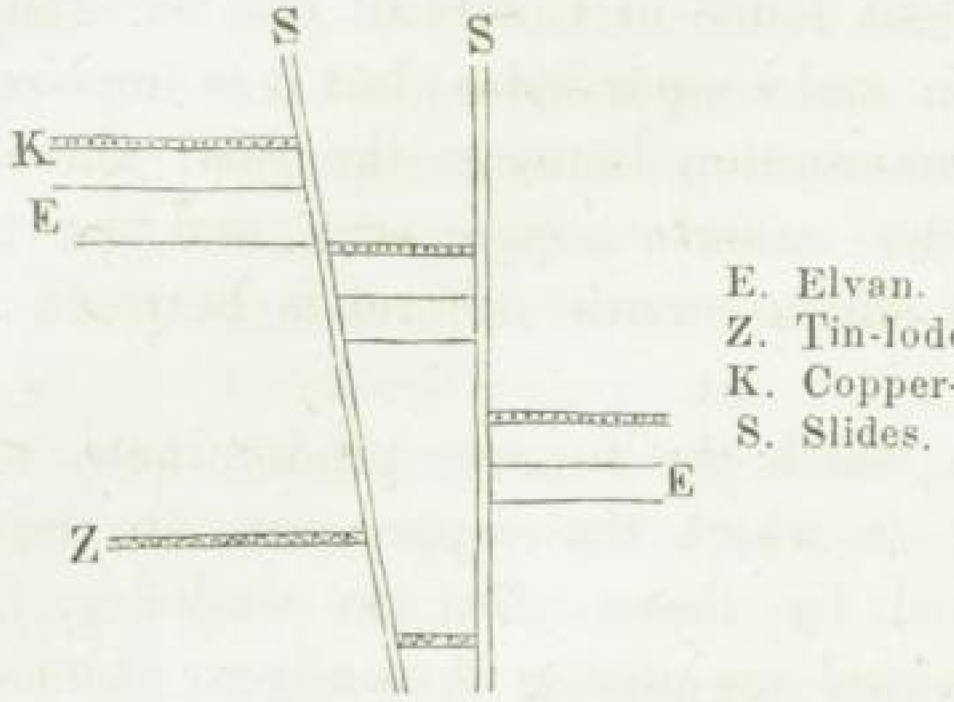
The independent lodes of Cornwall can be separated, as we have seen, into tin and copper lodes; but it is impossible to draw a sharp line of demarcation between the two; since many predominantly tin-lodes contain copper-ores, and the reverse; and since there is no characteristic difference between the gang in both.

The lodes, in which the tin-ores predominate, are certainly older than those, in which the copper-ores are most frequent, and are intersected by these. But the tin-lodes, like those of copper, are of unequal age among themselves; older and younger tin-lodes are distinguished, like older and younger copper-veins. Perhaps, both kinds of lodes may be divided into three different classes, as regards age:



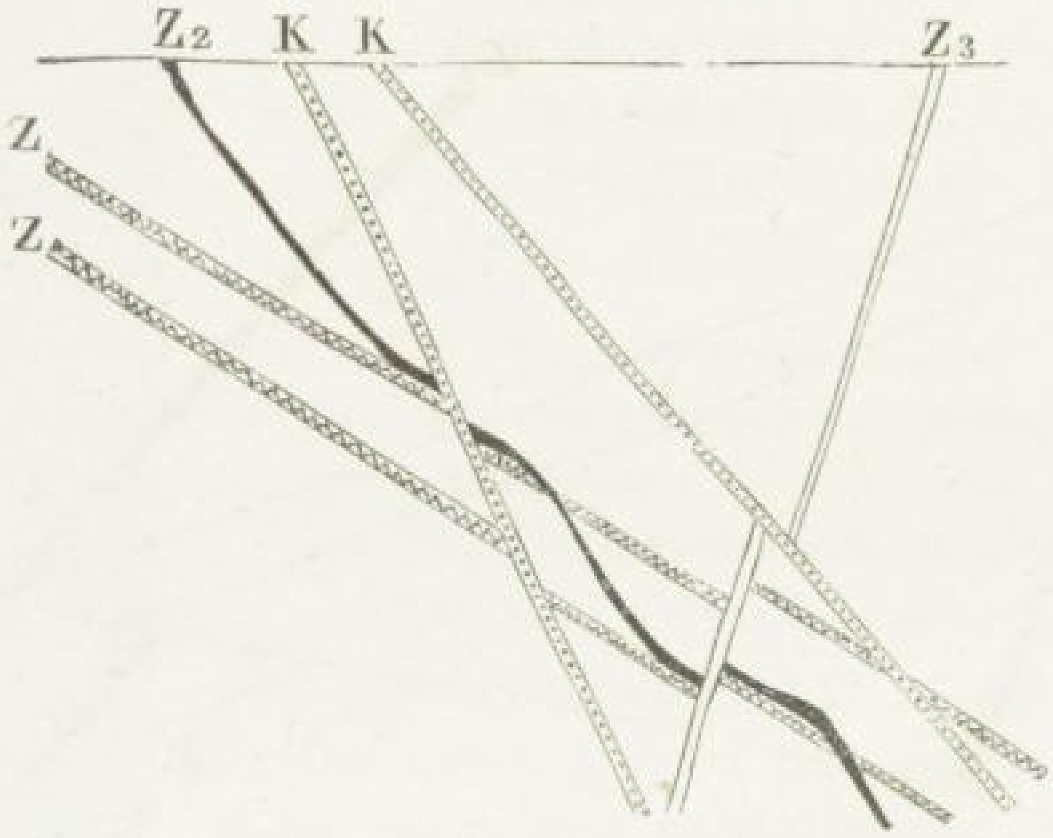
Polgooth mine.
Z. Tin-lodes, faulted by an
E. Elvan. F. Flucan.

The case exceptionally occurs, in the Polgooth mine, that tin-lodes are faulted by an elvan; which, however, De la Beche considers to be only apparent, and attempts to explain by the resistance, which the harder elvan offered to a prolongation of the fissure, while as a rule the reverse takes place by their junction; as, for example, in the Peever mine.

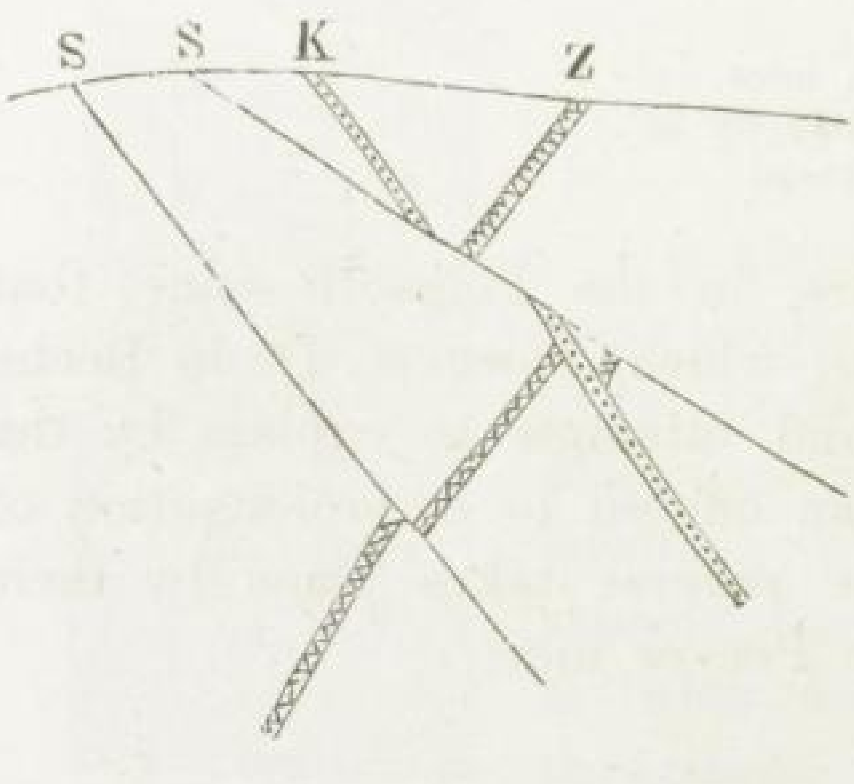


Peever mine.

In this last mine the following relations of intersection, faulting, and dislocation, were observed; from which there would seem to be a threefold age of the tin lodes; while, here also,



Peever mine.
Z. Oldest tin-lodes. Z_2. Younger tin-lode. Z_3. Youngest tin-lode.
K. Copper-lodes.



Z. Tin-lode. K. Copper-lode.
S. Slides.

the youngest tin-lode is intersected and faulted by a copper-lode. The normal relation of age is, however, represented by the adjoining woodcut.

Carne states, that some of the copper lodes even intersect the cross-courses; of which one, according to De la Beche, has dislocated the chalk and green sand, between Combe Beac and Combe St. Nicholas, and has approached them more than 200 feet to one another; as a rule, however, the first are intersected by the last. But since the oldest tin-lodes, at times, contain somewhat of copper-ore, the sharp line of demarcation is always again annulled; if these copper ores cannot be regarded as having subsequently penetrated into long previously existing tin-lodes. The accurate descriptions before me do not, unfortunately, suffice to completely explain these relations, and in default of a sufficient demarcation I shall, like Henwood, treat that which is peculiar to both the tin and copper lodes, in common.

The strike of the older lodes of Cornwall is very conformably E.—W. or WSW.—ENE.; but when examined in detail, numerous exceptions to these principal directions of strike occur, partly local, partly, and exceptionally, for single veins, or for portions of curved veins. The majority dip 20°—50° in N., but few being vertical, or dipping S.-ward. Carne states, that the older lodes dip toward N., the more recent toward S. Those in the slates generally dip towards the neighboring granite masses. The angle varies very much, both in the strike and dip of the same lodes, *i. e.* they do not represent planes, but undulated faces. Generally several of them occur together, forming a group, often found near the lines of junction of the granite with the slates; as in Cornwall these contact-regions are usually very rich in ores, in that not only the lodes are the most numerous and richest, but in them are found the, already mentioned, tin-floors and network of veins. Attempts have been made to prove, that the tin-lodes occur chiefly in granite, the copper-lodes in the slates; but there are many exceptions to this, and both kinds of lodes often cut through both kinds of rock, without any perceptible alteration having taken place in them from the transition.

The breadth of the lodes is extremely variable, both in the same vein, and in the various individual ones. They frequently extend as metalliferous clefts; while they are, in extreme cases, upwards of 40 feet broad. Henwood calculated, from a large number of observations, the following, as their average breadth:

the tin-lodes	3,06 feet.
the copper-lodes	2,93 „
those containing both metals	4,70 „
the lodes in granite	3,18 „
the lodes in slate	3,75 „

Where the average breadth of the fissure is surpassed, it generally contains numerous *horses of ground*; and it is then often doubtful, whether these are to be considered, as fragments of rock enclosed in the lode, or portions of the wall-rock surrounded by numerous leaders.

No real cessation of these veins has been observed, either in the strike or dip; and some of the lodes have been partially exploited for a length of two miles, single copper-lodes even seven miles.

In regard to the predominant mineral composition of both the tin and copper lodes, the accounts are somewhat conflicting. Carne, Dufrénoy, and Elie de Beaumont, state, that it predominantly consists, in all the lodes, of quartz with chlorite, tourmaline, or mica, particularly in the following combinations; quartz with chlorite and tourmaline, quartz with tourmaline, quartz with mica. Tourmaline and mica appear to mutually exclude one another. At times, considerable decomposed granite, or somewhat of fluor spar, occurs with these combinations. Henwood states, that feldspar plays an important part in the matrix, being combined with the above-mentioned minerals. He also states the nature of the veinstones to be somewhat dependent on that of the wall-rock. In granite the lodes which are most productive of tin-ore are, for the most part, composed of a pale greenish feldspar, of a confusedly crystalline structure, but seldom containing distinct crystals, with radiating groups of tourmaline and some quartz; through which form the tin-ore is interspersed in the form of crystalline granules. In a few cases the lode is very quartzose, and then the particles of tin-ore are generally larger. Occasionally the lodes consist almost wholly of quartz, with now and then some tourmaline diffused through it; in such cases they are seldom rich in ores of any kind.

The lodes which yield copper-ore in granite almost always, according to Henwood, contain a gossan near the surface. Their quartz is not always so soft, or so minutely divided, as in slate; but opens in small irregular masses, which yield to a slight pressure: a coating of earthy limonite appears to pervade the small and innumerable cavities, which penetrate this slightly coherent mass. Large quantities of feldspar abound, and the whole is often encrusted with a thin and almost impalpable coating of earthy black copper-ore; the proportion of this last mineral often encreases in depth, and passes into copper-glance, and sometimes into copper-pyrites.

Henwood states, that in slate the tin-lodes are generally composed of a very hard quartzose slate (locally called *capel*); sometimes intimately mixed with tourmaline, occasionally with feldspar, and frequently with chlorite: the tin-ore is interspersed amongst the earthy materials even more minutely than in the granite, and is almost invariably mixed with a much larger proportion of impurities: with the tin-ore is often associated wolfram with earthy red and jaspery iron-ores. The most characteristic mineral is, however, a variety of tourmaline-rock, consisting of alternate layers of tourmaline and feldspar; and both of these mixed with quartz: the laminæ are almost always much curved, and sometimes the layers of tourmaline are replaced by tin-ore. This substance sometimes forms a sort of transition between the lode and the country-rock.

He also states, that the lodes, which yield copper-ores in slate, contain large quantities of gossan of a pale hue, soft and drusy. In them also ore frequently occurs in small quantities, and blende is very plentiful, while iron-pyrites is constantly present. Their earthy minerals are mostly quartz; which, in the most favorable situations, is generally friable, sometimes mixed with small quantities of decomposed feldspar. Near the surface these are spotted with earthy black copper-ore; and lower down this is succeeded by copper-glance, and at length by copper-pyrites: fluor spar is occasionally mixed with them, and now and then chlorite occurs.

Dufrénoy and Elie de Beaumont enumerate, in addition to the ores already mentioned, and which are the chief objects of the exploitation, the following minerals, as being found in the tin-copper lodes: tin-pyrites, always associated with copper-pyrites, wolfram, mispickel, arseniates of iron and copper, phosphates of copper, uranite, and bismuth. In the ancient copper-lodes they found, tetrahedrite, tennantite, red copper-ore, native copper, malachite, azurite, phosphates of copper, arseniates of copper, iron pyrites, mispickel, and blende.

Carne states, that many minerals occur in small quartz-threads which traverse the mass of the lodes; thus wood-tin-ore in the tin-lodes, silver-ores in the copper-lodes.

Henwood has reduced the order of position to a tabular form; which is here subjoined, and in which the first column denotes the country-rock; the second, the mineral next to the side or wall of the lode; the next, that which is attached to it; and so on: the crystallized minerals are in italics.

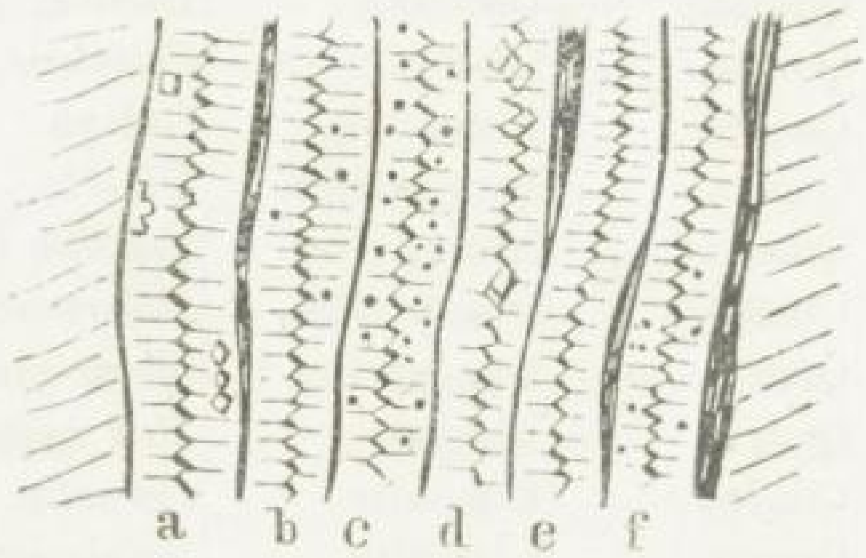
Rock.	Substance next adjoining rock	Substance next to that which adjoins rock.	Minerals adjoining those in last column	Locality.
Granite.	Quartz.	*Quartz.*	—	Almost every where.
	Amethyst.	Quartz.	—	Wheal Bellon.
	Quartz.	Opal.	—	Wheal Cairn.
	Quartz.	Quartz.	Chalcedony.	Pedn-an-drea.
	Quartz.	*Quartz.*	*Arseniate of iron.*	Wheal Corland.
	Quartz.	Quartz.	Wolfram.	St. Michael's Mount.
	Quartz.	*Quartz.*	*Arseniate of copper.*	Wheal Unity.
	Quartz.	*Quartz.*	*Uranite.*	Gunnis lake.
	Quartz.	*Cassiterite.*	*Scheelite.*	Wheal Friendship.
	Quartz.	*Native Copper.*	*Red copper.*	Wheal Gorland.
	Quartz.	Mineral pitch.	—	Carharrack.
	Quartz.	Malachite.	—	Gunnis lake.
	Feldspar.	Earthy phosphate of iron.	—	Park Noweth.
	Fluor spar.	*Fluor spar.*	*Quartz.*	Wheal Gorland.
	Fluor spar.	*Stibnite.*	*Quartz.*	Wheal Gorland.
	Cassiterite.	*Bismuthine.*	—	Balleswidden.
	Hematite.	*Specular iron.*	—	Park Noweth.
	Limonite.	Copper-glance.	*Earthy black copper-ore.*	Wheal Jewel.
Greenstone.	Quartz	Stalactitic quartz.	*Quartz.*	Wheal Edward.
	Quartz.	*Quartz.*	*Aragonite.*	Levant.
	Quartz.	*Quartz.*	*Wolfram*	Poldice.
	Quartz.	*Quartz.*	*Arseniate of copper.*	Wheal Unity.
	Quartz.	*Quartz.*	*Mimetene.*	Wheal Unity.
	Quartz.	Chlorite.	*Cassiterite.*	Wheal Vor.
	Quartz.	*Chlorite.*	*Mimetene.*	Wheal Unity.
	Quartz.	Arsenic pyrites.	*Arsenic pyrites.*	Wheal Unity Wood.
	Quartz.	Fluor spar.	*Fluor spar.*	Wheal Unity Wood.
	Quartz.	Limonite.	Pitchblende.	Wheal Edward.
	Quartz.	Limonite.	*Uranite.*	Wheal Edward.
	Quartz.	Limonite.	*Copper-glance.*	Botallack.
	Quartz.	Spathic iron.	*Spathic iron.*	Botallack.
	Quartz.	*Copper glance.*	*Aragonite.*	Levant.
	Quartz.	Chlorite.	Copper-pyrites, mineral pitch.	North Roskear.
Slate.	Quartz.	*Quartz.*	*Quartz.*	Wheal Friendship (Marazion).
	Quartz.	*Quartz.*	*Quartz, copper-pyrites.*	East Crennis.
	Quartz.	*Quartz.*	*Heavy spar.*	United Mines.

Rock.	Substance next adjoining rock.	Substance next to that which adjoins rock.	Minerals adjoining those in last column.	Locality.
Slate.	Quartz.	*Quartz.*	Copper-pyrites, and cryst. *copper-pyrites.*	United Hills.
	Quartz.	*Quartz.*	*Stibnite.*	Pengelly Mine.
	Quartz.	Chlorite.	*Anatase.*	Virtuous Lady.
	Quartz.	*Quartz.*	*Blende, fluor spar.*	Polberrow.
	Quartz.	*Quartz.*	*Celestine.*	Binner Downs.
	Quartz.	Fluor spar.	Galena.	Wheal Penrose.
	Quartz.	Iron-pyrites.	*Quartz.*	West Pink.
	Quartz.	Iron-pyrites.	*Spathic iron.*	Virtuous Lady.
	Quartz.	Iron-pyrites.	*Pharmacosiderite.*	Wheal Falmouth.
	Quartz.	Iron-pyrites.	Silver-glance.	Dolcoath.
	Quartz.	Limonite.	*Red copper-ore.*	Wheal Charlotte.
	Quartz.	Limonite.	*Cerusite.*	Pentire-glaze.
	Quartz.	Limonite.	*Anglesite.*	Mellanear.
	Quartz.	Limonite.	Pyromorphite.	Wheal Alfred.
	Quartz.	Hematite.	Oxide of manganese.	Restormel.
	Quartz.	Wood-tin.	—	Polberrow.
	Quartz.	*Cassiterite.*	—	In all tin-lodes.
	Quartz.	Native silver.	—	Herland.
	Quartz.	Silver-glance.	—	Wheal Brothers.
	Quartz.	*Ruby silver.*	—	Dolcoath.
	Quartz.	Native copper.	—	In all copper-lodes.
	Quartz.	Copper-glance.	*Red copper-ore.*	Providence Mines.
	Quartz.	Copper-glance.	*Copper-glance.*	Wheal Speed (Germoe).
	Quartz.	*Erubescite.*	—	Wheal Falmouth.
	Quartz.	Copper-pyrites.	—	In all copper-lodes.
	Quartz.	Copper-pyrites.	*Bismuthine.*	Fowey Consols.
	Quartz.	*Tennantite.*	—	Fowey Consols.
	Quartz.	Copper-pyrites.	*Fluor spar.*	Polberrow.
	Quartz.	*Red copper-ore.*	—	In almost all copper-mines.
	Quartz.	Galena.	*Galena, quartz.*	Wheal Rose.
	Quartz.	*Blende.*	*Calc-spar.*	Union Mines.
	Quartz.	*Blende.*	*Fluor spar.*	West Pink.
	Quartz.	Mineral pitch.	—	South Wheal Towan.
	Chlorite.	Cassiterite.	—	Most tin-mines in clay-slate.
Elvan.	Cassiterite.	*Cassiterite.*	—	Wherry Mine.
	Silicate of tin (?).	—	—	Wheal Coates.
	Quartz.	Limonite.	*Azurite,* Malachite.	Ting Tang.
	Quartz.	Copper-pyrites.	—	Ting Tang.
	Limonite.	Native copper.	—	Wheal Buller.
	Limonite.	*Red copper-ore.*	—	Ting Tang.

From this table may be learned, what minerals Henwood observed in the lodes of Cornwall.

The copper lodes are at times accompanied by clay-selvages, or clay-veins, partly at both walls, partly at one only. In the last case the clay traverses the lode obliquely, from one side to the other; or is separated, for a certain distance, from the wall-rock, forming a vein of clay traversing the wall-rock. These are evidently the consequences of a repeated forcing-open and filling of the fissures.

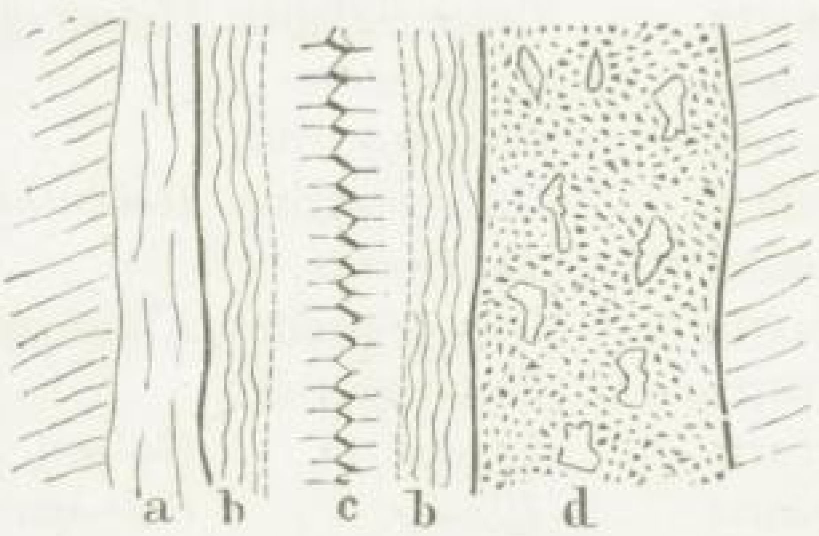
The texture of many of the lodes in Cornwall shows in the clearest manner the repeated opening and filling of fissures; by which processes they have gradually become broader: for example, the following vein-texture was observed in the Wheal-Cathedral mine, in the granite near Redruth.



a. Quartz with somewhat of fluor spar.
b. Quartz with somewhat of copper-pyrites.
c. Quartz with considerable copper-pyrites.
d. Quartz with somewhat of fluor spar.
e. Quartz.
f. Quartz with somewhat of copper-pyrites.

When taken strictly, these are evidently six parallel quartz-veins alongside of one another, and which have been formed one after the other. The quartz in each is crystallized from the selvages towards the middle, and the accessory minerals are also somewhat different.

The accompanying, still more complicated, case was observed in the Godolphin mine.



a. Quartz.
b. Agate.
c. Quartz, crystallized towards the middle.
d. Copper-glance.

Here are but three veins formed alongside of one another; but of a much more dissimilar texture, and composition, than in the preceding case: *b* and *c* evidently form one vein in common.

Such a combed texture is, however, by no means common to these lodes. Some of them have a predominantly brecciated structure, from the masses of wall-rock, or older portions of veins, which they enclose; in some even pebbles occur. As in the Wheal-Badger mine near Relistran, where boulders of granite, slate, and quartz, were found at considerable depths. In still others the principal matrix is traversed, in all directions, by more recent strings (fillings of cracks); which, at times, penetrate for some distance into the country-rock.

The most recent copper-lodes are distinguished, from the older ones, by the predominance of argillaceous substances in their matrix; and the lodes of Newlin probably belong to this class.

The cross-courses (locally also called guides and trawns) sometimes contain ores, which are but rarely found in the vicinity of the lodes. They strike NW.—SE. or N.—S. and dip, for the most part, in E. Their average breadth is about six feet, but it sometimes encreases to 36 feet. That of Porth Towan is said to traverse the entire peninsula from coast to coast, and every where accompanied by faults, which are 20—60 fathoms broad. The mass of these cross-courses consists almost entirely of quartz, which is crystallized in the middle; quartz frequently encloses masses of the country-rock. Many are very argillaceous, and are called cross-flucans, which Henwood does not distinguish from the other flucans.

The ores, locally occurring in the cross-courses, are most commonly those of iron and lead. Many are exploited as lodes of limonite, and furnish the greater part of the iron produced in Cornwall; thus, near Ledock and Roche. The two broad veins, striking N.—S., which are exploited in the Beer Alston mine for argentiferous galena, are cross-courses. In those containing argentiferous galena are sometimes found bournonite, silver-glance, native silver, stibnite, and ores of cobalt, especially near Redmoor, Penhale, Wheal-Golden.

Copper ores occur in the Tiddys cross-course, in that of North Downs blende and fluor spar. In the Polgoath district a cross-course contains considerable tin-ore. The cross-courses often intersect and fault all the tin-lodes, and the older copper-lodes. De la Beche recognised them in Devonshire, as being more recent than the Cretaceous. They are sometimes intersected by the most recent copper-lodes.

DISTRIBUTION OF ORES IN CORNWALL.

§ 231. The tin and copper ores are very unequally distributed, both in general, and in the separate lodes; so that in Cornwall, as commonly in vein-mining, portions occur almost barren of ores, alternating with exploitable portions, and rich pockets. Great pains have been taken in Cornwall to become acquainted with the causes, or laws, of this unequal distribution; but these efforts have hitherto been but partially successful. The rules formed by the miners, and founded on their experience, do not always hold true; and the presumed causes are in part contradictory. I subjoin the most important facts, which have been collected on this subject, by Henwood (*H*), Dufrénoy and Elie de Beaumont (*DB*), in Karsten's Archiv (*K*), and Voyage métallurgique (*V*); but it is certainly much more difficult for me to arrange the same in a conformable connection, than for the observers on the spot.

1. The entire mineral wealth occurs within a distance of two or three miles on each side of the line of junction of the slate and granite. Yet no part of this line itself appears to have been more productive, than any other spot of equal extent within the distance mentioned; and though the lodes not uncommonly run, for several fathoms, with granite on one side, and slate on the other; or with either of these rocks forming one wall, and elvan the opposite one; yet the portions, so contained between dissimilar rocks, are not generally the richest. The lead-ores occur more removed from the granite. (*H. D. B. V.*)

2. By the passage of the veins, from one rock into another, a change usually takes place in the amount of ore, in which the portion of the lode at the junction is often the richest; for example, near Botallack. (*D. B. V. K.*)

3. The tin-lodes occur more frequently in the granite, than in the killas; but possess a greater average richness in the latter, than in the granite. (*D. B. V.*) The tin-lodes predominate near St Just; the copper-ones at Redruth.

4. The lodes, essentially containing but copper ores, often contain tin-ore near or in the granite. (*D. B. V.*)

5. The copper-lodes occurring in the tin-district are the richest of their kind. (*D. B. K.*)

6. Whether the rocks be granite, slate, or elvan; their hardest portions are always quartzose, and in these the lodes are seldom rich. On the other hand, if the rock be neither very fine, nor particularly coarse-grained; the embedded crystals of feldspar of a greenish, pink, or brown hue, and their bounding-planes rather indeterminate, or passing gradually into the basis of the rock; and if further, that basis consist of greenish feldspar besides the other usual ingredients, viz. quartz, mica,

and sometimes tourmaline; then the character of the rock is considered a very favorable one, especially for tin-ore. (*H. D. B. V.*) A porphyritic texture is considered unfavorable, both in the granite and elvans.

7. The lodes, when they intersect the elvans, are very variable; they either remain the same, or they split up into innumerable strings containing but little ore, or they become broader and richer, at times accompanied by rich side-feeders. (*D. B. K.*) De la Beche states, that they are much more favorably developed, in such districts as are traversed by numerous elvans, than in those where they do not occur.

8. In elvan, the hard, fine-grained quartzose varieties, which also contain some tourmaline, often diffused as coloring matter, and sometimes in groups of radiating crystals, are considered uncongenial; as the lodes are frequently split into innumerable irregular and small veins, whilst they traverse that kind of elvan; but which re-unite, when they approach softer and more feldspathic varieties of the same rock. (*H.*)

9. The killas, in the neighborhood of the St. Just copper-mines, is a greenstone slate, in general tolerably fine-grained and lamellar; in which both tin and copper ores occur. The axinite, actinolith, and garnet-rocks, which are associated with the greenstones, do not seem favorable to the presence of metallic substances in the lodes which traverse them. (*H.*)

10. Henwood states, that many varieties of the clay-slate exert partly a favorable, partly an unfavorable influence on the ores in the lodes; but their description is so indefinite, and their influence apparently so contradictory, that I am not able to lay any particular stress on them. De la Beche also speaks of such differences; but they can only be learned by practical experience. Tin and copper ores are stated to act differently in this respect; and lead ores only occur in gray-slates distant from the granite.

11. Whether the rock be granite, slate, or elvan; when the joints, which are parallel to the lodes in their directions, fall toward the lodes in descending, it is considered a favorable indication; whilst, if similar joints separate from them, as they descend, it is considered an index of poverty. In all these cases many transverse joints seem to exercise an unfavorable influence on the produce of the lodes. (*H.*)

12. The cleavage-planes of the schistose slates are almost invariably curved and contorted, whenever the rock is quartzose,

and in such cases it is usually very fissile, and the laminæ are highly inclined: either of these conditions is accounted unfavorable. On the other hand, when the cleavage-planes are regular and moderately inclined, and when the rock exhibits a thickly lamellar structure, the lodes traversing it are generally productive.

Yet all these appearances are but local, and confined within very narrow limits; and in the same rock there is frequently an alteration in the lodes, as soon as the character of the rock is changed. (*H.*)

13. The junctions of two lodes always cause an enrichment, if the angle of intersection be less than 45°, if it be, however, greater, sometimes an empoverishment. (*D. B. V.*)

14. The older copper-lodes are generally enriched by contact with the younger ones, especially on the side of contact, which very probably took place from a subsequent impregnation. (*D. B. K.*)

15. The intersecting cross-courses generally cause an empoverishment. (*D. B. V.*)

16. The breaking up of lodes into leaders is generally accompanied by empoverishment: the leaders re-uniting with the lodes are called 'feeders'. (*D. B. V.* and *K.*)

17. When a lode contains both tin and copper ores at the same time; the tin-ores generally occupy an upper, the copper-ores a lower level, as at Seifen in the Erzgebirge; still the reverse exceptionally occurs (near Dolcoath); or both ores occur at the same level; in which case the two kinds of ore occur at the opposite selvages. (*D. B. V.*) Thomas states, on the contrary, that such lodes generally contain more tin-ores in the narrow portions, more copper-ores in the broad portions.

18. The majority of the lodes are said to encrease in richness for some depth, then to remain the same for some distance, after which they begin to decrease in productiveness. (*D. B. V.*)

19. The gossans of the copper-lodes are often argentiferous. (*D. B. V.*)

20. Where the lodes have a variable dip, their most perpendicular portions are the most productive. (*H. D. B. V.*)

STREAM WORKS OF CORNWALL.

§ 232. The alluvial deposits in Cornwall, as elsewhere, arise from the partial destruction of older deposits in place; and this origin is more readily perceived in tin alluvial deposits, as a rule, than in gold-placers.

The erosion and re-deposit of the tin-ores, in all the alluvial deposits of Cornwall, has taken place at a very late geological period, being subsequent to the Tertiary, and partly during the historical.

The majority appear to have been formed during a general submergence at the Diluvial period; while a few owe their origin, or alteration, to subsequent rain-floods or river-freshets.

The first occur on gentle slopes or in valleys, the last alone in valleys. Human bones, trunks of oaks, and beds of peat, are sometimes found in the freshwater strata of the Diluvial period; in those deposited by saltwater, shells, such as still occur in the neighboring sea. But few, so-called, stream-works are now worked in Cornwall. The tin, which the Phoenicians exported from Cornwall, was probably all obtained from stream-works.

Dufrénoy and Elie de Beaumont found but three stream-works at work, in one of which, the Sandrycock, the stratification is, according to Rashleigh, the following:

	Feet.	Inches.
1. Vegetable mould, about	—	3
2. Gravel, and micaceous sand, mixed with fine loam in alternate beds of various depths	8	3
3. Light-colored clay, with a little mica	5	3
4. Black peat	4	1
5. Light-colored clay	1	4
6. Stiff clay of a brown color with vivianite	3	10
7. Sea-sand and clay mixed	3	—
8. Fine sea-sand, containing mica and fragments of shells	4	—
9. Coarser sand without shells	6	—
10. Solid black fen	2	10
11. Tin-ground and loose sand of all sorts	1 – 6	—
12. Killas, on which the tin-ground rests		
	44	10

The succession at Pentowan, near St. Austel, is a very similar one. There, under the second light-colored clay, follows:

	Feet.	Inches.
Hardened clay	3	10
Argillaceous sand	3	—
Fragments of slate and shells of recent mollusca	4	—
Coarse sea-sand	6	—
Sandy clay, with recent shells	8	—
Sea-sand, with pebbles	6	—
All sorts of pebbles, with tin-ore	6	—

Deer-antlers and buffalo-horns have also been found in these deposits.

These are, therefore, for the most part, very recent marine deposits. Their total thickness varies between 20 and 70 feet. They every where contain the tin-ore in the lowest bed, as small crystalline grains, or rounded pebbles (wood tin), free from all the other metallic minerals, which are usually associated with the tin-ore in place; on which account they produce a very pure metal. Curiously enough gold is found in some of these stream-works; from which circumstance, as well as from the presence of varieties of tin-ores uncommon in the lodes, and from the absence of the other ores, it has been supposed that the alluvial deposits were not formed from the erosion of the neighboring lodes. Nevertheless, Carne has altogether refuted this hypothesis; and it has been subsequently found, that, near Davidstowe in North Cornwall, the quartz-veins traversing the Devonian strata contain iron-pyrites and somewhat of gold, which last is only perceptible after the decomposition of the pyrites to a gossan. De la Beche also mentions gold occurring in quartz at North Tawton in Devonshire; while Murchison speaks of its occurrence in the gossan of the Pattimore mine at North Molton in Devonshire.

THEORETICAL REMARKS ON THE CORNWALL ORE-DISTRICT.

§ 233. It is very evident, that the metalliferous deposits of Cornwall owe their origin to the granite; which has broken through the great primary sedimentary district, and partly altered it. These deposits appear as accessory ingredients in the granite; and, therefore, occur in or near it. The porphyries, or elvans, belong to the granite, being mere modifications of its texture and form.

A confirmation is thus found, in these deposits, for the almost universal observation, made on the Continent of Europe, that the tin-deposits almost altogether occur with granitic rocks. We have already become acquainted with this paragenésis[1] in the Erzgebirge, at Schlackenwald in Bohemia, in Brittany, etc., as being every where the same, with but slight modifications.

[1] From Παραγενήσις, association.

Hence, it is very probable, that the tin-ores always occur associated with such igneous rocks, rich in silica, as have solidified at great depths (deep plutonic); and thus, when they occur at the present surface, in consequence of erosion, they belong to the very ancient rocks. The tin-deposits (with exception of the alluvial deposits belong, wherever they occur, to the oldest ore-deposits. They are almost every where older than the Carboniferous period. From the above statement, some persons have concluded, that the formation of these deposits belongs to a fixed and very ancient period. This view appears to me illegitimate; after reviewing the facts I incline to the conviction, that they belong to the deep underground and, in so far, plutonic formations. As regards mining operations, this view is synonymous with the first, since the tin-deposits are only to be looked for in granitic rocks. This view does not, however, exclude their being exceptionally formed in these at a more recent geological period, and that they may then be found, if the erosion of the rocks originally overlying them takes place, more rapidly than usual. I see no reason, why they may not now be forming in the interior of the earth.

That the tin-deposits observed are not absolutely the oldest metalliferous deposits, but only locally and relatively so; and that consequently it is incorrect, to suppose certain metals, or ores, to have been formed during fixed geological periods; has been proved by Lyell;[1] who shows, that the lead and copper ores of Wexford, in Ireland, are far older than the tin-deposits of Cornwall. At Wexford granite occurs traversed by granite dikes, which dikes also intrude themselves into the Silurian strata. These Silurian rocks, as well as the dikes, have been denuded, before the Devonian strata were superimposed. Next, we find in the same county, that elvans have cut through the granite and the dikes before-mentioned, but have not penetrated the Devonian rocks. Subsequently to these, veins of copper and lead were produced, being of a date posterior to the Silurian, and anterior to the Devonian; for they do not enter the latter; and, what is still more decisive, streaks or layers, of derivative copper, have been found near Wexford in the Devonian, not far from points, where mines are worked in the Silurian strata. These lead and copper lodes must consequently be older than

[1] See his Elements of Geology, 1865, p. 768.

the Devonian; and as the Cornwall tin-lodes traverse Devonian strata, they must undoubtedly be, not only more recent than these, but younger than those lead and copper lodes. Lyell even considers the Cornwall tin-lodes, as being more recent than the coal-measures of that part of England. In Cornwall the copper-lodes are, as we have seen, decidedly younger than the tin-lodes; if tin-lodes also existed at Wexford, they would probably be older than the copper and lead lodes. The relative, but not the absolute, age of the various lodes may remain the same for every region. They are the results of events, which have taken place at unequal depths below the surface, in which the absolute period of formation of like or similar deposits varies much in different regions; that is, the succession of one locality may belong to a very different period, from the analogous succession of another locality.

Apart from these general remarks, it follows, from what has been observed in Cornwall, that the tin-lodes are here evidently of more recent age, than the granites which have traversed the Devonian strata. The majority of the Cornish tin-lodes too are undoubtedly more recent than the elvans; which also traverse the granite and Devonian rocks, and are consequently younger than these. But here some doubts are met with, whose complete elucidation would be very instructive, and of great importance. Some of the elvans appear to be but ramifications of the larger granite-masses, and of a like age to these. This is very possible, and does not exclude others from traversing the granite. We need merely suppose that here, too, the frequently observed phenomena of dissimilar, and non-contemporaneous products, of the solidification of the same principal mass, are repeated. The large granite masses sent-out ramifications into the slates, which had a somewhat different texture; and thus, in part, completely resemble the independent elvans; they themselves (the granite-masses) first became solid at their surface, while the fluid interior again penetrated into fissures, and filled these, both in granite and slate. In this manner more recent granite or porphyry dikes, or elvans, were formed in the granite and slate. The second doubt concerns the relation of the tin-lodes to the elvans. According to many and reliable observers, some of the tin-lodes are traversed by elvans, and are consequently older than these; De la Beche denies the last, and attempts to explain the indisputable appearances of the intersection in another manner.

This observer states, that all the elvans are older than the tin-lodes. Those persons who, like myself, have not observed the facts, can, naturally, express no opinion on the subject; but I would call attention to the fact, that altogether analogous cases occur, at Freiberg, to those asserted by Carne, Henwood, and others. The Freiberg lodes are in general more recent than the porphyry-dikes (much resembling the elvans), which here traverse the gneiss; still a lode of one of the oldest lode-formations is undoubtedly intersected and thrown by a porphyry-dike; and the first observation of this kind has been confirmed by two more recent and similar ones. From this we may conclude, that the porphyry-dikes, like the lodes, are of somewhat dissimilar age among themselves; and that both processes of vein-formation, extending through a long period, have interlaced, but in such a manner, that generally the formation of the lodes first began, as that of the porphyry dikes was almost completed.

Should the case in Cornwall be similar, it may naturally be concluded, that the formation of the tin-lodes immediately followed that of the granite and elvans.

With regard to the copper-ores in the Cornish lodes, it may be questioned, whether they have actually been formed contemporaneously with the principal vein-material in all the lodes. Where tin and copper ores occur separated from one another in the lodes of this district, the copper-lodes are always more recent than the tin-veins. Might not the same process, which caused the deposit of the copper-ores in the more recent veins, have also affected the older, long-existing fissures, in such a manner, that copper-ores penetrated into the older, partly stanniferous lodes, long subsequently to the period, when their vein-matter first penetrated? In order to answer such a question, it would be necessary to examine these veins once more, very carefully, from this standpoint. At a distance, and without new observations, nothing can be decided.

The period of vein-formation in Cornwall was a very long continued one; this is proven from the frequently repeated opening and filling of the same fissure. We have seen, that this has taken place six times in one fissure at Redruth: each of these fillings undoubtedly took a long time, and they must have been completely finished and solidified, as the wall of the fissure was separated anew. The repeated opening was also the cause of an encreasing breadth of these lodes, which in reality consist of the intimate union of several separate veins.

Let us now turn our attention to the manner of formation, especially that of the tin-deposits.

We have seen (§ 75) that at Altenberg in the Erzgebirge the tin-ore has penetrated, with some associated minerals, into the granite, after its solidification, through innumerable clefts; and has converted it into *Zwitter*. Such a subsequent rock-penetration and impregnation has also undoubtedly taken place in Cornwall, but in a somewhat different form. Not only has the tin-ore (with the silicates, tungstates, borates, and fluorides, usually accompanying it), penetrated into the narrow clefts and joints of the killas, granite, and elvans; but the feldspar-crystals, in the interior of somewhat decomposed elvans, are destroyed, and their place occupied by a mixture of cassiterite and quartz; while in the granite tourmaline has, in a similar manner, supplanted the feldspar. Daubrée concludes, from these and similar cases, as well as from successful experiments in the artificial formation of cassiterite; that this metal, and its normal accompanying minerals (quartz, wolfram, topaz, tourmaline, fluor spar, apatite, mica [containing fluorine], beryl, etc.), have penetrated the rock from below, as volatile fluorides and borates in a gaseous state, perhaps combined with steam; and have been deposited in their present state under favorable conditions. Even the possibility of aqueous solutions is not by this althogether excluded; and when I called the tin-ore-deposits in a certain sense plutonic, I by no means meant to indicate that they owed their origin to a solidification from the igneous-fluid condition.

De la Beche has attempted to combine, not merely the formation of the fissures, but also the matter filling them, into intimate connection with the eruption and solidification of the granite; in that he supposes the formation of the veins to have taken place, after the upper portion of the granite had hardened, but the lower portion was still in an igneous-fluid condition. Fissures, which extended from the bottom of the ocean, or the, then, surface of the land, through the slate and solidified granite, to the still igneous-fluid matter, were filled with water. This was heated below under very great pressure, converted into steam, and held in continual circulation by the differences in temperature above and below; it also penetrated the rock for considerable distances from the fissures, dissolving many substances at a great depth, which it re-deposited nearer the surface at a lower temperature, or exchanged for others, merely bringing the last residue to the surface. He takes this opportunity for mentioning a very interesting memoir, which Pryce published in 1778 in his 'Mineralogia Cornubiensis', on the filling of veins through such an exchange of the ingredients dissolved.

De la Beche's hypothesis has much in its favor: still it seems to me necessary to add, that the surface at that time was high above the present one, so that the granite, killas, and elvans, which we now see, did not attain the former surface, but were covered by immense rock-formations, which were subsequently eroded and destroyed.

There can hardly be a doubt, with respect to the origin of tin-placers. They are the products of a denudation and re-deposit of rocks and ores in place, which have been deposited on the present surface of the land, partly by salt water, partly by fresh-water. It is a most interesting fact, that a large majority, if not all, of these deposits have been formed during the most recent geological periods, even during that of man, since the remains found in them are those of existing species.

Considerable changes of level, and transformations in the form of the surface, must, therefore, have taken place during the historical period. It is further interesting, that the ore is only found in the lowest and oldest beds of the marine deposits.

XXVI. WALES.

THE LODES OF CARDIGANSHIRE.

§ 234. Cambrian clay-slates, and related rocks, predominate on the west coast of Wales. These slates are not disturbed by igneous rocks, and contain numerous lodes at the boundaries of Cardiganshire[1] and Montgomeryshire. The district containing

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[1] See: W. W. Smyth, in Memoirs of the geol. survey of Great Britain, 1848, vol. II. pt. II. p. 655; Keeper, in same, p. 643; Francis, in Mining Almanac, 1852

them is about 40 miles long and 5 to 22 miles broad, extending NNW. to SSE.; and the lodes, as a rule, strike ENE.—WSW., consequently almost at right angles to the longest axis of the entire belt. Their relative age cannot be accurately determined; and their composition is so similar, that they cannot well be separated into vein-formations. Traces of the continuation of these veins also occur in the eastern prolongation of their course, at a considerable distance, in Montgomeryshire.

From their somewhat unequal distribution into belts they may be classified in six groups:

1. Of these groups the first is designated by the Tal-y-Bont, Penybontpren, Llancyfelyn, and Trèrddol mines: the lodes of this group contain argentiferous galena, somewhat of blende, and occasionally copper-pyrites: they are contracted. dip somewhat to the West, and only traverse finely laminated clay-slate;

2. The second group, called 'Welsh Potosi', contains the Coginan, Cwm Symlog, Daren, Pen y Cefn, and other mines: the lodes attain a breadth of 20 feet in the rock, somewhat more compact than in the previous group, and contain very argentiferous galena;

3. The third group lies between Ystrad Meyric, and Devil's Bridge, along the Rheidol River: the great number of lodes found here vary, to some extent, in their character with the nature of the country-rock: they contain galena (very rich in silver), blende, iron-pyrites, and manganese ores;

4. The fourth group extends from Llanbedr to the central chain of Plynlimmon: argentiferous galena, blende, and calc-spar, are the characteristic minerals of this group;

5. The fifth group extends along the Plynlimmon chain, and contains, among others, the rich mine of Cwm Ystwyth: the lodes contain much copper-pyrites;

6. The sixth group comprises the mines around Llanidloes: the galena is, here, associated with heavy spar, and witherite; which are not found in the other groups.

To these must be added the vein-district of Llangynnog, in which are found feldspar-porphyries; while the districts above-mentioned are strikingly free from igneous rocks.

The predominating vein-stone, in all these lodes, consists of fragments of slate, combined with different varieties of quartz. Besides these, calc-spar, and (exceptionally) heavy spar, and witherite, are found; fluor spar is unknown. The ores are; galena, in part very argentiferous, cerusite, pyromorphite, copper and iron pyrites, spathic iron, and manganese ores. The matrix is but rarely arranged in symmetrical layers or bands; in the Nant-y-Creiau, for example, blende occurs at both selvages, on this galena, and quartz, with geodes of the same in the middle. These minerals usually possess an irregular granular texture, or traverse one another in a network of strings. The following unsymmetrical succession was observed in the Tyn-y-fron level of the Estymteon lode, passing from the hanging- to the foot-wall:

1. Iron-pyrites;
2. Galena;
3. Iron-pyrites;
4. Blende, with somewhat of galena;
5. Quartz;
6. Copper-pyrites, at the foot-wall.

This succession can only be the result of a repeated opening and filling of the fissure. This conclusion is proved by the frequent friction-surfaces within the lodes, fragments of older vein-masses enclosed in more recent ones, and a distinct double lode in Taylor's shaft at Goginan. The lode proper is there accompanied, and, in a parallel direction, partly intersected, by a vein of slight breadth; which, at the outcrop, is found altogether within the foot-wall, and has gradually reached the hanging-wall, at a depth of 26 fathoms; it then again passes to the foot-wall, and finally, at a depth of 100 fathoms, forms the hanging-wall for a short distance.

These lodes are often intersected, and thrown a few feet, by clay-fissures. The ores are by no means equally distributed in the lodes. The following facts have been established:

1. Where two lodes intersected at an acute angle; there, with but one exception, an enrichment had taken place;

2. Junctions, more nearly at right angles to one another, also act favorably, but only to a slight degree;

3. The union of several vein-branches is almost always accompanied by enrichment;

4. The majority of the ore-masses, not dependent on the causes mentioned, slant toward the West. At times this corresponds to the line of intersection of the stratification (by the lode); but it is not always the case. In other cases it corresponds to the line of intersection of the cleavage, which is

different from that of the stratification, and dips, at times, in an opposite inclination;

5. The distribution of the ores differs in one respect from that in the Cornish lodes, in which an enrichment takes place by the transition from a harder to a softer rock: in this district the reverse takes place; a hard wall-rock is favorable, a soft or decomposed one unfavorable. All the ores, particularly around Goginan, are found between hard, compact rock, whose stratification is only recognised by darker stripes; where the lodes pass into softer masses, the ores no longer occur.

A portion of Merionethshire,[1] in North Wales, consists of Cambrian and lower Silurian slates and sandstones, frequently broken through by greenstones. A portion of the slates, which belongs to the subdivision of the Lingula-flags, is of a talcose nature, and passes into a sort of talc-schist. The slate is traversed, in addition to the greenstones, by numerous and, in part, metalliferous quartz-veins, which contain galena, blende, iron and copper pyrites. Some of them are exploited for copper. Several, and particularly those which occur in the talcose schist, also contain a little gold.

XXVII. DERBYSHIRE.

GEOLOGICAL FORMATION.

§ 235. The ore-district of Derbyshire occurs, essentially, in the Subcarboniferous formation (mountain limestone), which is therefore here called metalliferous limestone. The succession of the strata, in a descending series, is as follows:

1. New-red-sandstone, mantling the ore district, but containing no metalliferous deposits;

2. Coal-shales and Millstone-grit: the lodes occur but rarely in the latter; they are unknown in the coal-shales;

3. Carboniferous limestone (mountain limestone), in part mag-

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[1] See: Ramsay, in Quarterly Journal of the geol. soc. 1854, vol. X., pt. I. p. 242.

nesian; containing cavities, and alternating with calcareous shales and with beds of an igneous rock, resembling greenstone (locally called toadstone).

The greenstone (toadstone), in part amygdaloidal, forms tolerably regular layers between the more or less thick limestone-strata; and it is doubtful, whether these greenstone-layers are to be regarded, as submarine streams of lava contemporaneous with the deposits of limestone, or as subsequent injections into fissures, parallel to the stratification. De la Beche considers them to be contemporaneous streams: Sedgewick, as subsequent injections or igneous bedded dikes. It is probable, that both occur in the same district; for our purpose this is a question of no importance. It is in the district, occupied by these peculiar alternations, of very fossiliferous limestone with a distinct igneous rock, that the aggregations of lead-ore-deposits are found, both in Derbyshire, and Cumberland.

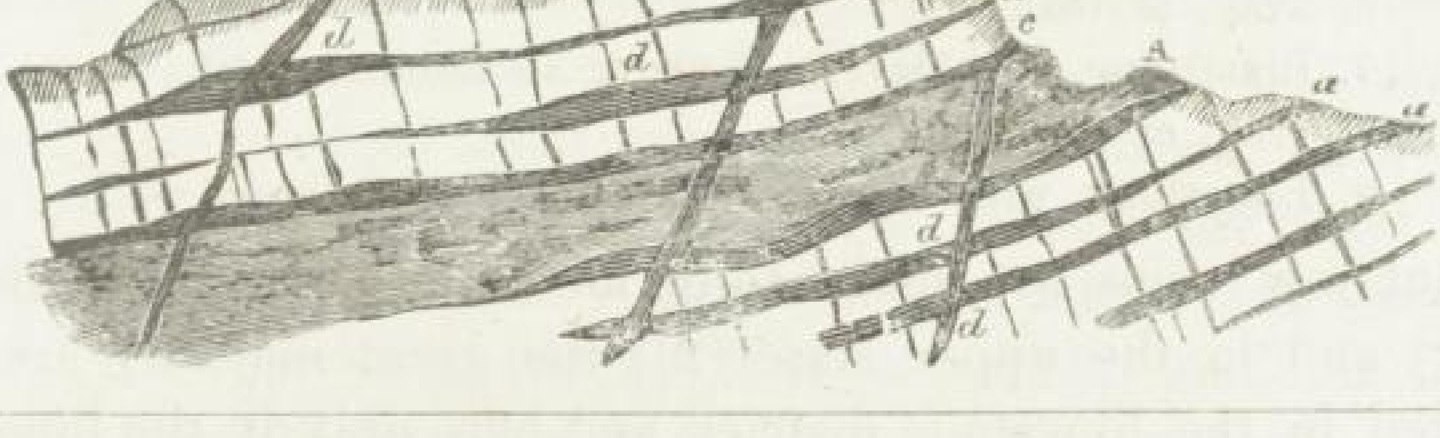
THE LEAD DEPOSITS.

§ 236. Three varieties or forms of lead-deposits are recognised in Derbyshire:[1]

1. Rake-veins; which are the lodes proper, filling distinct fissures;
2. Pipe-veins; which are masses or sheets of ore, generally parallel to the stratification, but quite irregular;
3. Flat-veins; these are thin layers in the fissures of stratification.

Besides these, the cross-fissures of the limestone are often metalliferous, and are called skrins.

De la Beche has attempted to show the manner in which these differently formed, but similarly composed, ore-deposits occur, by the following idealised woodcut.



[1] See: De la Beche, Geological Observer, 1851, p. 784; Brochant de Villiers, in Annal. d. mines, vol. XII. p. 339, 401; Elie de Beaumont and Dufrénoy, Voyage metall. en Angleterre, vol. II. p. 514.

The white, only shaded near the surface, is mountain-limestone: the dark layer, *A*, is greenstone (toadstone), which, De la Beche thinks, has flowed over the lower layer of limestone, and over which the upper one was subsequently deposited: *b b* are cross-fissures (skrins) in the limestone, and sometimes contain small quantities of ore: *c c* are rake-veins, true veins filling fissures, through which the material composing the other veins may also have penetrated: *d d* are pipe-veins,[1] irregular expansions filled with ores, at the intersections of the lodes with the fissures of stratification: the fissures of the stratification, *a a*, are often filled with thin sheets of ore, and then form the flat-veins.

It is evident, that the whole mass of limestone is traversed, in all accessible fissures and cavities, by ores and veinstones, which have penetrated subsequent to its formation: but in the greenstones either these substances have found but little space for deposit, or its mass did not re-act in the same manner on the solutions, as did that of the limestone.

All three or four kinds of ore-deposits are essentially composed of galena, heavy spar, fluor spar and calc-spar; quartz, pyrites, blende, and products of decomposition, are more rare.

The only veins, now generally exploited in Derbyshire, are the rake-veins: at least the half of these course WSW.—ENE., while the remainder appear to have no predominant direction of strike.

Their dissimilar condition, in the various strata they traverse, is very remarkable. The last succeed one another in the following order:

1. Millstone-grit;
2. Slates of the Subcarboniferous;
3. Limestone, containing thin beds of slate, 25 fathoms thick;
4. Trap, or toadstone;
5. Magnesian limestone, containing cavities, 25 fathoms thick;
6. Trap, or toadstone;
7. Limestone, with layers of slate, 35 fathoms thick;
8. Trap, or toadstone;
9. Limestone, with layers of slate, over 42 fathoms thick.

But few veins are found to be metalliferous in the Millstone-grit (1) and in the upper slate (2); the great majority are only exploited in the limestone district, and here only in the limestone

[1] They might with great propriety be called junction-segregations.

strata. As soon as a lode has been followed, from the surface to the first layer of greenstone; it either ceases, or only continues as a narrow cleft (containing no ores) through the greenstone. Beneath this the veinstone is at times found to have resumed its former condition in the next limestone-bed. Still, most of the mines are only exploited within one zone of limestone. Brochant de Villiers, Dufrénoy, and Elie de Beaumont, state, that out of 180 cases, 161 showed a complete disappearance of the lode in greenstone; while there were but 19 cases, where the vein was observed to continue, in the form of parallel fissures. These results cannot be regarded as altogether reliable; since, from a practical mining view, the vein would probably be considered to have ceased, though it actually continued through the trap in the form of barren fissures. A careful examination would almost always find traces of the continuation, since such continuations have been several times recognised; and consequently it cannot be supposed, that the greenstone has penetrated, subsequently to the lodes, in the form of dikes.

The Carboniferous limestone, in Derbyshire and Cumberland, only contains lead-lodes and their branches, when it also contains beds or dikes of greenstone. Similar lodes occur in a narrow belt of Carboniferous limestone, commencing in the north of Flintshire, between the upper Silurian Wenlock strata and Millstone-grit, and extending, without containing greenstone dikes, to the neighborhood of Llangollen. The lodes generally strike, at right angles to the course of the belt in which they lie, being either E.—W. or NW.—SE., but rarely N.—S. They are generally confined to the Subcarboniferous formation; but a small portion of them having been followed into the Millstone-grit, and two or three of them into the underlying Wenlock beds. Not one of them reaches into the Carboniferous formation proper. From this fact, they might be older than this last formation; but it cannot be proved with certainty, especially as some of them extend into the Millstone-grit. Were it the case, we should here have an interesting case of the unusually great age of a vein-formation, which extremely resembles the Freiberg barytic lead-formation, and belongs to the same combination, which in many regions extends into the Jurassic or Cretaceous, perhaps even into tertiary rocks.

'Conybeare and Phillips[1] state, that in some of the veins in the Carboniferous limestone of Derbyshire, the veinstuff, which is nearly compact, is occasionally traversed by (what may be called) a vertical crack passing down the middle of the vein. The two faces in contact are friction-surfaces, sometimes covered by a thin coating of lead-ore. When one side of the veinstuff is removed, the other side cracks, especially if small holes be made in it, and fragments fly off with loud explosions, and continue to do so for some days. The miner, availing himself of this circumstance, makes with his pick small holes, about six inches apart, and four inches deep; and on his return, in a few hours, finds every part ready broken to this hand. These phenomena and their causes (probably connected with electrical action) seem scarcely to have attracted the notice which they deserve.'

The isolated portion of limestone forming the peninsula of Great Ormes-head in the north coast of Wales, contains veins coursing N.—S. So that, on the whole, the British Carboniferous may fairly be entitled metalliferous, though not originally such, by depositions subsequent to its formation.

C. Moore[2] has found numerous fossils in lodes in Mountain limestone; they belong partly to the Subcarboniferous, partly to the Jurassic and Triassic periods.

XXVIII. CUMBERLAND.

LEAD-DEPOSITS.

§ 237. The geological formation of the ore-district of Cumberland[3] is entirely similar to that of Derbyshire, being a continuation of the same general conditions. The lead-deposits also occur in the Carboniferous or metalliferous limestone.

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[1] Conybeare and Phillips' Geology, p. 401; and Lyell's El. of Geol. 1865, p. 762.

[2] See: The Mining Journal, No. 1418, vol. XXXII.

[3] See: Wallace, Description of lead-ore in Veins of Alston Moor, 1861; Brochant de Villiers, in Annal. d. mines, vol. XII. pp. 339, 401; Dufrénoy, and Elie de Beaumont, Voyage métall. vol. II. p. 502; Mave, in Von Moll's Annalen, vol. V. p. 259.

This Carboniferous limestone consists of alternate strata of thick limestone-beds with subordinate layers of argillaceous shale and sandstone. In Cumberland this group of strata is also traversed by a compact or amygdaloidal greenstone (called trap or whin-sill); which extends, with varying thickness, between the strata, and parallel to these; from which Sedgewick concludes, that it has penetrated, as igneous rock, between the sedimentary strata, subsequently to their formation. The thickness of this greenstone is at times more than sixty-four feet. In Derbyshire we found several such layers of trap one above the other, in Cumberland there appears to be but one such.

Since the several limestone-strata have each its own peculiar mining value, each one has received its separate name from the miners. Of special importance are the two thickest, the so-called *great limestone,* 64 feet thick, and the *scar limestone,* upwards of 125 feet thick; each of which, however, properly consists of several separate beds. The remaining limestones attain a thickness of but 15—20 feet, being separated from one another by argillaceous shales or sand. In Cumberland, as in Derbyshire, the Millstone-grit overlies the Carboniferous limestone, and the lodes in it are not exploitable.

The ore-deposits are classified in Cumberland as rake-veins, pipe-veins and flat-veins.

The rake-veins are the most common and important. They traverse the Subcarboniferous formation from top to bottom, but with very variable breadth and character between the separate layers of the formation. Their matrix is in general precisely the same as in Derbyshire. Their breadth averages 1—4 feet, but is, in the Huldgillburn lode, within the *great limestone* 17 feet, while it decreases in the sandstone beneath this to 3 feet. The same is frequent in the other lodes; they being only broad and productive within the limestone. Their course is irregular; their dip, as a rule, vertical; but, still, resembling a flight of stairs. For while the veins are broad, and almost perpendicular, within the limestone; they often have a very gentle dip, with but slight breadth, and chiefly clayey matrix, in the intermediate schistose rocks; and again continue vertical, and broad, in the next limestone-bed. The veins are also poor in the sandstone, while in greenstone, or amygdaloid, they split up into unworkable strings. They are, therefore, only exploited in the limestone; and it is stated, that experience has shown, that the upper strata are generally far more favorable, than the lower ones. On this account the greater part of the lodes are only exploited to the fifth bed of limestone; which lies about 150 fathoms beneath the Millstone-grit; beneath which, and above the first limestone-bed, follows slate, 110 fathoms thick, in which the mines are not worked. There thus remains a zone of but 40 fathoms, in which the mines are exploited. At Alston Moor, however, the lodes have been found workable, as deep as the eleventh limestone-bed, which lies 210 fathoms below the Millstone-grit; by which the zone of exploitation is encreased to 100 fathoms. The several limestone-beds are found to vary somewhat in their influence, the most favorable being the *great limestone*. This influence of the wall-rock is so striking, that a perceptible difference occurs, even in those places, where, by reason of faults, the one side of the fissure is bounded by limestone, the other by slate or sandstone.

The pipe-veins seem generally to be local and irregular enlargements, of veins or vein-fissures, caused by the fissures of stratification, like the segregated masses of calamine in the Muschelkalk at Wiesloch in Baden, and segregations of lead-ores at Bleiberg in Carinthia. They are much less common than the rake-veins, and are only worth working when very broad.

The flat-veins correspond, in form, to thin beds between the strata, but appear to be merely side-branches of the lodes in the stratification-fissures. They too are seldom exploited.

Hence it may be asserted, as already stated in the preceding §, that the *metalliferous limestone* was by no means originally metalliferous, but only presented a good opportunity or cause for the subsequent depositions of ore in its fissures and cavities; as did other magnesian limestones on the continent of Europe.

XXIX. IRELAND.

WICKLOW.

§ 238. The ore-deposits of Wicklow, on the East Coast of Ireland, are the richest and most important of all those as yet discovered on this island. The County of Wicklow[1] is generally composed of lower Silurian slates, cut through by granite masses, porphyry- and greenstone-dikes. The clay-slate, in the neighborhood of the granite, is usually altered to mica-schist and quartzite; these being often intersected by ramifications of the granite. It appears, that the metalliferous deposits of this district occur, for the most part, near the limits of the granite, either within this, or in the adjoining schist. They may be separated into three groups, according to their nature of occurrence:

1. Lead-lodes in granite;
2. Deposits of iron and copper-pyrites in Silurian slates;
3. Gold-placers, near the granite mountain of Croghan Kinshella:

All of these deposits occur in the basin of the Ovoca river, which empties into the sea near Arklow.

1. Lead-lodes in granite. The most important are those exploited by the Glenmalure and Luganure mines. The broadest of these, that of the Old Glenmalure mine, is 20 feet broad. At one point, where it had penetrated the schist, it showed the following unsymmetrical arrangement:

a. A narrow layer of ore;
b. Quartz, containing particles of ore, very broad;
c. Fragments of schist;
d. Galena and blende, very broad; following which is the hanging-wall of slate.

In these lodes, the galena has been found, in places, three feet broad.

2. The copper and iron-pyrites mines of Ovoca may be passed over, as not especially interesting.

3. A deposit of clay, sand, and boulders, 20—50 feet thick, occurs in the Ballin Valley on the Croghan Kinshella mountain. This deposit contains scales, grains, and larger pieces of gold, occasionally also crystals. This is associated with quartz, magnetite, specular iron, iron-pyrites, iron-mulm, cassiterite, wolfram, pyrolusite, and chlorite. Sometimes are found united together;

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[1] See: The mines of Wicklow, 1857; Murchison's Siluria, p. 435; Weaver, in Philos. Magaz. 1835, vol. VII. p. 1; and Trans. geol. soc. 1819, vol. V., pt. I. p. 208; Henry, in Philos. Trans. 1753, vol. 47; Sanders, in Jahrb. f. Mineral. 1865, p. 245.

quartz, and chlorite; quartz, and gold; quartz, magnetite, wolfram, and gold. In some of the pieces the wolfram is traversed by limonite and gold.

XXX. SCANDINAVIA.

GENERAL REMARKS.

§ 239. Norway, Sweden, and Finland, consist, for the greater part, of old crystalline rocks, partly igneous and plutonic, partly metamorphic. Gneiss and granite are particularly prevalent; and, according to the investigations of Kjerulf and Dahll, the first is, also in part, of igneous origin, and has broken through the other schistose rocks; of which it sometimes contains fragments.

This igneous gneiss greatly resembles granite, it exhibits no alternation with other schistose rocks, but forms uniform districts. The metamorphic variety, on the contrary, forms frequent transitions into, or alternates with, mica-schist, quartzite, chlorite-schist, talc-schist, hornblende-schist, felsitic schist, crystalline limestone or dolomite; or contains, to a more subordinate degree, all sorts of metalliferous deposits, and other peculiar varieties of rocks; or is traversed by porphyries, greenstones, and gabbro. Overlying the gneiss are Silurian and Devonian strata; in places, covering large areas. More recent sedimentary strata are only found in the southernmost portion of Sweden. These last contain no metalliferous deposits. Diluvial deposits cover large areas of country to the North. Of the igneous rocks, there occur, in addition to granite and gneiss, syenite, porphyries, greenstones, and basalts.

There are but few true fissure-veins among the ore-deposits of Scandinavia. The majority of the deposits form irregular, segregated, and bedlike masses, or so-called Fallbands; *i. e.* impregnated zones of rock. Scandinavia is properly the home of segregations and Fallbands. Iron and copper-ores are the most richly represented; after these silver, and cobalt; far less frequently lead, zinc, nickel, gold, and tin; the last is only found, in any quantity, at Pittkaranda in Finland. The manner of occurrence at this last locality is very striking; since the tin-ores so constantly occur elsewhere with the oldest crystalline rocks.

It cannot appear strange, that the iron-deposits of Sweden are mostly composed of magnetite; if it is remembered, that they occur in crystalline schists, which have probably been altered to their present state by catogene metamorphosis. The Devonian belt of the Eastern Alps, so rich in spathic iron, would probably have furnished like results under similar circumstances.

Daubrée gives a general summary of the ore-districts in Norway and Sweden; which I here transcribe, making a few alterations, and completions, as regards Finland.

Norway.

1. District of Christiania: numerous contact-deposits at the junction of granite: silver-lodes of Kongsberg: cobalt-deposits of Skutterud;

2. District of Arendal on the South coast: belt of magnetic iron;

3. District of Tellemark:[1] numerous copper- and iron-deposits, in part argentiferous; e. g. near Omdal, and Bygland;

4. District of Trondhjem: deposits of iron- and copper-ores; e. g. at Röraas;

5. District of North Cape: copper-deposits of Kaafjord, and Reipas.

Sweden.

6. District of Tornea and Lulea-Lappmark: numerous deposits of iron-ore: near Gellivara an entire mountain of magnetic iron; the like at Kjerunavara and Luosanavara: copper-deposits with argentiferous galena at Sulitelma;

7. District of Herjedalen: the deposits of Trondhjem appear to continue to this point;

8. District of Dalecarlia and Westmanland: this is the richest district in Sweden: to it belong; Falun, the iron- and copper-deposits of Gangjärde, Garpenkerg, Nylshyttan with magnetite, Loos with cobalt and nickel ores, Löfas with lead and silver ores in the limestone of the mica-schist, Elfdalen with argentiferous lead-lodes in porphyry, Norberg with rich

[1] See: Scheerer, in Berg- u. hüttenm. Zeit. 1863, p. 157.

copper-ores containing lead-ores, Bisperg with magnetite in gneiss, and Sala;

9. District of Wermland and Nerike: neighborhood of Philipstad, Carlstadt with hematite in gneiss, Vena with Fallbands of cobalt-ores in gneiss, much resembling those of Skutterud;

10. District of Upland: Dannemora;

11. District of Westmanland: Nora, Nyakopparberg, and Nydarhytta, containing copper-ores; Hellefors, and Guldmeshyttan with argentiferous galena in Fallbands;

12. District of Södermanland: Tunaberg, island of of Utoe, Ferola, Sjosa, and Scotrang, with deposits of magnetic iron, cut through by granite-dikes;

13. District of East Gothland: near Atredaberg are rich copper-deposits in mica-schist;

14. District of Smaland: at Taberg, and Adelfors, are bog iron-ores, and copper- and cobalt-deposits in the gneiss of Gladhamar.

Finland.

15. District of Helsingfors: numerous deposits of magnetic iron in hornblende-schist, always accompanied by diorite, frequently cut through by granite-dikes: in the deposits garnet, augite, epidote, mica, chlorite, talc, etc. are often found: at Oryärfvi are segregations of copper-ores in mica-schist at its junction with granite;

16. District of Pittkaranda near Imbelax.

Only the most important of the above localities will be mentioned in the following.

CONTACT-DEPOSITS IN THE NEIGHBORHOOD OF CHRISTIANIA.

§ 240. The district around Christiania[1] consists of Silurian strata (clay-slate, alum-slate, sandstone, and limestone), broken through by granite, syenite, greenstone, and porphyry. No metalliferous deposits, worth mentioning, are found removed from the junctions of the sedimentary with the igneous rocks, but merely admixtures of iron-pyrites, or beds of hematite. On the

[1] See: Keilhau, Gaea Norvegica, Christiania, 1838, vol. I. pp. 61, 73, 107, 109, 125.

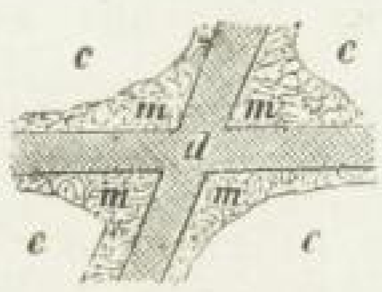
other hand very numerous, if not very important, iron-deposits, of very manifold composition, are found at the junctions of the granite and syenite with Silurian strata; which deposits, according to Daubrée, are irregularly shaped, and are therefore contact-segregations. They do not always occur precisely at the junctions, as partitions of the heterogeneous rocks, but always in the neighborhood of these last, and as it were within the sphere of the influences of plutonic activity; for example, in the Silurian districts, which are not broken through by large granite-masses, but by granite-ramifications. Keilhau has also established the fact of this manner of occurrence by numerous examples, although he attempted to explain the phenomenon by a very uncommon hypothesis; viz. that of the metamorphosis of the rocks; and considered these crystalline rocks not to be igneous.

These contact-deposits are mainly composed, either of magnetite; of copper pyrites, or argentiferous galena, and blende; or of combinations of these. In addition to the above, they contain iron-pyrites, mispickel, smaltine, bismuthine, molybdenite, calc-spar, fluor spar, apatite, garnet, epidote, datolith, axinite, helvine, etc. Magnetite, argentiferous galena, and copper-pyrites, are often associated together in the same deposit.

The iron-mines of Aaserud near Eidsfoss; and those in the parishes of Lyer, and Asker; and those of Vedelsja, near Drammen; as well as the copper-mine of Gjellabäck, are all worked on contact-deposits. The most frequent veinstones are garnet and calc-spar; helvine is quite common in the Hörte mine.

I will take, as examples, the mines of Aaserud and Narverud, and describe them concisely. At the first-named locality,

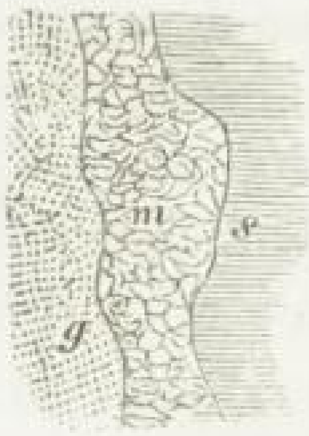
Vertical section.



Horizontal section.

the iron-ore *m* occurs in the hanging- and foot-wall of a hornblende-rock *d*, which last forms veins in crystalline limestone *c*; as the ore recedes from the dike it passes into carbonate of lime.

The ore-deposit at Narverud occurs at the junction of



Vertical section.

the granite *g* and slate *s*; the last-named rock has become very hard, from the influence of the granitic mass. The ore, which consisted at the outcrop of magnetite with garnet, contained such considerable quantities of iron- and copper-pyrites, at a depth of 4 to 5 fathoms, that the mine had to be abandoned.

Horizontal section.

More than sixty deposits of this kind have been found. Keilhau states, that the conditions of bedding in 53 of them have been determined: 19 were found at the junctions of the plutonic with the Silurian rocks; the remainder, at short distances from this junction: four were found to be entirely in granite or syenite; twelve in hardened slate or limestone: all were found to be only workable to a slight depth.

KONGSBERG.

§ 241. The district around Kongsberg[1] is composed of crystalline schistose rocks; predominating among which are quartzite and mica-schist, passing into gneiss; and hornblende schist, which occasionally passes into talc and chlorite schist. These are the oldest rocks in the whole of Norway. All of these schistose rocks alternate with one another; and the quartzite sometimes passes into a variety of sandstone, or conglomerate; from which, as well as from the frequent alternation of the strata, their original sedimentary and subsequent metamorphic origin can be recognised. Dahll and Kjerulf state, that these schists are traversed by large and small masses of a gabbro containing much labradorite; and border westwardly on an extensive district of igneous granite and gneiss-granite; which also contain fragments of the schists, at the junctions, and are

[1] See: Hausmann's Reise d. Skandinavien, vol. II. p 8. Böbert, in Karsten's Archiv, vol. XII. p. 267; Scheerer, in Leonhard's Jahrb. 1853, p. 720; and Berg- u. hüttenm. Zeit. Suplmt. to 1846, p. 73; 1866, pp. 171, 250; Kjerulf and Dahll, Ueber d. Erzdistrict Kongsbergs, 1860; Durocher, in Annal. d. mines, 4 ser. vol. XV; Crowe, in Mining Almanac, 1852.

consequently more recently formed than these last. Dahll and Kjerulf group all these rocks of Southern Norway as regards their age into the following groups:

1. Metamorphic schists, Azoic;
2. Granite and Gneiss-granite, igneous;
3. Slates of Osterdalen, Pre-Siluric;
4. Silurian formation;
5 Devonian formation;
6. Younger granite and syenite, at the fjords of Christiania; igneous, and more recent than the Devonian formation.

The age of the gabbro is not determined. All the metamorphic schists are somewhat garnetiferous; they strike N.—S. and dip almost vertically toward E. In these, and less distinctly in the gabbro, there are certain belts impregnated with sulphurets, and called Fallbands. These belts, or zones, strike and dip parallel to the schists, not retaining an equal breadth, but at times wedge-out, and recommence in the direction of strike; they diverge at acute angles, or even form side-leaders called 'Springbands'. These conditions must suggest the idea, that the sulphurets were not originally deposited with the matter forming the schists, but have penetrated by a subsequent impregnation. The sulphurets, which they contain, very finely, often almost imperceptibly disseminated, are particularly iron-pyrites, somewhat of copper-pyrites, and pyrrhotine; also blende, and even traces of native silver, and silver-glance. Owing to the decomposition of these sulphurets, the Fallbands can be very distinctly recognised from the non-impregnated rock, since the peroxide of iron gives them a rusty appearance. Two principal Fallbands are recognised westwardly of Kongsberg, the Unterberger and the Oberberger, as well as a large number of thinner and less widely extended ones, parallel to the above-mentioned. The Unterberger Fallband attains a breadth of 200 feet, the Oberberger 1000 to 1200 feet. Since the impregnation of the Fallbands does not lie exactly parallel to the stratification; but, on the other hand, their geographical distribution about corresponds to that of the gabbro; and since too altogether analogous impregnations of pyrites have been found in the gabbro itself, as well as in the fragments of schist it contains; Dahll and Kjerulf considered these impregnations to have been caused by the gabbro. The Kongsberg silver-lodes have only been found exploitable within these Fallbands; between all other rocks they are, generally, altogether barren. Even within the Fallbands, their contents do not remain constant, but are in places very meagre; without, as yet, any law for this unequal distribution within the Fallbands having been discovered. The enrichment within the Fallbands is one of the most striking cases of the influence of the country-rock; and it is by no means necessary to conclude, that the ores must have been secretions from the Fallbands. Dahll and Kjerulf are of the opinion, that the enrichment is not so exclusive, as is generally supposed.

The lodes, of which there are many around Kongsberg, course E.—W. almost at right angles to the strata and Fallbands: they generally have a considerable dip toward S., a few toward N. They are, as a rule, but a few lines or inches broad, and but rarely attain a breadth of a few feet. Their narrower portions average a greater richness in silver, than the broader ones; which are generally more filled with veinstones. Hausmann states, that those portions about an inch broad are the richest. Their breadth is stated, in general, to encrease for a certain depth, and then again decrease. In addition to the Fallbands, but within them, junctions of the lodes exert a favorable influence. The mineral matter, forming the lodes, is firmly attached to the wall-rock, without forming selvages; and the rock is often impregnated for some distance with silver. Hausmann remarks, however, that the lodes are most firmly attached to the wall-rock in thinly cleavable talc-schist, the richest in mica-schist, and mostly clearly defined in hornblende-schist. The predominant ores are native silver, and silver-glance: the former has been repeatedly found in large masses, at times somewhat auriferous. More rarely found are; ruby silver, kerargyrite (found only in the out-crop), galena, native arsenic, brown blende, copper-pyrites, pyrrhotine, and iron-pyrites. The veinstones are; calc-spar, fluor spar in octahedrons, heavy spar, and quartz; more rare are, magnesite, dolomite, heulandite, prehnite, harmotome, laumontite, anthracite, mountain-cork, mountain-leather, actinolith, axinite, adularia, and albite; Daubrée also mentions leucite and epidote. The anthracite forms small spheres in calc-spar.

This association greatly resembles that of Andreasberg (§ 104), even to the predominance of calc-spar scalenohedrons. Dahll and Kjerulf distinguish an older and a younger portion of the matrix; to the older portion they consider quartz, fluor spar, calc-spar and heavy spar, with native silver, to belong; to the younger portion, calc-spar, more recent quartz in geodes, zeoliths, a little native silver, ruby silver, silver-glance, pyrrhotine, galena, and iron-pyrites.

The question has been raised; whether in this case the metalliferous contents of the lodes have been derived from the Fallbands; or whether the ores in the Fallbands are impregnations, which have found their way from the vein-fissures. Dahll and Kjerulf are of the opinion, that neither view is correct, but that the impregnations of the Fallbands, as well as the mineral matter filling the lodes, are consequences of the gabbro eruptions, which took place in such a manner, that the Fallbands were formed previously to the lodes.

As proofs, that the presence of gabbro, in this district, is the principal cause of the metalliferous deposits, K. and D. adduce two examples, from among many like cases, where mixtures of niccoliferous pyrrhotine, copper-pyrites, and cobaltiferous iron-pyrites, together with interspersed crystals of hornblende, form contact-deposits between gabbro and crystalline schists. One of these cases is furnished by the Meinkjaer mine in Bamble, the other by the Steenstrups pyrites-mine near Kongsberg.

FALLBANDS OF COBALT-ORE AT SKUTTERUD AND SNARUM.

§ 242. The district around Skutterud[1] and Snarum, in the Parish of Modum, consists of crystalline schists, whose nature varies between gneiss and mica-schist, and through the presence of amphibole passes into hornblende-schist. Garnet, tourmaline, graphite, etc. occur as accessory minerals. These schists course N.—S. and dip almost perpendicularly. They contain metalliferous zones (Fallbands) similar to those of Kongsberg; the difference being, that the cobalt-ores predominating in them are finely disseminated, and pay for the exploitation; while the Kongsberg Fallbands, impregnated with sulphurets, are only im-

[1] See: Hausmann's Reise d. Skandinavien, 1812, pt. II. p. 85; Naumann's Beitr. z. Kenntn. Norwegens, 1824, pt. I. p. 8; Böbert, in Karsten's Archiv, 1832, vol. IV. pp. 277, 280; 1847, vol. XXI. p. 207; Schmidhuber's Bericht u. d. Kobaltwerk Snarum, 1847; Scheerer, in Leonhard's Jahrb. 1853, p. 720, Poggend. Annal. vol. 42. p. 546; Müller, in Berg- u. hüttenm. Zeit. 1858, p. 334; Durocher, in Annal. d. mines, 4 series. vol. XV.

portant, as zones of enrichment for the silver-lodes. Lodes are altogether wanting at Skutterud.

These ore-zones generally follow the strike and dip of the schists, and attain, according to Schmidhuber, a breadth of $2^1/_2$ to 6 fathoms; three to four of them coursing alongside of one another. The breadth of these zones, or belts, cannot well be accurately determined; since a gradual transition takes place, from the Fallband or impregnated rock, into the non-impregnated. The distribution of the ores within the Fallbands is not equable, richer and poorer or even barren layers being recognised. The first are called 'Erzbänder' (ore-bands), the last 'Felsbänder' (rock-bands); and their breadth varies from a few feet to two or three fathoms. In addition to the above, 'Reicherzbänder' (Rich ore-bands) are distinguished, whose breadth generally amounts to a few inches, and which course parallel to, and within the ore-bands. All these dissimilar zones, or belts, are indistinctly defined. A similar alternation, of barren and impregnated rock, is thus repeated within the Fallbands, as is characteristic, on a large scale, of the district. On the outer edges of this cobaltiferous Fallband district, are a few Fallbands containing mispickel, without any cobalt-ores being perceptible. The formerly current acceptation, that the cobalt-ores in the Fallbands did not extend to a greater depth than 9 fathoms, has been completely refuted by Böbert. He has shown, that poorer or barren portions, which occur at every level, have given rise to this false view; while in reality the ore is merely irregularly distributed in the Fallbands; this is a fact strongly opposed to a contemporaneous deposit of the ores and the rocks, and in favor of a subsequent impregnation.

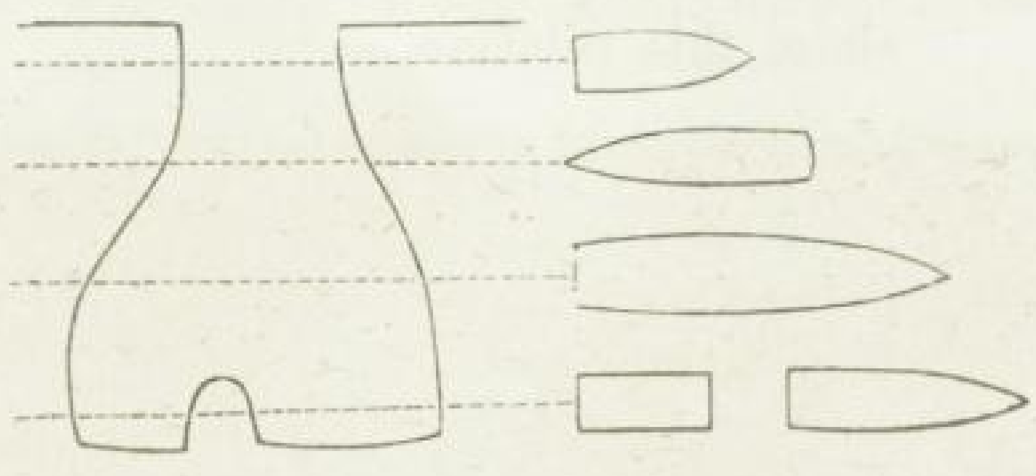
The predominant rock of the Fallbands is a quartzose, finely granular, foliated, mica-schist; which forms transitions into quartzite, quartzless mica-schist, and gneiss.

The ores and other minerals finely disseminated in these rocks are; cobaltine, skutterudite, cobaltiferous mispickel, leucopyrite, copper-pyrites, molybdenite, pyrrhotine, iron-pyrites, amphybole, tremolith, anthophyllite, sahlite, graphite, ittrotitanite, and some other rare minerals. Hausmann has particularly mentioned, also; magnetite, tourmaline, scapolith, and serpentine: to which Böbert adds; galena, native copper, malachite, chrysocolla, copper-glance, actinolith, epidote, amianthos, rutile, talc, garnet, titanite, and smoky quartz. The last quoted authority also found a small percentage of nickel in the ores; while it is certainly very remarkable, that so few and unrecognisable nickel-ores are found associated with the cobalt-ores at Skutterud. The cobalt-ores, viz. cobaltine, cobaltic mispickel, and skutterudite, are the object of exploitation: of these the last is the most rare.

The principal Fallband now worked, which is known to extend about six miles, is bounded to the East by an amphibolic rock (diorite containing somewhat of quartz), which protrudes into the Fallband with clearly defined bunches, from which small dikes or threads traverse the same in a zigzag course. This Fallband is also intersected by coarse-grained granite-dikes, which contain no ores, and whose branches penetrate the amphibole-rock.

MAGNETITE-DEPOSITS OF ARENDAL.

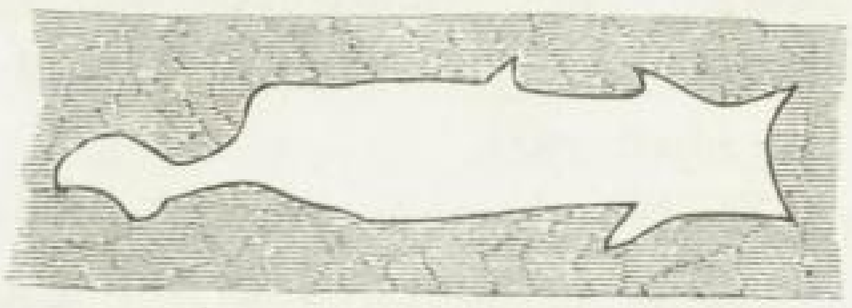
§ 243. The district of Arendal[1] consists of crystalline schists, particularly gneiss, which is at times almost mica-schist, or contains blende; and contains some beds of limestone. These schists strike NW.—SE., dip 60°—80° toward SE., and contain a large number of segregated deposits of magnetite, in a long belt, which is parallel to the coast, and extends from Oyestad to Flackstad. These deposits are bedlike, irregular, and lenticular segregations, accompanied by irregular ramifications. The irregular lenticular form may be seen from the accompanying woodcuts.



Vertical section, Horizontal sections, of the worked-out portion of the Aslocks mine in Naeskilen.

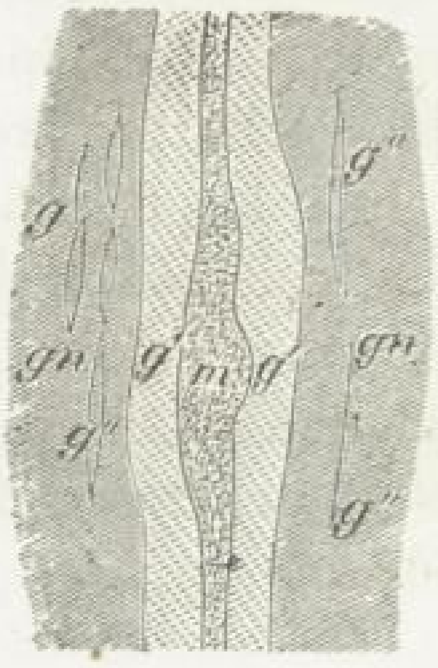
[1] See: Hausmann's Reise d. Skandinavien, pt. II. p. 138; Scheerer, in Leonhard's Jahrb. 1843, p. 631; Weibye, in same, 1847, p. 697; Aall's om Jernmalmleier og. Jerntiloirkningen i Norge, 1806; Kjerulf and Dahll, in Nyt Mag. f. Naturvidenskaber, vol. XI, and Leonhard's Jahrb. 1862, p. 557; Durocher, in Annal. d. mines, IV. series, vol. XV.

In the horizontal section, the mass of ore is $9\,^1/_2$ feet broad, and has been exploited for a length of 35 fathoms. The ore-masses often exhibit, in their interior, a somewhat foliated texture,

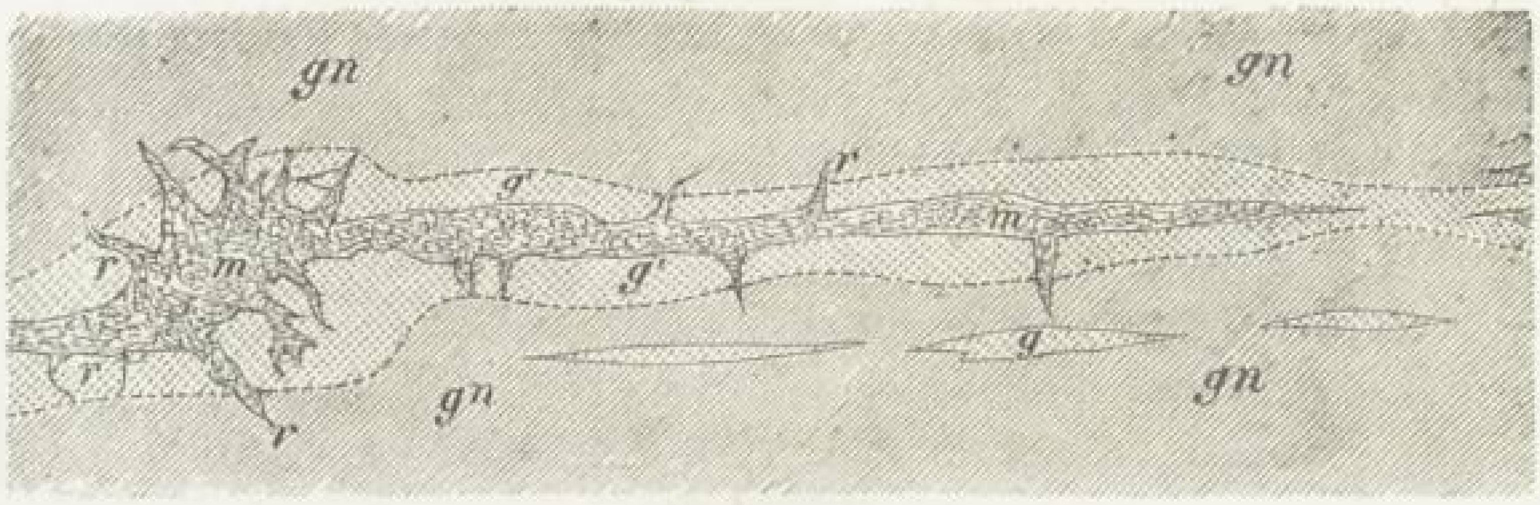


Horizontal section of the Thorbjorns mine near Arendal.

parallel to that of the enclosing gneiss; which also corresponds to their longest axis. Scheerer states that they are occasionally intersected by granite-dikes. The magnetite is usually mixed or combined with augite or coccolith, hornblende, garnet, epidote, calc-spar, and some of the minerals composing the gneiss. Still, this is not every where the case. Where the calc-spar is wanting the silicates of lime are also absent; and, besides those mentioned, there are many minerals which are found in and alongside of these ore-deposits; so that this locality has acquired quite a mineralogical celebrity.



There is often a purer kernel of the magnetite, forming the principal mass of the deposit; which is followed by a sort of shell, particularly rich in minerals This shell is sometimes penetrated by ramifications of the purer ore-kernel. The accompanying woodcuts are intended to show this relation.



The upper figure represents a vertical section, from which the deposit might easily be mistaken for a lode with distinct selvages; but this does not correspond to the general conditions. In both of the woodcuts, *m* denotes magnetite, *g'* the outer shell (chiefly composed of garnet, hornblende, epidote, etc.),

g'', lenticular masses of these ores in gneiss *gn*; and *r*, ramifications of the kernel through the shell.

Hausmann states, that these deposits, as well as the enclosing gneiss, are traversed by three other kinds of vein-formations; viz.

1. veins, whose composition is the same as that of the ore-deposits;

2. veins composed of feldspar and calc-spar with somewhat of titanite; these only occur within the ore-deposits;

3. coarsely granular granite-dikes, about one foot broad.

The minerals, mentioned by Weibye, are subjoined in alphabetical order; those occurring in the gneiss, apart from the ore-deposits, being designated with an asterisk:

Actinolith,*	Garnet,*
Adularia,	Grossular,
Albite,	Heulandite,
Amethyst,	Hornblende,*
Amphodelite,	Limonite,
Analcime,	Lithomarge,
Apatite,*	Magnetite,*
Apophyllite,	Malachite,
Asbestos,	Melanite,
Augite,	Mica,*
Axinite,	Milky quartz,*
Azurite,	Molybdenite,*
Babingtonite,	Oerstedite,
Beryl,	Oligoclase,*
Blende,	Pistacite,*
Botryolith,	Prehnite,
Bucklandite,	Pyrrhotine,*
Calc-spar,*	Quartz,*
Chalcedony,	Rose quartz,*
Chlorite,	Sahlite,
Coccolith,*	Scapolith,
Colophonite,*	Serpentine,
Copper-pyrites,*	Skutterudite,
Copper-nickel,	Sphene,*
Datolith,	Spinel,
Ekebergite,	Stilbite,
Erubescite,	Talc,
Fluor spar,	Tetrahedrite,
Gahnite,	Zircon:

In the gneiss, outside of the mines, occur;

Anthracite,	Hessonite,
Euxenite,	Keilhauite.
Gadolinite,	

Hausmann has called attention to the fact, that many of the minerals in these deposits have peculiarly curved surfaces, almost as if they had been melted; which last I by no means intend to assert. This appearance is particularly distinct in garnet, colophonite, augite, and apatite; particularly when implanted in calc-spar.

COPPER-DEPOSITS OF RŒRAAS IN NORWAY.

§ 244. The rock, containing the copper-deposits at Röraas,[1] is a talcose schist, passing into chloritic schist, containing much garnet and little quartz or mica; it is traversed by numerous quartz-veins. Hausmann calls the deposits beds; Daubrée segregations; and Durocher Fallbands. They strike parallel to the schist; and dip, like this, gently (about 10°) toward ENE.

In the Storvartz mine the deposit is 1—2 fathoms broad; and consists of nodular masses of ore; which are most frequent when the schist is chloritic, more rarely when it is quartzose and micaceous, most rarely in the garnetiferous schist. The ores also penetrate into the quartz-veins traversing the schist, are hence more recent than these, and, consequently, younger than the schist. Copper-pyrites occurs in the quartz-veins, but without iron-pyrites. The entire deposit varies between $^1/_2$ and 3 fathoms in breadth; and traces of the impregnation may be followed for a considerable distance from Sognefjord in Norway to Areskuttan in Sweden. Copper-pyrites is the principal ore, mingled with iron-pyrites, somewhat of pyrrhotine, blende, galena, quartz, chlorite, mica, talc, garnet, actinolith, grammatite, and amiantos.

Several similar deposits occur in the neighorhood.

Besides these copper-deposits, there are several of chromic iron associated with serpentine.

COPPER-DEPOSITS OF KAAFJORD AND RAIPAS IN NORWAY.

§ 245. Formerly copper-ores were exploited, and smelted,

[1] See: Hausmann's Reise d. Skandinavien, pt. V. p. 268; Durocher, in Annal. d. mines, IV. Ser. vol. XV; Duchanoy, in same, V. Ser. vol. V. p. 181.

at the 70° North latitude, around Kaafjord and Raipas[1] near Hammerfest.

The country consists of Silurian rocks overlying crystalline schists, which are intersected by greenstones (diorites and euphotides): thick beds of limestone occur to a subordinate degree.

The lodes at Kaafjord occur in a broad dike of diorite, which is about 5 miles long, and strikes N.—S. They course SW.—NE. and generally dip toward NW., more rarely toward SE. Their breadth varies between 1 and 15 feet. Netto states, that the matrix of these lodes is, for the most part, a breccia of quartz, calc-spar, iron- and copper-pyrites, united by finely comminuted and decomposed particles of diorite. Purer masses of quartz in the same occasionally contain specular iron, dendritic copper, and geodes of calc-spar. Iron-pyrites, containing selenium also occurs, and somewhat of blende at the Mühlstrom. According to Russegger, the lodes are traversed by quartz-veins, and are, like the diorite, much faulted. Ihle observed eighteen faults in a single shaft, and almost every where friction-surfaces in the fissures of the diorite.

The lode near Raipas occurs, according to Durocher, in a Silurian limestone-bed, 60 feet thick. The former dips vertically, and strikes NE.—SW., at right angles to the limestone, and is only metalliferous in this last; while, where penetrating the schists, it divides into barren clefts. The bed of limestone also contains layers of jaspery clay-slate, in which the lode is often but a cleft, while having a breadth of 8—10 feet in the limestone. Its matrix varies locally: Netto describes the following:

1. Fragments of quartz and clay-slate united by limestone containing copper-pyrites disseminated through it;

2. Red siliceous and yellow limestone, and brownish-red heavy spar, impregnated with copper-pyrites;

3. Fragments of quartz, limestone, and clay-slate, united by erubescite;

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[1] See: Russegger, in Karsten's Archiv, vol. XV. p. 759; Keilhau's Gaea Norwegica, 1844, p. 285; Ihle, in Leonhard's Jahrb. 1844, p. 369; Netto, in same, 1847, p. 143; Durocher, in Annal. d. min. IVth Series vol. XV.

4. Erubescite, with fragments of limestone, or yellow limestone containing erubescite. These are the richest points.

Sidebranches passing out of the champion-lode contain chalcedony, brownish-red heavy spar, and copper-pyrites; here and there with somewhat of erubescite, copper-glance, malachite, azurite, decomposed concretions of iron-pyrites, and traces of erythrine.

Russegger states, that the limestone is silicified near the lodes, and almost altered into hornstone.

COPPER-DEPOSITS AT FALUN (SWEDEN).

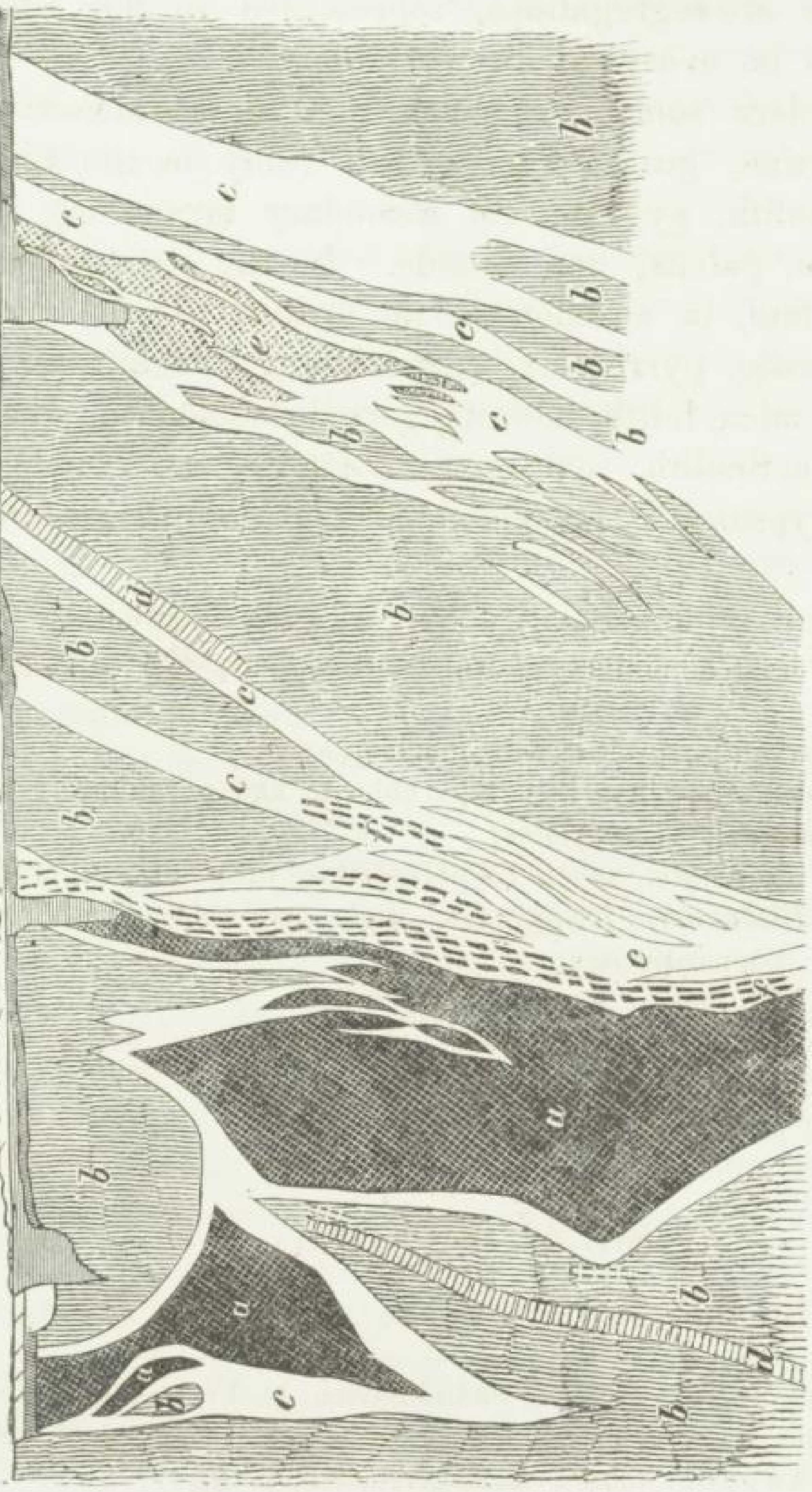
§ 246. The renowned segregations of copper-ores at Falun[1] are found in gray quartz occurring in thinly foliated mica-schist, which last is said to form but a subordinate layer in gneiss. These segregations are in part very broad, irregularly lenticular masses; which contract on all sides at some depth, and, in part, even wedge-out. The broadest and principal segregation of the Stor mine shows the following exploited dimensions (expressed in fathoms), determined by the limits of the quarry, which are exactly the limits of the deposit:

Depth below surface.	EW.	NS.	NW. SE.	NE. SW.
50	110	120	140	160
110	90	60	100	100
140	77	60	84	72
180	50	40	50	43

It appears from this, that the form of the segregation is an irregular semi-ellipsoidal; and Hausmann is inclined to believe, that there originally existed an upper portion, which has been destroyed and washed away with the enclosing rock: Stapff, that at other localities in Sweden, for example at Kafvelstorp in the parish of Nya Kopperberg, the upper portions of similar deposits have been distinctly polished by glacial

[1] See: Hausmann's Reise d. Skandin. pt. V. p. 55; Hisinger's Mineral. Geogr. v. Schweden, 1826, p. 36; Russegger, in Leonhard's Jahrb. 1841, p. 82; Stapff, in Berg- u. hüttenm. Zeit. 1861, p. 195; Tjäder, Karta öfver Fahlueller Stora Kopparbergs Gruvor. 1845; Durocher, in Annal. d. min. IV. ser. vol. XV.

action. This large mass of ore, in the Stor mine, is essentially composed of a mixture of quartz, iron- and copper-pyrites, traversed by talcose schist. The copper-pyrites is somewhat more common near the outer limits, than in the middle; and is occasionally combined with galena. Several smaller masses, of a similar character, occur alongside of this principal segregation; and they now form the chief object of exploitation. They are often intersected, in various directions, by peculiar layers of schist; which the miners call 'Skolars', and which are mostly composed of talcose and chloritic minerals. The breadth of these



a. and e. Ore-masses partly worked by quarries, at e. very quartzose; Tjäder calls this last deposit a conglomerate of quartz and pyrites. b. Mica-schist. c. Skolars, containing at f. nodular masses of limestone, indicated by thick black lines; the enclosed white portions in the middle Skolar are mica-schist, and should have been vertically shaded. d. A mixture of zeolith, quartz, and mica.

Skolars encreases from a few inches to twenty-four fathoms, generally between 1 and 11 fathoms. They strike and dip very irregularly, several of them uniting in their course and again separating; they occasionally contain small pockets or masses of ore: in some of the Skolars nodular masses and beds of limestone occur, whose influence on the ore-bearing character of the segregations is still undetermined.

The vertical section, copied from Tjäder, of the irregular relations of bedding and connections in the Drotting, Konung Fredrik, Adolph Fredrik, and Ulrica mines, represents an ideal view of the Southern portion of the already exploited deposit. The ore-segregations, represented in this section, do not appear to be every where workable.

The Skolars sometimes contain in their talcose, chloritic mass; serpentine, grammatite, garnet (only in the Erik Matts mine), automolith, gypsum (of secondary formation), iron and copper pyrites, galena, and blende. In the segregations there have been found, in addition to the principal ores mixed with quartz; marcasite, pyrrhotine, magnetite, automolith, serpentine, chlorite, talc, mica, iolith, falunite, garnet, malacolith, apophyllite, grammatite, actinolith, calc-spar, dolomite, andalusite, anhydrite, and gypsum. Hausmann also mentions goslarite and epsomite.

The Falun miners classify the ores, as follows:

I. Copper ores; admixtures of iron- and copper-pyrites with galena and blende:

1. *Hardmalm*, pyrites with much quartz;
2. *Segmalm*, pyrites with talc, chlorite and mica, rarely workable;
3. *Blötmalm*, pure pyrites;
   a. *Grönmalm*, much copper-pyrites, with but little iron-pyrites;
   b. *Blekmalm*, iron-pyrites, and pyrrhotine, with but little copper-pyrites;
   c. *Wendmalm*, pure copper-pyrites:

II. Silver ores; galena with but little pyrites and blende, containing traces of gold and selenium;

III. Pyrites; pure iron-pyrites.

SALA[1] (SWEDEN).

§ 247. In the district of the crystalline schists, mostly

[1] See: Hausmann's Reise d. Skandinavien, pt. IV. p. 268; Hisinger's mineral. geograph. Schwedens, p. 124; Durocher, in Annal. d. mines, IV. ser. vol. XV; Daubrée, Skand. Erzlagerstätten, p. 41.

gneiss, are found thick bedded masses of crystalline limestone; which, Hausmann states, partly pass into a felsite-schist, and are traversed by schistose layers (Skolars). Lead- and silver-deposits are found of a somewhat problematical nature.

Trap-dikes, a few inches broad, cut through the limestones, without appearing to affect the metalliferous contents. In addition to these, the limestone and trap are traversed by the Storgrufva vein, which, coursing NW.—SE. separates the limestone-masses into two portions. This vein, which is considered by some persons as belonging to the Skolars, is 10 to 12 fathoms broad at the surface, but soon decreases below to a few yards. Its matrix is principally composed of nodular masses of hard limestone mixed with serpentine; the interstices between which are grayish-green, foliated talc. The lode sometimes has selvages, consisting of talcose limestone, with actinolith, and grammatite.

The beds, or Skolars, traversing the limestone, consist chiefly of talcose minerals; talcose schist, foliated talc, and asbestos; associated with which are somewhat of quartz, calc-spar, malacolith, actinolith, amiantos, dolomite, galena, blende, iron-pyrites, and mispickel. These Skolars are of very variable breadth, and usually follow the general direction and inclination of the strata; but often differ from these, and split up into branches, which again unite.

The ores, of which argentiferous galena is the most important, are found in the limestone, and usually collected near the Skolars and the Storgrufva vein. There still appears to be some uncertainty about the manner in which the ores occur. Hausmann designates the deposits, as rich beds in crystalline limestone, which at times divide and diverge: Daubrée describes them, as indistinctly defined lodes, often serpentine in their course, which traverse the limestone almost at right angles to its strike: Durocher calls them ribbons, which are mostly vertical, and close to one another: Hisinger terms them metalliferous layers of limestone, mostly impregnated from the Storgrufva vein-fissure. As all these different views are the result of personal observations, it is impossible for non-observers to pronounce judgment.

Hisinger's description, of the mineral character of these deposits, seems to be the most reliable. Argentiferous galena is the principal ore, associated with which are, according to Hisinger; native silver (rarely on galena or serpentine), native antimony in limestone, stibnite (disseminated in galena), silver amalgam (very rare), cinnabar (very rare), blende, mispickel, iron-pyrites, pyrrhotine, argentiferous tetrahedrite, compact feldspar, black mica, chlorite, serpentine, talc, asbestos, actinolith, grammatite, sahlite, bredbergite (lime-garnet) implanted in galena, gypsum, calc-spar, dolomite, and heavy spar.

DEPOSITS AROUND PHILIPSTAD (SWEDEN).

§ 248. This portion of Wermland[1] consists of granitic gneiss, which passes into mica-schist, and contains beds of felsitic schist, dolomite, hornblende-schist, and chloritic schist. Several deposits of magnetic iron occur in these mica-schistose rocks; thus in the mines of Presberg, Age, Nordmarken, Taberget, and Langbanshytta; which course partly N.—S. partly SE.—NW. and attain a breadth of one to nine fathoms. These iron-deposits occur in the schist, and parallel to its course; they are accompanied by numerous minerals: thus at Persberget, by limestone, calc-spar, epidote, hornblende, asbestos, malacolith, soapstone, serpentine, garnet, compact feldspar, talc, quartz, iron-pyrites and bismuthine: in the Nordmark-mines, by argentiferous galena, blende, native silver, crystalline limestone, calc-spar, dolomite, mica, chlorite, garnet, serpentine, mountain-cork, epidote, actinolith, grammatite, hornblende, apatite, pyrosmalith, axinite, and apophyllite: in the Taberget mines, by blende, calc-spar, iron-pyrites, sphene, chondrodite, talc, dolomite, soapstone, asbestos, serpentine, chlorite, hornblende, epidote, actinolith, garnet, mica, compact feldspar, gadolinite (in gneiss alongside of the magnetic iron), malacolith, and fluor spar: in the Langbanshytta mines, where the deposits are enclosed in limestone or ferruginous and manganiferous dolomite, there occur specular iron, quartz, serpentine, mountain-cork, epidote, garnet, malacolith, dolomite, dialogite, aragonite, heulandite, calc-spar, gypsum, anthracite, asphalt, and iron-pyrites.

The recently observed occurrence of native lead, at Paisberg

[1] See: Hausmann's Reise d. Skandin. pt. V. p. 132; Hisinger's Mineral. geograph. v. Schweden, p. 165; Durocher, in Annal. d. mines, IV. ser. vol. XV; Igelström, in Berg- u. hüttenm. Zeit. 1866, p. 21.

(or *Pajsberg*) in Wermland, is of special interest. I therefore subjoin an extract from a memoir by Igelström: —

'At Paisberg there are ten mines worked on deposits of iron and manganese in crystalline dolomite: both kinds of ores are mixed in such a manner, that each can be extracted by itself; the iron-ore, for the production of iron; the manganese-ore, as flux in the blast-furnaces, so as to produce a good manganiferous iron.

The iron-ores of Paisberg consist, partly of magnetite, partly of specular iron: both of these ores are generally intermixed, the specular iron predominating.

The manganese-ore is hausmannite, first discovered (1866) three years ago. It is precisely like that found in Germany; and I have satisfied myself, by numerous analyses, that it really is hausmannite. I have, as yet, found this ore in but four localities in Sweden; viz. at Paisberg (in large quantities), at Nordmark, at Långbar, and in the parish of Grythyttan. The manner of occurrence is the same at all these localities, the hausmannite being found in crystalline dolomite. It would appear, as if the dolomite was an essential condition for the occurrence of the hausmannite, the latter having been sought for in vain in other rocks.

The hausmannite occurs in the dolomite, partly as scattered grains, which take an almost essential part in the composition of the rock, partly as granular masses: in this form it has been often mistaken by the miners for iron-ore.

The dolomites, so rich in hausmannite, form thick beds between the rocks containing iron-ores, which are here called '*halleflinta*' (felsite-schists). The dolomites are 20 to over 100 fathoms thick, and extend for a distance of over two miles. The hausmannite, together with the specular iron and magnetite, forms beds 6 to 18 feet thick, and 200 feet long, in the manganiferous dolomites. The grains of hausmannite do not occur every where in the latter, but in spots or belts within the strata, while the ore-beds show selvages. Braunite is occasionally found with the hausmannite, forming veins, strings, or beds, in the dolomite, as at Nordmark.

I considered these remarks necessary; as the native lead is only found with the hausmannite, and, therefore, the principal cause for the formation of the same is to be looked for in the hausmannite. This is the more obvious, if it be considered, that the native copper at Nordmark is also associated with the Hausmannite, and that the occurrence of both the native metals is under similar circumstances.

At Paisberg the native lead is only found within the bed of iron and manganese-ores, and not outside of this. The lead has filled all kinds of fissures, clefts, and other cavities in the bed, even such as intersect the crystallized rhodonite (paisbergite). Since the clefts and cracks, in which the lead occurs, are extremely fine, it can only be supposed that it has penetrated in vapor-form, or as an aqueous solution. Still some of the clefts filled with lead have a breadth of several lines.

The native lead occurs in almost all the ore-beds at Paisberg; it fills clefts or cracks in the manganese-ores, in the iron-ores, in the intermixture of heavy spar, rhodonite, and garnet, in the pyrochroite, in the serpentine, in the silicate of manganese containing oxide of lead, and in the dolomite, but in this last only within the ore-bed.

The lead forms thin cuticles or layers, thin foil-like plates or thicker sheets, upwards of $^1/_4$ inch thick. It appears filiform, as wire; and globular, acicular, or like a galvanized incrustation on crystals of paisbergite. It commonly appears white, like a fresh surface of metal, very soft and ductile, so that it can be scratched with the finger nail. Thicker sheets of the same are sometimes oxidized at the surface, being altered into cerusite and minium. According to my analysis, and one made by Prof. Nordenskjöld, it is very pure, and contains but 2 per cent of impurities.

As I have already remarked, the native copper at Nordmark occurs in an entirely similar manner; it forms sheets and wires weighing upwards of 900 grammes; while the largest piece of lead found, weighed but 50 grammes. At Nordmark, galvanic action, so to speak, can also be recognised; thus mica occurring in the metalliferous limestone is often found to be as beautifully encrusted with copper, as if it had been done artificially.

I consider a detailed description of the occurrence of native lead at Paisberg, as very difficult. It appears to me, however, certain, that the hausmannite was the real and principal cause for the same. The salts of the protoxide and sequioxide, or even of the protoxide alone, have had a reducing influence.

The material, for the deposit of native lead, possibly came from galena; this last is found but very rarely at Paisberg.'

MAGNETITE DEPOSITS AT DANNEMORA (SWEDEN).

§ 249. The predominating rock around Dannemora[1] is coarsely foliated gneiss passing into granite. The former contains, on the banks of the Dannemora, Gruf, and Film lakes, a broad belt of felsitic schist together with subordinate layers of chloritic schist, granular limestone, and magnetite.

The renowned and very thick deposits of magnetite at Dannemora consist, according to Erdmann's description, of separate lenticular masses of various sizes; which are partly in rows, partly parallel to one another, and in this manner form a segregated whole; whose principal course, like that of the surrounding rocks (chloritic schist, limestone, and felsitic schist), varies between N.—S. and SW.—NE., and dips 65°—80° in W.

The large quarry, in which the deposit is worked, has attained a depth of over 400 feet; and the thickness of the chief lenticular mass is, according to Hausmann's statement, 180 feet in the centre, but narrows in both directions of strike: its length is over a mile at the outcrop. This colossal mass essentially consists of fine-grained magnetite, with intimate and slight mixtures of chlorite, somewhat of calc-spar and brown spar, which can only be recognised in places; it is the purest in the middle. The pure masses of ore are cut through by some beds of chloritic schist (Skolars), which attain a breadth of 14 feet, and mostly dip in S. hence they are not parallel to the deposits. The ore-masses are also intersected by some narrow veins containing calc-spar and brown spar.

There have been found, as rarer admixtures, particularly near the limits, or at the outcrop; iron and copper pyrites, mispickel, galena, garnet, quartz (whose crystals sometimes contain small pieces of mineral pitch), anthracite, actinolith, grammatite, and heavy spar, which last is very rare in other parts of Sweden.

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[1] See: Hausmann's Reise d. Skand. pt IV., p. 69; Hisinger's Mineral. geogr. von Schweden, p. 107; Erdmann's Dannemora Jermalmsfält, 1851; Durocher, in Annal. d. mines, IV. ser. vol. XV.

ORE-DEPOSITS OF TUNABERG (SWEDEN).

§ 250. The district around Tunaberg [1] is, for the most part, composed of gray and red gneiss. The first contains numerous subordinate beds of granular limestone, dolomite, and eulisite;[2] but both varieties are cut through in many places by granite.

Numerous segregated deposits occur in the gray gneiss district, partly in the crystalline limestone, partly at the junctions of the same with the gray gneiss; of which, according to Erdmann (1848), 22 were exploited. The same are principally composed of limestone, with admixtures of hornblende, mica, and serpentine; and have a very heterogeneous composition; from them lead, silver, copper and cobalt ores are obtained. Copper-pyrites and cobaltine, are the principal ores obtained. Erdmann found, in addition to the preceding, the following ores and minerals; galena, erubescite, copper-glance, pyrrhotine, molybdenite, smaltine, iron-pyrites, native bismuth, blende, amphodelite, anorthite, apatite, calc-spar, chlorite, chondrodite, coccolith, diallage, epidote, garnet, graphite, hedenbergite, hisingerite, hornblende, iolith, labradorite, malacolith, oligoclase, olivine, orthite, orthoclase, polyargite, pyrargillite, pyrorthite, quartz, scapolith, serpentine, sphene, spinel, and tourmaline.

These minerals do not all occur in the same deposit; but some in one, some in another. Svanberg noticed, that the crystals of cobaltine, implanted in copper-pyrites, are very free from impurities; while those found in the limestone, contain a kernel of smaltine. The conditions of bedding, and the junctions of these deposits, are very peculiar. They often contain and enclose fragments of the adjoining rocks, not only of the limestone and gneiss, but also of the granite; which intersects the gneiss and limestone in dikes, but does not penetrate into the ore-deposits. These last have at times penetrated into the fissures of their wall-rock, and even into the granite-dikes. Erdmann has given interesting drawings of these. The following is a copy of the horizontal and vertical sections of Tunabergska mine.

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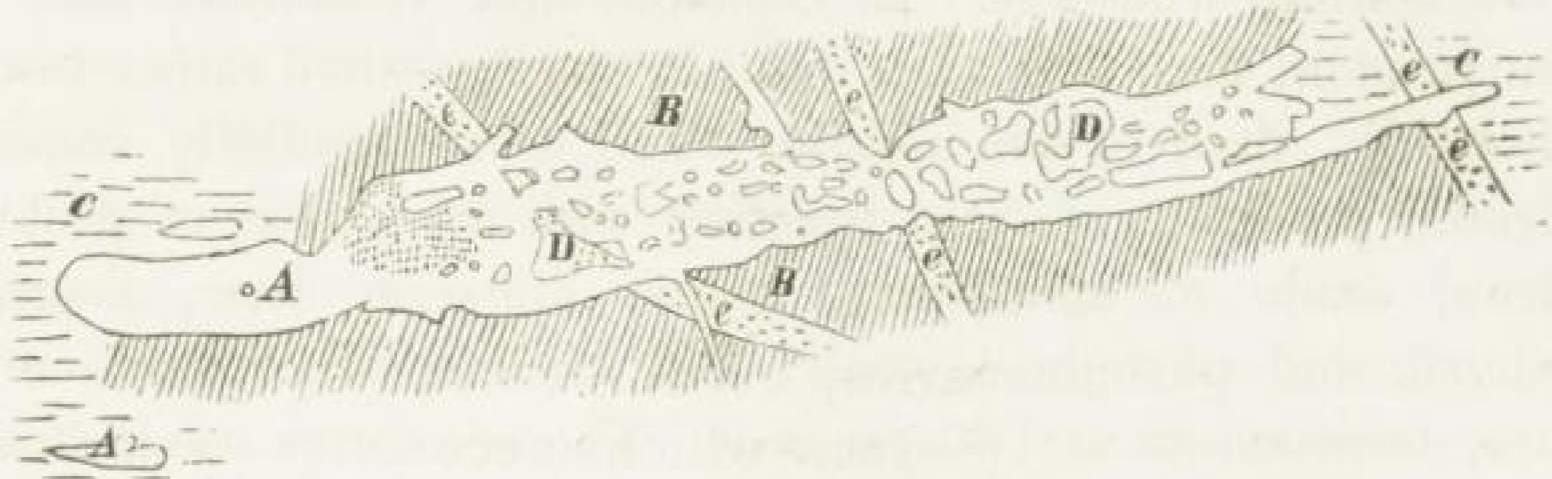
[1] See: Erdmann's Beskrifning öfver Tunabergs Socken, 1849, and in Berg- u. hüttenm. Zeit. 1850, p. 631; Hisinger's Mineral geogr. v. Schweden, p. 97; Durocher, in Annal. d. mines, IV. ser. vol. XV.

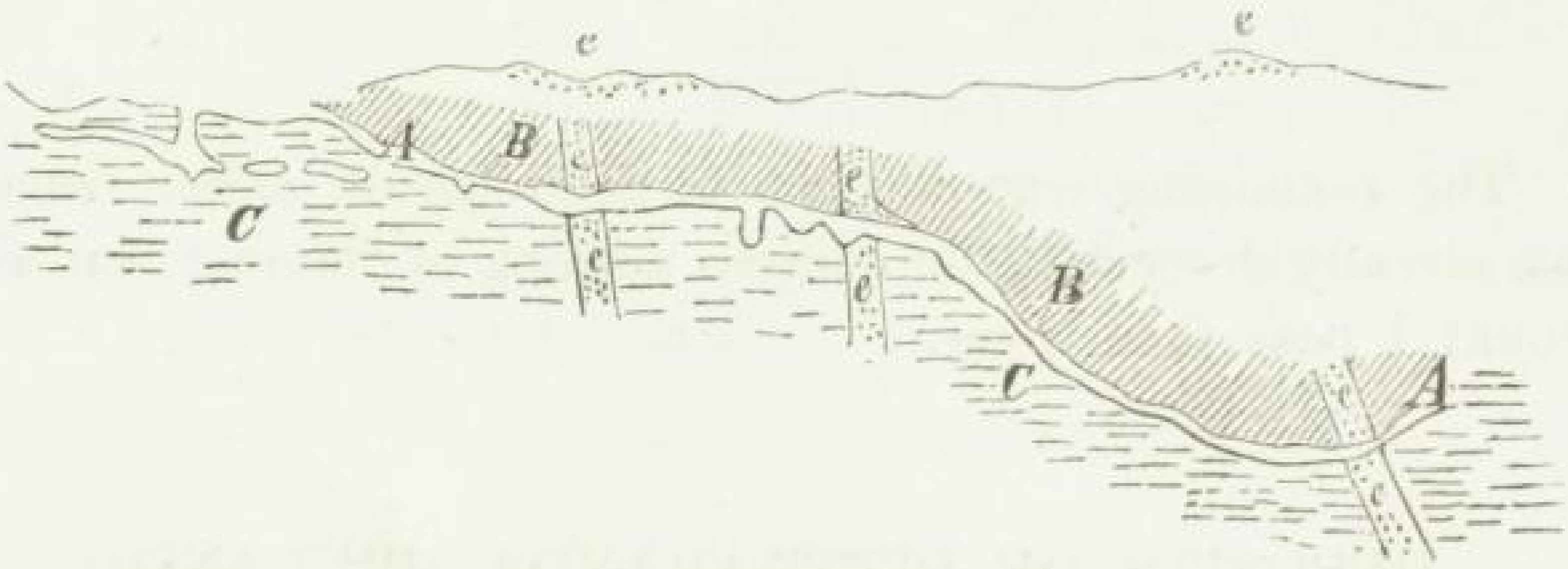
[2] Eulisite is the name given by A. Erdmann to a compound composed of protoxide of iron, resembling olivine, green pyroxene, and brownish-red garnet; it occurs, as a thick bed, in the gneiss of Tunaberg.

Ground plan.



A. The ore-deposit containing numerous fragments of lime-
stone, gneiss, and granite D.
B. Gneiss, forming the hanging-wall.
C. Limestone, forming the foot-wall.
D. Fragments in the deposit.
e. Granite-dikes.

Vertical plan of the same mine.



It is curious, that the enclosed fragments of granite mostly lie in the prolongations of the interrupted veins; and that even a fragment of limestone, traversed by a granite-dike, occurs in the prolongation of the first granite-dike on the left-hand side. It almost seems from this, as if the fragments were not really such, that is, not formed by energetic action, but by a gradual change of position. Even if a partial solution is just as imaginable here, as in the calamine-deposits of Silesia or Westphalia; the same fluid could scarcely be regarded as the solvent of the gneiss and granite.

The deposits of Hakansboda in Westermanland resemble, to some extent, those of Tunaberg.

THE LAKE- AND BOG-ORES OF SWEDEN.

§ 251. Many lakes and morasses of Sweden contain iron-ores, which have been formed in the most recent geological period, or are still forming.[1] The formation of the lake-ores (Sjömalm) is very interesting, in so far as they exhibit a great analogy to the oolithic iron-ores. In Smaland and Wermland such ores occur in more than 200 lakes, but always deposited rather towards their banks, than in the middle. The ores essentially consist of hydrated peroxide of iron, together with somewhat of protoxide of iron, oxide of manganese, silica, alumina, lime, magnesia, sulphuric and phosphoric acid. The amount of peroxide of iron varies, between 35 and 60 per cent. The ore forms small rounded grains, which according to their more pulverulent, pea-like, bean-like, lenticular, or reniform shape, are called '*Krutmalm, Pälemalm, Penningemalm, Straggmalm*, or *Purlmalm*.'

Hausmann thinks, that the iron in most of these deposits originated from decomposed iron-pyrites in greenstones; and considers it probable, that many of the ores in the lakes have been formed by the decomposition of neighboring bog-ores.

The remaining iron-deposits of Scandinavia either resemble those already described, or contain nothing of interest; on which account I pass them over.

DEPOSITS OF PITTKARANDA (FINLAND).

§ 252. The northern bank of Lake Ladoga is, for the most part, composed of granite, containing here and there deposits of crystalline schists; which occur in irregular belts, and are frequently cut through by more recent granite-dikes. The ore-deposit of Pittkaranda[2] appears to occur joined to such a belt of hornblendic schist, which has been exploited for a length of 1150 fathoms, and can be traced for a still greater distance. It consists of a number of different beds, distinctly separated from one another. Böbert calls the deposit a Fallband. Its principal mass seems to consist of malacolith, epidote, and compact chlorite. The chief ore is copper-pyrites, with which somewhat

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[1] See: Hausmann's Reise d. Skandinavien, pt. I. p. 152; Stapff, in Berg- u. hüttenm. Zeit. 1866, p. 72.

[2] See: Pusch, in Karsten's Archiv, and in Leonhard's Jahrb. 1836, p. 195; Durocher, in Annal. d. mines, IV. ser. vol. XV; Von Helmersen's das Plorezer Bergrevier, 1861.

of cassiterite often occurs, sporadically distributed. The latter ore also appears to be distributed (imperceptible to the eye) throughout the whole mass of the bed; and when crystallized only occurs in simple crystals. Besides the above, the following ores and minerals have been found; iron-pyrites, pyrrhotine, magnetite, galena, blende, wolfram, somewhat of molybdenite, heavy spar, garnet, actinolith, hornblende, quartz, mica, feldspar, fluor spar, and calc-spar. The form of this deposit is that of a parallel embedded layer; but, from the very unequal distribution of the ores in it, from the complex composition, as well as from the occurrence of distinct veins of a similar nature; it would appear to be a bedded lode, similar to the deposits at Breitenbrunn in the Erzgebirge (§ 85). The unequal distribution of the ores occurs in such a manner, that richer workable belts can be distinguished in the entire deposit; these dip, at a gentle angle, from East to West, and recur in this manner parallel to each other. The entire deposit strikes E.—W., and dips 25°—45° toward S. Blöde compares this deposit to that of Oryärfvi in Finland. This comparison is incorrect, since at Oryärfvi a thick segregration of quartz, within crystalline schists, contains pockets of cupriferous pyrites.

THE URAL MOUNTAINS.

GEOLOGICAL FORMATION.

§ 253. The Ural Mountains, extending over 20 degrees of latitude, form the natural eastern boundary of Europe. Their interior formation corresponds to this prominent trend; the limits of the rocks, their stratification, and even the great majority of the lodes, having a N.—S. course.

The geological formation of this long mountain-chain is a very regular, almost symmetrical one. Crystalline schists, and granitic rocks, form the central axis. Mica-schist, chlorite schist, and talc-schist, must be particularly mentioned, as belonging to the former, together with subordinate strata of gneiss, hornblende-schist, crystalline limestone, etc. Outside and next to this crystalline axis, which often forms the highest crest, are found siliceous schists, and jaspery rocks; over which lie, on both mountain slopes, Silurian strata which are particularly rich in limestones in their upper layers. Devonian rocks overlie these, chiefly on the Western slope; while on both sides are found thick strata of the Carboniferous Age, particularly such as correspond to the Subcarboniferous. Thus far the formation of the chain is symmetrical; and, although, in Murchison's map, the succession of metamorphic and sedimentary rocks is much thicker and more completely developed on the West side of the crest, than on the more precipitous Eastern slope; still the more recent examinations, of Antipoff and Meglizky, have shown, that strata of the Silurian, Devonian, and Carboniferous periods, are not wanting.

A wide district of thick Permian rocks overlies the Carboniferous strata of the Western slope, forming a hilly foreground; while eastwardly the Carboniferous, or still older, strata are overlaid by Tertiary or Post-Tertiary deposits, extending over the immense Siberian Steppes, and from beneath which the older rocks occasionally crop-out. Hence it would appear, as if the Ural Mts. formed even in the Permian period a watershed, though much lower than at present, and separated two great marine districts.

The igneous rocks are less evenly distributed than the sedimentary, although their distribution usually corresponds to the general trend of the chain. They chiefly occur on the Eastern slope; and appear, alternating with crystalline and old sedimentary strata, to form for a considerable distance the base, on which rest the Tertiary and Post-Tertiary deposits. The principal igneous rocks are; granite, syenite, various porphyries, diorite, and serpentine.

Cretaceous strata occur in the Southern portion of the chain, but only to a slight degree; and they are found overlapping the older rocks.

A large number of quartz-veins, often very broad, occur on the Southern East slope; these sometimes contain gold, and sometimes project over the more easily destructible rocks, like walls; their general direction is N.—S.

Of the great number of metalliferous deposits existing in the Urals, I shall only describe the following, as being the most important and interesting:

1. Copper-deposits at Gumeschewskoi, Bogoslowsk, and in the Permian formation;

2. Gold and platinum deposits at numerous localities, especially at Beresof, Katharinenberg, Nijny Tagilsk, Bisersk, and Miask.

COPPER-DEPOSITS OF GUMESCHEWSKOI.

§ 254. The peculiar geological conditions, under which the copper-ores occur at Bogoslowsk, and Nijny Tagilsk, are repeated at several points in the middle and Southern Urals, so that a great uniformity and agreement can be proved as regards the copper-formation in the Urals. In addition to other deposits, as yet but little examined, are the renowned copper-deposits of Gumeschewskoi[1] and Soimanowsk.

The well known mine of Gumeschewskoi, 35 miles South of Katharinenberg, occurs in a valley on the western side of the Urals, but near its crest. This valley is parallel to the trend of the mountain-chain, about $2^1/_2$ miles broad; and its slopes consist of metamorphic schists, with serpentine. There is a broad zone of crystalline, and compact limestone, at the bottom of this valley, which is traversed through the middle, in the direction of its course, by a dike of diorite, frequently associated with garnet-rock. This dike dips 40°—50° in E., has a very variable breadth, and has been opened for a length of about 350 fathoms by mining operations; still traces of the same have been followed for more than 1200 fathoms. In its known length this does not come into direct contact with the limestone traversed, but is separated on both sides, like the dike of diorite at Nijne Tagilsk, by a broad deposit of ochre-yellow, ferruginous clay, 90—120 fathoms broad at the surface, which decreases with the depth. The dike, itself, often contains, where still undecomposed and fresh, large and small pockets of a mixture of iron- and copper-pyrites, containing but little copper. In the upper portions, where a partial decomposition of the rock has taken place, oxydized copper-ores are found; particularly malachite, chrysocolla, and red copper; more rarely azurite and brochantite. These ores most frequently occur, in considerable

[1] See: G. Rose's Reise n. d. Ural, 1842, vol. I. p. 242; Müller, in Berg- u. hüttenm. Zeit. 1866, p. 252.

quantities, within the adjoining clays, especially collected, at the junctions of these with the limestone, in the hanging- and foot-wall of the diorite-dike. As yet only the oxidized ores have been extracted, while no attention has been paid to the sulphurets. Malachite has occasionally occurred, at this locality, in very large and beautiful masses: among others a block of malachite weighing about 60 hundredweight was found at a depth of 21 fathoms: limonite and clay-ironstone are the usual gang-stones to the copper-ores in the clays; less frequently quartz, hornstone, and jasper: the ores obtained average 3—4 per cent of copper.

COPPER-DEPOSITS OF BOGOSLOWSK.

§ 255. The copper-mines of Bogoslowsk[1] occur about 110 miles north of Nijny-Turinsk, and 33 miles from the Ural Mts.

Diorite and diorite-porphyry predominate in the neighborhood of these mines: there are also some insulated masses of limestone, which must be regarded as fragments of the Upper Silurian (according to Murchison, Devonian) strata. These last have been torn off by the crystalline rocks mentioned, surrounded by them, or traversed by dikes upwards of 50 fathoms broad. The diorite-porphyries traverse all these rocks, and appear to be even more recent than the dikes.

The lithological character of the diorite is very variable: feldspar, or hornblende, locally predominates in the homogeneous matrix; the rock occurs compact, or striped from the parallel arrangement of the minerals. The limestones are partly crystalline and white, partly gray and compact; they occasionally contain fossils. In addition to the preceding, there is also garnet-rock, which is, perhaps, to be regarded, as the consequence of metamorphic action.

The copper-deposits, of importance in mining, occur developed at the junctions of the various rocks; they have a general course of NNW.—SSE., parallel to the axis of the Urals; and

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[1] See: G. Rose's Reise n. d. Ural, I. p. 381; Beger, in Gornoi Journal, 1826, pt. II. p. 3; Protassoff, in same, 1830, pt. III. p. 75; Erman, in Archiv f. wissensch. Kunde Russland's, 1850, vol. VIII. p. 380; Von Helmersen, in Leonhard's Jahrb. 1860, p. 573; Müller, in Berg- u. hüttenm. Zeit. 1866, p. 160; Murchison's Russia and the Ural Mts.

occur, either at the junction of diorite with diorite-porphyry, or between diorite and limestone, or between diorite and garnet-rock. The ore-deposits, following the contours of these rock-junctions, appear either as veins or beds, or they are segregated in form, and to be compared to pockets branching out of one another.

The chief ore is copper-pyrites, partly in large pure masses, partly finely disseminated and mixed with calc-spar, garnet, actinolith, and quartz. In addition to copper-pyrites, there also occur; copper-glance, erubescite, and tetrahedrite; and in the upper workings red copper, malachite, azurite, chrysocolla, and native copper. Iron-pyrites is the most regular associate of the copper-ores; it is so predominant in places, that the deposit is then more correctly a cupriferous mass of iron-pyrites. Magnetite is also present.

The oxydized ores greatly predominate in the upper levels, accompanied by limonite, stilpnosiderite, and iron ochre; while the diorite is often, particularly in the immediate neighborhood of the ores, decomposed to clay.

Pure copper-pyrites occurs but rarely for several consecutive cubic fathoms: it is more commonly found in pockets, or finely disseminated.

COPPER-DEPOSITS OF THE PERMIAN FORMATION.

§ 256. The Permian formation, thus named by Murchison from the Government of Perm, occupies a large area, on the west side of the Ural chain, about twice as large as France. This formation corresponds in age to the German *Zechstein* and *Rothliegendes*, or the interval between Carboniferous and Triassic. Its lithological character is, however, entirely different from that of the contemporaneous strata in Germany; and even the fossils found in them vary much, although agreeing in general character, and some of the species found are identical.

The lithological composition, or succession of strata in the Permian formation, does not remain precisely the same within the large area they cover. In many localities near the Urals, copper-ores occur in the lower strata of this formation.

The chief subdivisions of this formation are, according to Stchurowski and Von Qualen, the following:

1. Upper Division; not thick, often forming elevated

plateaux, consisting of marly, tufa, siliceous, or chalky limestones: without copper-ores, and almost barren of fossils: probably corresponding in age to the German *Zechstein* formation:

2. Middle Division; chiefly consisting of thinly stratified clay, and sandy marl; with subordinate beds of limestone, marl shale, variegated marl, gypseous marl, sandstone, and bituminous shale: these beds contain but few copper-ores, and numerous fossils about equivalent to those in the *Zechstein* formation:

3. Lower Division; it is composed of red, brown, and gray sandstone, brown argillaceous marl, marl-shale, limestone, and conglomerate; with thin beds of bituminous shale, or thick masses of gypsum and rock-salt: this subdivision contains many copper-ores and numerous fossils, particularly in the sandstones and marl-shales near the Urals: the fossils in part correspond to those of the German *Rothliegendes* formation; they are remains not only of land-plants but also of sea-shells and Saurians: some of the fossil plants, particularly the Calamites, bear a considerable similarity to those of the older Carboniferous or Subcarboniferous formation of Western Europe.

It appears, from the above, that the copper-ores of the Permian essentially occupy a much lower horizon (in older strata), than that in which the copper-slates of Thuringia occur. Their manner of distribution is also different, they form separate concretions, and are usually associated with sandstones, hence called copper-sandstones: the geological horizon in which these copper-ores occur can be better compared to that of the copper-ore impregnations in the *Rothliegendes* of Bohemia (§ 143, 145) than to that of the Thuringian copper slates.

The character of these ore-deposits can be best shown by concise descriptions of some of the localities: I follow, for the most part, Murchison's description.

1. In the neighborhood of Yugofski and Motovilika, the strata, which are pierced by shafts 35 to 100 feet deep, consist of thick, flaglike grits of gray and dingy color, rarely ferruginous, sometimes of a greenish hue, and occasionally slightly calcareous, with layers of red and gray ribboned marl and shale. The ores of copper are disseminated through all the beds; but in this district the sandstones are most cupriferous: the ores are principally malachite, also red copper, copper-pyrites, tetrahedrite, and azurite. Plants of various species occur, and in some of the lower strata they are so numerous, as to have given rise

to thin seams of coal, exceptionally 2—3 feet thick. Concretions, often cupriferous, occur here and there; and they have been generally formed around carbonized stems of plants. Besides the copper-ores described by Murchison[1] Planer mentions volborthite, as being very common in the cupriferous sandstone, it partly occurs in the green coloring matter, partly in dendritic forms within the joints of the grit: copper-glance and vanadinite are more rarely found. All the strata mentioned are horizontal, and consist, in ascending, order, of;

1. gray and dark-colored shale, with plants and coal,
2. gray sandstone and ribboned shale,
3. red and greenish shales, and
4. argillaceous marl.

II. The intimate connection of copper-ore with the fossil vegetation is most instructively displayed at the mines of Klutchefski[2] near Biebelei, and at Kargala in the Steppes north of Orenburg: so general in fact is the connection of fossil-wood and copper-ore, that the discovery of the outcrop of the silicified trunk of a tree often induces the miner to follow it into the rock, and thereby to detect valuable cupriferous masses: sometimes the copper-ore interlaces with all the fibres of the silicified wood; at other times it is continuous through a mass of leaves, matted in sand, sandstone, or marl; and thus a small nucleus of vegetable matter has often proved a source of considerable wealth. Where the copper-ore permeates the coaly fibre, it is usually as azurite. As a general rule it may be said, that the sandstone and shale beds, in which plants occur, are the great matrix of the copper-ore; and that this is much more rarely found in the white and green marls—never indeed in the same quantity, and never, so far as is known, in the pure limestone.

III. Between the Ik and Bugulma[3] occur copper-grits and sandstones beneath white and yellow limestones, containing corals and minute fossils, which are referred to Cytherinæ.

4. In receding from the Ural chain, from Perm[4] to Kazan,

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[1] See Murchison's Russia in Europe and Ural Mts. 1845, p. 144.
[2] See the same, p. 154.
[3] See the same, p. 156.
[4] See the same, p. 160.

occurs a great cupriferous region, the western limits of which are about 66 miles, east of the latter city.

The portion of the Permian strata, which is cupriferous, extends for a distance of only 265 to 330 miles to the west of the Ural chain. In all the Permian tracts, more distant from these mountains, no trace of copper-ore is to be found. These circumstances alone would naturally lead to the belief, that the Ural mountains had afforded the sources, from whence the mineral matter proceeded.

The Ural chain was in remote periods the seat of intense metamorphism, during which copper-ores were abundantly formed in the older palæozoic rock. Hence Murchison is led to conclude, that such may have had some connection with the deposit of the adjacent copper sands and marls: not that they were formed by the erosion of pre-existing copper-lodes, and by the dissemination of their particles in the adjoining sea; for in no place do fragments occur indicating such an event: the fact being that beds composed of similar materials are so impregnated with the mineral in one spot, and so void of it in a contiguous locality, as to exclude the hypothesis, that this locally saturated mineral condition can have resulted from the grinding down of the detritus of other cupriferous rocks. Murchison is therefore inclined to the belief, that, when the Permian deposits were accumulating in the adjacent sea, springs charged with salts of copper were flowing into it from the neighboring Ural chain, then undergoing a peculiar change of composition; and that such springs deposited the greater part of their metallic contents in those portions of the bottom of the sea, which afforded them the strongest points of attraction. In support of this view, he cites the case of a peat-bog in Wales, whose ash was found to contain considerable copper. This explanation has much in its favor; but the question might be asked, whether an impregnation were not possible in this manner, subsequent to the deposit of the strata, as is the case in Bohemia.

DEPOSITS OF GOLD AND PLATINUM IN THE URALS.

§ 257. Gold has been found in rock, in but few localities in the Urals,[1] platinum not at all. Gold is at the present time

[1] See: Liboschitz, in Gilbert's Annal. d Physik, 1823, vol. XIV. p. 429; Somoinoff, and Fuchs, in same, vol. XV. p. 226; Von Engelhardt,

obtained from deposits in place, at Beresof alone, while platinum is only obtained from alluvial deposits. These two metals occur, partly together, partly separated, at numerous localities on both slopes of the Urals, principally the eastern flank of this long mountain-chain, in alluvium-deposits, the washing of which is in places very remunerative. The nature of these alluvium-deposits, or placers, is notwithstanding certain common lineaments, by no means a conformable one, as can best be seen from the description of some cases.

I preface such a description, by the enumeration of some of the principal localities, where gold and platinum are obtained in the Urals. The majority of these are washings, and lie on the eastern slope, or base, of the mountains. Passing northwardly they occur at the following places:

1. On the river Tanalyk which empties into the Ural at Tanalysk;
2. Placers, at numerous localities, on the Steppes east of the southern end of the mountains, in the basin of the Tobol, where auriferous quartz-masses crop-out here and there;
3. At the upper portion of the Kizil and Zangelka, and on the Mindyak, rivers;
4. In the district west of Kuizokowa;
5. At Soimonowsk;
6. In a district southerly of Miask;
7. On the Kyalim near Kavassi;
8. On the tributaries of Lake Uveldi, east of Kischlinsk;
9. Above Elisawetsk, southerly of Ekatharinenburg;
10. Near Beresof, northeast of Ekatharinenburg;
11. Above Mostowsk north of Ekatharinenburg;

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d. Lagerstätten d. Goldes u. Platins im Ural, 1828; Hoffmann and v. Helmersen, geogr. Untersuchungen d. Süd-Ural-Gebirges, 1831, p. 70; Rose's Reise n. d. Ural, I. pp. 152, 175, 227, 252, 281, 303; II. pp. 20, 386, 402, 583; Erman, Archiv. f. wissensch. Kunde v. Russland, 1843, vol. III. p. 120; 1849, vol. VII. p. 34; 1851, vol. IX. p. 183, 538; Zerrener's Anleitung z. Gold-, Platin- u. Diamanten-Waschen, 1851; Ssablin, in Berg- u. hüttenm. Zeit. 1852, p. 529; Cotta, in same, 1860, p. 495; Breithaupt, in Cotta's Gangstudien, vol. II. p. 114; Nebolsin: hist. Uebersicht d. Goldwaschversuche im russ. Asien; de Marni, in Bergwerksfreund, 1857, vol. XXI. p. 96; de Teploff, in bulletin d. l. soc. géol. d. France, 1833, vol. IV. p. 371; Murchison's Russia in Europe, etc. and Siluria, 1854, pp. 431, 436.

12. In the neighborhood of Nijny Tagilsk;
13. Southeast of Blagodat, near Turinsk;
14. West of Nijny Turinsk;
15. At Bisersk, and Krestowosdwischensk, on the west slope of the central chain;
16. At Peschanka near Bogoslowsk; and
17. North of Petro-Pawlowsk.

Platinum is common only at Nijny Tagilsk, and there with scarcely any gold; it occurs less frequently in the gold-washings at Bisersk, and Bilimbayewsk, on the west side of the mountains; as well as at Bogoslowsk, Kuschwinsk, Newyansk, Wereh-Yssetzk, Kischtimsk, and Miask, on the east side. Platinum sometimes occurs in the washings of Nijny Tagilsk, associated with chromic iron in serpentine fragments; and since serpentine is also known to be present near most of the other platinum washings, it appears, as if this were the rock, in which this metal is present in the Urals.

GOLD-DEPOSITS AT BERESOF.

§ 258. Beresof[1] lies ten miles NE. of Katharinenburg in an undulating wooded district.

A broad belt of fine grained granite cuts through the zone of crystalline schists (chlorite, talc, quartz, and clay-slates) forming the Urals. The broad belt of granite is supplanted, near this mining village, by dikes of a very fine grained granite. These dikes are important, as containing gold. The separate dikes are 3—25, mostly 10—15 fathoms broad, are usually vertical and often split into branches in their direction of strike, which is parallel to the mountain-chain. They consist, especially in contact with the lodes, of a rock containing iron-pyrites, altered and decomposed to limonite, a variety of granite which has been called Beresite.

At right angles to these beresites, occur innumerable quartz-veins, 1—15—36 inches broad; which are sometimes found so close together, that two or three of them occur within a length of one fathom in the beresites.

The quartz-veins are the ore-carriers proper of the gold;

[1] See: Müller, in Berg- u. hüttenm. Zeit. 1866, p. 108.

and even though they are as a rule only found to be metalliferous and exploitable within the beresites, they often extend into the schists. The ores are native gold, and iron-pyrites; which last is often altered to limonite, and occurs particularly at the selvages of the quartz-veins, and is somewhat auriferous in this, as in the undecomposed state. Besides these, there occur, in small pockets, and irregular aggregations; copper-pyrites, argentiferous galena, and tetrahedrite; also phoenicite, jossaite, vauquelinite, cerusite, pyromorphite, and bismuth ochre. Tourmaline, talc, pyrophyllite, and dolomite, are the veinstones. The mines have at present attained a depth of 12, to at the most 24, fathoms; the granite is said to be harder, and the percentage of gold smaller, in the lower workings.

Müller thinks, these lodes must be regarded as veins of secretion. The quartz is then derived from the granite, the gold from the crystalline schists; which is the more probable, as the chlorite schist of the Urals is often somewhat auriferous, and beds of serpentine often occur, in the crystalline schists of these mountains, also containing a little gold. The chrome of the fuchsite observed in the wall-rock is also favorable to the hypothesis, that certain elements have penetrated from the wall-rock; since the chromic acid, becoming free by decomposition of the fuchsite, gave rise to the formation of phoenicite, jossaite, and vauquelinite.

In general, these gold-deposits of Beresof are rather poor, and their exploitation has been stopped since 1860, as the working of the placers is much more profitable.

It is supposed, that the richest upper portion of these lodes has been destroyed and re-deposited in the placers which occur at Beresof, partly at outcrop of the deposits *in sitú*, partly near other rocks.

The most important of these placers in the neighborhood of Beresof are, according to G. Rose, the following:

1. The placer of Petro-Pawlowsk occurs in a flat basin, immediately on the outcrop of the auriferous quartz-veins; but is by no means generally the richest over these, being rather poorer than usual: it consists of a clayey mass containing fragments of quartz, chlorite schist, talc-schist, granite, and crystals of specular iron, magnetite, garnet and zircon: the stratum, washed for gold, is 9—18 inches thick:

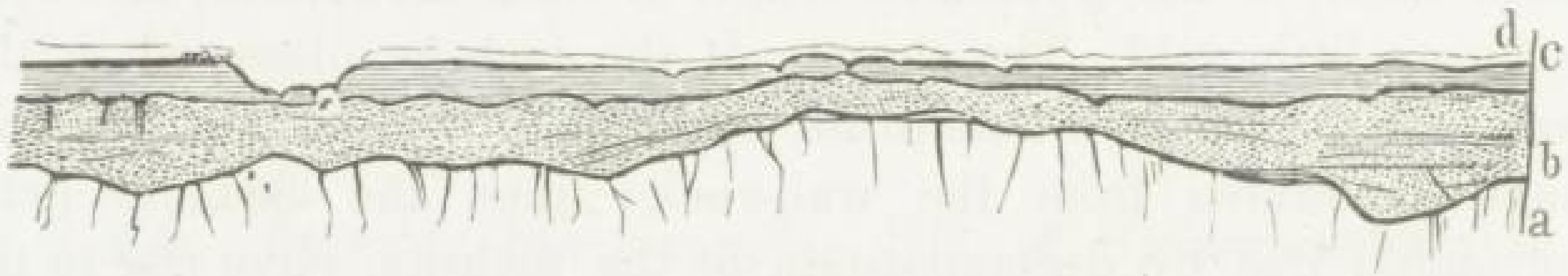
2. The placer of Marienskoi lies on euphotide: the stratum is 5 feet thick, of which but 1—1½ feet contain gold enough

to be worked: the clayey mass contains fragments of euphotide, clay-slate, and chlorite schist, as well as crystals of the above-mentioned minerals:

3. The placer of Nagorni overlies clay-slate: the clayey mass is about 14 feet thick, but only the lower stratum, 1—3½ feet thick, is washed for gold: it contains pebbles of talcose schist, and limonite; also crystals of pyrolusite, and specular iron:

4. The placer of Klerowskoi is covered by peat: since the upper stratum only contains sufficient gold to be washed, the lower beds have not been opened: pebbles of talc-schist, quartz, chlorite schist, and crystals of specular iron, magnetite, decomposed iron-pyrites, garnet, and zircon, occur in the placer:

5. The placer of Kalinowskoi lies on serpentine, which is cut through by granite dikes: of the 5—11 feet thick clayey mass, only the lower 1—2 feet are workable.



a. Beresite containing gold quartz-veins.
b. Auriferous detritus containing remains of mammoth.
c. Overlying clay.
d. Humus and bog.

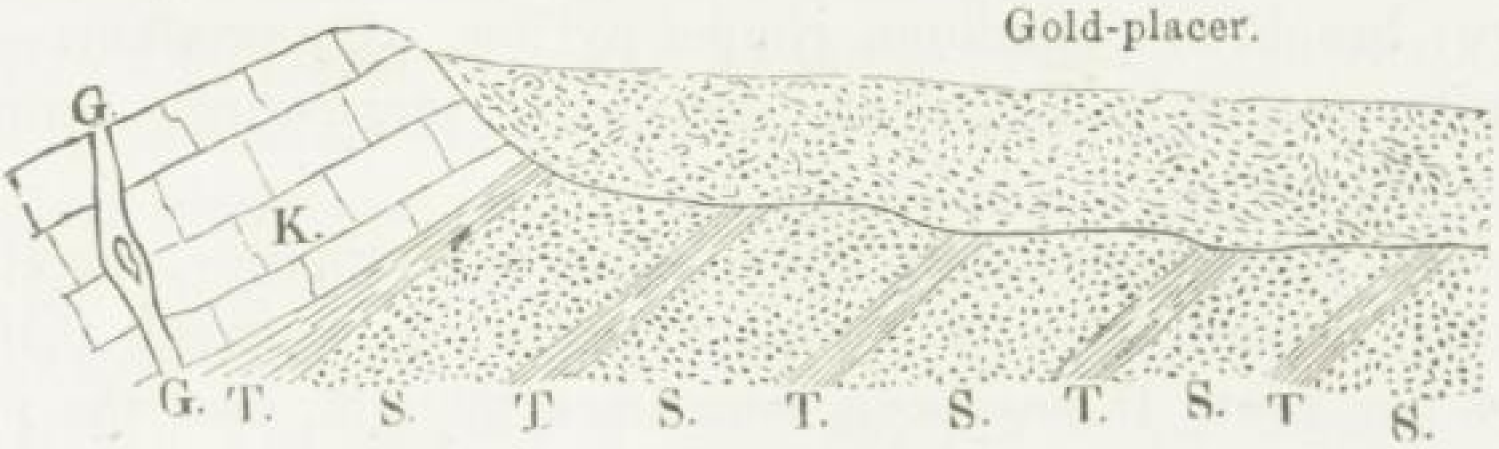
Murchison has given the above profile of a placer near Beresof, of which he says nothing.

OTHER GOLD-PLACERS IN THE URALS.

§ 259. After having become acquainted, in the preceding paragraph, with the occurrence of gold in placers and veins at Beresof; it will suffice to add a few observations on some of the other gold and platinum placers in the Urals, partly in a few remarks, partly in a table.

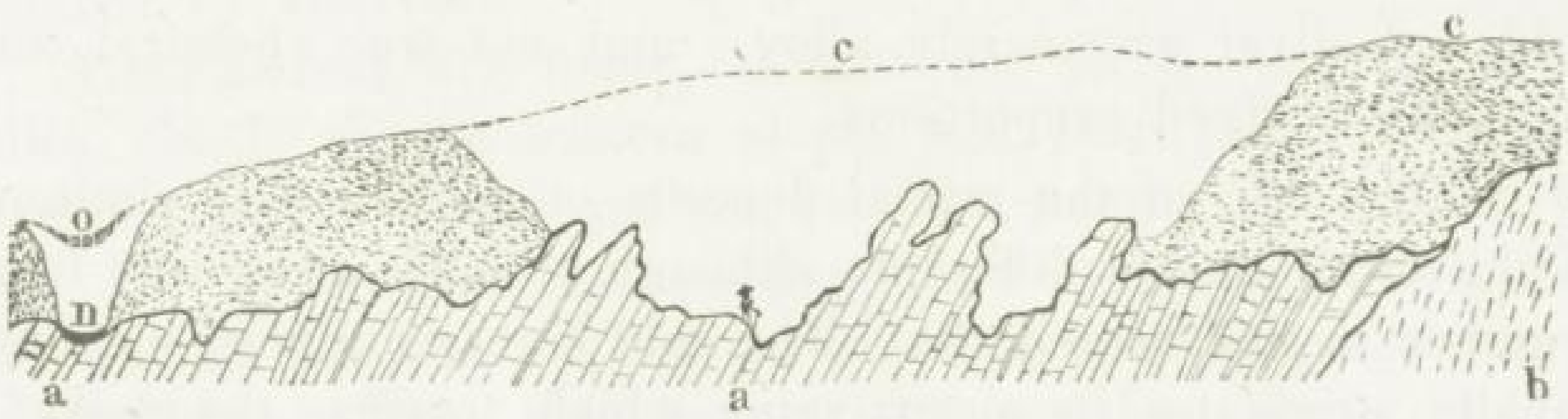
An undulated district of Steppes extends on the Asiatic side of the Urals; in which the older rocks only here and there crop-out from beneath the Post-tertiary deposits. Crystalline schists, Silurian, Devonian, and Subcarboniferous are here, according to Antipoff, often traversed by quartz-veins striking N.—S. parallel to the Urals, which here and there contain small quantities of gold, but so little that it cannot be profitably extracted. Gold-placers occur near these, which overlie the much tilted rock-strata unconformably, and from which gold is, in many places, obtained. Antipoff has drawn one of these placers, of which the following is a copy:

Gold-placer.



G. Auriferous quartz-vein.
K. Beds of bituminous limestone.
T. Clay-slate, alternating with
S. Layers of sandstone.

The following profile of a gold-placer at Solmanofsk, copied from Murchison, is also very interesting:



a. Beds of tilted limestone.
b. Igneous and serpentine rocks.
c. Gold shingle or gravel.
o. Bed of the rivulet before the works were commenced.
n. The present bed of the rivulet.

The highly uneven surface of the limestone *a*, is here evidently the result of erosion prior to the deposit of the alluvium; which has, however, been the principal cause for the unequal distribution of the gold occurring most richly in the depressions of the limestone.

In addition to the minerals already mentioned, some others have been found, especially native metals, in the platinum- and gold-placers. According to G. Rose, the minerals found in the placers of the Urals are as follows:

1. Gold,	6. Diamond,	11. Magnetite,
2. Platinum,	7. Cinnabar,	12. Chromic Iron,
3. Iridium,	8. Iron-pyrites,	13. Rutile,
4. Iridosmine,	9. Specular Iron,	14. Anatase,
5. Native Copper,	10. Ilmenite,	15. Pyrolusite,

16. Corundum,	19. Quartz,	22. Epidote,
17. Spinel,	20. Garnet,	23. Diallage,
18. Barsowite,	21. Zircon,	24. Hypersthene,
	and 25. Malachite.	

According to von Engelhardt, scales of native iron occur with platinum; while Zerrener mentions, in addition to the above; brookite, palladium, copper-pyrites, copper-glance, hausmannite, native lead, galena, crocoisite, tourmaline, actinolith, and diaspore.

The gold is generally more or less argentiferous, the amount varying, according to G. Rose's examination, between 0,16 and 38,74 per cent. It has been sometimes thought, that the placer-gold was purer (less argentiferous) than that extracted from deposits *in sitû*; but Rose has shown, than such is not the case in the Ural Mountains. He found, that the amount of silver was very variable in both cases; although the highest amount of silver was found in gold from veins, which contained, even in the same lode, very variable quantities. These combinations of gold and silver are merely alloys, and not true chemical combinations in fixed proportions.

The origin of the primal deposits of gold, and of platinum, in the Ural Mts. is different; although both are frequently found together in surface-deposits. The gold here, as in most localities, usually originates in quartz-veins which traverse the rocks; it is at least doubtful, whether a portion of the gold, as supposed by some persons, proceeds from eroded rocks (from granite at Bogoslowsk, from greenstones, from clay-slates, or even from limestones).

The platinum, on the contrary, appears to have been here chiefly associated with serpentine, in which it has been observed together with chromic iron. Von Engelhardt states, that the greenstones and syenitic rocks in the Urals also contain a little platinum.

If, however, both these metals often occur together in alluvial deposits, and certain other mineral grains with these (as quartz, garnet, magnetite, zircon, etc.), this paragenésis may possibly be a consequence of the resistance offered by these metals and minerals to chemical and mechanical agents. Were they existing in any district subjected to denudation, even though under very dissimilar circumstances, and but sparingly disseminated; it would not be surprising, if they have been deposited together by the great processes of concentration in nature. Besides, gold and platinum do not occur every where associated in the alluvial deposits of the Ural Mountains; nor are the accompanying minerals, quartz excepted, always present. Osmium and iridium, which generally occur together with the platinum, probably also came from the serpentine.

The lithological character of the gold-placers, in the Urals, is a very dissimilar one, every where corresponding to the local geological conditions; and it has not yet been possible to determine the greater or less amount of gold from these; the presence of much magnetite may, however, be regarded as a favorable sign. The amount of gold appears to be always dependent on the richness of and distance from the original deposits, as well as the mechanical conditions of the deposit. No law can be laid down, either in regard to level, or in regard to the horizontal distribution of the gold; although indeed the gold is often found in the level immediately over the rocks, being covered by alluvium.

Gold-placers are found, at intervals, for a distance of 500 miles, chiefly on the eastern slope, and base; some, however, near the highest crest, and on the west flank. They lie at the base of the mountains, covering plains and undulating hill-country, on the sides of broad valleys, in narrow gorges, or on gentle slopes. They are every where but the product of local erosion and denudation, and contain only fragments of such rocks as occur in the neighborhood; they do not bear the character of a general or Diluvial drift. The greater part are generally extended in one direction. Their rocky base is variable; the more uneven it is, so much the more favorable is the influence it has had on the deposit of gold.

Murchison states, that the deposits of gold, in the Urals, occur only in those rocks *in situ*, which are older than the Permian formation. But Murchison considers the gold they contain to be of far more recent origin, than the rocks themselves; and thinks, the gold penetrated the fissures during the last elevation of the mountain-chain, shortly before the Diluvial period. During the formation of the Permian, no elevated chain, according to this observer, could have existed; since masses of the rocks on the eastern slope, occur as boulders in this formation, in which there are no traces of gold and platinum. The upper portions of the original deposits are the richest in gold;

and Murchison thinks, they must have been still more so, previous to their partial destruction.

The denudation, which afforded the material for the alluvial deposits, is considered by all observers to have taken place at a, geologically, very recent period, more recent than the Cretaceous: Murchison is of the opinion, that it must have been but shortly before the Diluvial period: Zerrener and de Marni state, that at least two periods of denudation, and re-deposit, may be distinguished: in the first one, bones of now extinct mammals (*Elephas primigenius, Rhinoceros tichorinus, Bos, Equus, etc.*) were deposited at the same time: the more recent one may still continue; and de Marni has observed, over the older placers, more recent ones, which have filled crevices in the former. The older deposits, according to Zerrener, are thicker, and also more thickly covered.

Numerous other deposits occur in the Urals, in addition to those here described, which seem to me to be too unimportant, or uninteresting, to need mention.

THEORETICAL RETROSPECTS.

§ 260. A retrospect, of the somewhat tedious collection of facts in the descriptions of the ore-deposits (but few of which I have been able personally to visit), may be permissible, and even be advisable, in order to deduce some theoretical results. I do not attach any great value to such crude theories; and regret, that they offer rather negative, than positive results. Yet these theories may serve to excite further investigation, and are perhaps in part adapted to open-out new points of view for such research.

DIVERSITIES, DIFFERENCES, AND GROUPING OF ORE-DEPOSITS.

§ 261. While the rock-masses, of which the earth's crust is composed, can be quite easily separated into igneous, sedimentary, and metamorphic; the mode of bedding of which, and manner of origin, can in general be explained by very simple means; and whose mutual conditions of bedding can often be easily determined; the ore-deposits, on the contrary, offer a far greater variety, both in their form and mode of deposits, as well as in their composition, and conditions of age; and consequently far greater difficulties, as regards their interpretation.

Simple as the divisions into beds, lodes, segregations, and impregnations, may appear at first sight; there still arise a number of doubts, on a more careful examination, for the formal division, as also for the explanation of the condition. The forms, like the masses, undergo extraordinary modifications, and transitions into one another. Like masses occur in entirely dissimilar forms, and like forms are often found of very dissimilar composition of the masses. It seems as if the normal forms were rarer to find, than their numerous modifications; which are of such a kind, that the first question must often remain unsettled; viz. as to the form of the deposit. Beds swell out to segregrations, segregrations branch into lodes, lodes widen to segregations, form brecciated segregrations, or follow the stratification like beds. Very broad lodes have generally been formed, either through repeated tearing-open of fissures, and these having been filled; or they contain large masses of the wall-rock between their walls, so that they in reality consist of several separate lodes, or branches, united to one another. Impregnations accompany defined ore-masses, these pass into impregnations, or the impregnations form independent bedlike zones. Defined lines of demarcation are often entirely wanting, leaving free room for speculation to the observer. The causes of these inequalities, manifold diversities, and irregularities of form, depend, for the most part, on collateral and accessory circumstances; also on relations of structure, or other contingencies of the enclosing rock. On this account the forms of but few ore-deposits can be accurately compared; the majority already exhibit, in this respect, special peculiarities. Still many of them form similar associate groups entirely conformable to nature.

What has been said, with regard to the form of the ore-deposits, is also true, as to their mineral composition, age, and manner of formation. With regard to their mineralogical composition, they can be united or separated into very few or very many groups. In any case three chief groups suffice. These are,

1. Tin-deposits, commonly associated with quartz and wolfram;

2. Gold, silver, zinc, copper, cobalt, nickel, antimony, and quicksilver deposits associated with quartz, carbonates, heavy spar, fluor spar, etc.

3. Iron and manganese deposits.

They all three form numerous transitions into one another, and cannot be distinctly or sharply separated from one another.

Iron-ores occur in almost all of them; and even the most characteristic tin-deposits contain at times copper, silver, lead, or zinc-ores.

If they are more carefully separated, according to the distinctive metals; there is this difficulty, that a metal, or ore, hardly ever occurs alone; and that it is often difficult to determine, which is to be considered the more important, or the most characteristic. Even if this difficulty is overcome by the conventional value of the metal, there still remains the dissimilarity of the predominant or characteristic gang accompanying each metal, or ore; which are locally often very different, and may with at least the same right, as do the useful minerals, give rise to classifications. Hardly any two neighboring ore-deposits are altogether alike in composition; and frequently a lode is very variable at different points. Consequently the inducements to subdivision and classification have no limit; while clearly defined differences, without transitions, are entirely wanting. Nature does not accommodate itself to any system. The many difficulties, which have already suggested themselves respecting the crystalline rocks, are still greater as regards special deposits containing ores.

Their form, as well as their mineralogical composition, is dependent on the most varied local conditions.

Nevertheless it is evident, that the ore-deposits can be arranged into natural groups according to their composition. To the accustomed eye certain characteristic combinations of minerals are apparent; which are either only locally predominant, like the tellurides of gold in southwestern Transylvania; or are repeated with numerous slight modifications, in various localities on the globe; for example, the barytic lead and silver lodes, in which, however, other ores occur, or in which the characteristic heavy spar becomes more and more subordinate.

In the same manner, as it is often possible to distinguish the same minerals coming from various localities by means of unimportant, but constant peculiarities; it is also, at times, possible, to distinguish from one another cabinet specimens of ore-deposits which are very similar, by means of slight differences, so that they are known to come from decidedly different formations.

There are differences so trifling, as not to be easily explained, whose recognition is only possible through great practice; but which ought not to deter us from combining them in groups. The distinctions gradually encrease to a total difference; and a certain intuitive tact, not possessed by every observer, is then necessary, to distinguish the essential from the nonessential differences. All such groupings and separations, as in a measure depend on this kind of individual tact, must remain uncertain; these recognitions depending on the knowledge of the individual making them. The most certain method is, to take typical examples, to be called central points, around which other modes of occurrence may be grouped, approaching nearer now to one point, now to another. I shall attempt, in the following pages, to represent by examples some such natural groups of ore-deposits.

As it would, however, occupy too much space, were I to attempt to describe them in detail; I shall, instead, frequently refer to the proper authorities. I commence with the so-called ore- or lode-formations already long known in the Erzgebirge.

TIN-FORMATION.

§ 262. The stanniferous deposits in the Erzgebirge form partly lodes, partly impregnations in granitic, or also porphyritic rocks, in gneiss or in mica-schist. The peculiar mineral combinations occur most distinctly in the veins. Quartz is unquestionably the most common of these; this is every where so common, that it cannot be regarded as being characteristic of any particular manner of occurrence. On the contrary, wolfram and its products of decomposition, as well as some minerals containing boron and fluorine, such as tourmaline, and topaz, are very characteristic accompaniments of cassiterite. In addition to these the following minerals are frequently found accompanying the tin-ore; viz. beryl, arsenical pyrites, molybdenite, lepidolith, and a peculiar species of feldspar, which Breithaupt calls *Felsites paradoxites*. When, in addition to these, calc-spar, fluor spar, galena, blende, etc. occur in the stanniferous deposits, they must not be regarded as characteristic of these, and are in part evidently of subsequent formation; as in many ore-deposits the products of very different periods are often intimately combined with one another. The mineral matter, filling the geodes lying in crystallizations one over another, often indicates a very long period; toward whose close the conditions for the formation and grouping of particular minerals were entirely different, from those at its commencement. In a scientific examination such as are evidently of subsequent formation must of course be separated, as much as possible, from those originally belonging together.

At the separate localities in the Erzgebirge, where tin-deposits are known to exist, the form of their occurrence is, as remarked, somewhat different; but the mineralogical character, and geological position, are every where the same.

At Graupen narrow veins, accompanied by impregnations, intersect the gneiss; which for the most part consist of quartz and mica; in places, however, they contain much massive crystallized cassiterite. Somewhat beyond Graupen, there occurs a curious breccia in a quarry, in which gneiss, quartz-porphyry, and so-called syenite-porphyry, appear to have been forcibly kneaded into one another; and this breccia contains smaller pockets, and well formed geodes, of tin-ore, irregularly scattered through it.

At Zinnwald the mass of the greisen, which rock is so characteristic of many tin-districts, is intersected by broad, gently sloping, and more recent, narrower perpendicular, tin-lodes, which are both accompanied by impregnations. The first consist of lepidolith and quartz, symmetrically arranged, at times in the middle of red orthoclase (paradoxite); between which occur wolfram and cassiterite, together with some other minerals.

At Altenberg a fine grained granite is locally altered into a dark stanniferous rock, in which none of the ingredients can any longer be distinctly recognised. I have shown in a former memoir that the Altenberg Zwitter-rock is nothing but a granite, metamorphosed from innumerable thin clefts, and impregnated with tin-ore. The chemical analyses subsequently made, by Dr. Rube at my suggestion, entirely confirmed this view. It may also be questioned, whether the greisen may not be merely a granite altered by the formation of the tin-lodes.

At Seifen tin-lodes were formerly exploited which contained copper-ores. At Marienberg the tin-lodes accompanied by impregnations occur in gneiss; at Ehrenfriedersdorf they contain much mispickel, in mica-schist.

The so-called Stockwerke at Geyer consists of a granite mass in mica-schist, traversed by numerous parallel tin-lodes, from which the ores and other minerals have penetrated into the joints of the granite. It is true, that the same veins extend into the surrounding mica-schist; but they appear to contain less ore. Stelzner has very ably shown this in the 'Contributions to a geological knowledge of the Erzgebirge' (Freiberg, 1865).

At Eibenstock, Johanngeorgenstadt, and Platten, the tin-ore again occurs in true veins; these traverse the granite and mica-schist, but appear, in the last, to be chiefly stanniferous in the immediate neighborhood of the granite. The matrix of the narrowest veins consists merely of clay and quartz, with more or less chlorite or tourmaline; that of the broader ones is a mineral mixture, resembling granite. The cassiterite occurs finely disseminated in these veins, or merely as an impregnation in the wall-rock, which then assumes a character resembling the Altenberg Zwitter. Tourmaline schist occurs at the same time, and this is also penetrated by impregnations of tin-ore. This is the case with the topaz-rock of the Schreckenstein, which appears to be connected in some manner with the tin-ore-deposits of this region. At Breitenbrunn a bedded vein, resembling greenstone, in the mica-schist, contains, in addition to numerous other minerals, more or less cassiterite; and traces of this last have been found even in the silver-lodes around Freiberg.

At some distance from the Erzgebirge occurs the tin-ore locality of Schlackenwald[1] in Bohemia, with the same characteristic mineral combination, as lodes and impregnations, in a district of gneiss and granite, which last cuts through the first.

From all this it follows, that in this portion of Germany

[1] See: § 136; Rücker, in Jahrb. d. geol. Reichsanst. vol. XIV. p. 8.

a broad belt, of old plutonic and metamorphic rocks, has been impregnated in different ways by stanniferous solutions, which produced mineral deposits and alterations.

Outside of this region tin-ores are found in Germany, only on the northern slope of the Riesengebirge; where they occur sparingly, as an impregnation, at Querbach[1] and Voigtsdorf, in a belt of mica-schist which is embedded in gneiss. The minerals usually associated with cassiterite are for the most part wanting. In their places appear iron-pyrites, a peculiar specular iron, galena, blende and cobalt ores occur in the same bedlike impregnation.

The occurrence of tin-ore at Querbach somewhat resembles in shape that of Pittkaranda in Finland; it is a zone of impregnation in hornblende-schist lying between granite. The characteristic wolfram and molybdenite are not wanting; but in addition to these copper-ores, iron-pyrites, pyrrhotine, magnetite, galena, blende, garnet, actinolith, malacolith, etc. are also present.

This is the only locality of tin-ore known to exist in the Eastern portion of Europe, none having been found in the Urals, or even in Scandinavia so rich in granite.

In addition to those mentioned, workable tin-deposits are only found on the European continent in Brittany, in the Haute-Vienne, in Western Spain, and in Portugal.

At Ploërmel, Villeder, Piriac, Questembert, and in the Ouste Valley, the tin-ore occurs in quartzose veins within the granite, together with tourmaline, beryl, topaz, and mispickel; in addition to which, however, impregnations occur in the same neighborhood within hornblende-schist, together with garnet and epidote.

At Vaury, and Puy-les-Vignes (Haute-Vienne), lodes occur in granite and greisen, with wolfram, mispickel, molybdenite, and copper-pyrites.

At Penouta and Romilio, near Verin, and in the Montes and Avion mountains (Spain), lodes and pockets occur, in granite and mica-schist, containing hornblende, which also contain wolfram and beryl.

In Cornwall[2] the miners distinguish regular lodes, which traverse granite, killas, and elvans, irregular tin-floors in granite, and impregnations in granite and hornblende-schist. Wolfram

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[1] See § 148.

[2] See § 231.

is found among the accessory minerals, while more recent copper-ores are often combined with it.

Tin-placers, or stream-works, have been also worked in the majority of these European tin-districts, which alone would not afford any sufficient explanation of the nature of the original deposits. This is also the case, to a great extent, at the tin-mines on the Islands of Banca, Billiton, Malacca, and Carimon, which appear to be the only tin-localities worth noticing outside of Europe, although tin-ores have been found in a few localities in North and South America.[1] From the mineral fragments, which occur together with the tin on these islands, and from the rocks which crop-out to the surface, according to De Groote's account, in the neighboring mountains (granite, greisen, gneiss, etc.) there appears to be a great general resemblance with the manner in which tin occurs in Europe. From the Island of Billiton only have I seen fragments of a tin-lode in argillaceous mica-schist, which consisted, at its out-crop, chiefly of quartz, and limonite; and in which I was unable to find the characteristic minerals generally accompanying the cassiterite.

In general the mineralogical, as well as the geological relationship of all these occurrences of tin-ore is evidently very great; and they appear, from what has been said, to be almost entirely found in true plutonic, granitic rocks. The converse cannot, however, be asserted, that the tin-ores are constant companions of these rocks; for the number of granite districts, which contain no tin, far exceed those, where it is to be found.

The distribution of tin-ore in the earth's crust, so far as we know, is remarkably unequal.

In some regions it is uncommonly frequent, while in very large districts on the other hand no trace of it has as yet been found. How does it happen that so much tin-ore is found precisely in the Erzgebirge, Brittany, Castile, Cornwall, and some East India islands, adjacent to one another, while outside of these localities it is rarely met with?

It may well be asserted, that even gold is much more equally distributed, and is, in so far, more common; although it has in no single locality been found to such an extent as tin;

[1] It does not yet seem to be a solved problem, whether the tin-mines of Tenniscal in California can be profitably worked.

it also appears, that wolfram takes part in this unequable distribution.

Hardly another group of ores and their accompanying minerals can be found recurring in such a constant manner, with and under such analagous geological conditions, with varying form of the deposits, as that of the tin-ores.

FREIBERG OLDER SILVER-LODES.

§ 263. Quartz and carbonates occur combined with galena, blende, pyrites, and rich silver-ores. The following three formations of these lodes are distinguished around Freiberg, and have been already described:

1. Noble Quartz Formation, is the name given to the matrix of certain lodes, which consist for the most part of quartz or hornstone; and which contain, disseminated through this gang, or in geodes, here and there, rich silver-ores, argentiferous mispickel, more or less galena and blende. The minerals already mentioned under this head, in the paragraph on Freiberg, occur in addition to the quartzose principal matrix; which are, however, by no means all of contemporaneous formation, and of which only a few are characteristic.

2. Pyritous Lead-Formation. The matrix of the lodes of this formation, chiefly consists of sulphurets with quartz. Galena and blende, with but little pyrites, locally predominate; in some lodes on the contrary copper-ores prevail, and are then classed together as the Copper Formation. The principal minerals are in general irregularly mingled together, signs of a parallel combed structure being but exceptionally observed in the lodes.

3. Noble Lead-Formation. The essential minerals filling these lodes are quartz, brown spar or dialogite, galena, and blende. Rich silver-ores often occur, in geodes, and strings. A parallel combed structure occurs more commonly than in the last mentioned formation.

For the totality the following may be taken as examples of other occurrences: in Bohemia, the lodes of Przibram in the Silurian formation, those of Bleistadt in mica-schist, those of Adamstadt, Kultenberg, Ratiboritz, and Michelberg, in gneiss: in Silesia, the older copper and lead lodes in the green schist of Kupferberg: in the Carpathians, the lodes, accompanied by impregnations, of Kirlibaba (Bukowina), those in the Tertiary greenstone (timazite) of Kapnik, Turcz, Porpatak, Kremnitz, and Schemnitz: in the Alps, the lodes in the clay-slate of the Pfundrersberg, numerous ones in the mica-schist of the neighborhood of Mont Blanc, and at Allemont: in Brittany, the lodes in the clay-slate of Poullaouen and Huelgoat: in Wales, the veins in the clay-slate of Cardiganshire. These all possess a common character, and especially a scarcity of heavy spar, which occurs, at the most, only as an accessory mineral.

Possibly the auriferous quartz-veins of Culéra in Spain, as well as those in the Salzburg Alps, and numerous veins of various districts containing copper, nickel, and cobalt ores, may be considered as belonging to this class.

BARYTIC LEAD-FORMATION.

§ 264. The lead and silver lodes around Freiberg, containing considerable amounts of heavy spar, can be easily and distinctly separated from the others. They are decidedly of more recent age; and if in the older lodes somewhat of heavy spar or fluor spar occasionally occurs, it is only in geodes. The characteristic marks of the barytic veins is the predominant heavy spar; this is combined with fluor spar, quartz, galena, blende, and various kinds of pyrites. Their structure is at times a very distinctly combed one, and their geodes often contain beautiful crystallizations.

With slight modifications, especially as to the sort of ore they carry, these lodes, characterised by heavy spar, recur in numerous portions of the globe, and under tolerably dissimilar geological conditions. The periods of their formation also appear to have been very different. It is at least certain, that some of those known were first formed toward the end of the Tertiary Period.

The heterogeneousness of their wall-rock and of the kind of metal they contain, may be seen from the subjoined table, in which, though very incomplete, the essential metals are mentioned.

District.	Locality.	Wall-Rock.	Characteristic Metals.
Erzgebirge.	Marienberg.	Gneiss.	Lead, silver, copper, cobalt, and nickel.
	Ehrenfriedersdorf.	Mica-schist.	Silver, and copper-ores.
	Annaberg.	Gneiss.	Silver, cobalt, nickel, and bismuth.
	Weipert.	Gneiss.	Lead, and silver ores.
	Joachimsthal (with but little heavy spar).	Mica-schist, quartz-porphyry, and basalt.	Lead, silver, copper, cobalt, nickel, and bismuth.
	Schneeberg (a portion of the lodes).	Clay-slate, and mica-schist.	Lead, silver, cobalt, nickel, and bismuth.
Hartz.	Clausthal.	Subcarboniferous Formation.	Lead, silver, and copper.
Rhenish Mts.	Holzappel (with but little heavy spar).	Clay-slate.	Lead, silver, and copper.
Black Forest.	Wolfach.	Gneiss, and granite.	Lead, silver, and copper.
	Wittich.	Gneiss, and granite.	Lead, silver, cobalt, nickel, and bismuth.
	Schappachthal.	Gneiss.	Lead, silver, copper, and bismuth.
	Sulzburg.	Gneiss, and granite.	Lead, and silver.
	Badenweiler.	Granite, and variegated sandstone.	Lead, silver, and copper.
	Münsterthal.	Gneiss, and porphyry.	Lead, and silver.
Riesengebirge.	Kupferberg.	Diorite slate.	Lead, silver, copper, cobalt, and nickel.
Hungary.	Felsöbanya.	Tertiary greenstone.	Lead, silver, gold, and antimony.
Alps.	Stubegg.	Clay-slate.	Lead, and silver.
	Brixlegg.	Guttenstein limestone.	Silver, and copper.
	Schwatz.	Guttenstein limestone.	Silver, and copper.
Italy.	Val di Castello.	Mica-schist.	Lead, and silver.
	Massetano.	Strata of the Cretaceous Period.	Lead, and silver.

District.	Locality.	Wall-Rock.	Characteristic Metals.
The Vosges.	Urbeis.	Gneiss, and granite.	Lead, silver, and copper.
	Lembach.	Sandstone.	Lead, silver, and zinc.
	Giromagny.	Porphyry.	Lead, silver, copper, and gold.
Central France.	St. Julien.	Granite, and gneiss.	Lead, and silver.
	St. Just, and St. Germain.	Granite, porphyry, and Carboniferous Formation.	Lead, and silver.
	Villefranche and Najac.	Gneiss, porphyry, and Triassic strata	Lead, silver, copper, and nickel.
	Asprières.	Gneiss, granite, and diorite.	Lead, silver, and copper.
	Corbières.	Clay-slate, and gneiss.	Lead, silver, copper, and antimony.
	Milhau.	Granite, mica-schist, Trias and Lias.	Lead, silver, and copper.
Spain.	Hiendelencia.	Crystalline schist.	Lead, silver, and antimony.
	Carthagena.	Silurian strata and trachyte?	Lead, silver, and copper.
	Sierra Almagréra.	Mica-schist, and clay-slate.	Lead. and silver.
	Linares.	Granite, and Triassic sandstone.	Lead, and silver.
Great Britain and Ireland.	Llanidloes.	Clay-slate.	Lead, and silver.
	Derbyshire.	Mountain-limestone.	Lead, and silver.
	Cumberland.	Mountain-limestone.	Lead, and silver.
	Wicklow.	Granite.	Lead, and silver.

These examples, only taken from Europe, will suffice to show the great distribution of the vein-formation, characterised by heavy spar, but otherwise very unequally developed. The same is known to exist in nearly all countries, where vein-mining is carried on.

Since the older silver-lodes and the more recent barytic ones occur together in the same district around Freiberg, an enumeration of the chemical elements found in them, either in common or separately, may be of interest. I have endeavored, as far as possible, to arrange them according to the frequency, or the quantity, of their occurrence.

There have been found, common to the older and more recent lodes; silicium, sulphur, iron, oxygen, carbon, hydrogen, calcium, magnesium, lead, zinc, arsenic, copper, silver, antimony, manganese, chlorine, bismuth, gold, cobalt, uranium, tungsten, cadmium, aluminum, and indium. Phosphorus belongs to both, but probably not as an original ingredient. In the older lodes alone, occurs tin; in the more recent ones alone, as originally present, barium, fluorine, nickel, titanium, and selenium. (?)

The conformity of both is thus very great; particularly as we may assume that it is merely accidental, that nickel, titanium, and selenium, have not yet been discovered in the older lodes; since barium and fluorine also occur in the drusy cavities of the older veins.

About a half of all the known elements are therefore represented in the Freiberg lodes; they differ, however, from those which predominate in the widely distributed rocks of whatever kind.

The entire absence of potassium and sodium is most striking, as also the very subordinate occurrence of aluminum.

Even this great chemical difference teaches us, that the formation of the Freiberg, like all similar, lodes must have been a different one from that of the igneous, sedimentary, or metamorphic rocks. The absence of potassium, sodium, and aluminum, throws some light on the manner of formation. The compounds of aluminum were probably too slightly soluble to reach the vein-fissures in solutions; the alkalies, however, remained, as being most easily soluble in the solution, and flowed off with this as mineral springs.

VEINS OF IRONSTONE.

§ 265. These, consisting of hematite and limonite, with quartz, hornstone, and ferruginous quartz; appear to be in the Erzgebirge every where the youngest. They often contain, besides the minerals mentioned, ores of manganese, calc-spar, heavy spar, and many other minerals; among the latter also ores, such as chiefly occur in the older veins. Their separation from these is by no means a sharp one. In southern Saxony they are joined by veins of spathic iron containing copper-ores, which are at their out-crop almost entirely altered to veins of limonite. These and similar conditions found in other countries (as the so-called 'gossan' of numerous lodes etc.) may have given rise to the idea, that many of the veins of ironstone are possibly but the upper portions of other kinds of lodes. In this manner the average recent age of most veins of limonite and hematite would be explained; since it is certain, the like have been formed during all periods.

It might, if the idea was proved, act similarly with them, as with the volcanic and plutonic rocks; *i. e.* the upper portion of the older veins rich in iron, which corresponds to the volcanic portion of the igneous masses, is destroyed and washed away in the most cases; and then only the lower portions are found, which chiefly contain other ores, and in part altogether different minerals. Only in the younger veins has that upper portion commonly been retained; and possibly for this reason the veins of limonite and hematite are observed, on an average, as the most recent of the lodes. There is, however, much wanting in support of such a hypothesis, which must not deter a farther examination.

In fact copper-ores occur at a considerable depth beneath limonite, hematite, and magnetite, in the bedded veins of Berggieshübel in Saxony. At Przibram the out-croppings of some lead-silver lodes have been worked as veins of ironstone. Near Katzenthal in the Vosges only iron-ores were obtained in the upper workings; at a greater depth also argentiferous galena with blende, calamine, and heavy spar.

These are a few examples, which may be pointed to, as favoring the preceding hypothesis; though it must be confessed, they afford but slight proof.

I will here remark, that the manganese lodes of the Thuringian Forest, and around Ilfeld in the Hartz, must be included in this group. The manganese-ores only happen locally to predominate in them.

THE METALLIFEROUS GREENSTONES IN THE NEIGHBORHOOD OF SCHWARZENBERG.

§ 266. In addition to these lode-formations, and impregnations accompanying them, another special group of ore-deposits occurs in the Erzgebirge, which differs from the ordinary vein-deposits, and is also mineralogically somewhat differently composed. This group is that mentioned in the heading. They were formerly termed bedded veins in mica-schist; I showed in 1838,[1] that they are joined to rocks of a greenstone character, which traverse the mica-schist tolerably parallel to its foliation; and are consequently bedded veins. The ores are locally interwoven with these rocks in such a manner, that they may be termed local impregnations in the same. Breithaupt in his Paragenésis[2] distinguished this occurrence, as the *Pyroxene garnet-pyrites-blende-formation.* By this, however, only some of the principal minerals of these deposits (very rich in minerals) are mentioned, which while possessing a common general character are locally quite differently composed. It is not here necessary again to mention all the minerals which have been found in these deposits, the following may be regarded as particularly characteristic; pyroxene, hornblende, actinolith, idocrase, garnet, axinite, helvin, epidote, prase, pyrrhotine, iron-pyrites, copper-pyrites, galena, blende, lolingite, mispickel, specular iron, and cassiterite.

The greenstones, which locally contain these peculiar mineral aggregations, very frequently accompany embedded masses of granular limestone, evidently belonging to the mica-schist.

This is of itself an enigmatical phenomenon, since there is no apparent reason, why the penetration of the igneous greenstones so frequently followed the lime-beds. This is the case, however, not only in the district of the crystalline schist; but the same is repeated in the Silurian strata of southern Saxony, where certain diorites principally occur with limestone.

It would appear as if some of the peculiar minerals in the neighborhood of Schwarzenberg owe their origin to the contact of such heterogeneous rocks, although not, I think, to the influences of igneous-fluid eruptive masses alone, but also to the subsequent effects of solutions under the influence of such heterogeneous rocks.

The garnet predominates in places to such a degree, that the mass may be termed garnet-rock; in other places masses of magnetite occur, while in still others various kinds of pyrites, or zincblende, predominate. Erlanite[3] also occurs, combined with these peculiar deposits.

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[1] See: Erläuterungen z. geognost. Karte von Sachsen.

[2] See: Breithaupt, die Paragenésis der Mineralien, Freiberg, 1849, p. 134.

[3] See: § 85, and Erläuterungen z. geogn. Karte v. Sachsen, II. 1838, p. 219.

Some foreign occurrences may be joined to these deposits in the Erzgebirge, as being more or less closely allied to them; still the variations are so great, that it is not possible to form a determined group.

I would designate the following deposits as belonging here:

1. Those in the gneiss of Bodenmais[1] in Bavaria, which consist of irregular mixtures of pyrrhotine, blende, galena, magnetite, iron-pyrites, copper-pyrites, iolith, actinolith, garnet, pyroxene, feldspar, quartz, amethyst, serpentine, etc.

2. The contact-deposits which occur, in the Banat and Servia, between granular limestone and banatite, or also between granular limestone and mica-schist. They consist of similar irregular mixtures of pyrites, galena, blende, magnetite, etc. and are also combined with garnet-rock and its related minerals; and even though the garnet-rock is here evidently of another and older origin than the ores; still the whole occurrence is a tolerably similar, and locally changing one, as at Schwarzenberg. From their geological position much more distinctly opened, and in so far more instructive, than those of Schwarzenberg, are the deposits of the Banat; in which it might be possible to distinguish minerals actually formed by contact, from such as have been formed by subsequent infiltrations.

3. Belonging to the same class, as the contact-deposits of the Banat and Servia, as being in every way analogous, are those of Rezbánya in Hungary and Offenbánya in Transylvania; and both resemble, according to the descriptions of H. Müller and G. Rose, the copper-deposits which occur near Bogoslowsk in the Urals, accompanied by garnet-rock, between greenstone and limestone. Both the copper-ores of Chessy near Lyons, and of Rio Tinto in Spain, occur at the contact of greenstones.

All these form in common a not clearly defined group, but still belonging together.

THE TELLURIC AND AURIFEROUS LODES OF TRANSYLVANIA.

§ 267. Returning to the lodes proper, and no longer starting from the Erzgebirge as the normal type, we can distinguish

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[1] See § 134.

the telluric and auriferous lodes of Transylvania as a particular group.

The tellurium, as the single element with which gold is found mineralized, is the characteristic of these lodes; and this element belongs to the peculiarly rare ones. Up to the present time, but very few regions are known, in which ores of tellurium occur. The Tertiary greenstones in the neighborhoods of Nagyág, Zalathna and Offenbánya[1] are traversed by fissures in which auriferous tellurium-ores have been deposited together with quartz, brown spar, and some other minerals.

This was, until recently, the single important occurrence of the kind; while, on the contrary, the tellurium-ores of Sawodinsk in the Altai Mountains, of Spottsylvania, Fluvanna and Stafford Counties in Virginia, of Davidson County in North Carolina, and of Dahlonega in Georgia appear to be inconsiderable.

Very recently rich tellurium-ores, containing gold, silver, and lead, have been found in Calaveras County, California, forming lodes which traverse metamorphic schists.

THE SILVER-LODES OF ANDREASBERG IN THE HARTZ.

§ 268. These, together with those of Kongsberg in Norway, form a separate group. The sulphurets, elsewhere so common to lodes, are here very subordinate. The most common ores are rich silver ones, from which native silver has frequently been formed, combined with calc-spar, quartz, and all sorts of zeoliths, which elsewhere occur but rarely in lodes.

SEGREGATIONS OF PYRITES.

§ 269. The copper-deposits of Goslar, Agordo, Schmöllnitz, and Falun, form a fine group. They consist, for the most part, of large aggregations of pyrites in clay-slate or mica-schist. Their forms approach the lenticular, almost parallel to the strata; outwardly, they are surrounded by, or are connected with, impregnations of pyrites in the slate; inwardly they show, in part, traces of parallel structure, corresponding to the enclosing slate:

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[1] See: Cotta's Erzlagerstätten Ungarns u. Siebenbürgens, 1862, p. 65; Berg- u. hüttenm. Zeit. 1865, p. 374.

they contain in places friction-surfaces. Iron-pyrites predominates in all of them; copper-pyrites is mixed with the preceding to a subordinate degree; while galena, blende, quartz, and heavy spar, occur locally; traces of other ores, impossible to distinguish with the eye, are mixed with them; containing gold, silver, cobalt, nickel, and even some tin.

I have shown, that the broad pyrites-mass, of the Rammelsberg near Goslar, consists properly of a combination of smaller irregular lenses grouped together. This can be recognised at Schmöllnitz[1] in Hungary, while at Agordo in the Alps, and Falun in Sweden, the mass at least contains layers of slate. It is possible, that these immense segregations of pyrites are also thus divided into smaller masses, which may be easily overlooked in the ordinary methods of working them.

In all of them the origin of such immense aggregations of sulphurets remains unintelligible. They can in no case be regarded as subsequent fillings of cavities so large, as the space they now occupy. Since their composition, and their being completely enclosed on every side, is not compatible with the supposition of an igneous-fluid injection; there only remains the choice between contemporaneous deposit, and subsequent impregnation; which last, however, like pseudomorphs by replacement, must have been combined with the partial destruction and carrying away of the schistose rock. The pyrites-masses of Rio Tinto, and of the Province of Huelva, in Spain generally, resemble those here mentioned in form and composition; but their geological position appears to be different. According to Lan's description, they occur at the junction of igneous rocks with clay-slate; consequently they resemble much more the contact-segregations in Servia and the Banat.

The classes of the products of nature, which we form for a readier review and comparison, all carry more or less the stamp of incompleteness, or even of arbitrariness; they do not suffice for the totality of the phenomena.

Certain of nature's bodies may be capitally classed together; but others occur, which may be joined less well together, which unite in themselves the properties of two natural groups, and

[1] See: Cotta's Erzlagerstätten in Ungarn u. Siebenbürgen, p. 53; Berg- u. hüttenm. Zeit. 1861, p. 195, 1862, p. 452; Oesterreich. Zeitsch. 1863, pp. 101, 235.

consequently can be placed between them as uniting members; or even such as vary quite considerably from all. In this manner the pyrites-segregations are joined by the pyrites-beds, which themselves appear at times to consist of irregular lenticular bodies, or which locally extend into mere impregnations. Examples of these are the cupriferous pyrites-beds in mica-schist at Poschorita and Domokos in the Bukowina, and in Transylvania, in chloritic schist of Kitzbühel in the Tyrol, and in clay-slate near Mitterberg in the Salzburg Alps, also those in the talcose chloritic schist of Röraas in Norway.

LEAD AND ZINC DEPOSITS IN LIMESTONE AND DOLOMITE.

§ 270. Irregularly formed, more rarely veinlike, in part very massive aggregations of galena, blende, calamine, and smithsonite, occur in limestones and dolomites, of very dissimilar age, in Upper Silesia, in Westphalia and Belgium, at Wiesloch in Baden, in the Carinthian Alps, near Anduze in France, in the Spanish Province of Santander, as well as in the States of Wisconsin, Illinois, Iowa, and Missouri; they are all of a similar, but by no means contemporaneous origin. Great districts must have been penetrated by metalliferous solutions; from which the precipitation of the above ores took place, for the greater part, only in dolomite or limestone, frequently at their expense.

To be more clear, the solution traversed the considerably fissured rock; and this re-acted in such a way on it, that carbonate of lime and magnesia were dissolved, the ores being deposited in their place. These are pseudomorphs by replacement, on the grandest scale, and without crystal form, whose formation must have occupied a long period. At the same time existing cavities or fissures were filled up.

It is altogether inadmissible to suppose, that the deposition of the ores occurred, in these cases, contemporaneously with those of the limestone or dolomite; the whole manner, in which the ore is distributed, is opposed to this; entirely apart from the fact, that these rocks belong to very dissimilar formations, and that occasionally the marine fossils are even entirely mineralised; the animals consequently would have been compelled to have lived in a metalliferous solution, if the formation of the ores was a contemporaneous one. The ores occur partly in the rock and intermixed with it, partly in vein-fissures or on the clefts of stratification; and have penetrated from these to a greater or less distance in the rock. The deposits, in the fissures and clefts of the stratification, are decidedly of more recent origin than the rock; they are, however, entirely of the same condition as the other ores. This is most evident in the lead-deposits in the mountain-limestone of Derbyshire and Cumberland; which chiefly fill vein-fissures, in part with very regular, symmetrical combed texture, in which the ores are combined with considerable heavy and fluor spar, from which these *rake-veins* assume the character of the Freiberg barytic lead-formation; while the same ores occur combined with them in the fissures of stratification (*flat-veins*), and in irregular spaces (*pipe-veins*); from which fact they join most closely on the above-mentioned deposits. It is worth noticing, that the most of these deposits, rich in galena, contain an uncommonly small amount of silver, much less than is commonly found in the galena occurring in true fissure-veins. Whether the limestone re-acted less on the silver, or whether these solutions contained but a very small percentage of the same, is a still open question.

It appears to me proper, for the sake of convenience, to tabulate the different localities in which these ore-deposits occur.

Locality.	Formation.	Nature of Deposit	Where Described.
Santander in Spain.	Magnesian limestone of the Jura or Cretaceous Period.	Segregated and bed-like impregnations of calamine, galena, and blende; with copper-nickel and arsenic ores.	Compt. rend. 1858, vol. 47, p. 728; and 1859, vol. 49, p. 553; Mining. Mag. 1861, p. 73; Berg- u. hüttenm. Zeit. 1863, p. 163; Jahrb. f. Mineral. 1864, p. 849.
Pallières near Anduze in France.	Magnesian limestone of the Black Jura.	Segregations of galena, blende, and calamine; with pyrites, quartz, calc-spar, and fluor spar.	Ann. d. mines, 1859, vol. 15, p. 47.

Locality.	Formation.	Nature of Deposit.	Where described.
Bleiberg in Carinthia.	Hallstätter limestone (Upper Triassic).	Segregations, and lodes, of galena, blende, and calamine.	Berg- u. hüttenm. Zeit. 1863, p. 9, et seq. Jahrb. d. geol. Reichsanst. 1855, p. 169; 1856, p. 369; 1861-62, p. 292; and 1863, p. 25.
Windisch-Bleiberg in Carinthia.	Hallstätter limestone.	Impregnations of galena and blende alongside of clefts.	
Miss near Bleiburg in Carinthia.	Hallstätter limestone.	Segregated impregnations, pockets, and masses, of galena and blende.	Oesterreich. Zeitschr. 1863, pp. 52, 173, 373, 382.
Raibl in Carinthia.	Dolomite of the Guttenstein limestone (Lower Triassic).	Bedlike impregnations and matrices of fissures.	
Höllenthal, etc., in the Wetterstein district of the Alps.	Hallstätter limestone.	Impregnations of lead and zinc ores, alongside of fissures.	Gümbels Bayrisches Alpengebirge, p. 245.
Wiesloch in Baden.	Trochyten limestone of the Muschelkalk formation.	Segregations of galena, blende, and calamine.	Jahresbericht d. Mannheimer Vereins f. Naturkunde, 1860, p. 36; Ludwig, Reise d. Russland, 1862, p. 9.
Tarnowitz and Beuthen in Upper Silesia.	Dolomite of the Muschelkalk formation.	Bedded segregations of calamine, and pockets of galena.	Jahrb. f. Mineral. 1864, p. 482; Berg- u. hüttenm. Zeit. 1864, p. 353.
Oskusz in Poland.	Dolomite of the Muschelkalk formation.	Similar to Upper Silesia.	
Derbyshire and Cumberland in England.	Mountain-limestone.	Lodes, bedded fissures, and segregations; galena, blende, pyrites, heavy & fluor spar.	Wallace, Lead-ore of Alston Moor, 1861; Berg- u. hüttenm. Zeit. 1862, p. 447.

Locality.	Formation.	Nature of Deposit.	Where Described.
Aix-la-Chapelle and Belgium.	In mountain-limestone, at its junction with Carboniferous or Devonian Slate.	Segregations and impregnations of galena, blende, and calamine.	
Ruhr district in Westphalia.	At the junction of the magnesian limestone of the Devonian formation with the Lenne slates.	Segregations, ramifications, and impregnations, in limestone; galena, blende, & pyrites.	
Bergisch Gladbach.	At the junction of the Devonian limestone with the overlying Lignite formation.	Incrustations, and pockets, of galena, blende, and calamine.	
Wisconsin, Illinois, Iowa, and Missouri.	Magnesian limestone of the Silurian formation.	Segregated masses, and matrices of fissures; consisting of galena, blende, calamine, and pyrites.	Whitney's Rep. of a Geol. Surv. of the Upper Mississippi lead-region, 1862; Berg- u. hüttenm. Zeit. 1863, p. 310; Journ. d. Min. 1864, vol. VI. p. 479.

In this table, arranged according to the age of the enclosing formations, under calamine, are included both the carbonate and silicate of zinc, as is in common use among miners. In addition to the principal ores characteristic gangstones alone have been mentioned. Books of recent date are alone cited.

In addition to the localities mentioned, I might add one other, that of Kuczaina in Servia; and although this occurrence of calamine does not altogether agree with the preceding ones, it is one of the most instructive cases. The compact Jurassic limestone is broken through near Kuczaina by a porphyritic rock, which contains crystals of quartz, feldspar, hornblende, and mica, in a compact matrix. At the junction with the porphyry, there are found in the limestone irregular aggregations of argentiferous galena, blende, and pyrites; these correspond with the remarkable contact-segregations, which traverse the Banat from South to North, and also with those of Maidenpek. The unaltered Jurassic limestone contains, at Kuczaina, in addition to the contact-segregations (consisting of sulphurets), enclosed pockets, and open eroded depressions, consisting to a great extent of calamine without a trace of sulphurets. These evidently stand in some connection to the contact-segregations. They are either products of alteration of the same, or they were deposited from the same solutions as these, but nearer the surface, under different conditions, and only in limestone, not as contact-segregations at the junctions with the porphyritic and siliceous rock.

The granular deposits of galena in sandstones, as those of Commern in Rhenish Prussia, are to some degree related with the irregular lead-ore-deposits in limestone and dolomite; they are evidently to be regarded as impregnations penetrating into the rocks from innumerable clefts.

The nine groups of ore-deposits already mentioned can be easily distinguished and separated relatively, at least where they have been characteristically developed. This is more difficult with those now to be mentioned; material and form vary more and more; and the theme would not be solved, were a grouping of all the known ore-deposits to be attempted in this manner.

FALLBANDS.

§ 271. Certain zones in the mica-schist, at Kongsberg in Norway, were first called Fallbands; which contained small particles of pyrites and other sulphurets: they are themselves not exploited, but appear to have exerted a considerable influence on the distribution of the silver-ores in the vein-like deposits which traverse them. It appears doubtful, whether these particles of ore belonged originally to the rock, or whether they penetrated into it by subsequent impregnation. Their form and manner of distribution correspond to zones of impregnation.

Other ore-distributions of the same character, especially in crystalline rocks, were subsequently called Fallbands; for example, those containing ores of cobalt at Snarum and Skutterud in Norway, those containing ores of copper and tin at Pittkaranda in Finland, those containing tin-ore and pyrites at Querbach in Silesia. They thus form less a determined group, than a determined form of occurrence.

IMPREGNATIONS OF COPPER-ORES IN MECHANICAL SEDIMENTS.

§ 272. Probably the earliest known were those in the sandstones and argillaceous shales of the Permian formation along the western edge of the Urals.

Malachite, azurite, and volborthite; more rarely also red-copper, copper-pyrites, and tetrahedrite; occur unequally distributed, for the most part in sandstone.

They traverse its mass like a cement, they cover its clefts, and especially occupy the places of fossil plants, which are in part completely mineralised.

From the entire nature and manner of distribution of these ores in originally mechanical sediments, it follows without doubt, that they penetrated, as impregnations, subsequently to the formation of the rocks. The solutions, from which they were deposited, appear to have proceeded from the partial destruction of original copper-deposits occurring in place in the Ural Mountains, which essentially consisted of sulphurets; on which account the impregnations occur only near the edge of the mountains; while the same mechanical deposits, mostly sandstones, extend for a great distance into the flat hill-country, but entirely barren of ores.

Remarkably enough similar impregnations of copper-ores were found in two separate portions of Bohemia, in strata of about the same age, and lithologically closely related. They occur in the Rothliegendes, which occurs at the southerly base of the Riesengebirge, at Hohenelbe, Starkenbach, etc., and at Böhmisch-Brod in the interior of the country. The sulphurets are more completely absent, than in the Permian district, the impregnations are generally poorer, and more irregularly distributed in certain strata of sandstone or bituminous argillaceous shale. The general conformity of the ore-occurrence, and the almost like age of the rocks in which it occurs; has given rise to the supposition, that this presence of copper is the product of a particular geological period, in which copper-ores were especially deposited; some persons have even gone so far as to suppose, that the copper-slates of Thuringia were deposited by the same cupriferous sea of the period. But the copper-slate is not only altogether differently composed, it also belongs to a somewhat more recent period of deposit. The ores appear to have actually been deposited contemporaneously with the strata of mud; as a consequence of which they are much more equally distributed through these last.

On the other hand the impregnations in the Buntsandstein, at Twiste near Arolsen in Tyrol, very much resemble those in the government of Perm, and in Bohemia; only the strata, in which they occur, are much more recent; from which it becomes very evident, that one does not have to do with the common result of a contemporaneous general deposit of copper-ore, but with the subsequent local impregnation of certain rock-strata; whose formation, with regard to the ores, as well as to the rocks, may possibly belong to very different periods.

The manner of occurrence is similar at all these localities, and can be properly united into a natural group. It would even appear, as if the native copper of Lake Superior partly occurred in a similar manner. Mr. Hague recently sent specimens from the Albany and Boston mining-company, among which were red sandstone and conglomerates containing copper, partly disseminated, partly almost as cementing medium; while the copper in that region was formerly almost exclusively worked in igneous rocks.

DEPOSITS OF SPATHIC IRON.

§ 273. The Palæozoic slates of the eastern Alps are particularly rich in deposits of Spathic Iron, some of which attain very large dimensions: similar deposits extend down into the Azoic, in part already metamorphosed schists; and others occur in a much higher geological horizon between Triassic, or even still more recent deposits. The frequent irregularity of their form, and their, locally, often immense dimensions, have given rise to their being considered, partly as masses segregated in form, partly as the matrices of fissures. They have even been explained, as being eruptive or (better) injected rock-formations. Von Schouppe has proven, in the best known and probably most extensive occurrence of this kind, that of the Erzberg near Eisenerz in Styria; and for some of the neighboring ones; that they form irregular, but evidently contemporaneous deposits in a particular horizon of the Devonian[1] slates. According to

[1] Baron Adrian subsequently supposed that the iron-ores of the Erzberg belonged to a higher geological horizon, that of the Werfner slates.

this, they are true bedded segregations, or beds of irregular extent, often approaching a lenticular shape. It is very probable that the greater portions of the spathic iron-deposits in the eastern Alps form such bedded segregations between deposits of a somewhat dissimilar age; still true fissure-deposits occur in the same region. It would be difficult to clearly separate these occurrences one from the other; quite as difficult, however, satisfactorily to explain a like origin for both. Accurate examinations are here wanting. Spathic iron forms the principal ingredient in all; but this is combined with ankerite, dolomite, calc-spar, specular iron, pyrites, and some other minerals, which only occur sporadically, and possibly only in veins. In any case these deposits form a group in the eastern Alps, to which may be joined some more or less analogous occurrences in other localities; thus the very thick spathic iron, on or between clay-slate, near Dobschau in Hungary; the masses of spathic iron in the Zechstein of the Mommel and Stahlberg, in the southwestern edge of the Thuringian Forest, which from Danz' description are very irregularly embedded; the spathic iron in Zechstein on the Hüggel southerly of Osnabrück; and even broad veins of spathic iron in the Rhenish Devonian, whose chief representitive is exploited at the Stahlberg near Müschen. This group is united, however, by such veins, to numerous other lodes, in which spathic iron predominates more or less as the chief ore; while various other ores accompany it; as in the southern part of Saxony.

Since spathic iron is often converted near the surface into limonite, it is a matter of course, that the deposits here mentioned generally also contain much limonite. Others seem, so far as they have been examined, to have been entirely altered into limonite; for example the thick bed in mica-schist, at Arzberg near Wunsiedel in Bavaria; and the very extraordinary aggregation of pure limonite, at Gyalar near Hunyad in Transylvania; which appears to be in fact but a continuation of the iron-stone bed, partly still consisting of spathic iron, in the same mica-schist at Ruszkiza in the Banat.

Spherosiderite is merely a compact condition of the spathic iron; it is remarkable, however, that this condition inclining to the formation of spheres, has every where been found under similar geological conditions; viz. in the Carboniferous formation, or between bituminous shales, entirely independently of their age. It is rarely altogether wanting in such deposits, while it is hardly ever found between other rocks. It is not indeed found in sufficient quantities, to render its exploitation a profitable one in all coal-formations or bituminous shales; but single masses of the same are not often entirely wanting.

In the preceding grouping of ore-deposits according to their general relations, the kind of metal, from which they become important in practice, could be but partially noticed, and then only in those cases, where a metal is combined with a particular manner of occurrence.

Very commonly, howerer, the ores of several useful metals occur combined in the same deposit. It is of especial interest to the miner, to clearly understand, under what different conditions the same metals are found, especially in such combinations, and under such circumstances, that their exploitation appears to be profitable. This last condition excludes a large number of occurrences, particularly of the cheaper metals, which science cannot leave unnoticed. A review to this end, though very incomplete, is still of scientific interest.

I shall therefore try to sketch the manner, in which some of these metals occur, as concisely as possible; often merely referring to the preceding groups, thus calling attention simply to what is characteristic.

I. Gold: occurs native, visible to the eye, or invisibly mixed with various sulphurets, by whose decomposition an auriferous ochre is sometimes formed: it occurs mineralised only by tellurium:

1. in lodes, which occur in crystalline schist, plutonic igneous rocks, clay-slate, quartzite, sandstone, and very rarely, also, limestone: the lodes are predominantly quartzose, but also contain various sorts of pyrites, silver, lead, copper, and antimony ores, as well as carbonates, heavy spar, and fluor spar: when they are much decomposed near the surface, then a porous, cellular, or drusy quartz often contains an auriferous ochre or recognisable gold.

The lodes in which gold occurs mineralised by tellurium form a separate group.

Auriferous lodes are known to exist in great numbers, but containing very variable amounts, in Vermont, Virginia, North and South Carolina, Georgia, California, Colorado, and many other States of the Union; Canada, Mexico Central America, Peru, Chili, Brazil, Australia, New Zealand, Alaska, China, Hungary, Ural Mountains, and in small quantities in Great Britain, Sweden, Thuringian Forest, Bohemia, the Alps, Pyrenees, etc.

2. in bedlike zones, perhaps as impregnations, most commonly in quartzose, talcose or chloritic schists; at Salzburg, Carinthia, and Tyrol, South Carolina: as impregnations in sandstones along with lodes, at Voröspatak in Transylvania:

3. in surface-deposits, as placers, very common; mostly very pure gold.

II. Silver: mineralised by sulphur, antimony or arsenic, frequently also native; and, still more commonly, imperceptibly distributed in galena, somewhat more rarely in tetrahedrite, blende, pyrites, or the like; also, as amalgam, as chloride, bromide, iodide, selenide or telluride. All these silver-ores occur combined with all sorts of other ores, with quartz, carbonates, heavy spar, and fluor spar:

1. in lodes; which are found traversing crystalline schists, plutonic igneous rocks, or sedimentary strata, as recent as the Tertiary: the best known localities are Colorado, Montana, Idaho, Arizona, Utah, and Nevada in the United States; Chili and Peru in South America; the Erzgebirge, Bohemia, Silesia, the Hartz, Westphalia and Black Forest in Germany; the Vosges, Alps, Brittany, and Central France; Hungary, and Transylvania, the Pyrenees, and Southern Spain; Wales, Derbyshire, and Cumberland; and Kongsberg in Norway: while in the Urals, silver-lodes proper are scarcely known to exist:

2. as a true bed, exploitable silver is only found in the copper-slates of Thuringia:

3. segregated or irregularly shaped; the argentiferous ores occur as such in the Banat, at Kuczaina in Servia, and at Sinka in Transylvania; probably also, at Schwatz in the Tyrol, and in some mines of Derbyshire and Cumberland: it is stated, that the ores form a large segregation at Schlangenberg in the Altai Mountains:

4. impregnations occur frequently alongside of lodes. Surface-deposits, from which silver is extracted, are not known, nor do they probably exist.

III. Lead: most commonly as sulphuret (galena); and then, as a rule, also somewhat argentiferous, and combined with blende: oxidized, and combined with various acids, especially at the outcroppings of deposits; sometimes, but very rarely, native; as at Pajsberg in Sweden, and Northwest of Lake Superior.

These ores occur with those of various other metals, especially of silver, copper, cobalt, and nickel; as well as with those minerals, which form characteristic vein-stones of the silver-ores. As a rule, lead and silver are extracted from the same deposits:

1. in lodes like the silver-ores;

2. in true beds, scarcely any-where exploitable;

3. segregated, often together with zinc-ores;

4. grains, and small bunches, in the variegated sandstone of Commern in Rhenish Prussia, and in the Keuper sandstone of Franconia.

IV. Zinc: as calamine (silicate or carbonate), and blende with galena, etc. segregated in limestones or dolomites of various formations: also in numerous lodes, from which other metals are obtained.

V. Copper: native, as sulphuret, or combined in an oxidized condition with various acids, together with other ores, quartz, carbonates, heavy and fluor spar:

1. in lodes; which occur in crystalline schists, plutonic igneous rocks, or sedimentary strata, as far up as the Tertiary: very common:

2. as bed, finely disseminated in the copper-slates of Thuringia: the beds, or impregnations, of copper-pyrites in mica and chloritic schists: the bed, rich in copper-pyrites, in the hornblende-schist of Pittkaranda in Finland, is probably an impregnation:

3. segregated; irregular lenticular segregations of pyrites, in clay-slate or mica-schist;

4. contact-segregations, containing much copper ore, at the junctions of igneous rocks, especially with limestones.

5. irregular strings of tetrahedrite, and copper-pyrites, combined with gypsum, in clay-slate at Herrengrund in Hungary, and irregular pockets and impregnations in decomposed igneous rock at Parad in Hungary;

6. oxidized copper-ores, rarely with sulphurets of copper;

as impregnations in sandstones, conglomerates, and argillaceous shales:

7. Masses, and pockets, of native and oxidized copper, in serpentine and its accompanying rocks.

VI. Tin: almost only as oxide (cassiterite), rarely as sulphuret, in various formed deposits; which however all belong to a geological group of great age: not found in limestones. In addition to this, surface-deposits (placers) are common; from which the tin is alone obtained in the islands of Banca, Billiton, and Carimon.

VII. Cobalt, and Nickel: the ores of these metals occur, as a rule, together; commonly also with silver, lead, and copper ores; with quartz, hornstone, calc-spar, spathic iron, heavy spar, and numerous other minerals:

1. Lodes; in crystalline schists, plutonic igneous rocks, and sedimentary strata up to the Tertiary:

2. Impregnations; in crystalline schists, at Skutterud and Snarum in Norway (almost free from nickel):

3. Segregated masses; in granular limestone, or between this and gneiss; at Tunaberg in Sweden, where a large number of minerals occur with them.

VIII. Mercury: most commonly, as cinnabar; but also native, as amalgam, or as chloride (calomel):

1. in lodes; which occur in crystalline schists, clay-slate, the strata of the Carboniferous formation, and also some igneous rocks, together with tetrahedrite, pyrites, brown spar, calc-spar, heavy spar, and quartz: found at New Almaden and elsewhere in California, Moschlandsberg in the Palatinate, Almaden in Spain, Szclana in Hungary, in Transylvania, and South America:

2. Bedded; but probably as impregnations, with but few accessory minerals; in the bituminous shales of Idria and St. Anna in Austria, Vallalta near Agordo, in the talcose schist of Ripa in Northern Italy, also traces in clay-slate at Hartenstein in Saxony.

IX. Iron: we must here consider the various ores separately; still the most of them occur together:

1. Spathic iron; forms lodes, beds, and bedded segregations, in clay-slate, Zechstein, etc.

2. Spherosiderite, and clay-ironstone; form beds, or lenticular masses, parallel to the foliation, in almost all coal-

deposits, and bituminous shales; also, as grains, in an Eocene sandstone, on the northern edge of the Alps:

3. Magnetite; very frequently with somewhat of specular iron, chlorite, amphibole, garnet, quartz, and numerous other minerals; forms beds, lodes, segregated masses, and impregnations in crystalline schists, near their junctions with granular limestone, or of basic igneous rocks:

4. Chromic iron; almost every where associated with serpentine or gabbro; a small admixture of chromic iron is probably never altogether wanting in these rocks, but the same sometimes forms masses, segregations, or the filling of fissures in the same, which can be mined:

5. Specular iron; forms lodes in crystalline schists, and igneous rocks, even in lavas; at times associated with quartz, lievrite, etc. As beds of micaceous iron-schist, between chloritic schist, itacolumite, or granular limestone, combined with quartz:

6. Hematite; compact, ochreous, or fibrous; more rarely oolithic; frequently with ores of manganese, quartz, hornstone, or clay; more rarely with carbonates, heavy and fluor spar; forms beds, lodes, and contact-segregations, for the most part in crystalline schists, or at least in old sedimentary formations; often at the limits of crystalline limestone, or also at the limits of plutonic igneous rocks, at the same time forming lodes in these: the hematite in the Erzgebirge appears to be principially associated with granite or quartz-porphyry:

7. Limonite; compact, ochreous, or fibrous; with the same accessory minerals as hematite, also under the same conditions of bedding, but extending into the most recent sedimentary strata: the accompanying limestone is as frequently compact as granular, the igneous rocks, at whose limits contact-deposits occur, are also volcanic; as for example, basalt.

In addition to these modes of occurrence, which the limonite possesses in common with hematite; very recent deposits of hydrated peroxide of iron also occur, as ochre, at the mouth of springs; in marshy regions, as bog-ore; also in many lakes, as sea-ore; also filling all kinds of cavities, in limestone and dolomite, which are near the surface:

8. Pea-ore; round grains, which consist, either of hydrated peroxide of iron, or silicate of iron; they fill depressions, fissures, or real cavities in limestones: particularly common in Jurassic limestones.

X. M a n g a n e s e: as wad, manganite, varvicite, hausmannite, braunite, polianite, pyrolusite or psilomelane; often accompanied by iron-ores, or the accessory minerals usually with them: these ores form beds, lodes, pockets, segregations, contact-segregations, etc. in crystalline schists, and sedimentary formations; frequently occurring in limestone or dolomite, as well as in, and on, various kinds of plutonic igneous rocks.

DISTRIBUTION OF ORE-DEPOSITS.

§ 274. Many attempts have been made to discover fixed laws, with regard to the geographical distribution of ore-deposits, but as yet in vain.

When they are examined in their generality, or in their separate natural groups; they do not appear to change toward the equator, or the poles, either in frequency or richness; they occur just as frequently in the interior of continents, as on their coasts or on islands; similar deposits have been found beneath the level of the sea, and in the highest mountains. Ore-deposits are more commonly found in mountains, than in plains; as these last generally consist, at the surface, of very recent sedimentary deposits, in which ore-deposits are found as an exception.

After a full examination of the facts, it cannot be said, that in Europe there is a northern, and a southern region, in which ore-deposits occur: a southern one extending from the Iberian Peninsula to the Caucasus; and a northern one comprising Great Britain, Scandinavia, and the Ural Mountains.

These distributions are only consequences of the mountainous districts in both the European elevated plateaux, subject to be missing where the mountains are wanting.

One cannot speak of ore-belts correctly on such a vast scale. But mountainous regions do not always, nor every where, contain ore-deposits. Nor are these deposits governed by any known law.

Those mountains contain the least, in which all igneous rocks are wanting; for example, the Jura and the Northern Carpathians.

There is consequently no recognised law for the geographical distribution of the ore-deposits.

But the answer is different, when we ask after the geological distribution. Ore-deposits, in general, occur more frequently in older, than in the recent rocks; and are more common at the junction of various kinds of rocks, than in the midst of large districts of a uniform rock: these rules are much more characteristic in regard to lodes, segregations, and impregnations, than as applied to beds; but we have already become acquainted with the probable reasons for this in the General Part.

The question has been raised, as to the distribution of the ore-deposits; and especially of the lodes, segregations, and impregnations of the separate ores; whose individuals were, according to their nature, confined to relatively small extents, and not, like the beds, spread over large districts.

In order to more thoroughly discuss the question, and not merely to decide from a general valuation, I have attempted to draw the principal ore-districts on charts, by means of various colors. The work was a laborious one, but led to no satisfactory, or rather to an almost negative result. No particular law of the distribution of ore-deposits could be recognised on the map of Europe; neither a grouping in very long belts, nor one around a central point, about corresponding to rows of or central volcanoes.

At times a recognisable predominant direction of distribution, or belt, could be seen for separate districts; but in no case, of such a considerable length, that it could be used in a general terrestrial relation. There was always shown merely local belts, or districts corresponding to the general geological character; for example, that of the Erzgebirge. The broad, but indefinitely limited silver-belt extends, as Baron von Beust has long since shown, from the neighborhood of Meissen obliquely, at an acute angle over the ridge of the Erzgebirge, to Bleistadt in Bohemia, the principal towns passed over being Scharfenberg, Freiberg, Marienberg, Annaberg, Schneeberg, Johanngeorgenstadt, and Joachimsthal. This belt can, however, in no manner be brought into an assignable, or even probable connection with any other special geological phenomenon of the Erzgebirge. Neither particular varieties of rocks, nor their limits, nor any conditions of texture of the same, can be proved to be parallel to this belt. The belt strikes predominantly through large districts of gneiss, mica-schist, and clay-slate; although indeed dikes of quartz-porphyry occur in the same, especially at or near Freiberg, Oederan, Marienberg (rock difficult to determine), Annaberg, Joachimsthal, and Bleistadt.

The silver-lodes are not every where accompanied by dikes of porphyry; nor the porphyry-dikes, or masses, every where by silver-lodes; the porphyries also branch, on both sides, to a considerable distance beyond the ore-belt, without showing any particular direction of the distribution.

Even where the dikes of porphyry occur within the belt, no fixed, or in any way constant relation to a special frequency, or particular richness of the lodes, can be recognised. I, myself, am much inclined to believe, that the presence of these porphyries has locally a certain connection with the formation of the silver-lodes in the Erzgebirge, whose special conditions are not yet sufficiently known. This opinion or supposition cannot, however, cause me to ignore the fact; that neither the distribution, nor the direction of the porphyry-dikes, exhibits any constant parallelism with the belt of silver-lodes, or with the separate lodes, which themselves strike within the belt in tolerably variable directions: only the extents of their distribution partially coincide.

If this silver-belt in the Erzgebirge is followed still farther North-East, or South-West, in its direction of strike; plumbiferous silver-lodes are met with at Erbendorf, beyond the granitic Fichtelgebirge, resembling some of those around Freiberg, in whose neighborhood, as in the latter, quartz-porphyries are also found: but between these is a large district containing no ores.

The continuation is still more doubtful toward North-East. In the syenite-granite hills beyond the Elbe the traces of ore are much scattered and uncertain.

The most distinct are those in the Kupferberg at Grossenhain.

The total length of this silver-belt, from Grossenhain to Erbendorf, is but 130 miles, and by thus extending it we consequently cover even uncertain traces.

This cannot be called a geographical belt of general importance; *i. e.* one of importance for the entire earth. Still this district is one of the most interesting of all those known, since it does not follow the principal trend of the Erzgebirge; but rather intersects this, with a certain independence, obliquely; and since the gaps in the same appear to be mostly caused by granitic rocks (granite, syenite, and red gneiss), which, in this district at least, seem to have been unfavorable to the formation of silver-lodes.

Silver lodes occur in the Hartz, at Harzgerode, Andreasberg, and Clausthal, about corresponding to its axis of elevation; with which the course of most of the separate lodes also coincides. It almost appears, as if the fissures they occupy, were consequences of one of the elevations of this mountain-ellipse, whose longest axis is only 45 to 50 miles long: beyond this no trace of a prolongation can be found, at least I should consider it very much forced, were it attempted to combine them in any way with the lodes of Kupferberg and Eisenkoppe near Altenberg in Silesia; since these (although without any relation as to direction) are much nearer to the silver-lodes in the Erzgebirge and Bohemia. These last are particularly instructive, from the entire irregularity of their distribution. The separate localities, where the lodes occur, can in no manner be united into a belt; although curiously enough a North-South course of the separate lodes greatly predominates. They are irregularly distributed over a broad surface like the crystalline rocks of Southern Bohemia; whose limits, however, the lodes exceed, penetrating into the Silurian strata.

The silver-lodes of Holzappel, about parallel to the strike of the slates, form a belt about 40 miles long; closely allied to which are the copper, nickel, and cobalt lodes; which, irregularly distributed over the whole Devonian formation, without any recognised cause, attain in places a sufficient richness to render them exploitable; as at Dillenburg, Siegen near Siegburg, and at Rheinbreitenbach.

In the great Central district of France no other law of distribution can be recognised, than that which arises from the cropping-out of the older rocks in a very irregular form; although a majority of the lodes strike from North-West to South-East.

In Spain we find a silver-belt on the southern coast between Carthagena and Malaga; it ceases with the Sierra Nevada, and is consequently dependent on the upheaval of this range.

Similar, much isolated, groups of lodes occur at Linares and near Hiendelencia in the interior of the country.

According to Pissis,[1] 'all the silver-mines of Chili occur in a small belt, which extends from 26° 30′ to 34° South Latitude in the valley-depression, which accompanies the western base of the Andes, and is called in the Southern Provinces Llano Longitudinal. The stratified rocks in this region are every where much altered, principally by the effect of the trachytes, which have broken through. The ore-deposits do not occur equally distributed over the entire belt, but appear principally in the neighborhood of those places, where the trachytes crop-out to the surface.

Since this last takes place more frequently to the North, the silver-ores occur more frequently in the North, especially in the province of Atacama. Thus the province of Santiago possesses only four mines of slight importance. The province of Aconcagua, in which the trachyte is very rare, contains but one mine. In the province of Coquimbo occurs the mine of Arqueros, much more important than any of the preceding; while the Province of Atacama possesses the mines, from which come almost all the silver exported from Chili. In this last-mentioned province the ore occurs partly in somewhat tilted strata, which are here traversed in all directions by small metalliferous strings, and are called by the miners *mantos*. The rock traversed by the strings of ore varies, in the various localities both in age and composition; in many places it belongs to the Silurian formation, as in Tres-Puntas, where a string of ore occurs in gneiss; in other places, to the Devonian formation, as at Zapalar, Romero, and Cabeza de Vaca; or to the red Sandstone or the Lias, as at San Antonio, Chanarcillo, and Agua Amarga. The lodes are poor, when in contact with many rocks; and become strikingly richer, the nearer they approach rocks otherwise composed. The variety of the ores also varies according to the nature of the wall-rock: chloride, bromide, and iodide of silver, occur in considerable quantities only in limestone; sulphurets and ruby-silver belong to the red Sandstone or the Devonian formation; finally, galena occurs in gneiss or schist. These changes can be most distinctly represented; if it be supposed, that a lode traverses the whole succession of stratified rocks from the Lias to the gneiss: chloride of silver and native silver would occur in the Lias; in the lower layers of

[1] See: Neumann's Zeitschrift für Erdkunde, 1860, p. 251.

this formation, and in the Redstone, would commence pyrargyrite (? *el rosicler*); following this would be proustite with cobalt-ores, and finally galena. Some of the mines at Chanarcillo, which have reached a depth of more than 650 feet, confirm this supposition; while at Tres-Puntas, where the Lias is wanting, ruby-silver predominates; and the mines of Zapalar, which occur in the Devonian formation, chiefly contain galena. The percentage of silver in the ores consequently decreases with the depth; and since the ore-strings of the *mantos* only come from the fact, that the upper portion of a lode has split up in a porous layer, the uncommon richness of the same is easily explained; as for example, the *mantos* of Mandiola and Ossa in Chanarcillo, and the *Manto de la Presidente* in Cabeza de Vaca.'

The distribution of this very long belt is not an independent one, but evidently dependent on mountain elevations, or certain igneous rocks.

The farther it is attempted to extend such belts, and districts of lodes; the more undefined, or the more dependent on other circumstances, do they become. With a slight power of imagination it is easy to discover fancied belts of this kind; which, on a more careful examination, are soon found to be very defective; and very frequently altogether different directions of strike might equally well be claimed.

Necessarily therefore much more uncertainty and arbitrariness occur in the determination within the limits of the ore-deposits, than in the following-up of mountain-elevations; being, as a rule, much more dependent on phenomena of a scattered and disconnected nature.

On a close examination of the gold-deposits in the Alps, yielding a very small percentage of gold, there may be found a sort of so-called gold-district, which extends from La-Gardette, with numerous gaps, to the Rathhausberg near Gastein.

This district is composed, partly of auriferous veins, partly of beds, in which quartz forms the principal veinstone.

The axis of the Alpine chain splits in its eastern portion; its northern branch passing through Pressburg, forms the connection with the Carpathians. Nevertheless the geologists of the Viennese Reichsanstalt think, they can prove a geological continuation of the Alps, somewhat more southerly, through the mountains at Neusohl. At Schemnitz and Kremnitz, consequently more southerly, again occur auriferous lodes; is it attempted to unite them as a sort of continuation of the Alpine gold-belt, itself very incomplete, there is opposed to it;

1. The difference of the geological axis, according to the results of the Reichsanstalt;

2. The entire dissimilarity of the wall-rock; in the Alps crystalline schists, at Schemnitz and Kremnitz greenstones or timazites, which belong to the Tertiary Period, rocks which do not occur in the Alps;

3. The entire variation in the course of the individual lodes, in the Salzburg Alps N.—S. and NW.—SE., at Schemnitz NE.—SW.;

4. The very dissimilar composition of the gold-deposits at Schemnitz, and in the Alps;

5. The much greater geological conformity of the Schemnitz deposits with the gold-deposits of Nagybánya, Felsöbánya, Offenbánya and Nagyág, which do not for the greater part occur in the same direction;

6. The very similar deposits of Eule, Tok, and Bergreichenstein in Bohemia, lie much nearer to the Alpine gold-deposits, than those of Schemnitz and Kremnitz; while the quite differently composed ones of Baza, Magurka, etc. occur in their geological axis.

If, however, the mountainous borders of the great Hungarian basin are reduced, there already follows a gold-enclosure, much interrupted, but more in accordance with nature.

There remains at least a common geological relation of the gold at Schemnitz, Kremnitz, Nagybánya, Felsöbánya, Kapnik, Borsabánya, Olalaposbánya, Offenbánya, Vöröspatak, and Nagyág. These deposits occur every where in certain relations to trachytic or timazitic greenstones, porphyries, or Tertiary sandstones.

I do not lay much importance on this fact, but still somewhat more than on the apparent direction of strike of a gold-belt under such dissimilar geological conditions.

In the Urals there occurs a long belt of gold-deposits and their remains in placers; but this is essentially a consequence of the long extended mountain-elevation, whose general geological character is every where a consonant one.

The result of our examination is: that ore-districts have merely an extent and importance corresponding to mountain districts, but beyond this are entirely independent of each other. This also agrees with a sound theory, according to which lodes, segregations, and impregnations, are the consequences of local, not general geological occurrences; as is more and more recognised for the igneous rocks. No conclusion can be drawn from their mineralogical similarity; these are consequences of general chemical laws, modified by local conditions or events; precisely as geologists no longer consider the much more conformable mineralogical composition of the igneous rocks, as a reason for their contemporaneous formation in all parts of the world.

RELATIONS OF THE ROCKS TO THE ORE-DEPOSITS.

§ 275. The relations between the rocks and ore-deposits, already referred to, deserve special attention. They may be considered both as general contact-phenomena, and as particular relations of certain rocks to certain ore-deposits.

Experience shows that lodes, segregations, and impregnations, are usually found at or near the junctions of igneous rocks with sedimentary or metamorphic ones.

From the many cases of this kind, which occur, the conclusion may be drawn; that lodes, segregations, and impregnations, generally are the direct or indirect consequences of the junction of dissimilar rocks, and especially of the penetration of igneous rocks between others; they, therefore, like many mineral springs, are the consequences of plutonic action. It is not, however, to be assumed, that ore-deposits every where occur where igneous rocks have penetrated, since the contrary can easily be shown.

The conditions of formation were not every where fulfilled. Consequently the igneous rocks are by no means in all cases accompanied by the presence of ores; while on the other hand relatively few lodes, segregations, or impregnations, are known, which cannot be brought into a certain connection with neighboring igneous rocks.

In truth the conclusion, when so generally considered, is of but slight practical value.

The facts encrease, however, in importance; if we arrange them according to natural groups. For this purpose I will classify the rocks into:

I. Igneous:

1. Rich in silica, or acidic; granites, trachytes, etc.
2. Poor in silica, or basic; greenstones, basalts, etc.

II. Metamorphic:

1. Crystalline schists composed of silicates,
2. Crystalline limestones and dolomites;

III. Sedimentary:

1. Siliceous; sandstones, etc.
2. Magnesian; clay-slate, etc.
3. Calcareous; limestone, dolomite, etc.

The ore-deposits I separate according to their composition in the three natural groups already mentioned (I entirely pass over the true beds, as being altogether sedimentary deposits):

I. Tin-lodes, segregations, or impregnations;

II. Gold, silver, lead, zinc, copper, cobalt, nickel, antimony, and quicksilver lodes, segregations, or impregnations; which may be also regarded according to the separate predominating or characteristic metals;

III. Iron- (and manganese-) lodes, segregations, or impregnations.

The demarcations of these groups, from rocks and deposits, are not always distinct and fixed; nevertheless this grouping appears to me a very natural one. In order to avoid repetitions, and uncertainties, I shall comprehend lodes, segregations, and impregnations (here with exclusion of the beds), under the common name of ore-deposits, and only make exceptions, when a particular value is to be given to the form of the occurrence.

Iron-ore-deposits occur very often, at the limits of acidic, or basic, igneous-rocks, as immediate or indirect contact-formations; thus, in many parts of the Erzgebirge (especially at the limits of granite), in the Thuringian Forest, in the Hartz, in Westphalia, in Bohemia, Moravia and Silesia, in the Banat, in Italy, in the Vosges, in Brittany and the Pyrenees, in Norway and Sweden.

Magnetic iron-ore occurs very often under very peculiar relations of contact; in numerous regions especially with embedded masses of granular limestone or dolomite, between crystalline schists, or at the edges of granitic rocks or greenstones: thus, around Schwarzenberg, and Oberwiesenthal, in the Erzgebirge; in the Banat; at Dannemora, Nora, and on the Island of Utoe, in Sweden. It is then associated with numerous other ores, and certain minerals, which can be partly explained by combinations of lime with silicates. To the common occurrence of granular limestone with magnetite, also join-on, other ore-deposits in which magnetite is frequently but subordinate; thus, at Schwarzenberg, and Kupferberg, in the Erzgebirge; near Oravitza in the Banat, at Offenbánya in Transylvania, near Christiania in Norway, at Sula and Tunaberg in Sweden, and near Bogoslowsk in the Urals; so that these contact-deposits of the limestone again form in common a sort of natural, but among themselves very varied, subordinate group.

Since these deposits chiefly occur between and with such rocks, as the majority of geologists consider to be metamorphic; the question arises, whether, in the succession of the sedimentary rocks, combinations do not already occur, through whose alteration they might be formed. This is in fact the case: compact limestones occur combined with deposits of spathic iron, limonite, or hematite, in sedimentary rocks, which have not yet become crystalline; for example, in the Devonian of Southern Saxony, of the Hartz, and of the Rhine; in the brown Jura of Würtemberg, and of Bavaria; in the Muschelkalk and Jurassic of Upper Silesia, in the Devonian of the Alps, etc. Also, the very constant occurrence of oolithic ore in fissures, funnels, and cavities of limestones, in the Swabian Alp, in the Jura, near Thionville, etc., must be considered as belonging here. These are, indeed, in part true beds, but still often of very irregular shape, which by the occurrence of alterations might easily become still more irregular, and thus assume more the form of segregations. A sort of transition occurs, near Arzberg in the Fichtelgebirge, where the limestone between the mica-schist is altered to crystalline limestone, the iron-ore remaining in the condition of spathic iron (or decomposed from this into limonite).

Many of the segregations of magnetite, especially the Swedish, exhibit forms, which much resemble irregular beds; and the numerous minerals, which they contain besides the iron-ore, can mostly be explained by the possibility, that by the alteration numerous combinations of lime, silica, magnesia, and iron, were formed.

I must confess, that I am inclined to consider these segregations of ore combined with granular limestone, as more or less altered sedimentary beds, which partly altered their shape in a semi-fluid condition, and whose mass at times would have penetrated into the adjoining fissures of the less softened wall-rock. It is remarkable, that they are frequently traversed by more recent granite dikes; which is also the case in the granular limestone of Miltitz near Meissen, and of Kothigen Biebersbach in the Fichtelgebirge.

Should the proposed hypothesis prove correct, there would still remain unanswered the question, why carbonate of lime, and hydrated oxide of iron or other ores, should have originally been so often deposited immediately alongside of, or over, one another?

Somewhat different is the very constant ocurrence of bedded spherosiderites in such sedimentary deposits, which also contain coal, no matter what their age may be.

Gold is, in its original position, mostly combined with such rocks, as contain but little lime. We must not, however, while considering the rule, forget the exception. I am only aware of the following: the somewhat auriferous Liassic limestone of Grave in the Western Alps; according to de Marni the auriferous limestones of Kameno-Pawlowsk in the Ilmen mountains; the auriferous chromic dolomite of Russia, described by Breithaupt; and the auriferous quartz-veins, in mountain-limestone, of the Tobol district. Could the gold in the limestone at Grave be considered as an extremely fine mechanical deposit, this occurrence would then form no exception as contradicting the rule; the presence of gold in the limestone of Kameno-Pawlowsk is only a supposition, and I am ignorant under what conditions it occurs in the chromic dolomite. The lodes in the mountain-limestone of the Tobol certainly vary altogether from the rule; while on the other hand this law finds a sort of direct confirmation in the gold-lodes of the Salzburg Alps, which, where they continue in limestone, contain silver-ores instead of gold. Characteristic of the occurrence of gold is, also, its frequent combination with quartzose, talcose, or chloritic rocks; thus, in the Alps, in Merionethshire (England), in the Urals, in Brazil, in California, Georgia, North and South Carolina, and Nova Scotia. Still a fixed law cannot be deduced from these cases; since the number of gold occurrences known n o t to be combined with such rocks, may be just as great, as those where they a r e. It appears to me, therefore, impossible to deduce hopes of the presence of gold *a priori* from general lithological analogies.

Rich silver-ores, and very argentiferous lead-ores, occur more commonly in siliceous or argillaceous rocks, than in limestones or dolomites; more frequently than gold in these last. While galena, when in immediate contact with limestones, contains but little if any silver, and is commonly associated with blende, smithsonite, or calamine. For example, in Iowa, Wisconsin, Illinois, and Missouri, in the neighborhood of Aix-la-Chapelle and Liège, near Wiesloch in Baden, in Upper Silesia, the Carinthian Alps, the Bavarian Alps, at Pallières in France, in the Province of Santander in Spain, in Cumberland and Derbyshire in England. In all these localities the ores appear, as it were, to have been deposited at the expense of dissolved magnesian limestone, which they, in part, permeated.

It is worth noticing, that silver-lodes have been much more commonly found in grey gneiss and mica-schist, than in granite and red gneiss. In several districts, where these various rocks occur together, they appear to avoid the granite and red gneiss; being either entirely wanting, or in such small quantities, as not to be exploitable; thus, for the most part, in the Erzgebirge, partly also in the Black Forest, in Bohemia, near St. Julien in France and at Kupferberg in Silesia; where, however, the rock is, for the most part, a schist rich in hornblende.

Copper-ores are found especially in chloritic schists, in hornblende-schist, or in greenstones and serpentines, as well as combined with granites. Beds of copper-ore occur most frequently between those schists. Besides the above, two peculiar modes of occurrence of copper-ores are to be mentioned; viz. first, the impregnations in the older rocks, mostly sandstones or schists, containing the remains of plants; as near Twiste, Starkenbach, Hohenelbe, in the Permian district of Russia, and in Chili, where (according to Philippi's Journey through the Desert of Atacama) a copper-sandstone occurs of the same age as the Permian. The copper-ores in Thuringia occur probably as an impregnation.

Secondly, the broad segregated masses composed of copper and iron pyrites, which occur in like manner in the Devonian slates near Goslar, in clay-slate near Schmöllnitz, Agordo, and Rio Tinto, as well as in mica-schist or quartzite at Falun; in several of these localities, immediately surrounded by talc-schistose layers.

It is incomprehensible, under what peculiar circumstances such broad masses of these sulphurets can have been locally aggregated; scarcely at the same time with the deposit of the enclosing rock; but it is almost as difficult to explain their subsequent penetration in any satisfactory manner; still the occurrence of the segregations near Schmöllnitz, within a belt of schist containing disseminated pyrites, would tend to indicate a peculiar manner of subsequent impregnation.

Cobalt and Nickel ores, these almost constant mutual companions, scarcely appear united with particular rocks. We find them forming lodes at Schneeberg (Saxony) in clay-slate and mica-schist; at Saalfeld, Schweina, and Riegelsdorf (in Thuringia), in the copper-slate; near Friedrichsroda, in the Rothliegendes; near Dobschau (Hungary) in a rock resembling gabbro, as also above the gabbro as pockets in spathic iron; at Schladming (Styria), like a Fallband within a belt of mica-schist; on the Nockelberg (Alps), in magnesian limestone; in the Annivaer Valley, in chloritic mica-schist; and at Skutterud, Norway (exceptionally almost altogether cobalt-ores without nickel), as impregnation in mica-schist.

It would be still more difficult to lay down laws for the occurrence of antimony-ores, than for those of cobalt and nickel.

Quicksilver-ores occur under various forms and geological conditions, but rarely in exploitable quantities. They occur, as lodes, and as impregnations, in old metamorphic schists, in rocks of the Carboniferous formation, as well as in more recent ones; thus, in the Tihu Valley in Northern Transylvania. It might appear important, that the strata containing deposits of mercury in the Alps are recognised to be about, but not quite, of the same age, as those traversed by quicksilver-lodes in the Palatinate. These are but two cases, of the agreement in age of the country-rock, and difference in the nature of their deposits; they cannot consequently be used as the starting point of a law.

The tin-ores exhibit, on the contrary, a strikingly constant relation of their geological occurrence. They have been found in place only in plutonic, and more or less metamorphosed rocks of great age, never with limestones or dolomites, most frequently in granite districts, or at their junctions with metamorphic rocks, or very old sedimentary ones. Their combination with granitic rocks really occurs so often, that it may be correct to regard them as local contact-formations in the broadest sense of the term.

We find the tin-ores at the junctions of granite, very characteristically, in the deposits of Altenberg, Zinnwald, Ehrenfriedersdorf, Geyer, Eibenstock, Johanngeorgenstadt, Joachimsthal (all in the Erzgebirge), Schlackenwald (Bohemia), Brittany, and Cornwall. At Graupen and Marienberg the granites are somewhat more distant, or replaced by porphyries; the geological relations of the deposits in Spain are not sufficiently known. At Pittkaranda (Sweden), the cassiterite occurs, with the other ores and minerals, as a bedded lode, or belt of impregnation, in hornblende-schist traversed by granite dikes, under similar conditions as at Breitenbrunn (Erzgebirge). From what is known of the occurrence of tin-ore on the islands of Banka and Billiton, the original deposits occur there between granitic rocks. No other metal appears to be so constant in its occurrence: I shall return to the possible cause of these phenomena.

From what precedes it would appear, that the ores of the various metals occur, for the most part, combined with certain rocks, although there are exceptions to this.

DISTRIBUTION OF THE ORES IN THE DEPOSITS.

§ 276. Ores generally occur in true beds equally distributed. The number of real beds, however, will greatly diminish; if we omit those which, though called beds, are properly bedded veins, or impregnations. In the case of lodes, segregations, and impregnations, the distribution of ores is, as a rule, found much more unequal than in beds.

Inasmuch as no other causes of distribution can be recognised, for segregations and impregnations, than those which most distinctly occur in the lodes; I confine myself to what is stated in the general part, adding some remarks suggested by a review of the examples mentioned in this part.

Differences of depth, which are partly original, partly secondary, caused by alteration from above, occur in many localities. It is believed, that original differences of depth combined with secondary ones have been observed at Freiberg, Berggieshübel, Seiffen, Joachimsthal, Clausthal, Przibram, Felsöbánya, Schemnitz, in the Salzburg Alps, on the Monte Catini, in the Katzenthal, in the Sierra Almagrera, near Linares, in Cornwall, at Beresow, in South Carolina, at Oruro in Potosi, and near Caravella in Peru. I consider the cases especially important, in which the upper portions of lead, silver, or copper lodes are actually more ferrugineous, and mostly free from other ores; as at Przibram, Berggieshübel, and Katzenthal; as well as the pyritous lead-veins at Freiberg, and many lodes in Nassau, which appear to be actually more ferrugineous, and to contain less lead, at the surface, than at greater depths.

The idea, that gold-veins are richer near the surface than at considerable depths, must now be given up, at least as being a universal law; the lodes at Grass Valley in California, being as rich 1000 feet below, as at the surface.

Natural causes for the constant original differences of depth might be easily found in the dissimilar degrees of pressure and heat. Here theory has preceded observation, and is prepared to explain phenomena which have not yet been satisfactorily observed; which is for the greater part explained by the fact, that mines have mostly not attained sufficient depth for this purpose. The secondary differences of depth may be still more easily explained by decompositions and alterations, which occur so commonly, that I consider examples unnecessary.

Where chlorides, bromides, and iodides, of silver occur near the surface; it may be supposed that, during or after the formation of the lodes, they were covered by the sea.

Influence of the breadth on the distribution of ores, naturally leaving the encreased volume out of account, and only noticing the relative percentage, has been but slightly observed: broader portions contain richer ores at Geldkronach and Linares; the narrower portions are stated to be richest at Andreasberg, Clausthal, Carthagena, and Kongsberg.

The influences of the wall-rock have as yet been most frequently observed: in these we are obliged to distinguish modifications varied by their nature; viz. intersection by other ore-deposits or metalliferous rocks, original disparities of the rocks, disparity in their state of decomposition, and finally mechanical influences of the wall-rock on the formation of fissures. Here must also be considered the frequent occurrence of contact-deposits at the junctions of two different rocks, and especially of aggregations of ores at such junctions.

Intersected ore-deposits or metalliferous belts of rocks (Fall-bands) occasion enrichment; as at Freiberg, Ehrenfriedersdorf, Johanngeorgenstadt, Schneeberg, Camsdorf, Schweina, Riegelsdorf, Dillenburg, Horzowitz, Kupferberg in Silesia, Schladming; in Cornwall, and Cardiganshire, and at Kongsberg: at Nagyág, on the contrary, the junctions of the telluric gold-veins appear to be, for the most part, poor.

The original difference ot the country-rock shows itself to exert an influence on the metalliferous contents of the lodes at Freiberg, Graupen, Geyer, Joachimsthal, Johanngeorgenstadt, Eibenstock, Schneeberg, Tilkerode, Lehrbach, Harzburg, Zorge, Pfaffenberg, Andreasberg, Clausthal, Dillenburg, Wetzlar, Obermoschel, Wittich in the Kinzigthal and Münsterthal, at Schlaggenwald, Przibram, Adamstadt, Kuttenberg, Starckenbach, Rochlitz, Kupferberg, Vöröspatak, Offenbánya, Felsöbánya, Schemnitz, Dobschau, in the Salzburg Alps, on the Callanda and Mürtschen-Alp, in the district of the Aveyron, in Cornwall, Derbyshire, and Cumberland, at Kaafjord, Reipas, Sala, in the Urals, on Lake Superior, in South Carolina, at Piedad in Mexico, and in Chili.

A decomposed condition of the wall-rock has had a favorable influence at Nagyág, Offenbánya, and in Cornwall; an unfavorable one at Holzappel, and in Cardiganshire. Both can be explained, if it be admitted that the solution of the ingredients of the wall-rock (for example, the alkalies), taking place during the formation of the lode-matrix, has exercised some influence on the deposition of the ores. And thus a decomposition taking place, before the formation of the lode, must have influenced in a different manner (probably more unfavorably) the deposition of the ores, than if the same had taken place during the formation of the lode.

Decomposed wall-rock, as is well known, is a very common occurrence alongside of most lodes; the observation, with regard to the influence of this condition on the constitution of the lode, is but slight. Where all the wall-rock is decomposed, no such observations are possible; these can on the contrary, be only made in the more rare cases, where only certain portions of the wall-rock exhibit locally more decomposition; and these have been properly attended to in the process of mining. I come, finally, to the unequal distribution of ores, for which no determined causes, or rather no constant connection with other phenomena, have as yet been recognised.

It is a very old experience in vein-mining, that the masses of ore are not only distributed unequally in the lodes, but also extend with a certain local regularity through the same. Very often they extend with an almost regular breadth, consequently ribbonlike, either obliquely towards one side of the direction of strike, or parallel to the dip, in the direction of depth. This manner of occurrence is called in America 'Chimney', in France *Colonne*. On horizontal plans this condition is often clearly seem from the form and distribution of the workings. This mode of the ore-distribution often coincides, indeed, with the corresponding bed of the rock-alternation and its limits; and then the consequences are most probably to be regarded, as caused by the unequal influences of the country-rock; though their proper reason cannot be farther proved. Still, in many cases, such a relation has not yet been recognised, either from want of observation, or because not actually present. Such examples are those of Schneeberg, Holzappel, Heizenberg, Kleinkogel, and Schwatz in Tyrol, Ahrn, La Pause, Aveyron district, Pontgibaud, Poullaouen, Linares, Cardiganshire, and Pittkaranda.

It is to be regretted, that the observations in this connection often leave much to be desired; but it is very natural that the practical miner should only follow and extract his mass of ore, without troubling himself about slight changes in the wall-rock; especially where the lodes are so broad, that it is not necessary to remove any of the country-rock. I therefore suppose, that a portion of those still enigmatical chimneys of ore could be traced back, by more careful observation, to influences of the wall-rock, or perhaps also to unequal conditions of breadth; but there still remain some carefully examined cases, in which as yet no material causes have been recognised.

In most localities the ore-chimneys are parallel to one another, but at Poullaouen in Brittany they diverge in their course, which renders their explanation still more difficult. Durocher has attempted to explain such like phenomena by currents of vapor.

The most enigmatical are those in the Tyrol, stated to recur at equal distances apart; once in lodes of tetrahedrite in magnesian limestone, a second time in an auriferous bed or clay-slate.

I do not attempt to offer any opinion of such peculiar phenomena, for which there is no explanation. So long as they occur so rarely, they may still be regarded as merely accidental, and at least must not have too much value attached to them.

CONDITIONS OF AGE OF THE ORE-DEPOSITS.

§ 277. The conditions of bedding, the enclosure of fossils, of fragments, and of pebbles, serve us for ascertaining and determining the relative age of the rocks essentially composing the earth's crust These aids can only partially, or in an indistinct degree, aid us in the case of the ore-deposits.

The determination of the age of true ore-beds is still the easiest, their formation coincides with that of the rock enclosing them. Is the age of the last known, so is also that of the beds they contain; thus, the period of the formation of the copper-slates of Thuringia belongs, beyond a doubt, to that of the Zechstein formation.

The determination of the age, in the case of lodes, segregated aggregations, or impregnations, is entirely different, and far more difficult. I shall attempt to discuss this question somewhat more closely in regard to the lodes, as the most common and most distinctly stamped of these forms.

These is no doubt that lodes are always more recent than the rocks which they traverse; since it is unnecessary to attend to the possibility that an outcrop, rendered projecting by erosion, may subsequently be enclosed by a new rock, as in the outcrop of a bed of copper-ore on the Schatten Mount near Kitzbühel; such exceptional cases may be always recognised, by a careful examination, to be what they really are.

From this, however, we merely ascertain, that all lodes are more recent than their wall-rock. How much more recent they are, does not appear. The difference of age may be very great, or very small; besides, a result obtained in this manner, at one locality, cannot, without something farther, be used for another locality, where similar lodes occur.

There can be no doubt, that lodes are always older than those veins or rocks, by which they are distinctly in any manner intersected. The difference in age is, here too, undeterminable; and it is necessary to avoid the possible delusion, that the intersection is but an apparent one, perhaps caused by a fault, which does not coincide in age with that of the apparently intersecting mass, but arose from a subsequent fissure. Distinct intersections are, however, always decisive of the relative age.

Less certain are the conclusions, drawn from the overlaying of the outcrops of lodes, by rocks into which the lodes do not extend. Only by greater positiveness and distinctness of the relations, is it possible to draw a certain conclusion as to the relative age. The want of continuation of narrower lodes; or such as split up in this direction, in rocks of another character over, alongside, or beneath; can easily find an explanation from the fact, that one rock was not inclined in a similar degree to be fissured that the other was; since it possibly possessed a certain plasticity, by which the formation of fissures, which would remain open, was hindered.

Fragments of lodes in other rocks decide with the greatest certainty concerning the greater age of the lodes in comparison to the rock which contains portions of these. Such phenomena are as yet but seldom distinctly observed; which is very natural, if we consider the slight solidity, and easy decomposition, of the ores forming the lodes.

Fossils belonging to their period of formation do not occur at all in lodes. Where organic remains have exceptionally been found in them, they always proceeded from the wall-rock, and only accidentally fell into the fissures.

Consequently, the possibility of a certain determination of the age of lodes is confined to the above few cases, in so far as these are from their nature distinct. Beyond this, only hypotheses can be made, which depend on accompanying phenomena, on the similarity of the composition, on the direction of the strike, and such like; or which proceed from general theoretical views. These are, however, arguments, which cannot be carelessly used, but need a particularly careful examination.

After Werner's constantly asserted doctrine, of the successive formation of the rocks, rising from granite and gneiss to the basalt and the most recent deposits, had obtained a commanding influence; it was supposed, that the age of the rocks could be determined from their mineralogical composition. This opinion, subsequently recognised as erroneous, was still to a certain extent retained; after the incorrectness of many of Werner's theories, as to the manner in which rocks were formed, was admitted. Long subsequently it was generally believed, that the formation of the separate kinds of rocks belonged to determined geological periods; for example, a period of the formation of granite, of the formation of porphyry, of the formation of greenstone, trachyte, or of basalt, as well as a period of the formation of mica-schist or clay-slate, could be recognised;

that the age of the rocks could be ascertained from the rocks themselves. Many repeated disillusions were necessary, before this convenient method of determining the age of rocks was abandoned. By an examination of the mineralogical structure of the rocks it may be determined, whether they possess more or less of a plutonic character, and whether a less or greater alteration has taken place in them; but not whether they were formed or metamorphosed at a very early or at a later period.

The character of the rocks can hence be used, as an aid in the determination of age, in but very confined geological limits, within the extent of associated geological events; thus, in districts composed of igneous or sedimentary rocks, and even there not *a priori*, but only after the succession of the formations has been recognised at some one point. Beyond this it too easily misleads to uncertain conclusions. In districts separated from one another, the lithological conformity can only serve as a proof, that certain events of the formation, and conditions, have repeatedly recurred both in extent and time; the similarity or equality of the rocks does not show their equal; nor their dissimilarity, their unequal age. Like rocks may as well belong to like, as to different periods of formation; and just the same reversed. This well recognised truth does not, however, exclude certain rocks, wherever they are observed, from being as a rule of a very old, and others of a very recent formation. This fact is no contradiction of the preceding rule; and is easily understood, if it be admitted, that certain kinds of rocks are only formed in the interior of the earth (plutonic), or by metamorphosis; whereas others were products of the earth's surface.

It is known with certainty, that some granites are older than neighboring Silurian strata; whilst others, with no essential difference from the former, have broken through and altered Triassic or Jurassic strata. That true clay-slates occur widely distributed in the Swiss Alps, which formation belongs to the Cretaceous or to the Eocene; yet so similar as to be easily mistaken for the finest Silurian or Devonian roofing-slates of the Hartz or the Thuringian Forest; is so well known, as to prevent any value from being attached to such similarity in rocks, as determining their age; unless they occur in immediate connection, or at least in districts geologically united. Precisely the same is true, however, for all other igneous and sedimentary rocks, as well as for such as are metamorphic; this could be proved by numerous examples.

If nevertheless the granitic rocks for example, wherever they have been found, are of greater age than the trachytic or basaltic, and perhaps older than the Tertiary period; it by no means follows, that the formation of the granites ceased with the Tertiary period, and every where belongs only to a very early, though long continued geological age. That fact finds just as satisfactory explanation in the supposition, that all granites are true plutonic, igneous, or metamorphic rocks; which during the period of their formation never attained the surface, but became, or still become, what they are, under great pressure in the interior of the earth. Are they, as is very probable, eruptive masses formed by hardening from an igneous-fluid condition? If so, their original outcrop under a less pressure, and by a quicker cooling off, may have taken and still take another, perhaps more trachytic character. Such rocks, formed at some depth, can only attain the surface, and become accessible to observation, through considerable alterations, elevations, and erosions of the surface; which must necessarily occupy a long period. What, therefore, is seen of them must always be tolerably old. Precisely the same is true of the syenites, and their related rocks; and very simply explains the entire want of all true volcanic phenomena on such rocks.

It appeared necessary, that the preceding remarks should be made; though the idea of determining the age of rocks, by their nature, or by analogy, has long been abandoned; for this abandonment has not become universal respecting lodes, segregations, and impregnations. In this last case one often, at this day, meets with the attempt to establish the contemporaneousness of their formation from their mineralogical character, even where the geological districts are widely separated. If the last be proved from other causes, then the homogeneousness may always be rendered prominent. But it cannot then itself give a new support to the proof; just as little as would be the case in two occurrences of granite, which have been recognised as of contemporaneous age in districts altogether separated from one another; while, in many other places, granites quite like these are known to be of very different age.

The more widely extended, and more frequent, certain mineral combinations of the lodes are; as for example those, of heavy spar and quartz, with lead, silver, and other ores; so much the less do they authorise the conclusion, that they are of contemporaneous age, so much the more must it be assumed, that the chemical condition for this combination was a very general terrestrial one, which has frequently recurred both in extent and time, furnishing similar results modified by local conditions. In completing this law, I fear it may in so far be misunderstood, as if I wished to regard the rarer mineral combinations, as still belonging to determined geological epochs. The terms 'the more frequent', 'the more rarely' have in fact merely the meaning, that mineral formations, which are very frequently found, and which have been observed in many localities, and under very various conditions, were probably formed, very often, at very different periods; while many rarer mineral combinations arose under altogether peculia rlocal circumstances; and consequently, perhaps accidentally, are only known in one period.

One reason why, particularly in relation to the lodes, the preconceived opinion, that like composition betrays like age, could be longer maintained, than in respect to the rocks; is, that in the former an actual proof of age is often impossible to find; and this has naturally led to an adhesion to the preconceived, even though erroneous, opinion on this subject. This but renders it the more desirable to use all possible negative or positive aids for establishing the period of formation, and the equality or non-equality in age of some lodes.

To aid in this will now be my effort.

The lodes of the Central District of France; especially characterised by heavy spar and galena, often, however, very quartzose; reach, according to Gruner, upwards to between the lower strata of the Jurassic, but nowhere in this region into the upper strata of this formation. Gruner and Baron Beust conclude, from this, as well as from other subordinate circumstances, that the formation of these veins (in that district) belong to the Jurassic period.

The barytic lodes of the Black Forest containing silver, lead, cobalt, and nickel ores, occasionally intersect, according to Daub, the Jurassic limestone, which is the upper division of this formation in Swabia; hence they must be of more recent formation than the similar ones in Central France.

Lodes, very similarly composed to those just mentioned, intersect deposits near Massetano in Tuscany; which are certainly much more recent than the Jurassic, and belong either to the upper divisions of the Cretaceous, or even to the Eocene.

The broad champion-lode of Felsöbánya in Eastern Hungary, also consists in part of heavy spar, quartz, and galena. It traverses a greenstone or timazite, which has evidently broken through strata of the Eocene, and is consequently more recent than these: the lode is naturally still more recent than the greenstone.

It appears from Daubrée's researches, that the mineral water of Plombières still deposits minerals, which are characteristic of the variety of lodes mentioned; and it is by no means impossible, that there, at a corresponding depth below the surface, such lodes are still forming.

We have thus become acquainted with the lodes characterised by heavy spar and quartz, which were most probably formed during the Jurassic period; and others of a very similar composition, which are much more recent, perchance are still forming. For older periods of formation, indications, if not proofs, are found.

The lodes of Derbyshire consist, for the most part, of heavy spar, quartz, fluor spar, and galena. They traverse the strata of the mountain-limestone, as well as the lowest sandstone-layers of the Carboniferous formation; but they have nowhere been found in the upper strata of the Carboniferous; which is extensively represented in this district. I admit, that it is very difficult to arrive at a positive decision from these facts; since it is possible, that these upper layers, through their clayey and plastic nature, have (as is the case to a less degree in the embedded argillaceous layers of the mountain-limestone) offered a mechanical obstacle to the formation of the veins. The fact is, however, entitled to as much attention, as some opposed theoretical views, or as the similar occurrences in other countries, in which so little agreement in age is apparent; thus in France, Swabia, Northern Italy, and Eastern Hungary.

Ezquerra del Bayo remarks, on the very argentiferous barytic lodes in the neighborhood of Hiendelencia (Spain), that torn-off fragments of the same are found in an adjoining layer of mica-schist. I grant, that this fact needs a more accurate examination, before positive conclusions can be based on it.

For the barytic lodes in the neighborhood of Freiberg, very similar to the above, it can only be determined, in regard to their age, that they are younger than the other silver-lodes of this district; which must themselves be for the greater part more recent than the quartz-porphyries; which last, on the other hand, are older than the conglomerates of the adjoining *Rothliegendes,* in which pebbles of the porphyries are found. There are no measurable observations, to determine how much more recent the barytic lodes around Freiberg are than the other veins; if it be not concluded, from the mutual occurrence in one and the same district of veins, and from the occasional presence of heavy spar occurring sporadically in geodes of the older lodes, that the formation of all those veins may belong to one and the same great geological period, and are connected in a certain manner with one another. No great value can indeed be placed on such a conclusion; but, on the other hand, a determination of the age, from the similarity with a corresponding district of veins, would be still less authorised.

Many circumstances render it probable, that the process of the vein-formation at Freiberg stands in a certain connection with the upheaval of the quartz-porphyries. H. Müller has even proved, of the oldest lodes at Freiberg, that they are in some cases intersected and heaved by porphyries, that they are therefore older than these; which does not contradict the fact, that, as a rule, all the lodes around Freiberg intersect the porphyries. Then neither the porphyries nor the lodes were all formed contemporaneously around Freiberg; and it might thus well have happened, that the last irruption of porphyry found some of the lodes already completed. But precisely this circumstance renders it very probable, that at least a portion of the Freiberg lodes about corresponds to the period of the porphyry-irruption, or the last portion of this great period]; and consequently about coincides with the period of the *Rothliegendes,* with whose deposits the porphyries are so intimately connected by tufas and conglomerates. If, however, the silver-lodes around Freiberg, so productive in quartz, pyrites, and carbonates; whose difference in age has been recognised to be but slight; once belong to about the period, in which the porphyries were formed; it then appears to me most probable, that the, somewhat younger it is true, barytic silver-lodes of the same district, are also not far removed from this period, and must be regarded as the last products of a great process in the formation of the veins; until some facts are observed, supporting different views.

The probable determined geological age of the quartzose, pyritous, and carbonaceous silver-lodes, or the so-called 'noble quartz-, pyritous, and noble lead-formations' around Freiberg, again give rise to a new series of comparisons. We have seen, that these must be considered as about of like age with the *Rothliegendes.*

Near Schemnitz, we find lodes, on the contrary, whose composition is so similar, partly with the noble quartz-veins, partly with the pyritous lead-veins of Freiberg; that single cabinet-specimens from the two localities might certainly be confounded. Both combinations cannot be separated at Schemnitz according to their age, both traverse trachytic greenstones or timazites, which evidently belong to the Tertiary period. The veins are naturally younger than the rocks.

A similar case recurs in the ore-district of North-eastern Hungary. The composition of the lodes at Kapnik extraordinarily resembles, partly those of the pyritous lead-veins, partly those of noble lead-veins, rich in dialogite, around Freiberg. They again traverse, however, trachytic greenstones, or timazites, which have broken through strata of the Eocene. We find, westwardly of Kapnik, under entirely analogous geological conditions, between the same Tertiary country-rock, the broad lode of Felsöbánya, which contains in part much heavy spar, and shows in many parts a great similarity with the barytic lead-veins of Freiberg; while in other parts its composition more nearly approaches the pyritous lead-veins. Still farther to the west, we find then again, near Nagybánya, under precisely the same geological conditions, lodes which consist predominantly of quartz with gold and a little galena. Eastwardly of Kapnik, at Olalaposbánya in Transylvania, joins on a vein chiefly consisting of quartz, copper-pyrites, argentiferous galena, blende, and iron pyrites; consequently similarly, composed to the pyritous lead-formation of Freiberg, which traverses an Eocene sandstone.

All these various veins of Northeastern Hungary are, therefore, more recent than the Eocene, and probably belong to the second half of the Tertiary period. In their totality they tolerably represent all four of the Freiberg vein-formations; but there occurs no reason to transpose the time of their formation to very different periods. Only in their age in general do they appear to be very different from that of the Freiberg lodes.

The Cornwall tin-lodes are certainly of more recent origin, than the Devonian slates which they traverse; according to Lyell[1] they are even younger than the Carboniferous epoch. Apart from containing copper-ore themselves, they occur together with copper-lodes, which are here always of more recent age than those of tin; how much more recent, is not known. At Wexford in Ireland, not very distant from Cornwall, but in a different geological district, Silurian slates are cut through by lodes of copper and lead; which, according to the as yet undoubted examination of the Government-Geologists of Ireland, are older than the Devonian strata overlying them, in which streaks or layers of derivative copper occur. These copper-lodes of Wexford are consequently older than the tin-lodes of Cornwall, and much older than the copper-lodes of the same. Unfortunately they have not been mineralogically compared with them; at any rate the preceding fact, its correctness being granted, contradicts the very usual supposition; founded, it is true, on many observations; that tin-veins are generally the oldest of all lodes.

This presupposition may possibly be correct for each region, but not for two dissimilar geological districts, when compared together. To be more explicit, if tin-lodes also occurred in Wexford, it is very probable, from previous observations, that they would be older than the above mentioned copper-lodes.

AGE OF METALS.

§ 278. The preceding leads me to an allied subject; viz. to the supposition of determined geological periods for the formations of the different metals. Such a hypothesis has not, it is true, been logically argued by any one; but corresponding ideas are frequent; and it cannot be denied, that many facts may be given such an interpretation, that it would seem as if certain metals had been, for the most part, deposited during certain periods.

Especially in the case of tin, gold, and copper ore-deposits, has the idea at times arisen, that they belong for the most part to certain geological periods.

[1] See: Lyell's Elements of Geology, 6th Ed. p. 768.

Tin-ores in place, are in fact only found in very ancient rocks. From this, however, it by no means follows, as I have already indicated, that tin-ores were formed only in very early geological periods. If the formation of the granitic rocks, with which they are as a rule combined, is only possible deep in the interior of the earth, and if the same is perhaps true for tin-ores; it is then very comprehensible, that we can only observe these last, where such true plutonic formations have been laid bare by elevations and denudations requiring great periods of time. Under this supposition, the observable ones, and such as are accessible for mining, must always be of great age. In this it is, however, easily imaginable, that granites and deposits of tin-ore are still forming in the interior of the earth, and that the same have been formed in all periods under corresponding circumstances.

For gold, Sir Roderick Murchison and Oscar Lieber in particular, have expressed the opinion, that its formation, or deposit, essentially belongs to one or two determined geological periods. Murchison says, in his 'Siluria', that the original occurrence of gold is almost exclusively confined to Palæozoic, or still older rocks; that it occurs in the mostly metamorphic rocks of this early period, partly disseminated in crystalline schists, partly in quartz-veins which cut through these schists in the neighborhood of igneous rocks. This assertion contains, however, another interpretation, than might at first be expected; in that Murchison farther concludes, the gold might first have got into these rocks and veins, at least in the Urals, subsequently to the Permian formation, and even only after the formation of the older Tertiary strata; since in these, as in those, nowhere has the slightest trace of gold, but very many fragments of older rocks, been found. Murchison is of the opinion, that the formation of the gold-deposits in general belongs to a particular, and that a very recent, geological period. The formation of the original gold-deposits has, according to him, only shortly preceded the denudation, and collection, in Recent or Post-tertiary placers. Lieber, on the contrary, expresses much more definitively the opinion, that the formation of the original gold-deposits essentially belongs only to a very early period, which about corresponds to the Silurian epoch. He regards the occurrence at Vöröspatak as an exception, which he does not further explain. It is not to the point, that he considers the gold to have been deposited contemporaneously with the old rocks, and from these to have subsequently penetrated into the veins cutting through them.

The gold-periods of Murchison and Lieber are consequently very dissimilar: this circumstance must occasion doubts. Let us now see, how the gold-occurrences, described in this volume, suit the one or the other view; no regard of course being had to the quantity of gold in the different localities; since this is even in the richest gold-deposit so small, in comparison with the chief mass of the lode, that a distinct trace has almost the same geological importance, as one worth mining.

In the Tyrolese and Salzburg Alps, we have become acquainted with auriferous slates, and in or near these auriferous veins, which would, for the most part, be compatible with Lieber's hypothesis. Still there remains a doubt with regard to the veins; viz. they also cut through granite, which appears in the Alps to be of a relatively recent age. In order to satisfy Lieber's hypothesis, the penetration of the gold into the veins must have taken place much later, than its first deposit. On the Callanda in Switzerland we have seen, that an auriferous vein occurred even in Jurassic strata, the presence in which of gold, it would be difficult for this hypothesis to explain. The same is true of the auriferous slates of California; which appear to belong to the Jurassic and Triassic age. Murchison's hypothesis, of impregnation, is still applicable to all these cases, so soon as it is conceded to be admissible.

But near Graves in Westphalia the Lias limestone is somewhat auriferous; is this presence of gold explicable, either by fine mechanical washing-in, or by precipitation? if so, it is not compatible with Murchison's hypothesis, nor with Lieber's view, which expressly remarks, that the erosion and deposit of gold first took place at a Post-tertiary period. His gold-period of itself would not indeed contradict such a washing-in.

Traces of gold have also been found in the Miocene sandstones and conglomerates of the Valley of the Aar. These, like those of Graves, presuppose, even when they have merely been mechanically washed-in, the presence of gold-deposits more ancient than the Miocene, and probably in the Alps, from which the majority of boulders in the Miocene arose. This is opposed to Murchison.

But the majority of the Hungarian and Transylvanian auriferous deposits are altogether opposed to Lieber's gold-period. They cut through Tertiary rocks; and must therefore have been formed in, or subsequent to, the Tertiary age. In these districts, however, older auriferous rocks are wanting, from which the gold might have been transported into the lodes. The majority of the auriferous lodes cut through trachytic greenstones or Timazites of Tertiary age, while at Vöröspatak and Olalapos-bánya the gold-veins traverse Tertiary sandstones. This would appear to be a confirmation of Murchison's hypothesis. As a rule it is difficult to bring facts contradictory of this last hypothesis; which, if theoretically correct, explains almost all gold-occurrences. It is therefore hardly possible to oppose this hypothesis by any other, than logical and physical reasons.

According to Murchison, gold occurs almost exclusively in very old rocks, and has only penetrated these at the close of the Tertiary period. The first assertion is incorrect; since we have shown, that gold occurs repeatedly in Jurassic and Tertiary rocks. The last assertion appears to me, not only without a motive, but also theoretically inadmissible: in so far without a motive, that the not finding of gold in Permian rocks, and in Siberian Tertiary strata, gives no reason to assert, that it had not yet existed in rocks up to the period of their deposit, especially as it has been found in Alpine strata of the Lias and Miocene, besides which very slight and finely disseminated quantities might easily be passed over: inadmissible, in so far, as there is no reason to see, why impregnations of such an extent; as they must necessarily have been, in order to render the old rocks of the Urals, Brazil, Carolina, and even the Alps, auriferous; should not also have touched the more recent rocks, and deposits, in the same regions; especially since the older rocks do not generally and essentially differ lithologically from the more recent ones. A gold-impregnation, so comprehensive on the one side, and again so capriciously limited on the other, in such a recent period of gold-emanation; appears to me to be in every way an unnecessary and highly verturesome hypothesis; which in addition supposes, without a sufficient reason, a limitation of the period for the formation of gold, which we know to exist for no other metal, nor for any other mineral; which would consequently form a total exception. It is difficult to oppose such a hypothesis by facts, since the former would be prepared, for example, to explain the existence of gold in the

Lias, or Miocene, by a subsequent impregnation, but for the fact, that pebbles of the conglomerate (*Nagelfluhe*) of these formations are traversed by auriferous threads.

From all this I cannot consider a particular period, for the formation of gold, to have been either proved, or probable. According to Gahn, there is scarcely any iron-pyrites, in which, by a careful analysis, slight traces of gold may not be proved; and how extended is iron-pyrites in almost all rocks and formations.

It is certainly striking, that in Europe the sedimentary deposits of a particular, though very great, period often contain copper-ores. The most important cases are the following:

1. The lower sandstones of the Russian Permian;
2. The lower *Rothliegendes*, and probably also the strata of the Carboniferous formation, at the base of the Riesengebirge;
3. The *Rothliegendes* near Böhmisch-Brod in Bohemia;
4. The *Rothliegendes* near Zwickau in Saxony;
5. The copper-slates in Thuringia, and Hesse;
6. The Buntsandstein at Tweste near Arolsen (Tyrol);
7. The Buntsandstein at Chessy in France.

Should we be justified in concluding from this, that an emanation of copper-ores took place, which includes the period from the Carboniferous to the *Muschelkalk?*

Let us examine the preceding cases somewhat more closely, and then add others for comparison.

The lower layers of the Permian formation contain copper-ore-impregnations only in the neighborhood of the Ural chain, evidently springing from these. Murchison believes, that the metallic solutions have streamed from the fissures of the mountains, into the material composing those strata, during their deposit. This is possible; but it is also conceivable, that the solutions have penetrated the layers at some period subsequent to their deposit. We will leave this question here undecided.

The copper-ore-impregnations, at the southerly base of the Riesengebirge, have evidently, according to Porth's description, subsequently and locally penetrated the strata of the *Rothliegendes* and Carboniferous formations. How long after they were deposited, cannot as yet be determined; it may just as well have been in the Cretaceous or Tertiary, as in the Zechstein period. The age of the strata, and their impregnation, do not here stand in any determined relation to one another. The case appears to be similar at Böhmisch-Brod.

At Zwickau sheets of native copper have only been found very locally in one of the numerous coalshafts, in the fissures of the red argillaceous shale which occurs with porphyries and amygdaloids. These are also evidently of subsequent formation to the rock enclosing them; still it may be, that they belong nearly to the period of its deposit; and their formation is intimately connected with the upheaval of those igneous rocks.

The copper-ores in the lower subdivision of the Zechstein formation, especially that of the copper-slates in Thuringia and Hesse, undoubtedly appear to have been deposited contemporaneously with the copper-slate; since its distribution is a far too regular one, for a subsequent impregnation. This is therefore a characteristic case for the determination of the age of the ore-deposits, no matter how the metal may have been formed, nor how often its chemical conditions may have subsequently been altered. It is, however, the single characteristic case in all the seven.

The copper-ore, in the Buntsandstein near Arolsen again, bears the character of a subsequent local impregnation, whose true age is not as yet by any means determined; and the copper-ores in the Buntsandstein of Chessy are products of decomposition, or are impregnations caused by the decomposition and alteration of pyrites-segregations, which have been chiefly developed at the rock-junctions, but also reach up into the strata of the Lias-formation, and are consequently of a more recent age than these.

As it now appears, of the seven occurrences of copper-ores belonging to the same great period, there is but little support found to fix a copper-period; and if other deposits of copper-ores are noticed, such a period would either be completely obliterated, or extended through all geological ages.

The copper-lodes of Wexford in Ireland are, as we have seen, older than the neighboring Devonian. Gr. Breuner gives an account of an altogether analagous condition of lodes of copper-pyrites, at Snowdon in Wales, which cut through gneiss and clay-slates, but are overlaid by Palæozoic rocks.

Near Poschorita, in Hungary, copper-pyrites forms, together with iron-pyrites, a true bed in chloritic mica-schist; near Untersulzbach, in the Pietschgau, in chloritic clay-slate. Similar beds recur more than once in the Devonian, Silurian, or still older slates of the Alps; especially in the neighborhood of Kitzbühel; these can hardly be regarded as subsequent impregnations.

The segregated masses of Goslar, Schmöllnitz, Agordo, Rio Tinto, and Falun, in part accompanied by impregnations, may be somewhat more doubtful, as regards their age and origin; but it still remains most probable, that their formation belongs to an older period than the Carboniferous. Thus the copper-period extends downwards into the Silurian period. Cases of a decided character, and much more recent age than the Triassic, also occur. The broad lode of Olalaposbánya, so rich in copper-pyrites, and the cupriferous lodes of Felsöbánya, are both more recent than the Eocene; since they cut through Tertiary rocks. By these cases, the copper-period extends upwards into the Tertiary. Therefore there is nothing remaining as a defined copper-period; but we must recognise the fact, that the ores of this period were deposited at all geological ages, only locally at different times.

The idea might also have easily been formed; especially from the occurrence of calamine and smithsonite with lead-ores, as in Upper Silesia; that they belong to a particular period of formation; since these ores occur under similar conditions in the *Muschelkalk* near Tarnowitz, at Wiesloch, and repeatedly in the Alps; had it not soon been seen, that these ores occur every where, only combined with magnesian limestones as secondary products; which recur similarly also in the magnesian limestones of the Subcarboniferous formation near Aix-la-Chapelle, of the Devonian near Iserlohn, of the Lias near Pallières, and of the Jura formation in the Province of Santander; while similar ores occur in numerous lodes of the most various age.

I think, from the above it has been sufficiently shown, that neither the separate metals, nor their ores, nor the metals generally, belong to particular geological epochs. The relations, as to the age of the separate ores and minerals within the deposits, are of course entirely independent of this, and are to be recognised through their deposit on one another. These last are consequences of chemical processes, which have been repeated in the most various geological periods, and which it is chiefly the task of the chemist to investigate; we already owe much in this relation to chemistry, and to the researches of Gustav Bischof. I speak here merely of the geological age of the variously composed ore-deposits, and assert that the homogeneous ones do not all belong to the same, nor the heterogeneous ones to dissimilar geological epochs; but that rather, in general, all to all periods. Still, I will not deny, that the common occurrence of ore-deposits permits certain differences of age to be recognised.

All known tin-deposits are very old.

Deposits of gold, silver, lead, zinc, copper, cobalt, nickel, and bismuth ores, are known of very dissimilar ages; but none are decidedly more recent than the Tertiary, none in true volcanic rocks, none between Post-tertiary or Recent deposits; with the single exception of the secondary superficial deposits, or placers.

Deposits of iron-ores, on the contrary, occur between the oldest and the most recent formations and rocks; only they vary somewhat according to their relative age.

Deposits of magnetic iron are only found in very ancient rocks, deposits of hematite and spathic iron between somewhat more recent ones, limonite in the oldest and most recent. Bog-iron-ore is still formed in marshy districts, iron ochre at the mouths of springs, and specular iron in the fissures of volcanic rocks.

Do these facts rest on a real difference of age? Did the formation of tin-deposits first cease, and did this take place about the Carboniferous period? Have no deposits of the second class, and only such as contain iron and manganese, been formed since the Tertiary period? Such views might be put forward; but, as it appears to me, they would prove erroneous. These apparent differences of age, could, as remarked, be traced back to differences of geological horizon.

Tin-deposits were only formed at a great depth; they would therefore be only open to observation after a long process of denudation, and preceding elevation; those observed are, for this reason, always old.

Gold, silver, lead, copper, cobalt, nickel, and bismuth ores were also never formed on the outer surface of the earth, but always at a certain, though slight, depth below the same. It has not been determined, at what depth the possibility of their formation commences; perhaps it is not considerable; but as they are generally observed only when elevations and denudations have occurred subsequent to their formation, some time since which having passed, antediluvial ones alone are known.

Iron-ores, on the contrary, are deposited on the earth's surface; and, on this account, iron-deposits of very recent formation are found. Since they, however, like the previously mentioned ore-deposits, were at all times formed here and there; such occur belonging to the most various ages. But as the older deposits of iron-ores were frequently subjected to the catogene influence of a considerable covering of rocks, we often find them consisting of magnetite, hematite, or spathic iron; while the more recent almost exclusively contain hydrated peroxide of iron. Still the older ones were often, after their catogene alteration, subjected, through elevation and denudation, to anogene influences, and by this means placed in the condition of the more recent.

In this manner are formed three principal series of ore-deposits, which we have distinguished in another paragraph: viz.

1. Tin-deposits, occupying the lowest formation, therefore appearing as the oldest;

2. Gold, silver, lead, zinc, copper, cobalt, nickel, and bismuth deposits, belonging to an intermediate formation;

3. Iron-deposits (including those of manganese) originally formed in an upper formation, occurring therefore in the most recent rocks, but not wanting in the older ones.

As the iron and manganese ores have been subjected to many changes, in a catogene or anogene sense, through oxydation and reduction, hydration, and dehydration, absorption or loss of carbonic acid; so their condition differs in a degree corresponding to their age and geological horizon.

The three groups of ore-deposits are, like all such natural groups, not sharply separated from one another. The ores of one group rather occur sporadically in the deposits of another. Especially are the widely distributed iron-ores rarely wanting in any deposit: this is very natural, since already the original influence of level caused no defined demarcation; still, after change of horizon had taken place, posterior intermixture might follow. Besides, I am far from intending to convey the idea, that all the separate minerals of these deposits could only be formed in certain horizons, under particular conditions of pressure and temperature. That would be in contradiction to evident facts, especially to the natural and artificial formation of numerous minerals on the surface of the earth; as for example, galena, iron-pyrites, blende, copper-pyrites, heavy spar, calc-spar, etc. The especial grouping in deposits seems to me to be particularly caused through certain conditions of level. When therefore, in tin-lodes for example, other ores of a higher horizon often occur; these might have been formed contemporaneously under peculiar conditions, or have penetrated subsequently after a change of level. In fact they are recognised, as subsequently formed, at Zinnwald, Marienberg, and in Cornwall. It is certainly striking, that in Cornwall, at Seiffen, and Marienberg, copper-ores, where they occur in the same lodes with cassiterite, for the most part occupy a lower level than the latter; as Humboldt[1] states, that in the Veta d'Estanno at Potosi tin-ores occur at the surface, while at a greater depth rich silver-ores are found. Such apparent contradictions may find their explanation, through their formation at different periods, under essentially changed conditions.

That the completion of lodes has occupied very great geological periods, is seen from their texture, from the succession of minerals, and especially also, from the transformation of the minerals, which at times occurred between the periods of formation. During such great periods of formation the level, and the other conditions, may have been manifoldly altered. Besides, I do not attempt to estimate, even approximately, the amount of difference in level, which favored the formation of the one or the other mineral, in case the necessary matter was present. The existence of the mineral matter in a suitable state (in solution, as gas, or the like) is of course the first condition for the formation of the heterogeneous ore-deposits: the remaining conditions for the formation may all have existed; if, however, this matter was wanting, then of course no lodes would be formed. From this cause we are not *a priori* to expect, that all three groups of ores were formed above one another in every vein-fissure: it is a possible, but not therefore a necessary case. The question may well be asked, with what were the fissures filled (especially at their outcrop) at the levels unfitted for the precipitation of the ore-solution present? The limits of possibility are here very great. The fissures may have remained open cracks, or have been filled with any other matter, even have been

[1] See: Humboldt's Statistik von Mexico, vol. IV.

mechanically filled up; and these differing upper portions of the lodes may still exist, or they may have been destroyed by subsequent erosion. I would here call to mind, that the so common gossan of numerous lodes appears, in many known cases, not only to be the result of decomposition, but actually to contain more iron in different conditions, than the deeper portions of the lodes; thus, at Przibram argentiferous lead-ores are said to be entirely wanting in the upper portions. Vogelgesang states, that the lodes at Berggieshübel (Erzgebirge) contain almost only iron-ores in their upper portions; while at a greater depth copper and other ores are associated with these. Near Katzenthal, in the Vosges, there is a vein of limonite, in whose lower portions argentiferous lead-ores, blende, calamine, and heavy spar, were very unexpectedly met with.

These appear to be special positive confirmations of the hypothesis of horizon; which rests more on the dissimilar manner of occurrence of various ore-deposits, than on such rare special cases.

Probably a much greater number of such cases would be known, were it not that vein-mining, owing to the difficulties encreasing with the depth, is confined to a relatively slight distance; and, as a consequence, where the bounds of two groups of ores do not accidentally lie near the surface, the miner commonly opens-up only the level of one group. This incompleteness, in the possibility of observation, must not be used as a reason against this hypothesis. Another circumstance in its favor, to which I will draw attention, is the extremely rare occurrence of true ore-beds of the same composition as the two lower ore-groups, while true beds of iron-ore are very frequent. By far the greater number of the so-called ore-beds, which contain other than iron-ores, have on more careful examination been found to be impregnations, bedded lodes, or in some manner later than the enclosing rock; consequently formed under some covering. After such a sifting, there only remain some beds of pyrites, and the copper-slates, as true beds, whose present condition no longer appears to be the original one.

If this hypothesis of horizon should be correct, only iron-ores could in fact be deposited, bedlike, on the surface; and not the combinations of ores, which demand a somewhat lower level for their formation, without excluding scattered mineral formations formed under peculiar circumstances. Should such combinations be exceptionally found as true-beds; as for example, the copper-slates; it may be supposed, that the metallic substances were here deposited at the surface, contemporaneously with the rock; but that their present condition is a consequence of a long continuing subsequent covering. Original beds of magnetite, or hematite, have certainly never been deposited on the earth's surface by water; but this condition is the consequence of subsequent alterations.

I think I must here mention an objection, which might be made against the hypothesis of horizon. The mineral matter of the lodes may at times have, as it were, overflowed the fissures, and been deposited alongside of them.

I know of no distinct case of this kind. At Dobschau in Hungary there occur, it is true, concretions of cobalt and nickel ores above the outcropping of cobalt and nickel lodes, in the lower portion of a thick deposit of spathic iron; while those lodes also contain spathic iron, as gang. It might there be supposed, that an overflow of the matter in the lodes had taken place. But apart from the fact, that an actual connection with the lodes at Dobschau has not been found, it is there very probable, that the thick deposit of spathic iron was formerly overlaid by clay-slate, which occurs near at hand, bedded in such a manner, that such a supposition is credible; and which besides repeatedly contains beds of spathic iron in the neighborhood. In this case, then, an overflowing at the open surface would not have taken place.

Let us once more concisely review, in how far the hypothesis of horizon, as developed, coincides with the facts observed, and the general probabilities or analogies.

1. It corresponds to the general occurrence of the three natural groups of ores.

2. It corresponds to the frequent occurrence of iron-ores in beds, very recent veins, and vein-outcroppings; as well as to the rarity of other true ore-beds.

3. It corresponds to the probable supposition, that the elements were originally quite equally distributed in the earth; and renders superfluous the otherwise inadmissible hypothesis of metallic periods; since, according to this, all kinds of ore-combinations could be formed at all periods under certain circumstances; just as all sorts of rocks.

4. It corresponds to the fact, that like ore-combinations are often of unequal, and unlike ones of equal age.

5. It does not exclude the possibility, that the periodical succession of certain minerals, mineral combinations, or deposits, in the various parts of the earth, was a similar one, but at unequal geological periods. The events in the formation may have been similarly repeated, as regards time and place, in such a manner, that their results follow, as consequences of similar geological and chemical processes, in similar or like succession.

6. Finally, it explains (with the assistance of elevations, depressions, erosions, or overlyings) all kinds, conditions, and associations, of ores in their deposits. In entire districts upper deposits may be wanting, or lower ones be covered, and consequently inaccessible; in others, on the contrary, in consequence of elevations, and erosions, upper and lower deposits may occur together; since, according to this hypothesis, all the processes of formation are being continually repeated, though not every where alike.

MANNER OF FORMATION OF THE ORE-DEPOSITS.

§ 279. A principle, common to all ore-deposits, consists in the union of metalliferous minerals. If it be assumed, as most probable; that originally, and during the first period in the formation of the earth, the metals, like all the other elements, were quite equally distributed through its fluid mass, though in what condition remains as yet undetermined; and that the heavier metals were somewhat more aggregated, toward the centre of gravity, than at the surface; it follows, that subsequently, from certain causes, they were otherwise grouped, and for the most part collected in especial deposits of different forms. What the causes, and the peculiar circumstances, may have been of this new grouping, is the question to be answered. A question, which must necessarily, for the various forms and kinds of ore-deposits, be to a certain degree examined, and answered separately.

True beds have evidently been formed, in a manner analogous to that of the strata enclosing them, through mechanical or chemical precipitation from water. Other ores than those of iron occur, as we have seen, but exceptionally in real beds, and in these in such a manner, that a subsequent penetration is excluded. The copper-slates form such an exception. In the latter the chief mass of the bituminous marly slate contains copper, silver, lead, cobalt, nickel, bismuth, antimony, and arsenic; finely disseminated, for the most part, as sulphurets. Their ingredients were evidently deposited contemporaneously with the enclosing rocks; this is apparent from their uniform distribution; whether, however, they were deposited in their present condition, is indeed still doubtful. The rock was subsequently overlaid by other strata, and was probably subject, for a long period, to the influence of a considerable pressure, by which it was compressed; and the present condition of the ores might also have been developed by the same influences.

Limonites are deposited before our eyes on the earth's surface from ferrugineous waters, from which beds of hematite and magnetite could be formed under the influence of heat and pressure; as well as from these latter beds, near the surface, limonite might again be formed.

The deposit of carbonate of iron is far more difficult to explain; for example, the sphærosiderites of various formations, or strata containing coal; since, in the presence of the atmosphere, carbonate of iron is never precipitated from a carbonic-acid solution; but, owing to the rapid decomposition of the same, always hydrated peroxide of iron. Only when covered (preventing the influence of the atmosphere) can sphærosiderite, or spathic iron, be deposited. Therefore their formation, in the depths of a vein-fissure, is easily explained; but it will not apply to beds at the surface; these were perhaps formed under a considerable depth of water.

It appears to me, therefore, questionable; whether these last-named ores, where they occur as beds, were every where originally formed, as such; or whether occasionally oxidised deposits have not first subsequently absorbed carbonic acid. The interior cracks of their concretions often contain calc-spar, heavy spar, galena, blende, and various kinds of pyrites; consequently holding the ingredients of many lodes, which have subsequently penetrated, probably after the concretions had been already covered up. It is certainly remarkable, that the like concretions often contain well preserved organic remains; and that even the galena, which has subsequently penetrated, permits the fine network of *Neuropteris* to be recognised on its surface.

Just as compact limestone has been converted to marble, so could crystalline spathic iron have been formed, in an analogous manner, from beds or masses of compact sphærosiderite, through a subsequent crystallisation of the mass, of course under the long continued effects of pressure, heat, and moisture. Perhaps on this account beds of spathic iron are always found only in older deposits, never in very recent ones.

It is an ascertained fact, that limonite is formed from spathic iron, or sphærosiderite, through the effects of atmospheric causes. Under other circumstances, beneath a considerable covering, hematite and magnetite appear to have been formed from the limonite.

Let us now turn to the far more difficult problem of the formation of lodes. The fissures are, beyond a doubt, the consequences of mechanical causes, even if they have perhaps been essentially widened by the force of crystallisation of the mineral substances. The mineral matter forming the lodes has generally penetrated into the fissures from below, or from the country-rock, be it through solution from the immediate wall-rock, or from greater depths. In the great majority of lodes, it has not all penetrated at the same time, and certainly not in an igneous-fluid condition, but as aqueous or gaseous solution. Chiefly water, perhaps in combination with numerous gases, was the medium, which dissolved the scattered particles of the metals and other substances, absorbed them, and again deposited them, in a far more concentrated form, in the fissures, by a long continued process of precipitation. That is about all, that can be said in a general manner, as an explanation of the lodes; in detail there still remains, it is true, much that is doubtful. The unequal distribution in the fissures, the occasional symmetrically combed texture, and the composition of the lodes, varying to such an extent from that of the common rocks, all tend in the highest degree to show the correctness of the above explanation. Particularly striking and distinguishing, in comparison with the igneous rocks, is especially the rare or very slight amount of alkalies in the great majority of lodes; while their wall-rock, where it had contained alkalies, has frequently lost these for the most part in the neighborhood of the veins. They have been dissolved and carried off in solutions, while other substances have been precipitated from the solutions in their stead. The solution of the alkalies may often, re-acting, have aided the precipitation of the vein-materials; and it is therefore no wonder, if it be found, that lodes are particularly rich between decomposed rocks. The decomposition through the solution of the alkalies, during the deposit of the materials composing the lode, exerted a favorable influence on the precipitation; had the decomposition, on the contrary, taken place before the formation of the lode, such a decomposed rock must have been unfavorable to the formation of the lode, partly from mechanical causes, partly from the want of a reaction. Hence the local opposed conditions of the lodes between decomposed wall-rocks.

Of what kind the solutions were, from which the various ores and minerals were precipitated, what various causes (reactions) influenced the precipitations, are questions more of a chemical, than of a geological nature; though their explanation is of the greatest importance to geology.

We may thank G. Bischof for having explained many matters in this department, which were obscure; though we may consider many of the geological consequences, which his compendious work on geology contains, as less satisfactory. It is not my purpose to go more in detail into this chemical portion of the formation of lodes; since I do not consider myself fully competent to do this. It is sufficient to say, that the possibility of solutions, from which the various ore-combinations could be precipitated, has been shown by Bischof. He has shown, how (through numerous reactions) metalliferous precipitates, and subsequent alterations of the same, might take place in vein-fissures; and that small quantities of the various metals are contained, in a soluble condition, in the most different kinds of rocks. It is not essentially to the point, whether the solubility was great, or but very slight; since even the weakest solutions, or the slightest traces of a metal in a solution, could, during unmeasured periods, effect considerable deposits. The small amount of metals, proved to exist in numerous mineral springs, suffices to furnish, in time, the material for broad lodes; even so would the small percentage of metals in rocks suffice to furnish the material for the solutions.

In the examination of each particular case, it will be always necessary to consider the local relations; for the explanation will certainly not always be the same for the separate vein-districts; since a greater part of the dissimilarity of lodes is essentially a consequence of the local conditions, while another portion will be dependent on the local or periodical variation of the solutions circulating in the fissures, which last are also locally different. It must never be forgotten, that the totality of the lodes shows, from their entire condition, that they are not the result of a quickly completed process, but rather that of a long continued or periodically repeated one, with certain modifications.

How much there still remains to do, especially with the assistance of chemistry, is evident, not only from what has already been done; but also, for example, from the certainly striking fact, that it is not yet known, in what condition silver occurs in galena, or gold in pyrites; but much less, in what state of solution these noble metals may once have been, before they were deposited in the lodes.

With regard to the condition of solution, however, it is to be considered, as already remarked, that the same in a long continued process, needs merely to be extremely diluted; and that with the progess of accuracy and certainty in analytic chemistry, it is continually more recognised, that in many mineral waters, are contained very small quantities of all sorts of mineral substances, which were formerly neither discovered nor supposed to exist. Sea-water contains in solution 29 of the as yet discovered elements; among these, for example, silver, copper, lead, zinc, cobalt, nickel, iron, manganese, and arsenic; while in spring-water have been found arsenic, antimony, lead, copper, cobalt, nickel, tin, zinc, etc.

The segregated ore-deposits; which are not merely forced mechanically into accidental cavities, but rather consist of crystalline aggregates, which at times (as the segregated deposits of lead and zinc, the segregations of magnetic iron, irregular aggregations of pyrites, etc.) show certain relations to their wall-rock, or to the contact of two rocks; offer in part still greater obstacles in their formation to a satisfactory explanation, than the lodes; since in these the form and the frequently great breadth are to be considered as essential points. Some, as the aggregations of zinc-ores and galena in magnesian limestone, may possibly be but pseudomorphs by replacement on a large scale; the limestone being dissolved, and the ore substituted for it. With others it should be observed, that they are probably no longer in the original condition, in which they were formed, but have rather been essentially altered by catogene or anogene influences; and therefore, in order to explain them, it is necessary to go back to their probable original condition, and that of the rock enclosing them; as for example in magnetic iron-ore. During the alteration, changes in form might also have occurred, and many so-called ore-segregations are in fact nothing else than very broad and irregular lodes, concretionary beds, or very thorough impregnations.

In the case of the ore-impregnations, their explanation is in a measure evident from their name. It is assumed, that the ore-particles have penetrated a rock, subsequent to its formation, either only in its finest cracks and pores, or in the mass of the rock itself. Illusions are indeed possible; the ores distributed in the rock may have been formed contemporaneously with it, and have been afterwards altered with it. In such varied forms do the possibilities present themselves, as to require a particular judgment in almost every case. If we assume the subsequent penetration of the ores as proved, there still remain the questions, to be answered; as to the kind of solution, as to the causes of the precipitation, and as to the time of the occurrence.

In the case of the dependent or accessory impregnations, alongside of ore-deposits of another form, we find a portion of these questions comparatively easy to answer. Impregnations alongside of lodes were probably, as a rule, caused by the same solutions, by the same causes, and at the same time, as the lode; this is not essentially necessary, and cases the reverse of this are known. Thus, Gätschmann and Plattner have proved, that the impregnations of mispickel in the decomposed gneiss, alongside of the Freiberg lodes, are probably still taking place, caused by the decomposition of portions of the lodes. Daubrée has, in his 'Etudes sur le Métamorphisme', termed the ore-deposits, peculiar phenomena of metamorphism, in that he says, p. 74: '*les dépôts métallifères ne sont que des cas particuliers de phénomènes métamorphiques.*' A principal result of these examinations is, that the majority of the ore-deposits, especially all those which do not essentially consist of hydrated peroxide of iron, were formed, not on the earth's surface, but at some depth beneath the same; or have become through transformation, what they now are; and that for this reason, as well as from the common participation of water in their origin or transformation, they may be termed hydro-plutonic formations.

I close this effort, composed of suggestions as to the formation of ore-deposits, with the conviction, that the only positive result has been, to raise questions, not to answer them; but I am consoled by the reflection, that to induce enquiry will not be useless; as the want of knowledge of facts, combined with the state of chemistry, has rendered, up to the present time, the satisfactory solution of such involved and manifold phenomena difficult and unreliable.

DETERMINATION OF THE VALUE OF ORE-DEPOSITS.

§ 280. A determination of the value of true beds will never offer serious difficulties, after they have once been properly opened. Their average thickness, and an average percentage, can be determined, which in all probability will not be far below, or much beyond the reality; since thickness and percentage of ore generally continue in true beds for great distances with tolerable uniformity.

It is entirely different in the case of lodes, segregations, or impregnations. Neither the breadth, nor the percentage of metal, remains the same for any distance; at least it is but exceptionally the case. Both of these important points are, in general, so extremely variable, that an estimate of their value, in any degree reliable, must be left entirely out of account. It is almost a necessity of existence, to the calling of the vein-miner, that he should live in good hope, and expect from day to day a rich find; which no one can predict. It is true, that vein-mining has in recent times gained somewhat in reliability, through the ever encreasing attention which is paid to the mutual relations of the veins, the influences of the wall-rock, and other especial phenomena. It is to be hoped, that this will find still more support on some scientific basis; but no geologist, or vein-miner of much experience, will at present claim, that he can predetermine with any certainty the conditions of lodes. Were that possible, such a knowledge would in many places afford the best opportunity of becoming a rich man; since the possibility of cheaply buying shares or stocks in a mine are not wanting, so long as rich streaks are still undiscovered. These occur for the most part unexpectedly, if not unhoped-for. A share, in the Himmelfahrt mine at Freiberg, could have been purchased thirty years since for twenty five cents, which now (1868) are worth eleven thousand dollars; with a few such shares the purchaser would soon have become a rich man.

Any certainty as to the results, in such ore-districts as that of Freiberg, can only be attained through the multitude of trial-workings on as many hopeful lodes as possible. This encrease in the opening of workings is so expensive, that it is rare to find a mining-company in a position to bear such an insurance-tax on the results. The consequence of this is a sort of lottery, *i. e.* with but a small deposit; the possibility, but no certainty, of a large prize. Are the lodes of such a kind, that in their poorer portions, by the greatest realisation possible, they afford some profit, even though but small, this is already a great advantage; it is then possible, to await the rich finds, like great prizes, without becoming bankrupt through the great number of blanks. Such a condition exists in many of the Freiberg lodes: they are as a rule poor, but contain in places rich ores, thus offering a premium for continued industry. This condition is one of the chief causes for the extraordinary completeness in mining and metallurgy, which has given celebrity to Freiberg. It has long been necessary to realise on poor ores, and for this purpose to improve all the machinery as much as possible. So much thought and trouble is, as a rule, not used, where rich ores render it unnecessary.

If, as we have already seen, it is very difficult to predetermine the percentage of ores in lodes, segregations, or impregnations, there must also be many other facts considered in determining their value; for example, the greater or less difficulty, and consequently cost, of exploitation, of the transportation, of the smelting (rendered easier, or more difficult, by associated minerals, and other circumstances), as well as the variations in the value of metals in the markets. These last circumstances do not of themselves properly come within the bounds of a treatise on ore-deposits; but since the general value is often asked of an expert in ore-deposits, they are at least worthy of mention.

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N.B. Places, without epithet, are towns (*or* mountains); in *sm. caps.* kingdom, state, *or* mt. chain: numbers refer to pages: **thick,** to chief of many; *second,* & *third* (i. e. *ten,* & *hundred*) place of figures, is understood, not repeated: *e. g.* 304,23,99 = 304, 323, 399; **402,31,3,4-8**, = 402, 431, 433, **434-438**.

Abbreviations: n. e. w. s. North-, East-, West-, South-ern; *b.* berg, bis, *circ.* circle, *co.* county, *cont.* continent, *ct.* canton, *dp.* department, *dist.* district, *for.* forest, *fr.* France, french, *geb.* gebirge, *glac.* glacier, *grp.* group, *gr.* grand, *gt.* great, *h.* high, *isl.* island, *lt.* little, *mar.* maritime, *mi.* mine, *mt.* mount, -tain, *mth.* mouth, *n.* note, *oc.* ocean, *pr.* province, *r.* river, *s.* see, *sh.* shire, *sp.* Spain, spanish, *sra.* sierra, (*ridge,* saw) *t.* town, *tw.* between, *up.* upper, *val.* dale *or* valley, *wk.* work, *zo.* zone.

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ERRATA.

The following occur repeatedly :

For encrease	*read* increase.
" gang	" gangue.
" gangstones	" veinstones.
" amiantos	" amianthus.
" niveau	" horizon.
" cinnobar	" cinnabar.

Page.	*Line.*		
4,	25.	*For* Abn	*read* Mn.
5,	35.	" Lb	" Sb.
7,	30.	" Sercarmontite	" Senarmontite.
8,	22.	" CO	" CO_2
9,	32.	" Co O	" Ca O.
10,	16.	" dimonite	" limonite.
27,	7.	" *shorts*	" *shoots.*
38,	9.	" separated	" distinguished.
39,	26.	" apparently	" apparent.
40,	6.	" hardly	" scarcely.
46,	27.	" hardly	" scarcely.
51,	10.	" contribute	" contributes.
73,	37.	" seeing	" since.
76,	2.	*Insert* the	*after* that.
79,	38.	*For* some	*read* same.
102,	21.	" singuite	" pinguite.
	24.	" chloranthite	" chloanthite.
120,	31.	*Insert* schist	*after* mica.
132,	30.	*For* of	*read* or.
139,	14.	" have	" contain.
148,	29.	" is	" are.
151,	5.	" Cath rina	" Catharina.
153,	32.	" striking-out	" outcrop.
164,	6.	" schicken	" slicken.
180,	16.	" seem	" seen.
189,	4.	" an up and down	" a vertical.
196,	6.	" that	" the.
201,	16.	*Insert* shale	*after* argillaceous.
244,	3.	*For* Jura	*read* Jurassic.
245,	18.	" Jura	" Jurassic.
252,	22.	" Krakau	" Cracow.
256,	18.	" Infusia	" Infusoria.
	22.	" af	" of.

Page.	*Line.*		
265,	8.	*For* whence	*read* which.
266,	15.	*After* but	*insert* rarely.
270,	1.	" grammes	" of silver, *and*
		" kilogrammes	" of lead.
	39.	*For* breaking out	*read* eruption.
280,	6.	" entirely	" very.
281,	10.	" Mountains	" Mountain.
288,	1.	" similar	" different.
295,	24.	" melophyre	" melaphyre.
301,	5.	" lode	" granite.
302,	4.	" dialoge	" dialage.
	5.	*Insert* are	*after* pyrites.
310,	21.	" than	" Bavaria.
315,	40.	*For* under	*read* at.
318,	bottom of page	" Belemites	" Belemnites.
319,	35.	*Insert* is	*after* stone.
324,		Pyrites Stock *in wood-cut, should read* Pyrites Segregation.	
330,		*Table, for* A. globrus *read* A. glabrus, *and for* Meyophoria	
		read Myophoria.	
343,	24.	*Insert* the	*before* strata.
345,	9.	*For* are belonging	*read* belong.
364,	14.	" garnite	" granite.
	27.	" —formation	" —formations.
370,	12.	" spar	" spur.
382,	22.	*Insert* is	*after* breadth.
397,	27.	" schists	" metamorphic.
398,	23.	*For* from	*read* by.
401,	1.	" as	" so.
403,	27.	" is	" are.
405,	1.	" of	" somewhat.
434,	12.	" this	" his.
	16.	" in	" on.
458,	39.	" sequioxide	" sesquioxide.
470,	12.	" rock	" rocks.
471,	4.	*Insert* on	*after* principally.
472,	11.	*For* Wereh-Yssetsk	*read* Werch-.
483,	29.	" Schreckenstein	" Schneckenstein.
484,	32.	" Romilio	" Romillo.
498,		" Oskusz	" Olkusz.
499,		" Maidenpek	" Maidanpek.
503,	22.	" Müschen	" Müsen.
518,	8.	" Sula	" Sala.
523,	27.	" Geldkronach	" Goldkronach.
533,	30.	" joins on	" occurs.
536,	27.	" Westphalia	" the Western Alps.
537,	35.	" highly venturesome	" very rash.
538,	19.	" Tweste	" Twiste.
539,	41.	" Pietschgau	" Pinzgau.

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