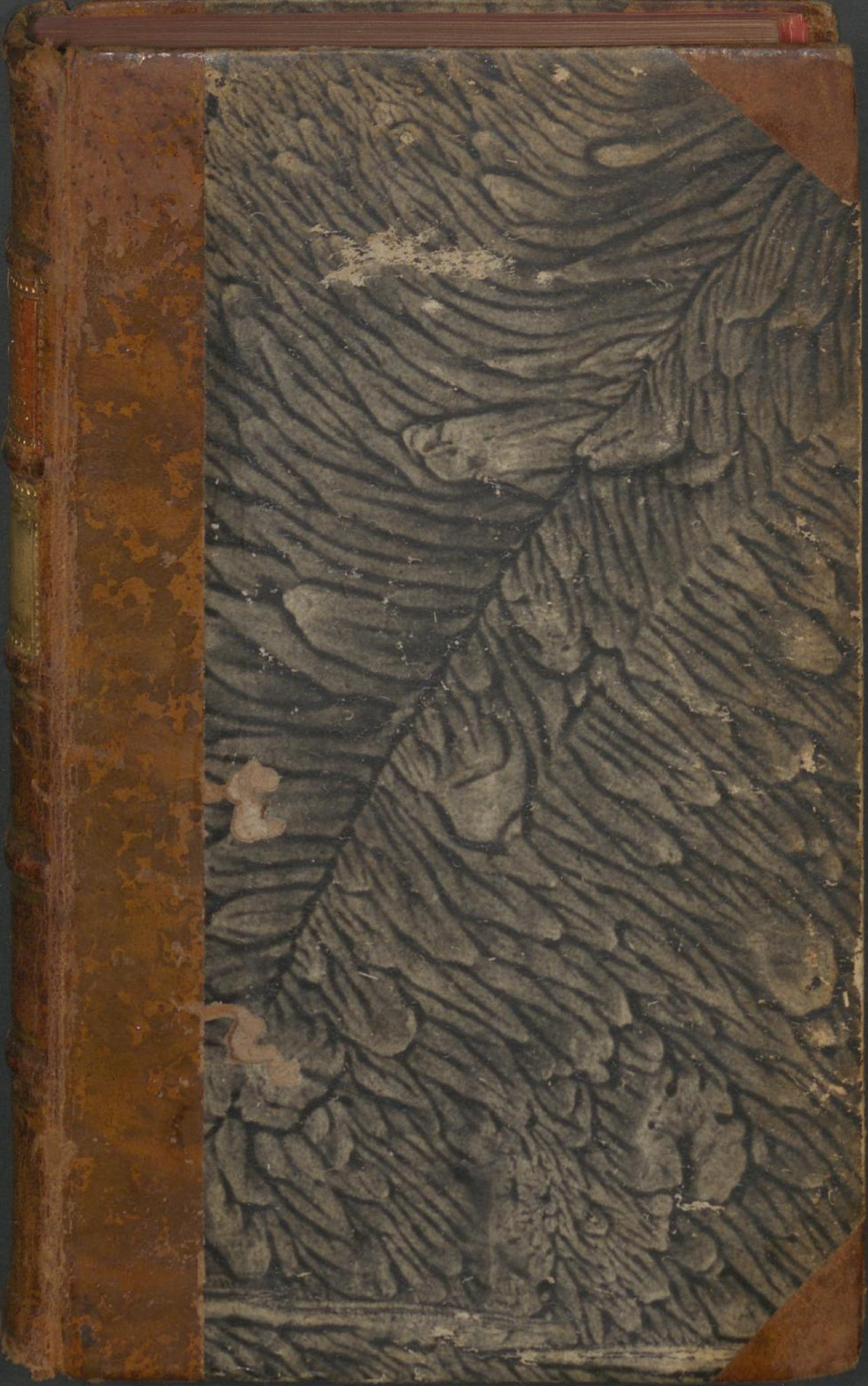

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ELEMENTS
OF
MINERALOGY.

VOL. I.

ELEMENTS

OF

MINERALOGY.

BY

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WITH
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VOL. I.

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PREFACE.

NUMEROUS and rapid as have been the improvements made in the branches of natural knowledge chiefly cultivated in France and England ſince the year 1784 (that in which the firſt edition of theſe Elements has appeared), thoſe that have fallen to the ſhare of Mineralogy, the branch with us leaſt attended to, have equalled and kept pace with them. In the preceding decennial period, from 1774 to 1784, Mineralogy may be ſaid to have for the firſt time aſſumed its rank among the ſciences, its ſimpleſt elements having been for the moſt part diſcovered, and eſtabliſhed within that period, its leading diſtinctions aſcertained, and the great art of reſolving the moſt complex into the ſimpleſt ſubſtances not barely improved, but in a manner created. In the ſucceeding period, from 1784 to the preſent year, our knowledge reſpecting each of theſe objects has been ſtill farther extended; preciſe lines of diſcrimination have been traced even in the minuter ſub-diviſions of the ſcience; the groſs indications of the unaſſiſted ſenſes, freed from their attendant fallacies, have been preſſed into its ſervice; the more refined chemical teſts ſtill farther perfected have been rendered more concluſive; many new ſpecies brought to light; the catalogue of the elementary ſubſtances nearly completed; and the great art of analyſis, extended far beyond its former limits, now nearly reaches the preciſion of an algebraic formula.

Having thus ſummarily marked the progreſs of the art, I ſhould conſider it as an act of injuſtice to ſuppreſs the illuſtrious names to whom we are indebted for theſe acquirements; if in the former period a Scheele and a Bergman challenged our gratitude and admiration, in the preſent, theſe ſentiments are juſtly due to a Klaproth and a Werner; to the former we owe the moſt accurate, ſubtle, and refined analyſes; to the latter, the ſelection, depuration, and judicious application of the external characters of foſſils; the former detects the internal principles, the latter depicts the ſubſtances to which thoſe principles belong; if the reſearches of the former have in many caſes led him to the diſcovery of new and unſuſpected elements, thoſe of the latter, by by a happy compariſon of the habitudes of adjacent foſſils, have led him to the true deſignation of their origin; by the joint efforts of both, as far as theſe inveſtigations have hitherto reached, not only the nature and properties of minerals ſingly taken, but alſo their relations, connections, and dependencies on each other, have received the fulleſt and moſt ſatisfactory illuſtration.

If from the proſpect of theſe improvements we now turn our attention to the cauſes of this unexampled progreſs, we may eaſily deduce them from the evident change, I may almoſt ſay revolution, that has taken place in the public mind within theſe laſt ten years. Nations in the full enjoyment of the moſt conſiderable natural advantages, extent of territory, fertility of ſoil, benignity of climate, have beheld within that ſhort period, with mixed ſentiments of aſtoniſhment, envy, and regret, that ſuperiority of opulence, reſources, and power, conferred by an unremitted and ſucceſsful application of the mathematical and phyſical ſciences on kingdoms to whom nature had in every reſpect been much leſs liberal; they obſerved the connexion of Mineralogy in particular, not only with ſubterraneous ſubſtances to which it was long erroneouſly ſuppoſed excluſively confined; but with all the inorganic matter that forms the earth's ſurface, and, conſequently, with Agriculture, Medicine, and the raw materials, or neceſſary inſtruments of all manufactures that ſupply either the neceſſaries, comforts, or luxuries of human life; in conſequence of theſe obſervations, all the European nations zealouſly concurred in paying a fuller attention to its cultivation *; many have been immediately rewarded by the diſcovery of ſubſtances within their own territories, before imported with great difficulty and expence from other countries †, mineralogical voyages were every where undertaken, mineralogical collections, if not firſt formed, became more numerous, and far more ſcientifically arranged; treatiſes on this object have appeared in all languages; Germany, in every inſtance, outpaſſed even its former exertions, and ſtill continues to uphold its antient ſuperiority; there a mineralogical ſociety has been formed, whoſe branches extend to all parts of the globe, and of whoſe tranſactions ſome volumes have already appeared; ſimilar, though leſs extenſive, aſſociations have taken place in other countries; eminence in this ſcience has at once been rewarded and multiplied by public eſteem, civil honours, and emoluments; and thus every motive to human induſtry happily applied.

It will, I ſuppoſe, be readily granted, that the multifarious ſtock of information, thus

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* Portugal excepted.

† As cobalt, coal, fuller's earth, tarras, &c.

promiſcuouſly

promiſcuouſly accumulated in ſeveral kingdoms, conveyed in various languages, and not always preſented in the moſt intelligible manner, could not eaſily be collected, digeſted, and arranged, or in many caſes readily underſtood; ſuch, indeed, were the difficulties attendant on ſuch an undertaking, that, were I not encouraged by an event as favourable as unexpected, I ſhould deſpair of attempting it with any proſpect of ſucceſs; the event I allude to is the acquiſition of the *Leſkean* collection of foſſils, the moſt perfect monument of mineralogical ability now extant; that the poſſeſſion of this cabinet ſhould eſcape the vigilance of the moſt learned nations and fall to the lot of Ireland, hitherto ſo inattentive to matters of this nature, was little to be expected; through the active zeal, however, of two of its moſt enlightened patriots *, and the influence ſecured to them by former ſervices of the moſt eſſential nature, the ſums requiſite for its purchaſe, and for building a repoſitory to receive it, were obtained; hitherto its treaſures have been unveiled only to my eyes; the time, however, approaches in which it will be laid open to the inſpection of the curious, and thence we may date the diffuſion of exact mineralogical knowledge, not only in this, but perhaps in the neighbouring

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* Right Hon. John Forſter, Speaker of the Houſe of Commons, and the Right Hon. William Burton Cunningham.

countries. I ſay exact, for among ſeveral intelligent foreigners who have lately paſſed into this kingdom, to whom I exhibited a few ſpecimens of various foſſils, I met none, except thoſe of the Wernerian ſchool, who could truly diſtinguiſh them.

From the inſpection of this cabinet, the uſe I was permitted to make of its ſpecimens, and the well-digeſted catalogue annexed to it, I derived numerous advantages, being enabled to rectify falſe deſcriptions, determine the ambiguous, enlarge the defective, diſcriminate or appropriate, as the caſe might be, ſubſtances to which either the ſame or different denominations had commonly heretofore been erroneouſly applied, and even to add new deſcriptions, ſuggeſt new diſtinctions, and ſupply additional characters or teſts of ſubſtances nearly bordering on each other: for this purpoſe I ſcrupulouſly examined the ſpecific gravities of moſt of the ſubſtances mentioned in the following work, as well as their fuſibility in various degrees of heat by the help of Mr. Wedgewood's pyrometer; and, to extract from theſe all the light they were capable of affording, I made many new experiments on the fuſibility of various combinations of the ſimple earths, to the advantage as I expect of the arts of pottery and vitrification.

The reader will probably be deſirous to know on what grounds the authority of the

Leſkean cabinet reſts, on which I ſo much rely; theſe I the more readily undertake to explain, as they lead me to a ſummary deſcription of the various parts of which it conſiſts, and the *marks* by which they are diſtinguiſhed in the quotations in which I refer to them.

Previous to the year 1780, Mineralogy, though tolerably underſtood by many as an art, could ſcarce be deemed a ſcience, being, for want of preciſe definitions of its objects, incapable of communication: the *ſame* ſubſtance, from ſome ſlight variation of appearance, was often denoted by different names, and *different* ſubſtances by the ſame name; its deſcriptive language, was, for the moſt part, arbitrary, vague, and ambiguous, each author uſing that which ſeemed to him beſt to anſwer his purpoſe; to obviate the confuſion thence enſuing, chemical teſts were applied; but even theſe were found in many caſes inſufficient, unleſs the ſubſtances expoſed to them were thoroughly analyzed; a work of great difficulty, involving an intolerable length of time, and, when executed, demonſtrative only of the individual ſubſtance to which it was applied. When any new ſpecimen occurred, it might ſtill be queſtioned whether it was or was not of the ſame nature as that already analyzed; recourſe muſt then have been had to deſcription, and thus the ſame inconveniences recurred.

curred. After many ineffectual attempts to obviate theſe difficulties, by Linnæus, Peithner, and others, deſcriptive language was at laſt reduced to as much preciſion as it was capable of receiving by Mr. Werner in 1774, and by the union of external characters *thus deſcribed*, with the reſults of chemical analyſes, the *denominations* of moſt of the earths and ſtony ſubſtances then known, were finally ſettled by the ſame illuſtrious author in his Notes on Cronſtedt, publiſhed in 1780.

All the mineralogical collections, therefore, formed before that year, or even ſince, if arranged on other principles, are neceſſarily in many reſpects defective and erroneous.

Of the many excellent diſciples formed by Mr. Werner, Leſke, the framer of the preſent collection, was one of the earlieſt and moſt eminent; upon Werner's principles, and with his aſſiſtance, it was arranged between the years 1782 and 1787. Upon the deceaſe of Mr. Leſke, it was reviſed, corrected, and enlarged, by Mr. Karſten, alſo a diſciple of Mr. Werner's, and, next to him, perhaps the moſt acute and judicious mineralogiſt now exiſting; to him we owe the catalogue that accompanies the cabinet, and which, like this, is divided into five parts; the firſt, deſtined to convey the knowledge of the deſcriptive language, by exhibiting to the

the ſenſes the characters deſcribed, is called the *characteriſtic* part, and is marked K; it conſiſts of 580 ſpecimens. The ſecond part contains the *ſyſtematic* or oryctognoſtic collection, as it is called, and thence marked O; in this, the ſimpler foſſils are diſtinguiſhed under their Genera and Species, according to the method then followed by Mr. Werner; it exhibits 3268 ſpecimens. The third part is called *geognoſtic* or geological, and thence is marked G, preſenting the ſubſtances found in primæval, ſtratified, aluvial, and volcanic mountains, and containing perhaps the completeſt collection of petrifactions now extant; it conſiſts of 1100 ſpecimens. The fourth is deſtined to preſent ſpecimens of the foſſils found in different parts of the globe, proceeding, in an orderly ſeries, from America to Aſia, Europe, and Africa, and hence marked S; this, though it preſents 1909 ſpecimens, is neceſſarily the moſt defective, being in reality the bare outline of an immenſe plan, which can be completed only by national opulence, when all parts of the globe have been thoroughly explored, and Mineralogy extended to the utmoſt limits of ideal perfection; yet, imperfect as it is, it may be, to perſons who have already made ſome progreſs in mineralogical knowledge, by far the moſt inſtructive, as it diſcovers an immenſe variety of ſubſtances of the ſame deno-

denomination, ſo multifariouſly diſguiſed that it required all the ſagacity of a Karſten to elucidate and diſtinguiſh them: this part is particularly rich in German foſſils, more eſpecially the Saxon, with the references to the accounts of Charpentier, and Leſke's mineralogical travels, in which they are more minutely deſcribed; here alſo we meet thoſe *ſuſpicious* foſſils found in the dioceſe of Fulda, and on the borders of the Rhine, which many have ſuppoſed to be volcanic, with references to Voight, who has deſcribed them under names alluding to this origin. The fifth is called the *œconomical* collection, being formed of 474 ſpecimens of the foſſils uſed in various arts and manufactures, as artchitecture, ſculpture, agriculture, jewellery, colouring, dying, cloathing, pottery, glazing, enamelling, poliſhing of metals, furnace building, medicine, metallurgy, &c.

The whole cabinet contains 7331 ſpecimens, and as (except that of the mineralogical ſchool at Fribourg, and that of Mr. Pabſt Von Ohain) it is the only one that contains ſpecimens of almoſt every known ſpecies, arranged on fixed principles, and, at leaſt for the moſt part truly denominated, its value may thence be eſtimated. That of Mr. Pabſt contains only 6673 ſpecimens.

Com-

Complete as this collection may appear, in compariſon with all others hitherto formed, it neceſſarily partakes of the imperfect ſtate of the ſcience itſelf; and being the work of an individual, far removed from opulence, and ſome years dead, it is defective with reſpect to ſome ſubſtances lately diſcovered, and alſo in Engliſh, alpine, and volcanic ſpecimens; of theſe laſt, however, at leaſt of thoſe of Veſuvius, the Royal Iriſh Academy poſſeſſes a very ample and well-digeſted ſeries through the bounty of the Reverend Mr. Graydon, not bought up from ignorant or ſwindling dealers at Naples, but painfully collected by himſelf on that mountain, and the neighbouring territory; his uncommon ſagacity in tracing appearances to their true cauſes, and the knowledge he acquired through a careful attention to local circumſtances, have enabled him to deduce the intricate filiation and connection of theſe productions with all the ſatisfaction and certainty that the nature of the ſubject can admit.

The preſent edition of theſe Elements of Mineralogy being grounded on a foundation ſo very different from the former, neceſſarily aſſumes a very different form, being much more copious, and, as I hope, infinitely more perfect. The external characters (cryſtallization excepted) are enumerated and deſcribed with very little variation

tion from Mr. Werner's tract on that ſubject; ſome new Genera, and many new Species, are introduced, the analyſis by different perſons annexed. Not ſlaviſhly addicted to any ſyſtem, I have taken the liberty, when I thought it neceſſary, of framing new diſtinctions, and even of introducing a new claſs; I have alſo added the deſcription of ſome Iriſh foſſils, which appeared not to have been known in other countries. Volcanic productions, that in the former edition were but ſlightly mentioned, will here be found minutely conſidered, and the origin of baſalt fully diſcuſſed. I have alſo treated of the analyſis of Earths and Stones much more at large than before, and impartially examined thoſe already made; in a word, I hope I have faithfully repreſented in this volume the preſent ſtate of the ſcience, as far as Earths and Stones are concerned. The ſecond part, which treats of ſaline, inflammable, and metallic ſubſtances, is in ſome forwardneſs, and will, I expect, be ready for publication in a twelvemonth.

Dublin, Jan. 1, 1795.

CON-

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ERRATA.

*** The Reader's Indulgence is requeſted for the following Errata, occaſioned by the Author's Abſence from London.

Page	Line	
30	18	for *Denritic* r. *Dendritic.*
90	3	*from bottom, for* remains hot *r.* remains red hot.
91	4	for *Erleſenſtein* r. *Erbſenſtein.*
93	9	*for* Tranſparency 3,4 *r.* Tranſparency 3.4.
ib.	10	*take out the comma after* ſtreight.
96	30	*for* Wettering *r.* Withering.
99	11	*for* which *r.* this.
ib.	21	*for* Ludi *r. Ludi.*
ib.	22	*for* Helmontii *r. Helmontii.*
103	13	*for* 1,2 *r.* 1.2.
104	2	*for* but contains *r.* but often contains.
105	1	*for* 1,0 1,5 *r.* 1.0 1.5.
106	11	*for* 3,2 *r.* 3.2.
ib.	13	*for* 2,1,0 *r.* 2.1.0.
110	11	*for* Moulders *r.* Moulder.
ib.	12	*for* Effervefces *r.* Efferveſce.
112	9	*for* each *r.* an.
117	26	*take out* or.
122	*ult.*	*for* and broad foliated *r.* and the broad foliated.
128	13	*for* and *r.* or,
ib.	27	*for* Phoſpholite *r.* Phoſphorite.
ib.	*ult.*	*for* phlolite *r.* phorite.
152	2	*for* dentritical *r.* dendritical.
154	22	*for* cuniform *r.* cuneiform.
161	*laſt but one,*	*for* 1,2 *r.* 1.2.
ib.	*ult.*	*for* 1,2,0 *r.* 1.2.0.
168	5	*for* 3,4 *r.* 3.4.
ib.	*ib.*	*for* 1,2 *r.* 1.2.
ib.	*ib.*	*for* 2,3,1 *r.* 2.3.1.
ib.	8	*inſtead of the comma after* ſurfaces *put a ſemicolon.*
ib.	*laſt but one,*	*for* 3,4 *r.* 3.4.
171	18	*for* 3,4 *r.* 3.4.
172	1	*for* But is *r.* But it is.
ib.	4	*from bottom, after* efferveſce *add a comma.*
184	9	*from bottom, for* made viſible *r.* made more viſible.
190	20	*for* dentritical *r.* dendritical.
203	—	*dele* Struvian Earth *entirely, it having been added by miſtake; it is only a variety of* Clay Slate.
204	10	*after* earth, *add* it is plainly only a variety of ſlate clay.
208	6	*for* ſtreight *r.* ſtraight.
ib.	22	*for* 25 *r.* 2,5.
209	21	*before* 157° *add* at.
210	18	*after* ly *add a comma, and take out the one after* cryſtallized.
ib.	20	*for* 3,4,2 *r.* 3.4.2.
211	18	*for* had porcelain *r.* had a porcelain.
219	7	*from bottom, inſtead of a comma after* laminæ *put a ſemicolon.*
220	9	*for* Verletri *r.* Veletri.

Page	Line	
222	12	*add a comma after* leaſt.
ib.	20	*for* feuilletées *r.* feuilletée.
227	23	*for* through it *r.* through it r.
ib.	*laſt but one,*	*for* 2,3 *r.* 2.3.
230	6	*for* and *r.* or.
232	19	*inſtead of the comma after* it *put a ſemicolon.*
234	5	*from bottom, for* 0,1 *r.* 0.1.
238	3	*from bottom, for* Pierre Raſoir *r.* Pierre de Raſoir.
239	2	*for* 0,1 *r.* 0.1.
ib.	16	*for* as hones *r.* for hones.
243	22	*for* corne- *r.* carne-.
246	4	*add a comma after* ſo.
247	22	*for* 3,4,2 *r.* 3.4 2.
248	3	*from bottom, for* 2,3,4 *r.* 2.3.4.
250	4	*from bottom, for* 3,4 *r.* 3.4.
ib.	3	*from bottom, for* 3,4 *r.* 3.4.
252	9	*for* 3,4,2. Cauſes ſingle *r.* 3.4.2. Cauſes a ſingle.
253	2	for *Gyraſale* r. *Gyraſole.*
ib.	7	*for* 3,4 *r.* 3 4.
ib.	14	*for* 3,4 *r.* 3.4.
256	9	*take out the word* Topaz.
263	5	*from bottom, for* has *r.* have..
264	6	*for* not different *r.* not a different.
267	1	*for* baſalt *r. baſaltes.*
270	8	*after* per ct. *add* of calx.
274	1	*for* 10,9 *r.* 10.9.
281	22	*for* &c. Lilalite *r.* Lilalite, &c.
288	19	*for* ſtria *r.* ſtriæ.
289		take out *Edler* in the running title.
ib.	14	*for* Opal Edler, Gelber, *r.* Opal, Edler, and Gelber.
ib.	18	*for* when placed between the eye *r.* when the eye is placed between it.
290	19	*for* decompoſed *r.* often found decompoſed.
291	24	*take out the comma after* lour, *and put one after* heated.
292	8	*after* Luſtre *put a comma.*
293	9	*take out the comma after* ſcarcely.
ib.	*ult.*	*take out* of.
294	1	*take out the comma after* Mayer.
ib.	12	*take out the commas after* water *and* matter.
ib.	22	*add* In *at the beginning.*
299	7	*take out* the *before* intermediate.
304	13	*for* partly a yellowiſh *r.* partly yellowiſh.
ib.	*laſt but one,*	*for* colour bluiſh *r.* colour is bluiſh.
305	17	*take out the comma after* tranſparency.
326	10	*take out the comma after* browniſh.
328	4	*for* them *r.* it.
ib.	19	*for* conſiderably *r.* conſiderable.
337	6	*for* Ferez *r.* Forez.
338	12	*take out the comma after* leaſt, *and put one after* general.
ib.	17	*for* by *r.* to; *and put a comma after* writers.
342	8	*for* Mem. 1773 *r.* Mem. Par. 1773.
350	9	*for* ſerpentines *r. ſerpentins.*
352	6	*for* Porphyry *r.* Porphyr.
354	4	*for* ſtone *r.* ſort.
ib.	19	*take out* the *at the beginning.*

Page	Line	
356	17	*for* Tranſparency 1 1,5 *r.* Tranſparency 1. 1,5.
365	17	*for* before. Brugman *r.* before, Brugman.
ib.	18	*for* 93. As *r.* 93, as; *and inſtead of the comma after* air *put a ſemicolon.*
367	18	for *Fluke* r. *Flube.*
369	4	for *Drae* r. *Drac.*
370	4	*for* the union of earths *r.* the mere reunion of different earths.
371	24	*for* disjunctive *r. disjunctive.*
385	8	*for* Argillite *r.* Argillites.
ib.	18	*for* Argillite *r.* Argillites.
387	2	*for* penetrates, as *r.* penetrates it. As.
389	20	*for* character *r.* characters.
390	15	*for* 2813 *r.* 2,813.
401	5	*for* Its *r.* their; *and take out* its *before* tranſparency.
403	18	*for* Neptumin *r.* Neptunian.
415	21	*for* mixture *r.* moiſture.
418	2	*from bottom, after* granite *put a ſemicolon.*
419	24	*for* but *r.* hot.
420	22	*after* ſulphur *put a comma.*
422	6	*take out the comma after* ſhorl.
423	3	*for* the *r.* though.
ib.	*ult.*	*for* Lipardi *r.* Lipari.
428	3	*for* The *r* Though.
ib.	5	*inſtead of the full point after* origin *put a comma.*
433	3	*from bottom, take out the comma after* Gerhard.
437	17	*for* baſalts *r.* baſaltes.
439	27	*for* either *r.* neither.
442	6	*for* are *r.* were.
ib.	15	*for* contained *r.* contain.
446	3	*from bottom, for* Volcanos *r.* Volcans.
448	3	*for* Fonda *r.* Fonds.
ib.	13	*for* reſolution *r.* revolution.
449	5	*from bottom, for* ſhinery *r.* ſhivery.
450	22	*inſtead of the ſemicolon after* volcanic *put a comma.*
453	28	*for* from *r.* form.
455	17	*for* baſalts *r.* baſaltes.
463	5	*for* charred *r.* cleared.
ib.	19	*for* heated *r.* treated.
470	4	*take out* 44.
ib.	5	*add* 44. *at the beginning.*
475	12	*for* the ſpirit of *r.* ſpirit of.
476	10	*for* ſtones I am *r.* ſtones of this ſort I am.
477	20	*for* lead (or *r.* lead equal (or.
ib.	5	*from bottom, for* fell *r.* fall.
484	10	*for* ſeparated *r.* ſaturated.
488	6	*for* the *r.* to.
ib.	8	*for* than the *r.* than in the.
489	1	*take out* with.
ib.	15	*after* yet *add* before.
ib.	20	*for* part of its *r.* part of it of its.
491	15	*for* ſolution *r.* ſolutions.
495	10	*take out the ſemicolon after* remainder.
ib.	11	*inſtead of the comma after* neceſſary *put a ſemicolon.*
496	11	*for* have been *r.* have thence been.

ELEMENTS

OF

MINERALOGY.

MINERALOGY, as diſtinct from *Natural Hiſtory*, is the art of diſtinguiſhing mineral ſubſtances from each other.

All bodies found in or on the earth, and not of vegetable or animal origin, are called Minerals.

The whole complex ſyſtem of minerals, called the *Mineral Kingdom*, is uſually divided into four parts: 1. Earths and Stones. 2. Salts. 3. Inflammables. 4. Metallic Subſtances. Of each of which I ſhall treat in the ſame order.

PART I.

Of Earths and Stones.

THE term earth denotes a taſteleſs, inodorous, dry, brittle, uninflammable, ſubſtance whoſe ſpecific gravity does not exceed 4,9, and gives no tinge to borax in fuſion. Yet quicklime is uſually called an earth, though it has a pungent taſte, and is very perceptibly ſoluble in water, and ſome ſorts lately diſcovered in very conſiderable proportion: ſo alſo is *Gypſum*, which is alſo in ſome degree ſoluble in water, and even contains a ſaline principle: perhaps, in ſtrictneſs, there is no earth which is not in ſome degree ſoluble. However, ſince a line muſt be drawn between ſalts and earths, I think it ſhould begin where ſolution is ſcarcely perceptible; ſalts terminating, and earths, in ſtrictneſs, commencing, where the weight of water requiſite for the ſolution exceeds that of the ſolvend 1000 times. But, not to depart too widely from the commonly received import of words that are in conſtant uſe, ſubſtances that require 100 times their weight of water to diſſolve them, and have the other ſenſible appearances of earths, may be ſo ſtyled in a looſe and popular ſenſe.

Stones differ from earths principally in coheſion and hardneſs, and therefore are included under the ſame general name: yet diamond is alſo called a ſtone, though it probably contains no earth of any kind.

Moſt earths are ſoluble in ſome acid or other, and many in all acids; the Pruſſian alkali can precipitate none of them from theſe ſolutions; whereas, it precipitates all metallic ſubſtances from their acid ſolvents *. This forms a diſtinct line of ſeparation between earths and metallic ſubſtances. The exception, formerly made in favour of barytic earth, is now found to have ariſen from a miſtake.

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* Except Platina.

CHAP. I.

Of Simple Earths, their Number, and Characters.

SIMPLE earths are thoſe which are incapable of being converted or analyzed by any means hitherto known, either into each other, or into any other ſubſtance.

Of theſe we have nine; the *Calcareous*, the *Barytic*, the *Magneſian* or *Muriatic*, the *Argillaceous*, the *Siliceous*, the *Scottiſh* or *Stronthian*, the *Jargonic*, the *Sydneian*, and the *Adamantine*.

Of theſe, the five firſt are by far the moſt general, moſt of the earths and ſtones hitherto examined being reſolvable into them. Next to theſe the Scottiſh is, I believe, moſt common; though, from its reſemblance to the calcareous, it has probably been often overlooked. The three laſt have very rarely, and the Sydneian indeed has only once, been met with.

White is the natural colour of all earths; the other colours which are found in them proceed from inflammable or metallic ſubſtances.

Of Calcareous Earth.

Calcareous earth, in its commoneſt ſtate, is called *limeſtone*, or *ſpar*; but in this ſtate it is combined with a peculiar acid, expellible by heat, and by moſt other acids in an aërial form, and hence called *aërial acid*, or fixed air, from its having exiſted in a fixed ſtate before its expulſion. When this acid is expelled, the earth, uncombined with any other ſubſtance, is then called *lime*, or *common* or *calcareous lime*, to diſtinguiſh it from other earths, which alſo form limes when free from all combinations, viz. the Barytic and Scottiſh earths.

Lime, ſimply ſo called, or calcareous or common lime, when unmixed with any other ſubſtance, is perfectly white, and, if in lumps, moderately hard and brittle, its ſpecific gravity 2,3.

It has a hot burning taſte, corrodes animal, and even vegetable, ſubſtances in ſome degree.

When in lumps it heats and burſts by the affuſion of water.

In the temperature of 60° it requires between 6 and 700 times its weight of water to diſſolve it, but in a boiling heat about $\frac{1}{2}$ leſs; but moſt of this exceſs falls as the water cools, ſo that the ſtrongeſt lime-water contains no more than about one grain per ounce troy: it never cryſtallizes while pure.

It is combinable with all acids, particularly with the nitrous and marine: 100 parts ſtandard nitrous acid take up, when ſaturated in the temperature of 60°, 38,68 of lime; and 100 parts lime require for their ſolution 258,5 of ſtandard nitrous acid: 100 parts ſtandard marine acid are ſaturated by 95,49 of lime; and 100 parts lime require for their ſolution 104,72 of ſtandard marine acid in the temperature of 60°.

Theſe ſolutions are with difficulty brought to cryſtallize; the vitriolic acid ſnatches the lime from both of them, and with it forms ſelenite or gypſum; which, if the ſolution be ſaturated, and not very dilute, precipitates, or may be made to do ſo, by evaporation, or the addition of ſpirit of wine.

Nitrous ſelenite, heated to redneſs, eaſily parts with its acid, particularly in open veſſels; but marine ſelenite obſtinately retains it in the ſame circumſtances. Both ſelenites have a bitter taſte.

Pure lime, except placed on clay, is infuſible not only by the greateſt heat of our furnaces, but alſo by that of the focus of a burning glaſs, or the ſtill greater given out by the action of pure air on burning charcoal, as Mr. Lavoiſier has ſhewn.

There are three fluxes uſually applied to procure the fuſion of earths, namely fixed alkalis (generally the marine), borax, and microcoſmic ſalt; of theſe borax is moſt appropriated to calcareous earth, and next to borax microcoſmic ſalt; they fuſe lime without efferveſcence; and mild calx (ſo I call lime united with fixed air) with ſome efferveſcence; but alkalis barely divide and diſperſe it.

According to Mr. Lavoiſier, 1000 parts lime are capable of abſorbing (when fixed air is not admitted), and of retaining, in a heat of 600° Fahr. 228 parts of water, that is, between ¼ and ⅕ of its weight; and mild calcareous earth, ſuch as powdered chalk in its uſual ſtate of dryneſs, can abſorb about ½ of its weight of water, without letting any drop out of it; but, if expoſed to the open air, it will ſoon dry, and give it out.

Barytic, or Ponderous Earth.

This earth, when free from all combination (a ſtate in which nature never preſents it), forms alſo a lime with many of the properties of common lime, but differs from it by many others. It is ſoluble in water; but, in the temperature of 60°, it requires, according to Bergman, 900 times its weight of that ſolvent to hold it in ſolution.

This lime is ſoluble in the nitrous and marine acids, though much more difficultly than common lime; but with theſe acids it cryſtallizes, and the cryſtals are not deliqueſcent as thoſe afforded by common lime are.

Theſe ſolutions are precipitated by the vitriolic acid as thoſe of common lime; but the ſelenite, of which common lime is the baſis, is ſoluble in about 450 or 500 times its weight of water; whereas that which has barytic lime for its baſis is inſoluble in leſs than 40000 times its weight of water.

If barytic lime-water be added to a ſolution of tartar vitriolate, or Glauber's ſalt, it ſeizes the acid of theſe ſalts, and forms a precipitate; it alſo precipitates the ſolutions of nitrated and muriated ſtronthian.

The uſual fluxes affect it as they do calcareous earth.

Magneſia, or Muriatic Earth.

Various clays, ſtones, and ſalts, particularly Epſom ſalt, contain this earth; but uncombined,

or

or combined ſimply with fixed air, unmixed, it ſcarcely ever occurs; when pure, it is perfectly white: its ſpecific gravity is about 2,3.

It requires about 7900 times its weight of water to diſſolve it in the temperature of 60°.

It is combinable with all acids; with the nitrous and marine it forms ſalts that difficultly cryſtallize, and are deliqueſcent. If to a ſaturate ſolution of theſe ſalts the vitriolic acid be added, though it takes the magneſia from the abovenamed acids, yet it forms no precipitate, as it does when it ſeizes the calcareous, barytic, or Scottiſh earths, in the ſame circumſtances. The ſalt, formed of the vitriolic acid and magneſia, is alſo very ſoluble in water; whereas the ſalts, formed of this acid and the preceding earths, are very difficultly ſoluble; the former is bitter, the latter are inſipid, or nearly ſo.

Magneſia, in its pure ſtate, is not as eaſily diſſolved as when combined with fixed air; 100 parts of it require for their ſolution 194 of the vitriolic ſtandard acid, 286 of the nitrous, and 215,8 of the marine.

And 100 parts of the vitriolic ſtandard acid take up 51,54 of pure magneſia; 100 parts of the nitrous acid 34,96; and 100 parts of the marine 46,34.

This earth, expoſed to the ſtrongeſt heat, will neither burn to lime nor melt; it is fuſed by the ſame fluxes as lime and mild calx, and with the ſame appearances.

In its uſual ſtate of dryneſs mild magneſia is capable of taking up $1\frac{1}{20}$ times its weight of water without letting out any drop; but, if expoſed to the open air, it ſuffers it to evaporate, though more ſlowly than calcareous earth does.

Earth

Earth of Alum, or Argill.

This earth forms the baſis of common alum, and hence is by many called aluminous earth; it is alſo the true clayey part of common clay; and hence, to diſtinguiſh it from the other heterogeneous parts, it is called argill.

It is ſeldom found nearly pure, and never abſolutely ſo; the pureſt is extricated from alum by precipitation with the cauſtic volatile alkali; it is very white, ſmooth, and unctuous; its ſpecific gravity, when thoroughly dry, and free from fixed air, is 2,00; it is very diffuſible, but not more ſoluble in water than pure magneſia.

It is combinable with moſt acids, but (except in the act of precipitation) with great difficulty; with the vitriolic it forms alum; with the nitrous and muriatic it difficultly cryſtallizes.

When heated it hardens and diminiſhes in bulk, but it is infuſible in the ſtrongeſt heat of our furnaces: the heat, however, given out by pure air appears to affect it, and diſpoſe it to fuſion, more than it does any of the before-mentioned earths.

Microcoſmic ſalt ſeems the flux beſt ſuited to argill; it diſſolves it with conſiderable efferveſcence. Borax is nearly as powerful, and produces leſs effervеſcence; but alkalis act nearly as on the preceding earths.

Even in the moiſt way cauſtic alkalis are capable of acting on argill.

In its uſual ſtate of dryneſs it is capable of abſorbing 2½ times its weight of water without ſuffering any to drop out, and retains it, when expoſed to the open air, more obſtinately than the foregoing earths: however, in a freezing cold, clay contracts more than any other earth, and, in contracting, ſqueezes out its water, and thus parts with more of it in that circumſtance than other earths do; a fact of ſome importance in agriculture, as well as mineralogy.

Siliceous Earth.

This earth is generally found in a ſtony ſtate, it abounds in flint, and is thence called *ſiliceous*; but it is ſtill purer in mountain cryſtal, and in quartz: the pureſt is perfectly white or colourleſs; its ſpecific gravity is 2,66.

In its uſual ſtate of concretion it appears inſoluble in water; but, in that ſtate of diviſion in which it exiſts, when precipitated from its ſolution in fixed alkalis, it is perfectly ſoluble in 1000 parts of water.

In general it combines with no acid, except that extracted from the ſtones called fluors, a variety of which is generally known under the appellation of Derbyſhire ſpar; but, in the moment of precipitation from its ſolution in fixed alkalis, many eminent chemiſts think it capable of uniting with moſt acids *; at leaſt, it is certain that an alkaline ſolution of ſilex, much diluted with water, may be ſaturated and ſuperſaturated with an acid without any precipitation;

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* Mr. Dolomieu, 40 Roz. 379, thinks it is in its uſual ſtate united to inflammable air, but freed from that air when united to alkalis, and in that caſe combinable with acids, in ſeparating from which it again retakes this air from water.

and this is one of the ſureſt characters of this earth.

By the experiments of Mr. Lavoiſier, it appears that the ſtrongeſt heat that can be applied, namely, that excited by pure air, is incapable of melting it. The ſlight degree of emolleſcence that ſome others have obſerved, moſt probably proceeds from ſome ſlight mixture with ſome other earth.

Fixed alkalis, whether vegetable or mineral, are the true ſolvents of ſiliceous earth in the dry way: 1 part mineral alkali will flux two of ſiliceous earth with efferveſcence. Borax alſo fuſes them, but much more ſlowly, and without efferveſcence. Microcoſmic ſalt is ſtill leſs effectual.

Cauſtic fixed alkalis attack ſiliceous earths alſo in the moiſt way, when very minutely divided, and take up nearly $\frac{1}{6}$ of their weight.

Siliceous ſand is capable of abſorbing about $\frac{1}{4}$ of its weight of water without letting any drop from it; but, on expoſure to the open air, it ſuffers it to evaporate much more readily than any of the foregoing earths do in the ſame circumſtances.

Of the characterizing Power of the foregoing Earths.

Having ſet forth the diſtinctive characters of the foregoing earths, ſingly taken, we are now to remark the different powers they poſſeſs of impreſſing or communicating their reſpective characters, when mixed or combined with each other, to the compound of which they form a part.

1. Calcareous earths feel dry, meagre, and harſh, when *in a looſe or ſemi-indurated ſtate*; and this property they communicate to other earths *in the ſame ſtate*, when they conſtitute at leaſt 40 or 50 *per cent.* of the whole. When in a ſtony ſtate they are never hard enough to ſtrike fire with ſteel; and they impreſs this property on compounds in a ſtony ſtate, in which they enter in the proportion of 30 *per cent.*

2. Barytic earth, when not the principal ingredient in a compound, has ſcarcely occurred in any conſiderable proportion. Its high ſpecific gravity it undoubtedly communicates, but the porous ſtructure of the compound may be ſuch as to conceal it.

3. Magneſia feels ſmooth; in a ſtony ſtate it never occurs ſingle, but it impreſſes a character of ſmoothneſs and unctuoſity on all compounds in which it has not the oppoſite characters of calcareous earth to encounter, and into which it enters in the proportion of 18 to 20 *per cent.* It alſo gives a greeniſh caſt to ſtones, and a bias towards a fibrous, ſtriated, or ſlaty ſtructure, and ſome luſtre, particularly of the ſilky kind.

4. Argill is alſo ſoft, ſmooth, and unctuous to the feel; it ſtrongly abſorbs water, and hardens when heated. In looſe or ſemi-indurated mixtures it imparts theſe properties to calcareous earths only when it exceeds them in quantity. With magneſia it can have no ſtruggle; but, on ſiliceous earths, it impreſſes its characters in ſome degree, even when it amounts only to 13 or 14 *per cent.* of the whole. In ſtony compounds, if it exceeds 20 *per cent.* and is mixed with magneſia, it gives a bias to a ſlaty or lamellar ſtructure.

ture. In the proportion of 20 or 30 *per cent.* it generally diminiſhes, and when in a greater proportion extinguiſhes, the character of ſiliceous earth: to this obſervation there are very few exceptions.

5. Siliceous earths, in a ſtony or ſandy form, are remarkable for their hardneſs, tranſparency, and luſtre; but their power of communicating theſe properties is inferior to the powers of communication poſſeſſed by the foregoing earths. When ſilex is exceedingly comminuted, as it is after the precipitation from alkalis, it is light and ſpungy.

Scottiſh, or Stronthian Earth.

This is a new earth, firſt noticed as ſuch, as far as I can find, by Dr. Crawford, who ſent me a ſpecimen of it in the year 1790. I have ſince ſubjected it to various experiments lately read to the Royal Iriſh Academy, an account of which may be found in their Tranſactions; from this paper I ſelect the following particulars:

1. It has hitherto been found only in a mild ſtate, united to fixed air: of this ſpecies I ſhall hereafter give a deſcription.

2. Like common limeſtone it loſes its air in a ſtrong heat, and then forms a lime.

3. This lime is much more ſoluble in common water than that afforded by common limeſtones, and is alſo ſpecifically heavier.

4. This lime, like the barytic, decompoſes tartar vitriolate; but the ſelenite it forms is itſelf decompoſed by barytic lime.

5. It decompoſes the ſolutions of common gypſum, and of nitrated or muriated calx.

6. Vitriolic acid dropped into this lime-water immediately forms a viſible precipitate, which it does not in common lime-water.

7. This lime-water has alſo the ſingular property, of affording, when ſaturated, compreſſed rhomboidal cryſtals, which are nothing elſe but pure lime.

8. Its ſolution, in the nitrous or marine acids, may be rendered ſo ſaturate as not to diſcolour litmus; whereas the ſolutions of barytes in thoſe acids have always an exceſs of acid.

Jargonic Earth *, *or Jargonia.*

This earth hath been diſcovered by Mr. Klaproth; it has as yet been found only in the ſtone called *Jargon*, or *Circon*, of Ceylon, of which more hereafter.

This earth reſembles argill more than any other earth, though it differs eſſentially from it in ſome reſpects. Its colour is white, and its ſpecific gravity probably exceeds 4,000.

1. It is incapable of uniting to fixed air; at leaſt, when precipitated from acids by mild alkalis, it takes up none.

2. It is ſoluble in dilute vitriolic acid (as alſo in the nitrous and marine); and with a ſlight exceſs of this acid it forms, in a moderate heat, by ſpontaneous evaporation, ſtelliform cryſtals of an aſtringent taſte, eaſily ſoluble in water. Its

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* 3 Berl. Beobacht. 147.

ſolutions, like thoſe of argill, are precipitable by cauſtic volatile alkali, as well as by the fixed.

3. It is alſo ſoluble in the concentrated acetous acid; this ſolution will not cryſtallize; but, if it be evaporated to dryneſs, the ſaline powder thus had will not attract the moiſture of the air, as acetous alum does; neither does the acetous acid act ſo powerfully on argill as on this earth.

4. It is inſoluble in a boiling ſolution of cauſtic fixed alkali, in which argill is perfectly ſoluble.

5. It is infuſible, not only by fixed alkalis, but alſo by microcoſmic ſalt, to which argill yields. Borax however melts it, but without any efferveſcence, in which reſpect alſo it differs from argill.

Hence it is plain Mr. Klaproth is juſtified in reckoning this a new earth, of which, it were to be wiſhed, we were acquainted with many more of the properties.

Sydneia, or Sidney Earth *.

For the diſcovery of this ſingular ſubſtance, we are indebted to that celebrated philoſophic artiſt Mr. Wedgewood.

This earth is contained in a compound mineral imported from Sidney Cove, in South Wales, conſiſting of fine white ſand, ſome colourleſs mica, a few black particles reſembling black lead, and a white earth which appears to be argillaceous, with which the new earth appears to be mixed, and from which it is extracted by the

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* Phil. Tranſ. 1790, 306.

the marine acid. It was found to poſſeſs the following properties: its colour is white.

1. It is fuſible in a heat of 150 of Wedgewood, which no other ſimple earth is.

2. It is ſoluble immediately and directly in no other acid but the marine, at leaſt not in the nitrous or vitriolic.

3. The marine acid, to diſſolve it, muſt not only be in large proportion, and concentrated, but alſo heated above 140° Fahr.

4. From this ſolution this earth is not precipitable by the Pruſſian alkali; but it is by common alkalis, which inſtantly render its ſolution milky.

This ſolution is alſo precipitable by affuſion of pure water in the ſmalleſt quantity if ſaturate; but, if unſaturated, it may bear a conſiderable addition of that fluid without precipitation.

The addition of ſpirit of nitre to a ſaturate ſolution occaſions no precipitation; and, if the quantity of nitrous acid added exceeds, or equals, that of the ſaturate ſolution, it will protect it from precipitation by water.

Neither does the addition of the concentrated vitriolic acid precipitate the ſaturated ſolution, but it has a ſtronger affinity to this earth than the marine has; for, if the quantity of vitriolic acid added be nearly equal to that of the ſolution, heat and effervеſcence will ariſe, the liquor will become turbid, and the marine acid will be expelled in white fumes; the mixture then heated to boiling becomes tranſparent, and continues ſo; this vitriolic ſolution is alſo precipitable by water like the marine.

5. The marine ſolution does not cryſtallize, but becomes butyraceous and deliqueſcent. The butyraceous maſs is pale yellow, and not corroſive; it parts with its acid in a ſtrong heat.

Adamantine Earth.

Of this ſubſtance, which was lately diſcovered by that excellent analyſt Mr. Klaproth in a ſtone called *adamantine*, or *diamond ſpar*, very little is as yet known. In decompoſing this ſpar he found an earth which conſtituted about $\frac{1}{4}$ of its weight, which was inſoluble in acids, and infuſible by alkalis; by this laſt property it differs from ſiliceous, and by the former from all other earths; he does not however poſitively aſſert that it is not ſome unknown compound of other, earths. 2 Berl. Beobacht. 297 *. Its exiſtence is alſo ſuſpected in ſome other ſtones, as will be ſeen in the ſequel. Its ſpecific gravity probably exceeds 3,000.

Calces of Iron.

To theſe ſimple earths we muſt alſo annex the conſideration of calces of iron, as they almoſt always accompany earthy or ſtony ſubſtances, are mixed or combined with them, and are the ſource of many both of their external appearances and internal properties.

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* Mr. De la Metherie, in the 2d vol. of his new edition of Mongez's *Manuel du Minéralogiſte*, ſays, Mr. Klaproth found this earth ſoluble in the vitriolic and acetous acids; but this is plainly an overſight.

Calces of iron are formed of iron, combined with different proportions of pure air, and frequently of water alſo, and fixed air.

One hundred parts metallic iron are capable of taking up 66 or 70 of pure air. When 100 parts iron contain but 40 of this air, the compound is ſtill magnetic.

SECTION II.

Of the Formation of Stony Subſtances.

The ſlighteſt acquaintance with the ſtony ſubſtances that come under our inſpection is ſufficient to convince us they were once in a ſoft or liquid ſtate. Many of them have the appearance of having been cryſtallized, like ſalts, in ſeparating from their ſolvent whatever that may have been; and theſe cryſtals diſcover all the variations to which ſaline cryſtals are liable. Many of them incloſe organized ſubſtances which they could not have admitted but when in a ſoft or liquid ſtate; many of them appear to have been formed round mineral ſubſtances, as theſe, having received their ſhape and form from the operations of art, could never have introduced themſelves into them. The bare mention of theſe circumſtances is ſufficient, as this point has, I believe, never been diſputed. The only difficulty that at preſent occurs is to aſcertain the nature of that fluid which

which was capable of holding in ſolution or ſuſpenſion that immenſe maſs of ſolid ſubſtances of which the globe of the earth conſiſts. On this head I ſhall only remark, that, with regard to ſtony ſubſtances that are placed deeper than one mile beneath the level of the ſea, we have no reaſon to affirm they were ever in a ſoft ſtate, as we are perfectly unacquainted with them; and, with reſpect to thoſe that are nearer to, or on the ſurface of, the earth, we may, for the preſent, ſuppoſe that fluid to have been in moſt caſes mere water, in ſome circumſtances aided by ſaline ſubſtances, and, in comparatively much fewer caſes, aided by volcanic fires. The probability, that fire has been the univerſal agent of this ſolution, we ſhall afterwards examine in a diſtinct diſſertation.

Suppoſing then the ſimple earths, and ferruginous and bituminous ſubſtances, already mentioned, reduced to that degree of diviſion which ſolution requires, to exiſt in that maſs of waters which now conſtitutes our oceans, ſeas, lakes, and rivers, this maſs, conſiderable as we ſee it, is nevertheleſs evidently inſufficient to hold them in ſolution; they will therefore ſoon unite, and thoſe ſooneſt which have moſt affinity to each other, and leaſt to the fluid in which they are ſuſpended. Hence ſome will be cryſtallized, and ſome will be formed by ſimple depoſition, as we ſee clay depoſited by water.

Hence ſtony ſubſtances, formed in the aqueous fluid, owe their origin ſome to cryſtallization, ſome to depoſition, and ſome partly to the one partly to the other.

Cryſtallization is that operation by which ſolids diſſolved, or finely diffuſed in a fluid, coaleſce by virtue of their mutual attraction into maſſes of a determinate and angular ſhape: if this operation be accompliſhed in the moſt perfect and regular manner, the ſhape of the cryſtal will be determined by that of the firſt molecule formed, the ſubſequent additions being made to certain ſurfaces according to certain laws; but, if the operation be diſturbed by any impediment, certain ſurfaces will receive greater additions than others are allowed to receive, and in that caſe either no determinate angular ſhape will enſue, or a ſhape very different from what nature ſeemed principally to have had in view will ariſe.

Hence this operation is ſuſceptible of various ſtages and degrees of perfection.

As the additions made to cryſtallized ſurfaces are gradual and uniform, theſe ſurfaces have generally a ſmooth and poliſhed appearance; however, the mixture of foreign ſubſtances, that are capable of impeding the operation, diminiſh this luſtre in proportion to their influence.

Cryſtallized ſubſtances are alſo very frequently tranſparent; and theſe that are naturally ſo would always be ſo, were they not diſturbed in the courſe of the operation; but ſome are naturally opaque.

The greateſt impediment to cryſtallization is want of liberty of the diſſolved particles to arrange themſelves according to the laws of the attraction of the different ſurfaces; this reſtraint may ariſe either from agitation, which diſturbs the direction of their ſpontaneous attraction, or from their being forced into contact with each other in a fluid in which they are too much crowded, or by the introduction of foreign ſubſtances, which prevent their mutual contact.

Some ſubſtances are more apt to be diſturbed by the introduction of foreign ſubſtances than others; thus we ſee calcareous ſpars cryſtallized in a regular form, though mixed with a conſiderable proportion of ſilex, in the calcareous ſandſtones of Fontainbleau.

The firſt ſtep in the proceſs of cryſtallization is the formation of grains, the ſecond is the increaſe in one dimenſion, the third in two dimenſions, and the fourth in three dimenſions; the grains themſelves, however, to be viſible, muſt receive accretions in the three dimenſions. If the proceſs be uninterrupted, no traces of diſtinction will be perceived, and the whole will appear perfectly uniform; but, if it be diſturbed in the firſt ſtep, no cryſtallization can take place; if in the ſecond, the grains will appear diſtinct, ſmall or groſs, coarſe or fine, according to the nature of the diſturbance, whether by the interruption of the proceſs, or the acceſſion of foreign matter; this latter generally produces coarſe or rude grains in proportion to the quantity.

If the diſturbance only takes place in the third ſtage, we ſhall have fibres or ſtriæ, as complete ſurfaces cannot be formed; the ſtriæ, having more extenſion in breadth than the fibres or filaments, argue a ſmaller degree of diſturbance than the mere fibrous appearance.

If, during the third ſtage, the ſtriæ be forced into contact, by the gradual dereliction of the fluid that kept them ſuſpended, they will form lamellæ in proportion as they are deſerted, which will either adhere to each other, and then fall confuſedly, being too heavy to be ſupported by the menſtruum, or, if ſupported, will be ſuperimpoſed on each other.

But if the proceſs of cryſtallization be diſturbed only in the fourth ſtage, then the form and ſhape only of the cryſtals will be more or leſs altered.

All theſe ſteps are noticed and deſcribed by chemical writers; and particularly by the celebrated Rouelle, in the Memoirs of the Academy of Paris, on the cryſtallization of ſalts.

Depoſition is an effect that takes place when ſolids have little or no tendency to cryſtallize, are divided ever ſo minutely, and ſuſpended in a fluid ſpecifically lighter, and to which they have no affinity, or which is not ſufficiently abundant to hold them in ſolution; it takes place ſo much more ſlowly, as the particles ſuſpended approach more to the ſpecific gravity of the fluid, or are more minutely divided.

Depoſition is either ſimultaneous or periodical; in the former caſe vaſt unwieldy ſtony maſſes have been produced, in the latter ſlaty maſſes.

The fluid from which ſtony ſubſtances have been depoſited appears to have contained a mixture of bitumen, and moſt probably alſo of carbonaceous ſubſtances; and hence ſome proportion of theſe is often found in ſtones formed by ſubſidence.

In general, depoſition muſt be a later operation than cryſtallization; but it muſt frequently have happened that both ſhould take place at the ſame time, from an unequal mixture of ſubſtances, ſuſceptible ſome of the one, and ſome of the other; and hence many ſtony maſſes owe their origin partly to the one, and partly to the other.

SECTION III.

Of the diſtinctive Characters, and ſyſtematic Arrangement, of Earths and Stones.

THE object of mineralogy, at leaſt in the ſenſe in which that word is taken in this work, being to point out the method of diſtinguiſhing the various ſubſtances of which it treats, it is neceſſary at the outſet to give a general idea of the means it employs, to prove their ſufficiency, and remove every ambiguity and obſcurity that may attend their application. On the moſt general view of the ſubject, it is plain theſe means can be no other than the properties of the ſubſtances themſelves, or at leaſt ſuch of them as are moſt obvious, of moſt eaſy application, and at the ſame time characteriſtic of the ſubſtances to which they belong; we muſt therefore examine what thoſe properties are.

The properties of ſubſtances, as far as we can underſtand them, are the relations which they bear to our ſenſes, and to other ſubſtances on or from which they are capable of producing or receiving ſome peculiar obſervable change. Theſe laſt-named ſubſtances are called *chemical agents*; the properties which relate to our ſenſes are called the *external*, and thoſe that relate to chemical agents the *internal*, characters of bodies.

In the Treatiſe I formerly compiled on this ſubject I conſidered the *internal* properties of minerals as the only that were ſufficiently characteriſtic of the ſubſtances to which they belonged. A more mature conſideration has undeceived me.

I perceived that names having been given to different mineral ſubſtances, ſometimes by reaſon of their external properties, ſometimes by reaſon of their internal, and the buſineſs of the mineralogiſt being to diſtinguiſh the ſubjects to which thoſe different names have been given from each other, he muſt in ſome caſes rely chiefly on the external, and in others chiefly on the internal, characters; but, if any ambiguity remain, the deciſion muſt reſt with theſe.

Thus diamonds, rubies, emeralds, and other precious ſtones, received their names, and were well diſtinguiſhed from each other, long before their *internal* properties were known, if even at preſent they can be ſaid to be ſo: there muſt ſurely then be ſome means of diſtinguiſhing them, and theſe means can be no other than their external properties: it were indeed a melancholy circumſtance to a jeweller if there were no other certain way of diſtinguiſhing diamonds than their internal properties; for, the only one of that kind with which we are at preſent acquainted is their deſtructibility by heat; he ſhould therefore deſtroy the ſtone before he could know it.

What I have ſaid of precious ſtones may be underſtood of far the greater number of ſtony ſubſtances; either they have not been analyzed, or the analyſes given of them preſent different reſults, and conſequently are undeciſive; yet, ſince they *can* be diſtinguiſhed, it is plain this diſtinction *may* be made by external characters.

It muſt be remarked, however, that, in diſtinguiſhing earths and ſtones which have never been analyzed, or which, independently of any analyſis, have received their denomination from *mere external* characters, ambiguities frequently ariſe;

ariſe; and doubts may remain, which can be removed only by the application of chemical teſts or internal characters, not indeed analyſes, but other teſts of more eaſy and ſpeedy application.

Again, many minerals have received their denominations merely from internal properties, ſuch as limeſtones and marls, &c. The only certain teſts of theſe are chemical agents, though external characters may afford a high degree of probability.

The over-zealous diſciples of Mr. Werner contend for the ſufficiency of external characters, in all caſes, with reſpect to ſtones that have been already analyzed. It were an eaſy, if not an invidious, taſk to refute them, from the miſtakes into which the moſt eminent of them have fallen, through too great reliance on theſe characters; but, in juſtice to Mr. Werner, I muſt ſay, that he recommends the aid of eaſy chemical teſts, and has in ſome caſes happily applied them.

It has been objected to external characters, by myſelf and many others, that they are not of a fixed and permanent nature, nor appropriated purely and ſingly to any particular ſpecies, but common to many, and incapable at leaſt as to their gradations of a definition ſufficiently preciſe. The firſt part of this objection is certainly true, if applied only to one or two of thoſe characters; but, if they be taken in their totality, it will very rarely happen that they ſuit any mineral but one, and in ſuch caſes chemical teſts may decide; yet even this aſſiſtance may be ſometimes unſucceſsful, as in nature many ſpecies border upon, and paſs into, each other, and thus deny ſufficient grounds of diſtinction. As to the difficulty ariſing

ariſing from the vague definitions of thoſe characters, this has been in great meaſure removed by Mr. Werner, and I have endeavoured to render them ſtill more preciſe.

The neceſſity of applying theſe characters, and employing them in that ſtrict and determinate ſenſe which Mr. Werner has affixed to them, muſt be obvious to every reader of mineralogical writings. Who does not lament in ſeeing moſt of theſe (thoſe only of the Wernerian ſchool excepted) rendered uſeleſs by the defective and imperfect deſcriptions of the minerals of which they treat? Through the neglect of adequate deſcriptions the ſame name has been imperceptibly applied to minerals widely different from each other; and, converſely, minerals of the ſame ſpecies have been diſtinguiſhed by different appellations.

I now proceed to a brief enumeration and explication of the external characters given by Mr. Werner*, or at leaſt of ſuch of them as I think neceſſary, with the few improvements I think I have made in their deſcriptions: theſe conſiſt in denoting the degrees of intenſity of ſome particular qualities by figures,

External Characters.

Theſe are, *colour*, *ſhape*, *luſtre*, *tranſparency*, *texture*, *coheſion*, *denſity*, *adheſion* to the tongue or fingers and general *feel*, *colour of a ſtreak*, *abſorp-*

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* There are terms of which I could never learn the preciſe meaning, particularly the word *Derbe*.

abſorption or *diffuſion* in water, *ſmell*, and *taſte*; to which Mr. Werner adds the various *refrigerating* powers of bodies, but theſe I moſtly omit as too vague.

Internal Characters.

Relation to acids, changes operated in low heats, fuſibility and other changes in higher degrees of heat, phoſphoreſcence, magnetiſm, electricity, and, laſtly, the reſults of a juſt analyſis.

Colours.

Of theſe I ſhall name only the moſt ſimple, and thoſe whoſe denominations require ſome explanation.

White. Milk white—contains a ſlight mixture of blue.

Grey—a mixture of white and black, in which however the white predominates.

Lead grey—grey with a ſlight mixture of azure blue.

Pearl grey—pale grey with a ſlight mixture of violet blue.

Smoke grey—dark grey with a ſlight mixture of blue and brown, as in flints.

Steel grey—nearly the ſame, but with a more metallic aſpect.

Black.

Blue. Indigo blue—the deepeſt, nearly black.

Azure blue—ſomewhat lighter.

Smalt blue—paler than the foregoing.

Lavender blue—blue with a mixture of grey, and a ſhade of red.

Violet blue—reddiſh blue.

Celeſtial blue—pale blue with a ſlight ſhade of green.

Green—reſults from a mixture of yellow and blue.

Verdigris green—that in which no ſhade of yellow is perceptible, rather bluiſh.

Celadon green—bluiſh green with a ſhade of grey.

Mountain green—pale greyiſh green.

Emerald green—pure green.

Meadow green—lively green, in which however the yellow predominates.

Apple green—green verging to white.

Leek green—dark green with a mixture of brown.

Piſtachio green—meadow green with a mixture of brown.

Sparrow graſs green—pale yellowiſh green with a mixture of grey and brown.

Olive green—pale yellowiſh green with a ſtrong mixture of brown.

Canary green—pale yellowiſh green without any mixture of brown.

Yellow—reſults from a mixture of orange and green.

Sulphur yellow—pale greeniſh yellow.

Lemon or gold yellow—the pureſt.

Honey yellow—yellow with a mixture of reddiſh brown.

Wax yellow—darker than the foregoing.

Copper yellow—pale metallic with a ſhade of red.

Braſs yellow—pale metallic with a ſhade of green.

Straw yellow—well known.

Wine yellow—pale reddiſh, and ſomewhat browniſh.

Ochre yellow—ſomewhat dark with a ſhade of brown.

Iſabella yellow—browniſh yellow with a ſhade of browniſh red.

Orange yellow—reddiſh yellow.

Red. Aurora red—high red with a ſhade of yellow.

Hyacinth red—high red with a ſhade of brown.

Brick red—well known.

Scarlet red—well known.

Copper red—metallic with a ſhade of yellow.

Carmine red—the pureſt.

Blood red—darker, well known.

Cochineal red—high red with a mixture of bluiſh grey.

Crimſon—high red with a ſhade of blue.

Fleſh red—pale red of the crimſon kind.

Roſe red—pale red of the cochineal kind.

Peach-flower red—pale whitiſh red.

Mordoré—dark red of the crimſon kind, mixed with brown.

Browniſh red—blood red mixed with brown.

Brown—reſults from a mixture of red, black, and yellow.

Reddiſh brown—brown verging to blood-red.

Clove brown—dark brown with a ſcarcely perceptible ſhade of crimſon.

Yellowiſh brown—pale brown with a ſhade of ochre yellow.

Tombac brown—metallic yellowiſh brown.

Liver brown—greyiſh brown.

In examining the colours of foſſils the internal is chiefly to be regarded, as the external is often ſtained or tarniſhed, and the ſurface frequently of a different nature from decompoſition or mixture with a foreign mineral.

Shape.

The ſhape of foſſils is either *indeterminate*, *particular*, or *regular*.

Indeterminate, or *amorphous*, is that which can be compared with no other.

Particular Shapes.

Dentiform, ſhort, ſomewhat crooked, cones.

Filiform.

Capillary ſtill finer.

Interwoven, or *reticular*.

Denritic, or *arboreſcent*.

Coralliform, or forked and crooked *.

Stalactitic, cones iſſuing from a common ſtem.

Tubuliform, ſlender cylinders adjoining each other.

Ramified.

Botryoidal, like grapes.

Kidneyform, or *reniform*, round elevations bearing other ſmall elevations.

Bulbous, preſenting rounded elevations with ſome depreſſions.

Depreſſed, an elevation beat in in the middle †.

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* Zackig.

† Geſtoſſen.

Specular, preſenting a flat poliſhed ſurface like a mirror.

Cellular, preſenting cells formed of laminæ croſſing each other.

Perforated, traverſed with round holes.

Corroded.

Determinate.

Under this head are comprehended the various forms of cryſtallized ſubſtances, reſulting from the aſſemblage of a determinate number of ſides.

The varieties of form which cryſtallized bodies preſent I ſhall not attempt to enumerate, and ſo much the leſs as I think their detail of very little uſe. Thoſe who wiſh for more information on this head may conſult Romé de Liſle, Mr. Werner, and an excellent Diſſertation by Mr. Wideman, in the 4th volume of the Berlin Obſervations.

A ſurface on which very minute cryſtals abound is called *druſy*.

Luſtre.

Luſtre is the gloſs, and often brightneſs, which foſſils diſcover, ſometimes on their external ſurface, but more frequently on their internal ſurface, when freſh or broken. Of this luſtre Mr. Werner diſtinguiſhes various ſorts; the *metallic*, the *pearly*, the *waxy*, that of *greaſe*, the *glaſſy*, and the *common*. When no particular ſort is mentioned, it is underſtood to be of the common kind.

There are alſo different *degrees* of luſtre, which I denote by figures.

4. denotes the ſtrongeſt, and is perceived at a certain diſtance, ſuch as that of diamonds and poliſhed metals.

3. denotes a weaker, ſuch as that of cryſtals or metals not much poliſhed [*].

2. denotes a ſtill weaker, as that of ſilk, or ſtill leſs gloſſy [†].

1. when only a few particles reflect any luſtre, or it is exceeding weak.

0. dull, reflecting no luſtre at all.

When luſtre is mentioned ſimply, without ſpecifying which, the *internal* is underſtood.

Tranſparency.

Of this Mr. Werner diſtinguiſhes ſeveral *degrees*, which I note by figures.

4. denotes that degree which allows objects to be clearly diſtinguiſhed [‡].

3. that which ſuffers objects to be perceived, but not diſtinctly [§].

2. that which tranſmits light, but does not permit objects to be diſcerned [‖].

1. that which tranſmits light only at the edges.

0. denotes perfect opacity.

When a foſſil poſſeſſes theſe qualities in various degrees, I place the figure denoting the moſt uſual degree firſt, and the leaſt common degrees follow in their order.

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[*] Sehr glanzende of Werner, and glanzende.

[†] Wenig glanzende.

[‡] Durchſigtig.

[§] Halb durchſigtig.

[‖] Durch ſcheinend.

Texture or Fracture.

The texture of a foſſil is diſcovered by breaking it; and hence Mr Werner commonly calls it the *fracture*; though this appellation be not the moſt juſt, yet, as it is now in conſtant uſe, and well underſtood, I ſhall alſo employ it in the ſame ſenſe. Mr. Werner no where mentions in what direction this fracture ſhould be made; but I think it may be collected that it ſhould be made in the direction in which it may moſt eaſily be effected, and moſt commonly the croſs fracture is to be underſtood: the natural ſeams or joints of the ſtone are to be avoided.

The form of the internal ſurface of a foſſil, which its fracture preſents to us, reſults from that of the minute particles that compoſe it, and are called the *grain* of the ſtone or foſſil; theſe may be ſo minute and cloſe as ſcarcely to be diſtinguiſhed, or more open and diſtinct: according to the direction and mode of union of theſe particles the fracture is diſtinguiſhed into *compact, fibrous, ſtriated, foliated, and ſlaty.*

Of the Compact Fracture *.

The compact fracture is that in which the minute particles of a foſſil are either uniformly

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* Much obſcurity prevails in this part of Mr. Werner's treatiſe, which he has of late I underſtand much improved; and hence I may have miſtaken his meaning in ſome inſtances, more eſpecially as I cannot procure the original (which I loſt), and am obliged to uſe the French tranſlation. I alſo add ſomewhat from Mr. Karſten.

arranged, or at leaſt have no particular determinate direction nor inequalities, but thoſe ariſing from the mere act of breaking it: of this fracture there are ſix ſorts, the *uneven*, *even*, *conchoidal*, *ſplintery*, *earthy*, and *hackly*.

The *uneven* takes place when great inequalities prevail in the direction of the line of fracture.

The *even* is that which preſents flat ſurfaces with ſcarcely any prominent parts.

The *conchoidal*, otherwiſe called *teſtaceous*, preſents round elevations and depreſſions like ſhells: the *perfect* is ſingle, and the elevations are often wrinkled; the *imperfect* is flatter, or the elevations and depreſſions are more minute and more numerous.

The *ſplintery* diſcovers ſcales ariſing from ſplits or fiſſures parallel to the line of fracture, which are thicker at the end at which they ſtill adhere than at the end at which they are ſeparate; and conſequently are opake at the thick, but ſomewhat tranſparent at the other end, elſe their ſeparation would ſcarcely be perceived: theſe ſplinters are either *coarſe* or *fine*, ſometimes ſo minute as to be ſcarcely diſcernible. From the ſize of theſe ſplinters minerals are denominated coarſe or fine grained.

The *earthy fracture* is that which preſents ſmall rough prominences, as dry clay: it is however diſtinguiſhed into *coarſe* and *fine*. It is commonly deſtitute of luſtre and tranſparency.

The *hackly* preſents ſharp points, eaſily perceived in feeling it.

Of the Fibrous Fracture.

This preſents either lines or threads, ſome ſo fine as to be ſcarcely perceptible, and ſome groſſer or coarſer. Theſe are *ſtraight* or *curved*, *parallel* or *diverging*, or *ſtellated*, that is, diverging like the rays of a ſtar from one common center, or *bundled* together, or *interlaced*.

Of the Striated Fracture.

The ſtriated fracture conſiſts of long narrow ſeparable parts, laid *on* or *beſide* each other; they have proportionably more length than breadth, and are thicker at one end than at the other; however they frequently differ in breadth, and hence they are divided into *fine*, or *narrow*, or *broad*. Their direction is alſo either *ſtraight* or *curved*, *parallel* or *diverging*, or *ſtellated*, or *bundled*, or *interlaced*.

Of the Foliated Fracture.

This diſcovers plates nearly as broad as long, with poliſhed ſhining ſurfaces, and commonly even ſpecular; ſome have large, ſome exceeding minute *facettes*, ſome *ſtraight*, ſome *curved*, ſome *undulating* or *wavy*, ſome *parallel*, ſome *diverging*: when ſmall and irregularly placed, they are often called ſcales. Minerals that conſiſt of grains, and are at the ſame time foliated, are called *granu-*

larly foliated. When the lamellæ abound in cracks, I call that fracture the *ſhattered foliated.*

Of the Slaty Fracture.

This Mr. Werner has not explained. It ſeems to differ from the foliated in this, that the laminæ are larger, thicker, and have not a poliſhed, or at leaſt not a ſpecular, ſurface.

The imperfectly ſlaty is often called *ſhiſtoſe.*

We may alſo diſtinguiſh the *thick*, *thin* or fine ſlaty, and alſo the *curved* and undulating.

Shape and Sharpneſs of the Fragments.

When a foſſil is broken into fragments, the ſhape of theſe is moſt frequently *indeterminate*, but ſometimes *cubical*, *rhomboidal*, or *pyramidal*, or *trapezoidal*, although theſe forms are often diſguiſed; alſo the *long ſplintery*, the *broad ſplintery*, and the *tabular* which conſiſts of plates that grow thinner and ſharp at the extremities, are obſervable.

When, in the ſequel, the form of the fragments is not mentioned, it is to be underſtood that it is *indeterminate*.

The ſharpneſs of the fragments muſt alſo be noticed; 4 denotes the ſharpeſt, as thoſe of glaſs; 3, ſharp, but in a leſſer degree; 2, rather ſharp; 1, rather blunt; 0, perfectly blunt.

Diſtinct Concretions.

Theſe are diſcovered by their diſtinct and ſeparate poſition in the internal ſtructure of a mineral, or by the intervention of a delicate rift or fiſſure; they are of three ſorts, the *granular*, *lamellar*, and *columnar*.

The granular have nearly an equal breadth and thickneſs, and appear rather rounded; they are either *groſs*, *coarſe*, *ſmall*, *fine*, *angular*, &c.

The lamellar are thoſe whoſe length and breadth are conſiderable in reſpect to their thickneſs; they are *thick* or *thin*, ſpherically convex, &c.

The columnar are thoſe whoſe length much exceeds their breadth and thickneſs, which are nearly equal.

Coheſion.

Under this head, the firmneſs, hardneſs, and impenetrability of minerals are noted; thoſe that ſtrongly reſiſt fracture are *firm*; thoſe that a blow ſhivers into many pieces are called *brittle*.

Of hardneſs Mr. Werner diſtinguiſhes many degrees: 1° he calls thoſe minerals *hard* that give fire with ſteel, and among theſe he diſtinguiſhes thoſe that *yield to the file*, as the white copper ore, hæmatites, &c.; thoſe that yield but ſlightly, as flints, cryſtal, calcedony, &c.; thoſe that *do not yield at all*, as diamonds, rubies, emeralds.

2° he denominates thoſe *half hard* that do not give fire with ſteel, and are difficultly ſcraped by

a knife,

a knife, as fluors, zeolytes, calcareous ſpars, baſalts, &c.

3° he calls *tender* or ſoft, thoſe that may eaſily be ſcraped by a knife, but not by the nail, as baroſelenite, mica, ſerpentines, &c.

4° he calls *very ſoft or tender*, thoſe that may be ſcraped by the nail, as ſteatites, gypſum, talc, &c.

I diſtinguiſh the various degrees of hardneſs by figures.

3. denotes the hardneſs of chalk.

4. a ſuperior hardneſs, but yet what yields to the nail.

5. that which will not yield to the nail, but eaſily and without grittineſs to the knife.

6. that which yields more difficultly to the knife.

7. that which ſcarcely yields to the knife.

8. that which cannot be ſcraped by a knife, but does not give fire with ſteel.

9. that which gives a few feeble ſparks with ſteel, as baſalt.

10. that which gives plentiful lively ſparks, as flint.

The ſuperior degrees are diſcovered by obſerving the order in which ſtones cut each other. Under this head alſo, *flexibility* and *elaſticity* may be noticed.

Denſity.

This is found by taking the ſpecific gravity of ſtones, &c. in diſtilled water at the temperature of from 59° to 64° Fahr.

As the temperature of 62°, the true temperature for taking ſpecific gravities, does not always prevail, the ſpecific gravity of a ſolid being found at any other temperature between 45° and 75° Fahr. may be found by the following table, ſuch as it would be if examined when both it and the water were at 62°.

Tempe-rature.	Specific gravity of Water
45	10008
50	10007
53,6	10005
55	10004
57	10003
59	10002
60,5	10001
62	10000
64	9998
66	9997
68	9995
69	9994
70	9993
71	9992
72	9991
73	9989
74	9988
75	9987

Then as the ſpecific gravity of water at 62° is to its ſpec. gr. at *n* degrees between 45° and 75° incluſively ::, ſo is the ſpec. grav. of any ſolid *found at n* degrees to that which it would be found to poſſeſs at 62°.

Again, as diſtilled water cannot always be procured, it is proper to know what the ſpec. grav. found in common or pump water would amount to, if inſtead of pump water diſtilled water had been uſed. This may be diſcovered in the following manner: ſuppoſing you have ſome particular ſolid, whoſe loſs of weight in diſtilled water of the temperature of 62° is known, but if the temp. 62° does not then prevail, firſt find what the loſs of weight of the ſolid would be in diſtilled water of the given temperature by the annexed table, and this analogy.

As the ſpec. grav. of diſtilled water at 62° is to its ſpec. grav. at *n* degrees, ſo is the loſs which a ſolid ſuffers in it at 62° to the loſs which it ſuffers in it at *n* degrees. By this means you find the loſs that particular ſolid would ſuffer at *n* degrees, the given temperature, in diſtilled water;

this ſolid therefore ſhould make a part of the mineralogical *ſupellex*.

Then knowing the loſs of *this* ſolid in diſtilled water at the given temperature, and alſo its loſs in pump water at the ſame degree, and, dividing the latter by the former, you have the ſpec. grav. of the pump water at the ſame degree.

2dly. The ſpecific gravity of *pump* or other water being thus had, you may find what ſpecific gravity the ſolids under examination would have in diſtilled water in the ſame temperature as that of the pump water in which their ſpecific gravity is ſuppoſed to have been already obtained; by this analogy, as the ſpec. grav. of diſtilled water at the given temperature is to that of pump, water at the ſame temperature, ſo is the loſs of the ſolid examined in pump water to the loſs it would experience in diſtilled water: then dividing the weight in air by this loſs, the ſpec. grav. it would have in diſtilled water at this temperature is obtained; after which the ſpec. grav. it would have at 62° is found by the firſt analogy.

Mr. Briſſon has determined with much accuracy the ſpec. grav. of a great variety of minerals, but unfortunately he was ill informed of the true denomination of many of thoſe ſubſtances, and neglected deſcribing them, which renders his work in many caſes of little uſe. He tells us in his preface, that he took them at 14° of Reaumur, but does not ſay whether he employed the true thermometer of Reaumur, or that improved by himſelf. I ſuppoſe, however, he meant the latter, as it is employed in the meteorological obſervations of Paris ſince the year 1761; in that caſe his 14° anſwer very nearly to 61° Fahr. In the following work the ſpecific

ſpecific gravities of many minerals are given that were never before examined, as well as of a great number that had been examined, but not in all their varieties.

Mr. Werner, though he recommends an accurate determination when it can be obtained, divides in general all minerals into 1° *ſupernatant*, that is, that float on water. 2° *light*, viz. thoſe whoſe ſpec. grav. extends from 1, to 2,000. 3° *not remarkably heavy*, whoſe ſpec. grav. extends from 2,000 to 4,000. 4° *heavy*, whoſe ſpec. grav. extends from 4, to 6,000; and 5° *very heavy*, whoſe ſpec. grav. exceeds 6,000. This groſs determination may be learned by long experience of weighing them in the hand.

The moſt convenient inſtrument for taking ſpec. gravities is that invented by Mr. Nicholſon, of which a deſcription may be ſeen in vol. II. of the Memoirs of Mancheſter, or Mr. Magellan's improved edition of Cronſtedt.

When the ſpec. grav. of any ſtone is much inferior to that of the ſpecies to which it otherwiſe ſeems to belong, it were proper to reduce it to powder, and take its ſpec. grav. in that ſtate alſo.

ADHESION to the *tongue* and *fingers*, COLOUR of a *ſtreak*, DIFFUSION in *water*, are eaſily underſtood.

As to the FEEL, we may diſtinguiſh thoſe that are *rough*, *ſmooth*, or *greaſy*.

The SMELL may be *ſulphureous*, *bituminous*, *urinous*, or *earthy*.

The TASTE *aſtringent*, *ſaline*, &c.

As to the REFRIGERATING POWER, that is, of impreſſing a ſenſation of cold when felt, though in general it is too vague to deſerve notice, yet in ſome particular inſtances it may be uſeful to obſerve

obſerve that in the ſame temperature precious ſtones feel colder than the artificial or falſe gems, or other ſtones of the ſiliceous claſs; and theſe, than ſtones of the argillaceous or calcareous; and marble, than alabaſters or gypſums; and traps or baſalts, than ſerpentines.

Of the internal Properties of Minerals.

Of this ſort are 1° their magnetic and electric properties.

2°. *Their relation to acids.* Their ſolubility therein, either partial or total, when entire or in powder, with or without heat, efferveſcence, change of colour, gelatination, &c.

3°. *Their relation to fire*; and 1°, *in low heats*, their decrepitation, diſcolouration, induration, loſs of weight, phoſphoreſcence, &c.; 2°, *in high heats*, the calcination, infuſibility or fuſibility, at different degrees meaſured by Mr. Wedgwood's Pyrometer, an inſtrument of indiſpenſable utility in mineralogical reſearches; its ſcale commences at the heat at which iron is viſibly red in the day time, that is, at about 1077 Fahr. and extends to 170° of his ſcale, and perhaps farther: each degree of Wedgwood is equal to 130 Fahr. above 1077. An idea of the heats it meaſures may be had by the following table:

Braſs melts at	21°
Swediſh Copper	27
Fine ſilver	28
Fine gold	32
Leaſt welding heat of iron	90
Greateſt of ditto	95
Greateſt of a common ſmith's forge	125
Heat of copper and braſs founderies	140

Caſt iron melts	- -	130
Heat of iron founderies	-	150
Greateſt heat of a good wind furnace		160

By the help of a large bellows, loaded with 130 lb. wt. I raiſed in my forge a heat of 168° in leſs than half an hour.

Of FUSIBILITY, there are various degrees approaching more or leſs to vitrification.

The firſt or loweſt degree is *emolleſcence*, or that degree of ſoftneſs which alters the ſhape of the body; or, if the ſubſtance be in powder, produces *agglutination*. Opake bodies by this heat become often ſlightly tranſparent at the edges.

The ſecond *degree* is the *porcelain* ſtate. In this ſome points are vitrified, but the greater number are not, and conſequently the grain can be diſtinctly perceived; this alſo has its degrees. Some porcelains are deſtitute of luſtre, and ſome have a ſlight glazing; on theſe laſt the fire has had a greater effect. Some porcelains are porous, and ſome compact.

The third is that in which the granular appearance is deſtroyed, but no tranſparency induced. Bodies in this ſtate, if they are metallic and compact, are called *ſlaggs*, if porous *ſcoriæ*, if they have a vitreous gloſs, *enamels*.

The 4th is that in which the ſubſtances acquire a ſemitranſparency. And

The 5th, that in which they become completely tranſparent. Both enamels and vitrifications are ſometimes compact, ſometimes porous. Some ſubſtances are incapable of becoming either tranſparent or ſemitranſparent.

The moſt commodious furnace for examining the effect of high heats on minerals is a forge furniſhed

furniſhed with a large bellows, loaded if neceſſary. The length of time which wind furnaces require to produce their full effect is the cauſe that the ſubſtances frequently melt by being long in contact with the clay of the crucibles, whereas a forge may be brought to its full heat in leſs than an hour; and after the firſt experiment, which heats the hearth, in leſs than half an hour; and does not give time to the minerals under examination to act on the crucibles, as I have learned from repeated experience. Swanſey coal I find the beſt. I call thoſe bodies

Very eaſily fuſible that melt at between 30° and 40° of Wedgwood; and

Eaſily fuſible thoſe that melt between 100° and 125°.

Moderately fuſible when they melt between 125° and 135°.

Difficultly fuſible when they require a heat of from 135° to 150°.

Very difficultly fuſible when a heat from 150° to 165° is neceſſary for their fuſion.

If platina crucibles be uſed they ſhould be coated.

Mineral alkali, borax, and microcoſmic ſalt, deprived of the water of cryſtallization, are the fluxes generally uſed. I ſeldom uſe any.

The heat of the blow-pipe rarely extends to 125°, and never exceeds 130° of Wedgwood.

The laſt of the internal characters of mineral bodies is determined by the products or rather educts of their analyſis, of which I ſhall treat more amply in the ſequel.

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SECTION IV.

An Idea of the Claſſification of Earths and Stones.

ON the moſt general view of an indiſcriminate heap of earths and ſtones, we may readily perceive that ſome have an HOMOGENEOUS aſpect; none of the parts of which their volume conſiſts bearing the appearance of being compoſed differently one from the other.

Others on the contrary viſibly involve two or more heterogeneous ſubſtances, either adhering to, or inhering one in the other: theſe are called AGGREGATES.

Laſtly, others ſeem to participate of the nature of two (or perhaps more) heterogeneous foſſils, without however any viſible ſeparation of one from the other: theſe I call DERIVATIVES.

Thus we have three primary diviſions of earths or ſtones.

In reducing each of theſe into minuter diviſions, we naturally begin with the homogeneous as the moſt ſimple.

The CLASSIFICATION of earths and ſtones conſiſts in their arrangement in a certain order relatively to each other.

ORDER, when not arbitrary, neceſſarily ſuppoſes both *diſtinction* and *reſemblance*. Without *diſtinction* all the bodies to be arranged would be equally entitled to the ſame place in the ſeries. Without *reſemblance* no reaſon could be aſſigned why a body ſhould occupy one particular place rather than another place, there being no relation to connect it with the preceding.

Hence it follows, that thoſe bodies which reſemble each other moſt, ſhould be grouped together; and, conſequently, that there ſhould be as many heads of general diviſion as there are general grounds of reſemblance.

If it be aſked whence this reſemblance ſhould be taken; whether from the external or internal characters? I anſwer, it ſhould be taken from both, it being the reſult of the joint conſideration of both.

Now upon examining the *totality* of homogeneous earths and ſtones, it will be found that thoſe reſemble each other moſt that contain the largeſt proportion of the ſame *ſimple* earth, or moſt of the characterizing properties of the ſame ſimple earth; and, as there are *nine* ſimple earths, it follows that there muſt be *nine genera*, or primary diviſions of homogeneous earths and ſtones.

In the ſame manner, under each head or *genus*, we may conſider thoſe ſubſtances as *ſpecifically* different that reſemble each other leaſt, or that differ in ſome important property relatively to human uſes; for ſyſtems being fabricated to help the memory, by pointing out the moſt important diſtinctions, and none being more ſo than thoſe that are applicable to human uſes, ſhould never loſe ſight of their primary end and deſignation. I am well aware that ſome very eminent mineralogiſts would wiſh to reſerve diſtinctions relative to practical utility, for a branch of mineralogical knowledge, which they intitle ŒCONOMICAL MINERALOGY; and when theſe diſtinctions are not of conſiderable importance, and would introduce

duce confuſion, I think they may be reſerved for a ſeparate work of that nature; but when they do not claſh with other natural diviſions, I would not heſitate to place them in the ſame rank; and in effect theſe ſame mineralogiſts allow potters earth, fullers earth, tripoli, &c. a place in what they eſteem the natural ſyſtem.

Hence 1°. The generic earths, combined with an acid, are ſpecifically different from thoſe that are not.

2°. The ſame generic earth, combined with different acids, forms different ſpecies.

3°. The ſame generic earth, combined with a *notable* proportion of one or more of the other earths, forms a different ſpecies from the ſame generic earth, either uncombined or combined with a leſs *important* proportion of other earths. I call a proportion *notable* or *important* when it introduces a conſiderable alteration in the external or internal characters of the compound. Thus ſuch a proportion as induces a conſiderable change in the ſpecific gravity, or in the fuſibility of any ſubſtance, is notable or important; ſo in the calcareous genus ſuch a proportion of foreign earth, or earths as would prevent it from burning to lime, is certainly of importance, and the diſtinction grounded in nature: ſo proportions that alter the fuſibility of ſubſtances, with reſpect to the degree at which they are fuſible, are certainly notable, and a good foundation for ſpecific diſtinctions.

But varieties of proportion, or even of ingredients, that produce no notable change, either in the internal or external properties of a compound, make no alteration in the ſpecies; and in fact there are ſcarcely any earths or ſtones that have,

have, ſtrictly ſpeaking, the ſame proportion of ingredients. Traps or baſalts, and zeolytes, vary conſiderably.

4°. Any earth which forms leſs than $\frac{1}{20}$ of a compound is almoſt always of little importance.

5°. Water forms an important part of any compound when it exceeds $\frac{1}{25}$ of the whole.

6°. Calces of iron influence in ſome meaſure the properties of a compound when they exceed $\frac{1}{33}$ of the whole. If they are themſelves magnetic, they communicate that property to compounds of which they form above $\frac{1}{10}$.

Species are further diviſible from ſome particular points of agreement into *families*, or *claſſes* and families; ſometimes it is neceſſary to form diſtinctions where ſpecific characters are not decided; in which caſe I diſtribute the claſſes into *tribes* and families, as will be ſeen in the ſequel. The minuter diverſifications are called *varieties*. The term *ſpecimen* correſponds with that of *individual* in the animal kingdom.

SECTION V.

Experiments on the fuſible and infuſible Proportions of Simple Earths.

As the fuſibility of ſimple earths when mixed together in certain proportions, while thoſe earths ſingly taken are infuſible, forms one of the moſt ſurpriſing phænomena in natural philoſophy, and one of the moſt important grounds of ſpecific diſtinction among earths and ſtones in mineralogy, I have taken the pains of aſcertaining, with more accuracy than has already been practiſed, the proportions and degrees of heat at which it takes place (many of which had never before been tried), and alſo the fuſibility of mixtures in which an earth is introduced that never before had been eſſayed. Theſe experiments are alſo productive of two capital advantages: 1. They lead to the knowledge of the compoſition of ſome minerals, of whoſe analyſis we are as yet ignorant; and, 2dly, they ſerve as a teſt of the analyſis already made; for it is plain, that analyſes that aſſign a *fuſible proportion* of ingredients to an infuſible ſtone or earth, or an *infuſible proportion* to one that is fuſible, muſt be erroneous.

To promote theſe purpoſes as far as poſſible, it is neceſſary to introduce and ſet forth not only my own experiments, but all thoſe of my predeceſſors in this enquiry, in which the proportions were aſcertained with due accuracy, and the ingredients ſufficiently pure. The experiments of Kenkel, who firſt remarked this phænomenon, do not appear. Mr. Pott made numerous and important experiments with compound ſtones and earths, but ſcarcely any on mixtures of the ſimple earths. M. D'Arcet and Macquer alſo ſcarcely ever employed any but compound ſubſtances. Mr. Achard ſeems only to have undertaken preciſely the ſame taſk as I have; however, many of his experiments are liable to objections, which I ſhall preſently mention.

Mr. Lavoiſier has alſo examined, with the moſt ſcrupulous accuracy, the fuſibility of moſt minerals in the heat excited in burning charcoal by pure air, inſtead of common atmoſpheric air, and alſo the fuſibility of a few mixtures of ſome of the ſimple earths: this heat is ſo powerful as to prevent all difference in the degrees of fuſibility from being perceived; in ſo much, that, from the fuſibility experienced in this mode of applying heat, it does not at all follow that the ſame ſubſtances or proportions would be fuſed in the higheſt heat of our furnaces. But we may well draw this negative concluſion, that ſubſtances or proportions, which do not melt in the heat excited by pure air, are certainly infuſible in the heat of our furnaces.

The experiments of Mr. Achard are made on mixtures in various proportions of calcareous, muriatic, argillaceous, and ſiliceous earths, taken two and two, three and three, and in ſome caſes four and four.

To obtain the calcareous earth uncontaminated with any other, he diſſolved chalk in the marine acid,

acid, diſtilled the ſolution to dryneſs, kept the reſiduum in red heat under a muffle for two hours, by which means the marine acid was expelled from every earth contained in the chalk, except the calcareous; this, by the affuſion of water, he rediſſolved, and precipitated it by ſalt of tartar *; hence we ſee it was mild calcareous earth, and not lime, that he uſed in his experiments. Magneſia he procured from a purified ſolution of Epſom ſalt; and argill from a purified ſolution of alum, both by precipitation with a fixed alkali; the earth of alum, however, obtained by this means, always retains a portion of the alkali.

To procure pure ſiliceous earth, he melted the white ſand of Freyenwalde with four times its weight of ſalt of tartar, and formed a *liquor ſilicum*, which he precipitated by vitriolic acid; the precipitate, after edulcoration, he digeſted in marine acid, until nothing more was diſſolved; the reſiduum was pure ſiliceous earth.

The calx of iron he obtained by ſolution in nitrous acid, and precipitation by a fixed alkali; hence it was perfectly calcined.

Theſe earths, mixed in the different proportions that will preſently be mentioned, he expoſed to the ſtrongeſt heat of the royal porcelain furnace in Berlin, and left them in it as long as was neceſſary to bake the porcelain †.

What the heat of this furnace was cannot be directly aſcertained, but may be collected from various circumſtances. 1°. Mr. D'Arcet aſſures us, that the heat of a porcelain furnace exceeds

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* Mem. Berl. 1779.

† Mem. Berl. 1780 64.

even that produced in the focus of the beſt burning glaſſes: this, however, is not credible. Mr. Wedgewood, an irrefragable witneſs in matters of this nature, tells us that common Chineſe porcelain ſoftens at 120°, and ſinks down at 156° of his pyrometer. It muſt therefore be baked in a much lower heat. Nankeen indeed even reſiſts this heat, but it ſeems the only ſort that does; yet a good wind furnace affords a heat of at leaſt 160°, much ſuperior conſequently to the higheſt porcelain heat. But, 2dly, Mr. Klaproth informs us, that the heat of the royal porcelain furnace of Berlin is capable of reducing manganeſe to a regulus, and therefore it muſt be at the leaſt equal to 150° *, that being the heat neceſſary to melt down iron. Nevertheleſs, it may be doubted whether this furnace always produces this heat, as Mr. Achard aſſures us that he found a mixture of ſilex and calcareous earth infuſible in all proportions †; and yet I found a mixture of equal parts of both fuſible at 150°, and ſo did Swab, 2 Mem. Sued. p. 443; though poſſibly his failure in this inſtance might have proceeded from his having uſed mild calx, whereas Swab and I have uſed lime, and this appears to me moſt probable.

But the great defect of this mode of eſſaying the fuſibility of earths ariſes from the well grounded ſuſpicion that their fuſion is frequently procured by their action on the matter of the crucible, which furniſhes them both with the argill and the ſilex, and conſequently forms a mixture very different from that whoſe fuſibility

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* Chym. Ann. 1789. 11.

† Mem. Berl. 1780. 32.

is intended to be explored. That the fuſion of ſeveral earths and mixtures, eſſayed both by Mr. Achard and Mr. D'Arcet, aroſe from this cauſe, can ſcarcely be doubted. Mr. Achard found a mixture of two parts calcareous earths and one part magneſia vitrifiable*, yet Mr. Lavoiſier, who tried their fuſibility in a much higher heat, found them perfectly infuſible in every proportion †, and I found a mixture of thoſe ſubſtances, in the proportion mentioned by Mr. Achard, to paſs through the crucible. The length of time, during which they are expoſed to heat, neceſſarily renders them liable to this accident, which is avoided by the briſk and ſudden mode of heating them which takes place in a forge. Yet it muſt be allowed that action on the crucible can only take place where calx, or magneſia, or barytes, are employed, either alone or with a ſmall proportion of argill and ſilex; and conſequently the fuſibility obſerved by Mr. Achard in other caſes is above ſuſpicion.

In my experiments the lime was formed of the pureſt Carrara marble. The magneſia was Henry's calcined, whoſe purity I never had cauſe to ſuſpect. The ſilex was pure tranſparent cryſtal, heated to redneſs, quenched in diſtilled water, and then reduced to impalpable powder in a glaſs mortar, which it did not corrode. The barytes was the natural mild barytes. Of the calces of iron, I employed two ſorts; one thoroughly calcined by ſolution in the nitrous acid, and expulſion of the acid in a red heat; the other common ruſt, from which much of its water and

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* Mem. Berl. 1780. 65.

† Mem. Paris 1783. 595. and 599.

fixed air had been expelled by heating it to redneſs. The heat was communicated in a forge, and never laſted above three quarters of an hour, and moſt commonly but twenty or twenty-five minutes. The reſults and the degree of heat will be ſeen in the following tables. To eſtimate the heat, I placed one of Mr. Wedgewood's pyrometers in a crucible nearly of the ſame ſize as that which contained the ſubſtances to be tried, and ſet both at an equal diſtance from the nozzle of the bellows.

To avoid prolixity, I ſuppreſs Mr. Achard's experiments when made on the ſame mixtures, and attended with the ſame reſults; when they are mentioned, they are marked [*A*].

TABLES

Of the Fuſibility of the Simple Earths mixed in various Proportions, in Heats not exceeding 166° of Wedgewood.

CALX and MAGNESIA.	Heat.	1°. Of Binary Proportions.
50 parts calx 50 magneſia	150°	melted, only where in contact with the crucible, into a grey, partly vitrified and partly porcelain maſs. Per Lavoiſier alſo they melt in no proportion; and alſo Bergm. 372.
80 calx 20 magneſia	150	went through the crucible.
75 calx 25 magneſia	160	went through the crucible.
66 calx 33 magneſia		went through the crucible.
80 magneſia 20 calx	165	did not melt but where in contact with the crucible, which it ſlightly corroded and blackened.
66 magneſia 33 calx	138	did not melt but where it touched the crucible.
30 calx 10 magneſia	156	melted into a fine greeniſh yellow glaſs, but the crucible was corroded throughout.
CALX and BARYTES		infuſible in all proportions per Lavoiſier.
CALX and ARGILL. 88 calx 12 argill		infuſible even by the heat of pure air. Ehrm. § 208.

CALX and ARGILL.	Heat.	Of Binary Proportions.
75 calx 25 argill	150	not melted, except where in contact with the crucible it formed a compact porcelain browniſh red maſs.
66 calx 33 argill	150	remained a powder.
		Hence the contrary reſults obtained by Achard ſeem to proceed from the action of the mixtures on the ſilex of the crucible. Mr. Bergman alſo found calx and argill infuſible in all proportions. 4 Berg. 337, and Macquer. Mem. Paris, 1758, 356 in 8vo.
66 argill 33 calx		melt by pure air. Ehrm. § 208. infuſible, per Achard, Mem. Berl. 1780. 65.
75 argill 25 calx		melt by pure air, ibid; infuſible per Achard, ibid.
80 argill 20 calx		melt by pure air, ibid; infuſible, Achard, ibid.
50 calx 50 argill		infuſible, Achard, loc. cit. and formed only a looſe powder in this as in the former caſes.

CALX and SILEX.		
50 calx 50 ſilex	150	melted into a maſs between porcelain and an enamel; white, glazed on the ſurface, ſemitranſparent at the edges, and gave fire with ſteel, though feebly. Yet Mr. Achard found them infuſible in every proportion, perhaps becauſe his calx was mild.
50 calcareous ſpar 50 quartz		melted by pure air, Lavoiſier; but by continued heat became leſs fuſible.
80 ſilex 20 calx	156	not melted, formed a brittle maſs.
80 calx 20 ſilex	156	formed a yellowiſh white looſe powder.

	Heat.	Of Binary Proportions.
Barytes and Magnesia		do not melt in any proportion even by pure air.
Barytes and Argill.		
80 argill 20 barytes	150	ſcarcely hardened.
75 argill 25 barytes	156	no ſign of fuſion, a looſe powder.
66 argill 33 barytes	152	as the former.
50 argill 50 barytes	150	as the former.
80 barytes 20 argill	148	ſomewhat harder, but no ſign of fuſion.
75 barytes 25 argill	150	harder, but no ſign of fuſion.
Barytes and Silex.		
80 ſilex 20 barytes	155	formed a white brittle maſs.
75 ſilex 20 barytes	150	a brittle hard maſs ſemitranſparent at the edges.
66 ſilex 33 barytes	150	melted into a hard ſomewhat porous porcelain maſs.
50 ſilex 50 barytes	148	a hard maſs not melted.
80 barytes 20 ſilex	148	the edges were melted into a pale greeniſh maſs, between a porcelain and an enamel.
75 barytes 25 ſilex	150	melted into a ſomewhat porous porcelain maſs.
66 barytes 33 ſilex	150	melted into a yellowiſh and partly greeniſh white porous porcelain.
Magnesia and Argill	150	theſe were not tried by Mr. Achard: in my trials they had no action on each other in whatever proportion they were uſed.

MAGNESIA

	Heat.	Of Binary Proportions.
MAGNESIA and SILEX.		
50 magneſia 50 ſilex		melt with great difficulty even in the heat of pure air. Mem. Par. 1787, p. 598, into a white enamel; but in inferior heats they are infuſible in all proportions by the experiments of Achard, Mem. Berl. 1780, 33, and Margr. 1778, 4, and 1 Bergm. 372.
ARGILL and SILEX.		
50 argill 50 ſilex	160	barely hardened, but no ſign of fuſion. Mr. Lavoiſier found a mixture of equal parts quartz and argill vitrifiable by pure air. But this experiment is ſuſpicious, as the quartz he uſed was more fuſible than pure cryſtal, and conſequently impure. In a porcelain heat Mr. Achard found them infuſible in all proportions; and Bergm. 337.
IRON highly calcined and CALCAREOUS EARTH.		According to Mr. Achard's experiments, they melt at leaſt into a porcelain maſs, in every proportion, not exceeding 4 parts of the one to 1 of the other; but thoſe mixtures, in which the calces of iron exceed the calcareous earth, are by far the moſt fuſible.
IRON fully calcined and MAGNESIA.		
A 80 magneſia 20 calx iron		infuſible, Achard, Mem. Berl. 1779, 53.
75 magneſia 25 calx of iron	155	remained a browniſh black powder. Mr. Achard had the ſame reſult.
A 66 magneſia 33 calx of iron		remained a brown maſs.

CALX of IRON and MAGNESIA.	Heat.	Of Binary Proportion.
A { 50 magneſia 50 calx of iron }		hardened, but did not melt.
A { 80 calx of iron 20 magneſia }		melted, and paſſed through the crucible.
A { 75 calx of iron 25 magneſia }		half melted.
A { 66 calx of iron 33 magneſia }		half melted.
IRON fully calcined and BARYTES.		
80 barytes 20 calx of iron	155	melted into a partly browniſh and partly reddiſh ſhining ſlagg.
75 barytes 25 calx of iron	150	melted into a black bright foliated ſubſtance, reſembling horneblende or an iron ore.
66 barytes 33 calx of iron	150	melted into a hard black compact maſs, partly of a metallic and partly of a glaſſy appearance.
75 calx of iron 25 barytes	156	melted into a compact metallic ſlagg.
66 calx of iron 33 barytes	150	melted into a browniſh black ſlagg, rather compact; much of the barytes ſeemed to have ſublimed, as the cover and upper part of the crucible received a beautiful metallic white glaze
IRON fully calcined and ARGILL.		
80 argill 20 calx of iron	160	remained a powder. Mr. Achard had the ſame reſult.
75 argill 25 calx of iron	160	remained a powder. Mr Achard found it ſomewhat more inclined to melt.
66 argill 33 calx of iron	166	a pale reddiſh powder. Mr. Achard found it more inclined to melt.
50 argill 50 calx of iron	160	a yellowiſh-red powder. Mr. Achard found it more inclined to melt, and greyiſh black.

Iron fully calcined and **Argill.**	Heat	Of Binary Proportions.
80 calx of iron 20 argill	160	melted into an opake porous black ſlagg. Mr. Achard alſo found a black porous maſs which pierced through the crucible.
75 calx of iron 25 argill		this experiment failed with me. Mr. Achard found a porous melted maſs.
66 calx of iron 33 argill		this alſo failed with me. Mr. Achard found a porous melted maſs; but the crucible was much corroded.
Iron fully calcined and **Silex.**		
A 80 ſilex 20 calx of iron		ſeemingly melted, black and friable; yet I believe it was not melted, otherwiſe the next mixtures muſt have been ſo.
A 75 ſilex 25 calx of iron		not melted, black and friable.
A 66 ſilex 33 calx of iron		not melted, black and friable.
A 50 ſilex 50 calx of iron		ſlagg.
A 80 calx of iron 20 ſilex		melted into a porous ſlagg that pierced the crucible.
A 75 calx of iron 25 ſilex		melted, and pierced through the crucible.
A 66 calx of iron 33 ſilex		melted, and pierced through the crucible. Hence we ſee that the compounds of ſilex and calx of iron, in which the iron exceeds, act on argill.
Ruſt of **Iron** and **Lime.**		
90 lime 10 ruſt	125	a broad hard maſs, began to act on the crucible.
80 lime 20 ruſt	125	a hard brown maſs.
	150	a liver-brown porcelain maſs.

	Heat.	Of Binary Proportions.
Ruſt of **Iron** and Argill.		
50 argill 50 ruſt	156	formed a greeniſh black looſe powder.
Ruſt of **Iron** and **Silex.**		
90 ſilex 10 ruſt	150	a yellowiſh brown indurated brittle maſs.
80 ſilex 20 ruſt	125	not melted, but formed a brown hard maſs.
75 ſilex 25 ruſt	150	a brown hardened powder.
66 ſilex 33 ruſt	150	a blackiſh brown indurated powder.
Argill and **Metallic Iron.**		
50 argill 50 metallic iron	160	melted into a hard greyiſh black maſs; but other proportions, in which the argill exceeded, I found infuſible at 160.

Ternary Proportions, the firſt in greateſt quantity.

Calx, *Magneſia*, and *Argill*.

A	3 parts calx 3 argill 1 magneſia	porous porcelain maſs.
A	3 calx 2 argill 1 magneſia	powder.
A	3 calx 1 argill 1 magneſia	powder.
A	3 calx 3 argill 2 magneſia	ſomewhat porous porcelain.

A	3 calx 2 argill 2 magneſia	powder.
A	3 calx 3 magneſia 2 argill	powder.
A	3 calx 2 magneſia 1 argill	vitrified.

Magneſia, Calx, and *Argill.*

No compound, in which the Magneſia exceeds the other two ingredients, is fuſible.

Argill, Calx, and *Magneſia.*

A	3 argill 2 calx 1 magneſia	a porcelain.
A	3 argill 2 magneſia 1 calx	a porcelain.
A	3 argill 3 magneſia 1 calx	porous porcelain.
A	3 argill 3 magneſia 2 calx	porous porcelain.
A	3 argill 2 calx 2 magneſia	porcelain.

Calx, *Magneſia*, and *Silex*.

A	3 calx 3 ſilex 1 magneſia	powder.
A	3 calx 1 ſilex 1 magneſia	green glaſs.
A	3 calx 2 ſilex 1 magneſia	green glaſs.
A	3 calx 3 ſilex 2 magneſia	porcelain or enamel.
A	3 calx 2 magneſia 1 ſilex	porous enamel.
A	3 calx 2 magneſia 2 ſilex	porcelain.
A	3 calx 3 magneſia 1 ſilex	between a porcelain and an enamel.
A	3 calx 3 magneſia 2 ſilex	an enamel, texture ſtriated.
A	2 calx 2 magneſia 1 ſilex	powder.
A	1 calx 1 magneſia 1 ſilex	greeniſh glaſs.
A	2 calx 2 ſilex 1 magneſia	opaleſcent glaſs.
A	2 calx 1 ſilex 1 magneſia	greeniſh glaſs.

Magneſia, *Calx*, and *Silex.*

No Compound, in which the Magneſia predominates, melts; but, when it barely equals either, it may form a Porcelain.

Silex, *Calx*, and *Magneſia.*

A	3 ſilex 1 calx 1 magneſia	powder.
A	3 ſilex 2 calx 1 magneſia	porous porcelain.
A	3 ſilex 2 magneſia 1 calx	powder.
A	3 ſilex 2 calx 2 magneſia	powder.
A	3 ſilex 3 magneſia 1 calx	powder.
A	3 ſilex 3 magneſia 2 calx	harder powder.
A	2 ſilex 1 calx 1 magneſia	enamel.
A	2 ſilex 2 magneſia 1 calx	hard powder.

Magneſia, *Argill*, and *Silex*.

1. No compounds, in which magneſia predominates, will vitrify or form a porcelain.

2. A compound, in which it equals each of the other two, will not form even a porcelain. Per Achard.

Argill, *Magneſia*, and *Silex*.

A	3 argill 3 ſilex 1 magneſia	porcelain.
A	3 argill 1 ſilex 1 magneſia	powder.
A	3 argill 2 ſilex 1 magneſia	hardened only.
A	3 argill 3 ſilex 2 magneſia	porcelain.
A	3 argill 2 magneſia 1 ſilex	hardened only.
A	3 argill 2 ſilex 2 magneſia	porous porcelain.
A	3 argill 3 magneſia 1 ſilex	powder.
A	3 argill 3 magneſia 2 ſilex	porcelain.
A	2 argill 2 magneſia 1 ſilex	hardened only.

Silex, *Magneſia*, and *Argill*.

A	3 ſilex 1 argill 1 magneſia	ſlightly porcelain.
A	3 ſilex 2 argill 1 magneſia	hardened only.
A	3 ſilex 2 magneſia 1 argill	greeniſh glaſs.
A	3 ſilex 2 argill 2 magneſia	hardened only: yet, quere; for, afterwards, he allows it to have melted to a porcelain. See Berl. Mem. 1780, pp. 38, 39.
A	3 ſilex 3 magneſia 1 argill	porcelain.
A	2 ſilex 2 argill 1 magneſia	nearly porcelain.
A	2 ſilex 1 argill 1 magneſia	porcelain.

Calx, *Argill*, and *Silex*.

A	3 calx 3 argill 1 ſilex	green glaſs.
A	3 calx 1 argill 1 ſilex	green glaſs.
A	3 calx 2 argill 1 ſilex	friable maſs.
A	3 calx 3 argill 2 ſilex	porous enamel.

A	3 calx 2 ſilex 1 argill	greeniſh glaſs.
A	3 calx 2 argill 2 ſilex	between a porcelain and an enamel.
A	3 calx 3 ſilex 1 argill	greeniſh glaſs.
A	3 calx 3 ſilex 2 argill	greeniſh glaſs, nearly white.
A	2 calx 2 argill 1 ſilex	hardened only.
A	2 calx 1 argill 1 ſilex	greeniſh porcelain.
A	2 calx 2 ſilex 1 argill	greeniſh porcelain.

Argill, Calx, and *Silex.*

A	3 argill 1 calx 1 ſilex	very hard only.
A	3 argill 2 calx 1 ſilex	friable maſs.
A	3 argill 2 ſilex 1 calx	porous porcelain.
A	3 argill 2 calx 2 ſilex	ſemitranſparent, half vitrified.
A	3 argill 3 ſilex 1 calx	reddiſh porcelain.

A	3 argill 3 ſilex 2 calx	yellow, and ſemitranſparent.
A	2 argill 1 ſilex 1 calx	friable maſs.
A	2 argill 2 ſilex 1 calx	greeniſh porcelain.

Silex, *Argill*, and *Calx*.

A	3 ſilex 3 calx 1 argill	greeniſh white glaſs.
A	3 ſilex 3 argill 2 calx	yellow enamel.
A	2 ſilex 1 argill 1 calx	greeniſh porcelain.
	71 ſilex 24 argill 5 calx	at 145° it barely hardened. at 153 it formed a porous porcelain, glazed only at the ſurface.
	63 ſilex 32 argill 5 calx	at 145 barely hardened. at 153 a ſomewhat porous porcelain.
	67 ſilex 23 argill 10 calx	at 145 melted into a porous frothy enamel, ſemitranſparent.
	60 ſilex 30 argill 10 calx	at 135 formed a frothy ſemitranſparent enamel.
	57 ſilex 38 argill 5 calx	at 135 formed a porous porcelain.
	54 ſilex 36 argill 10 calx	at 135 a frothy ſemitranſparent enamel.

Miſcellaneous Experiments.

40 argill 25 ſilex 20 aërated calx 1,3 highly calcined iron	barely coaleſced at 144° into a grey maſs, glazed on the ſurface. *Same mixture*, with the ſubſtitution of 13 calx of iron, inſtead of 1,3, which is the *hyacinth of Bergman*, melted at 144° into a reddiſh porous ſlagg.
46 argill 39 ſilex 8 aërated calx 6 highly calcined iron	*Saxon topaz* of Bergman, melted at 144 into a greyiſh ſlightly porous porcelain maſs.
41 argill 34 ſilex 20 ruſt of iron	*ſhorl* of Wiegleb melted at 148 into a porous black ſlagg, with a ſtrong metallic appearance. *D°*, with *highly calcined iron*, formed a greeniſh black porous ſlagg, ill melted.
46,66 ſilex 48,5 magneſia 4,75 ruſt of iron	*aſbeſtos* of Wiegleb, a reddiſh yellow, ſomewhat indurated, powder, except where it touched the crucible, which it corroded at 148.
43 ſilex 22 magneſia 34 ruſt of iron	the *actinolite*, or *Strahl ſtein*, of Wiegleb, melted into a greyiſh black, ſomewhat porous and fibrous, maſs, perfectly opake, at 148.
67 ſilex 14 argill 11 barytes 8 magneſia	*felſpar*, by my analyſis, melted at 148 into a white porous enamel.
65 ſilex 32 argill 2 calx of iron	*felſpar* of Wiegleb refuſed to melt even at 158, and barely hardened.
43 ſilex 37 argill 1,7 calx 4 calx of iron	*felſpar* of Sauſſure refuſed to melt at 140, formed a hard porous maſs.

37 ſilex 22 argill 16 magneſia 23 ruſt of iron 2 calx	*hornblende*, by my analyſis, melted into a black compact glaſs at 156°.
41 ſilex 16 calx 17,5 magneſia 17,5 calx of iron	*hornblende* of Wiegleb melted at 137° into a greeniſh black glaſs.

Corollaries.

Hence it follows, 1, that all binary combinations of the five earths are infuſible, and in every proportion, under 166°, except two: 1ſt, *Calx* and *Silex*, in equal parts, and in a heat not under 150°, and in that only into an enamel; and, 2dly, *ſilex* and *barytes*: Theſe appear to act on each other in a heat not below 150°, where the ſilex is to the barytes in the proportion of 3 to 1, or 2 to 1, or the barytes to the ſilex in the proportion of 4 to 3, or 2 to 1, but ſcarcely when they were in equal quantities.

2. With reſpect to calces of iron and the 5 ſimple earths, we may obſerve, firſt, that where the lime *exceeds the calx of iron* even in the proportion of 9 to 1, it is ſo far affected by it as to be converted into a porcelain in a heat of 150°, and then begins to act on the argill or ſilex of the crucible. When the lime is in the proportion of 4 to 3, or 2 to 1, the compound is yet more fuſible, but ſtill only into a porcelain: yet Mr. Achard found it to cryſtallize, which argues a farther degree of fuſion.

But if the calces of iron exceed the lime in the proportion of 4 to 3, or 2 to 1, the compounds are ſtill more fuſible, and paſs through the

the crucible, which ſhews they have a ſtrong action on the argill or ſilex, or both.

2dly. With regard to *barytes* and *calces of iron,* I found them to act on each other much more powerfully than lime and calces of iron: at 150°, they melt in every proportion from 4 to 1 of either. Other proportions have not been tried.

3dly. As to *magneſia* and *calces of iron*, Mr. Achard found that, where the magneſia exceeds the calx of iron, they have no action on each other, at leaſt at 150°, nor even when they are in equal quantities: but, when the calces of iron exceed the magneſia as 4 to 1, they melt perfectly; when only as 3 to 1, they melt leſs perfectly; and when as 2 to 1, ſtill leſs perfectly.

4thly. With reſpect to *argill* and *calces of iron*, in my own experiments, when the argill exceeded the calces of iron, I obſerved no tendency to fuſion even in heats from 160° to 166°, nor even when they were in equal proportions; but, when the calces of iron exceeded the argill in the proportion of 4 to 3, or 2 to 1, the compound was fuſible apparently in the ſame proportion, that is, moſt when 4 to 1, &c.; when I uſed ruſt, i. e. ſemicalcined iron, the compound was greeniſh. The heats from 156° to 160°.

5thly. As to *ſilex* and *calces of iron*, it appears, that they are infuſible when the ſilex exceeds; but if the calces exceed, the compound will be fuſible.

Of Ternary Combinations.

Calx, *Magneſia*, and *Argill*, at 150°.

1. No compound of theſe, in which magneſia predominates, will melt in any degree in a heat below 166°.

2. No compound of theſe, in which calx predominates, will vitrify, except they lie in the proportion of 3 calx, 2 magneſia, and 1 argill. Proportions approaching to this may give porcelains or enamels.

3. Proportions, in which the argill equals either, and exceeds the other as 3 to 1, may form porcelains at 150°.

Calx, *Magneſia*, and *Silex*, at 150°.

1. If the calx exceeds, theſe may afford ſeveral fuſible compounds.

2. If the magneſia exceeds, they will afford no fuſible compound.

3. If the ſilex exceeds, they afford few fuſible compounds.

Argill, *Magneſia*, and *Silex*, at 150°.

1. If the argill exceeds, nothing more than a porcelain can be produced.

2. If the magneſia exceeds, not even an imperfect fuſion can be had.

3. If the ſilex exceeds, a porcelain may be produced in ſeveral inſtances, and a glaſs in one, namely, when they are in the proportion of 3 ſilex, 2 magneſia, and 1 argill.

Argill, Calx, and *Silex.*

1. If the calx exceeds, either a glaſs, a porcelain, or an infuſible maſs, may ariſe, according to the proportion.

2. If the argill exceeds, a porcelain may in many caſes be obtained, but not a glaſs.

3. But if the ſilex exceeds, a porcelain or enamel is frequently obtainable, probably alſo a glaſs, for the heats I tried were not very high.

Of Calces of Iron.

Compounds, that owe their fuſibility to calces of iron, have always the appearance of a ſlagg.

SECTION VI.

Calcareous Genus.

Under this head I comprehend all thoſe earths and ſtones, apparently homogeneous, in which calcareous earth predominates.

1ſt Species.

Native Lime.

Whether this really exiſts has been much queſtioned; its exiſtence, however, is not naturally improbable, ſince ſeveral ſtones contain uncombined calx, as appears by various analyſes; and that lime once formed may remain a long time uncombined, even though expoſed to the atmoſphere, is evident from common experience. I have found lime in lime kilns, of which a great part remained unſaturated four years after it was burned; but ſeveral reſpectable teſtimonies eſtabliſh its real exiſtence. Dr. Woodward tells us, that a whitiſh gritty earth, found at Clipſton ſtone pit in Northamptonſhire, was found by Dr. Moreton to contain lime, and make a cement, by barely mixing it with water. Dr. Falconer of Bath, a man of unqueſtionable ſkill and judgement in matters of this nature, informs us, that he obſerved a ſoft whitiſh ſtone in the neighbourhood of that town, containing a quantity of uncombined calcareous earth, and capable of diſſolving ſulphur. According to Mr. Monnet, it is found in great quantity on the mountains of Upper Auvergne that form the valley of Vic; it is there of a yellowiſh colour, being mixed with calx of iron. He thinks it of volcanic origin *; it is eaſily diſcovered by the taſte, or ſolution in water and precipitation by the ſolution of corroſive ſublimate in the form of a reddiſh powder.

2nd Species.

Combined with fixed air, aërated or mild calx.

Carbonate de Chaux.

This ſpecies preſents ſuch varieties both in colour, form, texture, and other external characters, and is liable to ſuch numerous and important contaminations from other ſubſtances, that it is exceeding difficult, if not impoſſible, to eſtabliſh ſuch lines of ſeparation between the different diſtinctions that preciſion requires, as ſhall not in ſome inſtances be confounded, and include thoſe that were meant to be excluded. The diſtinctions I introduce are therefore not always abſolutely exact, but thoſe that upon the whole appear to me the cleareſt and moſt important.

All the ſubſtances included under this head efferveſce with acids, and do not include above 12 or 15 per cent. of foreign combinations.

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* Woodward's Catal. 7. 1 Falconer on Bath Waters, 156, 257. Monnet, Mineralog. 515.

1ſt Claſs.

Mild calx in a looſe or ſemi-indurated form.

1ſt Family.

Agaric mineral, bergmilch or bergmehl of the Germans.

1ſt variety. *Duſty*; bergmilch of Werner: its colour is white red, or yellow formed of compacted particles, but exceeding friable, and hence duſty: feels dry, does not adhere to the tongue, and ſo light as nearly to float on water: gives no gloſs to the ſkin.

2d variety. *Somewhat unctuous*; white, formed of ſcaly particles, adheres to the tongue, very friable, feels ſomewhat greaſy, and gives a gloſs to the ſkin when rubbed on it, falls to duſt in water, entirely ſoluble in nitrous acid, almoſt floats on water. *Lazius Hartz*, 228.

Both theſe varieties are found in the clefts of rocks, or at the bottom of ſome lakes.

3d variety. *Silvery chalk*. Of this I find ſome, but an imperfect, account in Crell's Annals for 1790. Its colour is ſilvery white, and in its ſtructure it reſembles mica; it feels ſoft and ſomewhat unctuous like talc, it is almoſt entirely ſoluble in nitrous acid, and the ſolution has all the properties of a ſolution of calcareous earth; it ſcarcely differs, as it ſeems, from the foregoing.

2nd Family.

2nd Family.

Chalk.

White, or yellowiſh white.

Luſtre 0.

Tranſparency 0.

Fracture earthy.

Fragments 0.

Hardneſs 3. 4.

Spec. grav. of a ſpecimen that did not moulder in water in 24 hours 2.315. Dr. Watſon found that of coarſe hard chalk 2,657.

Adheres ſlightly to the tongue.

Feels dry, and ſomewhat rough.

Stains the fingers and marks.

It ſlowly falls to pieces in water, and thence into powder, but ſome moulder very readily.

I found common chalk to loſe 3 per cent. of of its weight in a heat of 500 Fahr. and by ſolution in acids 0,42; the reſiduum, which is chiefly argillaceous, dried in the ſame heat, weighed about 2, ſometimes 3 per cent. 100 parts chalk therefore contain about ,95 of mild calx, 2 of argill, and 3 of water; or 53 mere calcareous earth, 42 of fixed air, 2 of argill, and 3 of water.

Chalk in general is infuſible even by the heat of pure air; but that of Boulogne (frequently mentioned by French writers) is fuſible. Ehrm. § 209; therefore not ſo pure as that found in other places.

Mr. Rinman, Hiſt. Ferri. § 201, mentions a blue chalk found in the neighbourhood of Upſal; it contains iron.

According

According to Mr. Lavoiſier *, 100 parts chalk contain 52,603 of pure lime, 31,949 of fixed air, and 15,402 of water; but this large proportion of water is barely inferred from the quantity abſorbed and retained by quick lime in a heat of 600° Fahr. and which he ſuppoſes muſt alſo be contained in chalk, a ſuppoſition that ſeems to me inadmiſſible, as lime certainly has a ſtronger affinity to water, and retains more of it than aërated calx has, or can retain. Beſides, by his own firſt experiment, 1404 grains of chalk loſe by ſolution in nitrous acid 576 grains, that is, at the rate of 41.025 per ct. which is farther confirmed by the quantity of air given out in that experiment, viz. 800 French cubic inches in the temperature of between 16° or 17° of Reaumur, barometer at 28 French inches nearly. Now by his own rules of reduction, 800 cubic inches, at the temperature of 16°, 5 Reaumur, would make but 775,24 cubic inches at 10° of Reaumur, and theſe would weigh by his rule of eſtimation 552, 88 grains, which amounts to 39,47 per ct.

3d Family.

Arenaceous limeſtone. *Ganil.*

This is ſo called from its brittleneſs, and not from its containing ſand.

The colour of the ſpecimens I have ſeen was yellowiſh white.

Luſtre 1, from a few ſhining particles.

Tranſparency 1.

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* 1 Lavoiſier, 201.

In the lump it cannot be broken but by a hammer, but ſmall pieces of it fritter between the fingers.

Its ſpecific gravity 2,742. It phoſphoreſces when ſcraped with a knife in the dark, but not by laying on a hot iron.

It contains 47 per ct. of fixed air, and is almoſt intirely ſoluble in nitrous acid. It was found on the ſhores of Rhaghery, a ſmall iſland of the coaſt of Antrim, by my ingenious friend Dr. Hamilton; its name in the Iriſh language purports limeſtone in the form of ſand. Another ſpecimen, exactly reſembling it, was found at Codrilla, on the Weſt ſide of Veſuvius, and preſented to me by that very accurate obſerver the Rev. Mr. Graydon. It has alſo been diſcovered on the ſummit of Mount Gothard in Swiſſerland: this laſt phoſphoreſces when laid on burning coals, yet contains no acid but fixed air. 2 Chy. Ann. 1790, 132.

I have met with another ſpecimen of this ſtone, which exactly reſembles that which I have deſcribed, except that its ſpecific gravity is but 2,691, and that it has not the phoſphoreſcing quality. It contains but 42 per ct. of fixed air. Does not the phoſphoreſcing property, therefore, originate from the large proportion of this air?

4th Family.

Teſtaceous Tufa. *See Leſke*, § 527, 562, 571.

1ſt variety. White or yellowiſh white, exceeding porous and brittle, formed of various broken ſhells compacted together, found in the neighbourhood of Syracuſe, Palermo, and the promontory of Paſſoro in Sicily. *Borch Lithologie des Siciliens*, 287.

2d variety. *Marly Tufa.* This is alſo yellowiſh white, reſembling mortar, and frequently contains ſmall ſhells, deſtitute of luſtre and tranſparency, and very porous; its fracture earthy, its hardneſs from 6 to 8. See the ſpecimen, *Leſke*, § 571.

3d variety. *Stalactitic Tufa.* This conſiſts of whitiſh grey fiſtulous concretions variouſly ramified or compacted together, or of browniſh grey concretions reſembling moſs; both exceeding light and brittle, devoid of luſtre and tranſparency; their fracture earthy hardneſs, from 6 to 7.

Second Claſs.

INDURATED.

1ſt Family.

Compact Limeſtone.

This term is here taken in a technical ſenſe to expreſs a particular fracture already explained.

Its colour is uſually grey, blended with various ſhades of other colours, as dark or light grey, bluiſh grey, yellowiſh grey, pearl grey, blackiſh grey, leſs commonly greyiſh white, Iſabella yellow or ochre yellow, or fleſh or browniſh red, or greeniſh grey, or greyiſh black; often with

with many of theſe colours together in blotches, veins, ſtripes, or ſpecks.

It frequently abounds with impreſſions or petrifactions of muſcles, ſnails, corals, pectinites, gryphites, mytulites, &c.

Its luſtre 0, or barely 1, from a few ſhining particles; its tranſparency 0, rarely 2. Its fracture compact, moſt commonly ſplintery, coarſe or fine, rarely paſſing to the conchoidal; ſometimes uneven, ſometimes earthy, rarely ſlaty.

Its fragments 2.

Its hardneſs from 5 to 8, rarely 9*, except mixed with quartz.

Its ſpec. grav. 1,3864 (before abſorption of water) to 2,72. Thoſe that have their ſpec. gr. below 2,4 are exceeding porous.

Efferveſces with acids, and thus loſes from 0,38 to 0,42 of its weight.

Burns to lime. Dr. Higgins has remarked that limeſtones kept ever ſo long in a red heat loſe only $\frac{1}{4}$ of their weight; in a heat that melts copper they loſe about $\frac{1}{3}$; and in a heat that melts caſt iron, that is, from 120° to 130° Wedgwood, they loſe as much as they can loſe, that is, from 38 to 44 per ct.

All theſe ſtones contain ſome ſlight contamination from other ſtones, argill, or iron, amounting at moſt to about 10 or 12 per ct.; if more than 15 the limeſtone is ſo notably degraded as ſcarcely to afford lime, and ſhould then be excluded from the ſpecies we here conſider; theſe contamina-

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* Mr. Anderſon, in a valuable tract on limeſtones, mentions ſome found in Sunderland, which in external appearance reſemble flints, and give fire with ſteel, yet burn to lime as pure as that of chalk. Eſſays on Agriculture, vol. II. p. 188.

tions are rarely leſs than 2 or 3 per ct. The carbonaceous principle ſhould alſo be reckoned among them; for, as Dr. Higgins obſerves, limeſtones, calcined in veſſels that do not allow a free communication with the air, afford a grey lime from ſome mixture of the coaly principle that remains unconſumed. Hence alſo limeſtones loſe leſs of their weight when diſtilled in a retort than when burned in an open fire.

Variety 1. *Thoſe of ſplintery fracture.* Their colour is generally grey, bluiſh grey, or greyiſh blue; their hardneſs from 7 to 8, and their ſpec. grav. from 2,6 to 2,72.

Of this ſort is the greyiſh blue limeſtone of Dublin; it is perfectly opake; its ſpec. grav. 2,708; it does not imbibe water, at leaſt in 24 hours; it contains 0,41 of fixed air, and 0,03 of a mixture of blue argill and iron; it gives an earthy ſmell when breathed on.

The limeſtone of Paris contains 8 per ct. of argill, quartz, and iron. Dijonval, 142.

Variety 2. *Thoſe of conchoidal fracture.* Theſe are generally Iſabella yellow, or dark blackiſh grey, or yellowiſh or reddiſh brown. Moſt of thoſe I have ſeen are, however, ſo mixed with argill as rather to paſs for marlytes; but, if the fracture be uneven and imperfectly conchoidal, they are purer from argill: the colour of theſe is bluiſh or greyiſh blue black; of this ſort is the ſpecimen, Leſke, O. 1232; ſee alſo N. 1212 and 1220.

Variety 3. *Of an earthy fracture.* Their colour is generally white or light grey, or greyiſh, yellowiſh, or reddiſh white, or reddiſh brown. They are all porous, and ſome exceeding porous, and hence they abſorb from about $\frac{1}{4}$ to $\frac{1}{3}$ of

their

their weight of water; their ſpec. grav. is therefore variable, being different both before and after abſorption, and the difference proportioned to the quantity abſorbed. The lighteſt ſtone of this ſort I have read of has its ſpec. grav. 1,3864, and after abſorption 1,7528: it therefore abſorbed above ¼ of its weight of water. It is dug in the quarry of Bourré near Montrichard, in the neighbourhood of Tours: its colour is white, very ſoft, and fine grained *. The denſity of the heavieſt ſcarcely exceeds 2,55. The hardneſs of theſe ſtones is from 5 to 7.

Portland ſtone, whoſe ſpec. grav. is 2,461, and Bath ſtone, whoſe ſpec. grav. is 2,494, belong to this variety, as does Ketton ſtone, whoſe colour is reddiſh brown, and conſiſts of ſmall rounded particles compacted together like the roe of fiſh: Its ſpec. grav. 2,456. It contains 90 per ct. of mild calx and 10 of argill, with a minute quantity of calx of iron. It ſeems the ſame as the *cenchrites*, 4 Crell Boytr. 432.

Several calcareous depoſitions, ſome even from Carlsbad, belong to this variety; ſome preſent a number of rounded depreſſions in their fracture; thoſe which I have ſeen were either white or brick red.

Compact limeſtones often paſs into marl. See Leſke, G. 734, 735, and S. 1357; but it firſt grows ſlaty.

Variety 4. *Of a ſlaty fracture.* Under this head I comprehend thoſe whoſe ſingle laminæ have a compact fracture, but upon the whole ſlaty. Of this ſort are,

1. The calcareous flagſtones of Woodſtock. Its colour is light bluiſh grey, or yellowiſh, pow-

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* Briſſon, p. 259.

dered over with ſmall reddiſh white round particles of a farinaceous appearance. The laminæ are of about $\frac{1}{10}$ of an inch in thickneſs, and are themſelves of a compact fracture. Its ſpec. gr. from 2,585 to 2,614. It affords about 0,34 grs. of air, which had ſomewhat of an hepatic or putrid ſmell. It contains a mixture of ſilex, argill, and iron; and hence gives fire with ſteel, though with difficulty. Its luſtre 0, tranſparency 0; but its impurities are not ſufficient to render it fuſible, at leaſt at 130°.

2. Limeſtones, of an Iſabella yellow colour, frequently bearing vegetable impreſſions. The laminæ of theſe are frequently from $\frac{1}{4}$ to $\frac{3}{4}$ of an inch in thickneſs, and preſent a ſomewhat conchoidal fracture; that in Leſke, O. 1240, burned to lime at 120°. See alſo G. 354, 355.

3. Limeſtones, of a light bluiſh grey colour, whoſe laminæ preſent a ſplintery fracture, as in Leſke, S. 1357. Theſe paſs into marls for the moſt part.

The yellowiſh grey limeſtone, Leſke, S. 961, is both ſandy and ſlaty.

4. Granular limeſtones are alſo ſometimes ſlaty, but much more rarely. See a ſpecimen of this ſort in Leſke, S. 1326.

2d Family.

Foliated and *granular*. Its moſt uſual colours are white, or light grey, or yellowiſh, greeniſh, or reddiſh white; ſeldomer reddiſh brown, fleſh-coloured, or bluiſh grey, or greyiſh black.

Its luſtre 2,1; tranſparency 2. 1,5, of the darker ſorts 1.

Its fracture foliated, often very ſmall and fine, always ſtraight, ſometimes in the groſs ſlaty.

Its fragments 2.

It preſents granular diſtinct concretions, often ſo ſmall and fine, that the foliated texture is difficultly diſcerned.

Its hardneſs from 7 to 8; its ſpec. grav. from 2,71 to 2,8376; where the denſity is higher, it is impure.

It ſcarcely ever contains petrifactions, or impreſſions of marine exuviæ.

Many of theſe efferveſce very ſlowly with acids, as will be ſeen in the ſequel.

Parian marble is ſaid to be the pureſt ſtone of this family. Its colour is pure white. Its ſpec. grav. according to Briſſon, 2,8376. Carrara marble is next in purity. I found it to contain about 0,45 of fixed air, and 0,03 of argill, with minute quartz cryſtals. Its ſpec. grav. 2,717.

Mr. Cronſted, in the Memoirs of Stockholm for the year 1763, tells us he met in Iemptland a black thin ſlaty limeſtone, of a ſparry texture, which, from its external appearance, would ſcarcely be taken for limeſtone, and yet afforded excellent lime. In ſome places it was dark grey, and undulatingly ſlaty.

Mr. Woulfe preſented me with another of the ſlaty kind from Scotland; its colour dark bluiſh grey; its luſtre 1; tranſparency 1; fracture, thick ſlaty. The laminæ about the thickneſs of an inch; their ſurfaces ſtrewed over with mica. Fracture of the laminæ granularly foliated, yet mixed with the ſplintery. Fragments 3; hardneſs from 8 to 9; ſpec. grav. 2,718.

Some limeſtones are at the ſame time both granular and fine ſplintery, as may be ſeen in the ſpecimen, Leſke, O. 1254, which is of a beautiful bluiſh grey colour; and ſome conchoidal, and exceeding minutely foliated, as the ſpecimen in Leſke, S. 349.

3d Family.

Foliated and ſparry.

Spars*. 1ſt variety. *Common Spar.*

Its moſt uſual colour is white or greyiſh white, alſo yellowiſh or reddiſh white, more rarely olive or leek green, honey or ochre yellow, or fleſh, or browniſh, or purpliſh red; ſtill more rarely brown, or bluiſh grey, or greyiſh black.

It occurs both amorphous, cellular, ſtalactitic, kidneyform, globular, or interſperſed through, or pervading in veins, other mineral ſubſtances, or inveſting them, or filling their cavities; or cryſtallized in various forms; for a minuter deſcription of which we muſt refer to Mr. Rome de Liſle: the moſt general are the rhomboidal, but frequently we find them cryſtallized in hexagonal priſms, terminated by a pyramid often at one end, rarely at both, and ſometimes at neither. The angles of the pyramid never correſpond with thoſe of the priſm, which diſtinguiſhes them from quartzy cryſtals: the pyramids ſometimes reſemble the head of a nail. Very frequently ſpars occur in the form of a dog's tooth, often in that of leaves, &c.

Its luſtre 3,2, never 0 or 1, but when either decompoſing or debaſed by foreign ingredients.

Its tranſparency 2, 3, 4, 1, if of the amorphous kind 2. 1,5. 1.

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* With us the term *ſpar*, without addition, always denotes *calcareous ſpar*.

Its

Its fracture foliated, generally ſtraight, rarely convex or undulated.

Its fragments generally rhomboidal, or tending thereto.

The amorphous generally preſents diſtinct granular concretions, ſeldom lamellar or columnar; ſome ſeem really ſtriated, as in Leſke, O. 1268: the columnar give it a ſtriated appearance, as in Leſke, O. 1428.

Its hardneſs from 5 to 6; ſpec. grav. from 2,693 to 2,718.

By my own experiments, pure ſemitranſparent amorphous ſpar loſes from 43 to 45 per ct. of its weight by ſolution in acids. Mr. Sauſſure, junior*, found ſome rhomboidal ſpars loſe 0,395 by ſolution in nitrous acid; Mr. Bergman only ,34: it is probable he uſed the vitriolic acid to diſſolve it.

White or grey opake ſpars generally contain argill, but certainly not exceeding 12 per ct. for they are all infuſible by pure air. The brown ferruginous ſpars, on the contrary, are all fuſible by the heat produced by that air.

Reddiſh and violet ſpars generally derive their colour from Manganeze. 16 Roz. 15 Laſius, Hartz 327.

2d variety. *Arragon ſpar* †.

White or greeniſh white, and in the middle ſomewhat blue.

Luſtre 2. Tranſparency 2. 1.

It is found cryſtallized in hexangular priſms, whoſe planes are concave.

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* 40 Roz. 165.

† Bergm. I. 1788, 91, 96. 3 Berl. Beob. 364. 1 Chym. An. 1788, 388.

Fracture ſparry; but, as it preſents columnar diſtinct concretions, it appears as if ſtriated.

Hardneſs 6. Spec. grav. 2,778.

Moderately heated, it phoſphoreſces, emitting a red light, and then falls into powder.

It diſſolves ſlowly, but entirely, in nitrous acid, with effervefcence; and contains no fluor acid, as Mr. Klaproth evinced, by diſſolving it in vinegar. It probably contains more fixed air than the former variety, and probably a mixture of ſtronthian.

4th Family. *See Leſke*, O. 1435.

Striated or fibrous. Stalactite, alabaſter, ſinter.

Its colours are grey, white, yellowiſh or greeniſh white, or pale green, or light or cherry red, or reddiſh brown, or bluiſh grey, or ſtriped or veined with theſe colours.

Its forms various, amorphous, or branched, jagged, tubular, globular, &c. the ſurface ſeldom ſmooth.

Its luſtre 1, but ſometimes abounds in ſhining particles, often 0. Its tranſparency 2. 1.

Its fracture ſtriated or fibrous, ſometimes very faintly, the ſtriæ ſeldom parallel, oftener diverging as from a common center, or ſtarry; it frequently diſcovers diſtinct ſtratified concretions of different colours, ſometimes parallel, often curved or angularly undulating, or concentric.

Its hardneſs from 5 to 7. Its ſpec. grav. according to Briſſon, from 2,3259 to 2,876; this laſt undoubtedly from an abundant mixture of metallic

metallic or actinolitic particles; but its moſt uſual relative denſity is from 2,6 to 2,77.

It efferveſces with acids, and burns to lime.

Calcareous ſediments and incruſtations belong to this family chiefly; that of Carlſbad has its ſpec. grav. from 2,63 to 2,690, and contains but little of iron, ſilex, or argill.

A fibrous or ſtriated limeſtone found near the lake Onega, which conſiſts of aſbeſtine or ſhorlaceous particles, interwoven with the calcareous in the proportion of 1 per ct. the hardneſs of the former is 9, of the latter from 7 to 8. It alſo contains 8 per ct. of argill. Act. Petrop. 1782, 270.

Calcareous infiltrations, filling the cavities of other ſtones, are frequently of this family, and have often been miſtaken for zeolytes.

Though moſt ſtalactites have a fibrous fracture, yet there are many whoſe fracture is earthy.

The fibrous limeſtone from Poland, Leſke, O. 1435, is very remarkable, as it much reſembles fibrous gypſum. Its colour is yellowiſh white. Its luſtre 2. Tranſparency 1. Its fracture fibrous, with ſlender acicular ſeparate concretions ſtanding in different directions. Its hardneſs 7. Very brittle. Its ſpec. grav. 2,741. It ſtrongly efferveſces with acids. Feels harſh.

5th Family.

Swine ſtone. Bluiſh or blackiſh or yellowiſh grey, or greyiſh black, or yellowiſh or blackiſh brown, or Iſabella yellow.

Luſtre 1. 0. Tranſparency 0. 1.

Fracture

Fracture various; that of the blackiſh varieties generally fine ſplintery paſſing into the conchoidal; that of the Iſabella yellow fine ſplintery; that of the yellowiſh grey earthy. All commonly ſlaty, and diſcover ſcattered particles of a foliated texture.

Its hardneſs from 6 to 7. Spec. grav. of a ſpecimen of the grey kind, which I tried, and was penetrated with ſpar, was 2,701, of that examined by Briſſon, 2,7121.

Its moſt diſtinguiſhing characteriſtic is an urinous or alliaceous ſmell, which it emits when ſcraped or pounded.

It is generally preſumed to contain ſome bituminous ſubſtance, and with good reaſon; though I could procure none from the ſpecimen I tried by diſtillation, nor any air diſtinct from fixed air; for the whole of the air I procured from it was eaſily abſorbed by lime-water, but of fixed air I found it to contain 0,45.

Swine ſtone, compoſed of laminæ, alternately white and yellow, is found in the vicinity of Veſuvius. Gioeni, 13.

Mr. Bergman informs us, that, in the mountains of Weſt Gothland, this ſtone occurs in great plenty, and is there burned to lime, the expence of fuel being much diminiſhed from the aliment the ſtone itſelf affords when heated to redneſs[*]. This quality is known in many parts of the county of Galway, where this ſtone abounds, but fuel is ſcarce; and hence it is often employed to heat rooms, as it remains hot many hours.

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[*] 5 Berg. 125.

The browner ſorts are I believe moſt frequently marls or marlites.

7th Family.

Oviform. *Erleſenſtein.*

Their colour is generally yellowiſh grey, or brown.

Luſtre 0. Tranſparency 0 or 1.

They conſiſt of a number of globules cloſely compacted together; their hardneſs from 6 to 7.

3d *Species.*

Mild calcareous earth, mixed with a notable proportion of other earths, iron, or manganeſe.

Mixed with barytes or baroſelenite. *Baryto-Calcite.*

Of this ſtone, which I have not ſeen, Mr. Bergman gives the following account *.

Its colour, dark or light grey, almoſt white.

Tranſparency 2.

Form, either that of a wedge, or ſome ſegment of a ſphere, or rounded, or cryſtallized in quadrangular priſms.

Fracture ſtriated, and preſents ſeparate columnar concretions, more or leſs diverging as from a common center.

It contains 92 per ct. of aërated calx, and 8 of aërated barytes.

Spec. grav. not given, but I conjecture it to be nearly 2,78.

It efferveſces with acids.

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* 1 Chy. An. 1734, 388.

4th *Species*.

Mixed with magneſia. *Muricalcite*.

Of this ſpecies, there are two families, neither of which has as yet been accurately deſcribed.

1ſt Family.

In an earthy form.

Of an olive colour. It conſiſts of a large proportion of mild calx, and a ſmaller of magneſia; and, though it has the appearance of a clay, yet contains no argill. 13 Roz. 60, found near Thionville.

2d Family.

In a ſtony form, and amorphous.

A ſtone of this has been miſtaken for the white or ſparry iron ore. It is found near Creutzenwauld, and contains 75 per ct. of aërated calx, 12 of magneſia, and 13 of iron, *per Bayen*, 13 Roz. 59. Mr. Chaptal informs us he has detected ſome proportion of magneſia in many of the limeſtones of Languedoc, 2 Chapt. 65.

3d Family.

Cryſtallized. *Compound ſpar*. *Bitter ſpar* of the Germans.

Greyiſh white, or verging to the dark pearl grey.

It occurs partly ſhapeleſs, partly in blunted fragments, partly cryſtallized in rhomboids, ſmall or middle ſized.

The ſurface of the fragments is longitudinally ſtreaked, that of the cryſtals rough.

External luſtre greaſy, 1. internal, pearly, 3. Tranſparency 3, 4.

Fracture ſtreight, foliated. Fragments rhomboidal.

Preſents groſs-grained diſtinct concretions.

Hardneſs 8, brittle. Spec. grav. 2,480.

It does not efferveſce with acids until it is pulverized, and then but gently, though completely ſoluble therein; if previouſly heated, it will diſſolve more quickly. Heated to redneſs for half an hour, it does not decrepitate, but loſes 45 per ct. of its weight. In a porcelain heat, it vitrifies with the crucible, which it tranſpierces. By Mr. Klaproth's analyſis, it contains 52 per ct. of mild calx, 45 of mild magneſia, and 3 of iron mixed with manganeſe. 5 Berl. Beobacht. 55.

It is found in Tyrol, and generally mixed with chlorite and talc.

5th *Species.*

Mixed with a notable proportion of argill or clay. *Argillo-calcites.*

1ſt Claſs.

Readily diſintegrable by expoſure to the atmoſphere.

Marls,

Marls, or *Calcareous Marls* *.

1ſt Family.

In an earthy or ſemi-indurated form. *Mergel erde* of Werner.

Generally yellowiſh grey, more rarely yellowiſh white.

Luſtre 0. Tranſparency 0.

Surface duſty.

Slightly compacted together, frequently looſe.

Feels dry and rough. Spec. grav. from 1,600 to 2,4.

It ſtrongly effervesces with acids, and, when diſſolved therein, the reſiduum, dried in a heat of 100° Fahr. weighs from $\frac{2}{3}$ to $\frac{4}{5}$ of the whole; that is to ſay, this marl contains from 30 to 80 per ct. of calx.

It is fuſible in a heat of from 130° to 140° of Wedgwood.

In water it ſoon falls into powder, and is not ductile; the compacted part farther moulders by expoſure to the air.

It conſiſts of mild calcareous earth, in the proportion of from 66 to 80 per ct. the remainder clay, with which mica, and other foreign ingredients, and frequently ſhells, are mixed. But clay itſelf contains two ingredients, namely, argill and ſilex; and hence this family divides into two branches;

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* Though there are different diſtinctions of marls, yet by the term *marl*, without farther addition, calcareous marls are underſtood.

branches; the one in which the argill exceeds, or at leaſt amounts to 20 per ct. of the whole reſiduum; the other, in which the ſiliceous ingredient amounts to more than 80 per ct. of the whole reſiduum. This diſtinction, which is of ſome importance in agriculture, cannot be directly made but by means of a chemical analyſis; however, it may be inferred from the property which the reſiduum, after ſolution, has or has not of making a good brick; if it cannot be formed into a brick, then the ſiliceous ingredient exceeds; if it can be made into a brick, and this brick is liable to crack in drying, then the argillaceous ingredient exceeds.

2d Family.

In a ſtony or indurated ſtate. *Verharteter Mergel* of Werner.

Yellowiſh white, or yellowiſh or bluiſh grey, or Iſabella yellow or brown, or reddiſh or yellowiſh brown, or brick red, or fleſh coloured, or greyiſh black.

Surface often duſty.

Luſtre 0. Tranſparency 0.

Fracture earthy, ſometimes inclining to the ſplintery, or conchoidal, frequently ſlaty.

Hardneſs from 5 to 7. Spec. grav. (when it can be taken) from 2,3 to 2,7.

It is fuſible by a heat of 133° into a dark green compact glaſs.

Moſt frequently crumbles ſoon after immerſion in water.

It efferveſces ſtrongly with acids, and by ſolution therein loſes from 0,25 to 0,32 of its weight.

The reſiduum, after ſolution, being well waſhed and dried, weighs from $\frac{2}{3}$ to $\frac{1}{5}$ of the whole.

It conſiſts of mild calx and clay in the ſame proportion as the former variety, and frequently a large proportion of marine ſhells. Moſt marls contain a ſmall proportion of magneſia, and ſome veſtiges of marine acid *; they are liable alſo to various other contaminations.

By expoſure to the air and moiſture, it ſooner or later, generally at fartheſt within a year, chips and falls to pieces. This diſintegration is remarkable, for it does not proceed ſolely from the abſorption of water, and the dilatation and contraction of this abſorbed water, by the varying temperature of the atmoſphere, as it takes place in climates under which this variation is not conſiderable; nor does it proceed from the abſorption of air by *ferruginous* particles it may contain; for marls that contain ſcarcely any iron, or which contain iron in a ſtate that admits of no farther calcination, equally fall to pieces after expoſure to the atmoſphere, and ſo do the ſhells contained in it. I ſuſpect it to proceed partly from the abſorption of moiſture, and partly from the abſorption of air by the carbonic principle of the marine exuviæ, or ſhells found in the marl.

Marls that contain only 66 per ct. of mild calx are frequently burned to obtain lime; this lime takes leſs ſand indeed, but is unfit for conſtructions under water. D. Wettering remarked, that marls, which contain above $\frac{1}{4}$ of their weight of aërated calx, will not form bricks. Dr. Higgins obſerved that mortar, which contained $\frac{1}{8}$ of of its weight of argill, was ſubject to chip by

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* Per Monnet, 4 Roz. 180.

expoſure to the air and moiſture. *On Cements*, 121.

It has, however, been obſerved by Mr. Maquer, that limeſtones, which contain only 0,15 or 0,16 of argill, poſſeſs all the properties of limeſtones; Mem. Par. 1728: yet this muſt be reſtrained to the caſe in which they are not expoſed to an high degree of heat, or he muſt mean *pure argill*; for, if they contained that proportion of *clay*, they would undoubtedly be fuſible.

This *family*, like the foregoing, is diviſible into two branches; the one, in which the argillaceous part of the clay exceeds the ſiliceous; the other, in which the ſiliceous is to the argillaceous in a higher proportion than 4 to 1.

1ſt Branch.

Of this ſort, I do not recollect that any have as yet been analyſed.

2d Branch.

Siliciferous Marls.

Theſe, as before ſaid, poſſeſs the ſame characters as the foregoing, except that they do not harden when calcined; nor does the reſiduum, after ſolution in acids, form a brick. Theſe properties, it muſt be underſtood, are ſuſceptible of various gradations, as the compoſitions neceſſarily vary from each other. Of this ſort, a few are mentioned by Dr. Withering, Phil. Tranſ. 1773.

1. *A browniſh white marl*, reſembling a calcareous incruſtation. It contains 53 per ct. aërated calx; the remainder ſand.

2. *A lead-coloured friable flaky marl*, contained 48 per ct. aërated calx; remainder ſand.

3. *A browniſh-grey marl*, very hard, in irregular lumps, contained 53 per ct. aërated calx; the remainder ſand.

4. *A lead-coloured marl*, in powder or ſmall hard lumps; it contained 66 per ct. aërated calx, with ſand, and a ſmall proportion of argill.

2d Claſs.

Not readily diſintegrable by expoſure to the atmoſphere.

Marlites.

Light or dark grey, or bluiſh or yellowiſh grey, or browniſh red, or fleſh coloured, or greyiſh black.

Luſtre 0, tranſparency 0, when the limeſtone is of the compact kind; but, when it is of the granular, ſome luſtre and tranſparency are perceived, as in the ſpecimen, Leſke, 564.

Fracture moſtly earthy or conchoidal, ſeldom ſplintery, frequently ſlaty, more rarely granularly foliated, ſometimes mixed.

Hardneſs from 4 to 8. Spec. grav. from 2,3 to 2,877.

Efferveſce with acids, though ſometimes ſlowly.

They are not diſintegrated by expoſure to the atmoſphere, at leaſt in 6 years. Hence we ſee they differ but little from marls in their external characters; however, the property of reſiſting the influences of the atmoſphere, at leaſt for a conſiderable time, is too important a ground of diſtinction to be paſſed over.

1ſt Family.

In which, next after the calcareous ingredient, the argillaceous predominates.

Argilliferous Marlites.

1. A dark blue limeſtone, of a conchoidal or ſemilenticular form, opake, dull and ſlaty, hard as 8. Spec. grav. 2,877. It contained 0,50 of mild calcareous earth, 32 argill, 12 ſilex, and 2 of iron.

2. Orbicular maſſes (geods), containing brown or bluiſh grey marl, ſplit into compartments, and interſected with veins of ſpar, called Ludi Helmontii. I cannot, however, ſay that I particularly examined theſe.

3. *Mollaſſe*, a grey or yellowiſh grey ſtone, found in the neighbourhood of Lauſanne, and various parts of France, at leaſt thoſe ſorts of it that, after a length of time, are injured by expoſure to the air, ſeem to belong to this family.

4. Various ſtalactites, ſuch as thoſe conſiſting of hollow cones, including others of the ſame

ſort found in Hælſinburgh, and which, according to Baron Born, are difficultly ſoluble in nitrous acid, and when calcined, and thrown into water, depoſit a conſiderable proportion of argill. 1. Raab. 304.

5. Various red and green marbles, ſuch as the browniſh red marble of Ingermania, variegated with red and green. Its fracture earthy. Its hardneſs from 6 to 7. It abounds in petrifactions, efferveſces weakly with acids, by calcination becomes grey, and affords a bad lime. By Mr. *Georgi's* analyſis, it contains 65 per ct. of aërated calx, 17 of argill, 12 ſilex, 3,5 of ſalited calx, and 2 of iron, Act. Petrop. 1782, 276. It entirely reſembles that of Robock in Kinneculla, which Mr. Bergman tells us is fuſible in a ſtrong heat, and yet affords a weak lime, Mem. Stockh. 1768; and the green Campan of the Pyrenees, which, by Mr. Bayen's analyſis, conſiſts of 0,65 aërated calx, 0,32 argill, and 0,03 of iron ſlightly calcined.

6. Some bluiſh and yellowiſh grey limeſtones of a compact texture, ſuch as that found in the biſhoprick of Fulda, which contains 75 per ct. of mild calx, and 25 of argill. Voight *Fulda*, 15.

7. Various porous limeſtones, which afford a very poor lime, are probably of this family.

8. Mr. Ferber, in Nov. Act. Petrop. 1785, p. 263, mentions a very ſingular foſſil, a marl cryſtallized in an octohedral form, like alum, which contains argill and ſilex; but nothing farther concerning it is as yet known.

2d Family.

In which, next to calx, ſilex predominates.

Siliciferous Marlites.

Of this there are many varieties, ſeveral of which give fire with ſteel at the ſame time that they efferveſce with acids.

1. A browniſh red and white marble of Finland, of micaceous or ſcaly texture, whoſe hardneſs is 9. It contains 74½ per ct. aërated calx, 16 ſilex, 5 argill, 3 magneſia, and 1 of iron. Per *Georgi Act. Petrop.* 1782, 276.

2. A greyiſh blue marble from Pergula, near the lake Onega, of a minute ſcaly texture, yet ſomewhat angular in its fracture. Its hardneſs from 8 to 9. It contains 79 per ct. aërated calx, 18 ſilex, 2,5 argill, and 0,5 iron. *Ibid.*

3. A greyiſh black marble ſpotted with white, from Sardopol, on the lake Onega, of a minute ſcaly texture, with a few micaceous particles. Its hardneſs from 7 to 8. Contains 66 per ct. of aërated calx, 19 ſilex, 10 mica, 4 argill, and 1 of iron. *Ibid.*

4. A fleſh coloured marble, variegated with white, alſo from the lake Onega. Its hardneſs 9. Contains 75 per ct. aërated calx, 16 ſilex, 5 argill, 2 mica, and 2 of iron. *Ibid.*

5. A blackiſh calcareous ſlate, found near Courmayer, in the Alps, is fuſible, and contains 0,615 calx, 0,275 ſilex, 0,06 magneſia, 0,0225 argill, and 0,015 iron. 2 Sauſſ. 298.

6. A blackiſh limeſtone, found in Tauria, exactly reſembling a flint mentioned by Prince Gallitzin in his deſcription of that country, 1 Bergbau, 298; and another reſembling horn ſtone found at Furſtenberg, which with limeſtone contains a quantity of ſand; of which Langer makes mention in his mineral hiſtory of Paderborn, p. 8; and the ſlaty limeſtones found on the Grampians in Scotland, which efferveſce with acids, and give fire with ſteel, 1 Bergb. 399, are of this family.

7. Silicicalcareous freeſtones, which are often porous, and ſerve for filtering ſtones, ſuch as *Pierre de Liais*, which, according to Monnet's Mineralogy, 12, contains 33 per ct. ſilex. Its ſpec. grav. according to Briſſon, is from 2,07 to 2,4.

8. Arenaceous limeſtone, ſuch as that found at Sharzfeld in the Hartz, Laſius, 193. Its ſpec. grav. 2,489.

9. A radiated ſtelliform limeſtone (Sternſpath) found on the Carpathian mountains by Mr. Fichtel. Its colour white and greeniſh. Luſtre ſilky. According to Mr. Bindheim, it contains 0,66 per ct. mild calx, 0,30 ſilex, and 0,03 iron; but he tells us it is fuſible by the blow pipe, which could not happen if it did not contain argill alſo, or the ſiliceous ſtone muſt have been of the fuſible kind, and even ſo it would ſcarcely be fuſible.

10. Mr. Chaptal informs us, that ſome limeſtones in Languedoc contain ſo much ſilex, that when calcined they need only be beaten up with water to make good mortar. 2 Chapt. 34.

3d Claſs.

Argillocalcites, penetrated with bitumen, ſulphur, or pyrites.

1ſt Family.

Bituminous Marlite. Bituminoſer Mergel Schiefer of Werner.

Colour greyiſh or browniſh black. Fracture partly ſtraight, partly curved, or undulatingly ſlaty; the internal ſurfaces of the former rough, of the latter ſmooth. The laminæ either thick or thin. Fragments tabular.

Luſtre of the ſtraight ſlaty 0, of the curved ſlaty 1,2. Tranſparency 0.

Hardneſs 5. Spec. grav. from 2,361 to 2,442.

Feels dry. Often contains copper pyrites.

It efferveſces with acids, even the ſpecimens that have moſt the appearance of coal, as thoſe in Leſke, O. 1538, 1535. The ſpecimen 1537 efferveſces but weakly.

It moſt commonly bears impreſſions of fiſh or marine plants.

It ſeems to be the ſhale bind of 4th Watſon, 344, yet its ſpec. grav. according to him, is 2,681.

This ſtone muſt not be confounded with bituminous ſhale (brand ſchiefer), which it much reſembles; *that* is an argillite, ſcarcely efferveſces with acids; *this*, a calcareous ſtone, ſtrongly efferveſces with acids: its ſpec. grav. at a medium 2,388.

The former is found in coal-mines, the latter is not attached to them, but contains copper ore.

2d Family.

Pyritaceous Limeſtone.

Dark grey, or yellowiſh grey. Luſtre 1, from ſome interpoſed ſhining particles.

Tranſparency 0. Fracture compact, often ſlaty. Hardneſs from 8 to 9, brittle. Spec. grav. 2,703.

Gives a grey powder, is not magnetic.

Soluble in acids, and ſometimes with effervеſcence.

Detonates with nitre.

Calcined with charcoal affords a liver of ſulphur.

Diſtilled, it affords ſome flowers of ſulphur, and volatile vitriolic acid.

By the analyſis of Baron Servieres, it contains 75 per ct. mild calx, and 25 of pyrites, conſiſting of 14 parts argill, 7 quartz and ſulphur, and 4 of iron *.

6th Species.

Argentine. Schiefer ſpath of Werner.

Colour greyiſh, reddiſh, or greeniſh white.

Luſtre, where freſh broken, and in the direction of the lamellæ, 3,2, and of the ſilvery kind, as I think; ſome call it intermediate between that of wax and mother of pearl.

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* 21 Rozier, 394, 22 Roz. 207.

Tranſpa-

Tranſparency 1,0 1,5.

Fracture curved foliated, in the groſs ſlaty. Fragments 2.

Hardneſs 5 to 6. Very brittle. Spec. grav. 2,647. Hath ſomewhat of a greaſy feel.

Efferveſces ſtrongly with acids.

Heated to redneſs, it turns reddiſh brown; by a heat of 155° it is converted partly into a brown porcelain maſs, and partly into a reddiſh brown glaſs, which attacks the crucible.

Its compoſition is not yet known, and I had too little of it to allow a farther examination; but, from its action on the crucible, I think it probably contains magneſia, and a ſmall proportion of argill and calx of iron.

According to Mr. Kärſten, its ſpec. grav. is intermediate between the heavy and not remarkably heavy. Leſke's Catalogue, p. 273. Mr. Hoffman, however, did not find its ſpec. grav. ſo high. That which I examined was taken from the ſpecimen in Leſke, O. 1499.

It has hitherto been found only in Barman's Grün, near Schwartzenberg, and Konſberg, in Saxony, and in the Snara pit, in Norway. The ſilvery chalk, already mentioned, ſeems however nearly related to it.

7th Species.

Combined with manganeſe and iron *.

Sidero Calcite. Braun ſpath of Werner, ſpath perlé of Romé de Liſle.

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* Karſten in Leſke, p. 275. 1 Bergm. I. 1789, 190. 12 An. Chy. 165.

Colour white or greyiſh, yellowiſh or reddiſh white; the red ſometimes riſes to the roſy, ſometimes ſinks to the brown or darker red; the yellow degenerates often into Iſabella or browniſh black. Sometimes many of theſe colours occur together, and frequently preſent an irideſcent or tarniſhed metallic appearance.

It is found amorphous, cellular, rounded, but more generally cryſtallized.

Its external luſtre (when not much decompoſed) is metallic or pearly, 3, 2; its internal, glaſſy, 2 or 1. Tranſparency of the cryſtallized 2, 1, 0, of the others, 0.

When cryſtallized, its forms are various: 1, lenticular; 2, rhomboidal, with plane or convex faces; 3, pyramidal and ſolid, with convex faces, or pyramidal and hollow, all ſmall and low.

Fracture partly ſtraight, partly curved foliated; the fragments of the former tend to the rhomboidal form; of thoſe of the curved foliated, indeterminate.

Hardneſs 8, brittle. Spec. grav. 2,837, per Briſſon; yet that of the ſpecimen, Leſke, O. 1504, had its ſpec. grav. only 2,396. It conſiſts of a groupe of yellowiſh pyramidal cryſtals ſeated on a porous incruſtation, probably of the ſame ſubſtance; that examined by Mr. Briſſon was a ſolid rhomboid.

It efferveſces with acids, ſometimes briſkly, ſometimes very ſlowly *; if the ſtone be white, the nitrous acid leaves on it a yellow ſtain.

It frequently occurs decompoſed by expoſure to the atmoſphere.

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* 1 Bergm. I. 1789, 189. 7 Roz. 224, 226. Phil. Tranſ. 1779, 29. That of Leſke, O. 1504, efferveſces briſkly, though not ſo ſtrongly as calcareous ſpar.

When heated, it decrepitates, and becomes red or brown, and often magnetic. In a ſtrong heat, the white tranſparent cryſtals loſe about 0,455 of their weight; 0,40 being fixed air, and 0,05 water. 40 Roz. 163. For the amorphous ſee the ſpecimen Leſke, S. 178 and 772.

It conſiſts of variable proportions of aërated calx, aërated manganeſe, and iron.

This ſtone hath been ſo long miſtaken by myſelf and others, that a hiſtory of the opinions concerning it may be ſomewhat intereſting.

Romé de Liſle is the firſt who has given any thing like a deſcription of it in the firſt edition of his Cryſtalography, A. D. 1772. He there tells us it conſiſts of a number of cryſtals, or rather rudiments of cryſtals heaped on each other, of a ſilvery white or golden hue, and calls it *pearly ſpar*; but he totally miſtook its nature, for he reckoned it among the fluor ſpars, p. 155.

In the year 1778, Mr. Woulfe read a paper before the Royal Society of London, printed in the Tranſactions of 1779, in which he gives a much fuller account of this ſtone, which he conſiders as a *non-deſcript*. It forms, he tells us, flat rhomboidal cryſtals, and diſcovers great variety of colours, being found either white and ſemitranſparent, or pearl coloured, or reddiſh, or of different ſhades of brown or yellow; ſome of the luſtre of gold, braſs, or copper. Its hardneſs only inferior to quartz or felſpar, and efferveſcing with the three mineral acids. He then proceeds to its analyſis, which, making allowance for the time (manganeſe being then in a great meaſure unknown), has undoubtedly great merit. He diſtinctly proved the exiſtence of calcareous earth, of magneſia, or ſome new ſubſtance with which the

the vitriolic acid afforded white rhomboidal cryſtals of a ſtyptic bitter taſte, and iron; whence he concluded that 180 grs. of this ſpar contains 109 of mild calx, 63 of *magneſia* or ſome new earth, and 8 of iron; or 100 parts of the ſpar contain 60,5 mild calx, 35 of this new earth, and 4,4 of iron.

By this account, I was led to think this ſpar contained magneſia as well as calcareous earth, and hence, in my *former Elements*, I called it *compound ſpar*.

In the mean time, Mr. Romé de Liſle, in the ſecond edition of his Cryſtalography, made a nearer approach to the true nature of this ſtone, though he ſtill miſtook it. He tells us, p. 616, 619, 622, that it frequently paſſes into the ſparry iron ore. This obſervation at once opened to me its true compoſition, for, the agreement of his decompoſition with that of Mr. Woulfe perſuaded me that his *ſpath perlé* was that new ſpar deſcribed and analyſed by Mr. Woulfe, who indeed ſuſpected ſome connection between it and the ſparry iron ore, though a fallacious experiment afterwards induced him to deny that this ore contained calcareous earth; but the experiments of Mr. Bayen and Mr. Bergman prove that point beyond contradiction.

Lately Baron Born, in the catalogue of the foſſils of Miſs Raab, though well aware that the ſpath perlé of Romé de Liſle was the ſame as the *braun ſpath* of the Germans, and that this latter contains manganeſe as well as mild calx, was nevertheleſs perſuaded that the ſtone analyzed by Mr. Woulfe was totally of a different nature, and that it really was compoſed of mild calx and magneſia. To this miſtake I was, I muſt own, in a great meaſure acceſſary, as I did not mention that Mr. Woulfe himſelf ſuſpected that what he called magneſia was not true magneſia, but a new earth. A ſtone, however, of the ſame nature as that which I had wrongfully aſcribed to what I called *compound ſpar*, Baron Born aſſerts, has been found in the valley of Zillerthal in Tyrol, in a ſteatitic rock; the deſcription he gives of it exactly correſponds with that of Mr. Woulfe, except that it neither efferveſces nor diſſolves in acids, both which Mr. Woulfe expreſſly ſays the ſtone deſcribed by him does: the Baron, therefore, in all probability was deceived.

1. From what has been ſaid, it may be inferred that *braun ſpar*, or ſidero-calcite, exhibits in its compoſition various gradations to or from the the ſparry iron ore; like this it ſometimes efferveſces with acids, and ſometimes this efferveſcence is ſcarcely perceptible. *Bayen. Mem. Etrang.* 9, 704. 2 *Bergm.* 198. 2. The proportion of calcareous earth varies conſiderably in this ore, ſo that ſometimes it contains no more than 2 or 3 per ct.; and hence it eſcaped the action of tartar vitriolate in Mr. Woulfe's experiment; for, if ſelenite were formed, yet a few grains of it would remain diſſolved, and afford no precipitate. 3. This ore contains manganeſe, and it is this which, with the vitriolic acid, formed white bitter rhomboidal cryſtals in Mr. Woulfe's experiment; to this the fatiſcence, or effloreſcence, or decompoſition, of the ſidero-calcite is owing. 4. The varying denſity of this ſtone is alſo an evident conſequence of its varying compoſition as well as texture.

8th Species.

Mixed with a notable proportion of iron.

Ferricalcites.

Reddiſh, yellowiſh white, or browniſh yellow, or browniſh red, or dark or yellowiſh brown, or browniſh blue.

Luſtre 0, 1. Tranſparency 0. Fracture generally ſlaty, often granularly foliated.

Hardneſs from 7 to 8. Spec. grav. from 2,8 to 2,9.

Moulders by expoſure to the atmoſphere. Efferveſces with acids.

They contain from 7 to 14 per ct. iron, and moſt frequently a proportion of clay; but, after the calx, iron is the characterizing ingredient; ſome, however, only contain ſo much as to render them capable of decay. Theſe are rifty, and preſent numerous diſtinct concretions. See the ſpecimen in Leſke, S. 530, &c.

1. A brown foliated limeſtone, found near Rabenſtein in the Hartz; it is fuſible per ſe, and conſequently contains clay. Its ſpec. grav. 2,848. *Laſius* 192.

2. A brown iron-ſhot limeſtone, conſiſting of entrochites cemented together by a ferruginous cement. Its ſpec. grav. 2,882. *Ibid.*

3. A bluiſh limeſtone of a ſlaty ſtructure, which acquires a ruſty colour by expoſure to the air, and is fuſible by the blow-pipe. 2 *Sauſſ.* 187.

4. A yellowiſh white limeſtone, of a granular or foliated texture, which becomes brown by expoſure to air. By calcination, it loſes from 20 to 50 per ct. of its weight. It contains about 10 per ct. of iron and manganeſe. Found at Hællefors in Sweden. *Schwed. Abhand.* 1754, 291.

5. A red limeſtone, found alſo at Hællefors, contains 10 per ct. iron. Rinm. § 189.

6. A pale red or yellow limeſtone, found at Rytterſhutten in Sweden. Its hardneſs 9. Spec. grav. 4,988. Does not efferveſce with acids; becomes magnetic after roaſting; and contains, according to Meſſrs. Elyart, about 54 per ct. pure calx, 24 iron, and 22 ſilex. *Schwed. Abhand*, 1784, 121.

7. Greyiſh red compact limeſtones of a porous texture, almoſt paſſing into ſand ſtones, void of luſtre and tranſparency, with an earthy fracture, and reſembling mortar, as in Leſke, S. 132. See alſo *Derivatives*.

9th Species.

Superſaturated with fixed air, and frequently phoſphoreſcent.

Dolomite.

Firſt Family.

Common Dolomite. Dolomie of Sauſſure *.

Pure or greyiſh white, or yellowiſh white, or light red.

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* 40 Roz. 162.

Luſtre 0, 1. Tranſparency 1. Fracture conchoidal or granularly foliated.

Hardneſs from 8 to 9. Spec. grav. from 2,85 to 2,862.

It efferveſces ſlowly with acids unleſs pulverized.

Does not wither by expoſure to the atmoſphere. Phoſphoreſces by colliſion either againſt each other, or on being ſcraped by a knife; but this property is not found in all of them. Duly calcined, it loſes 0,46 or 0,47 of its weight, and is converted into lime *. By the analyſis of Mr. Sauſſure, the younger, 100 parts of it contain 44,29 of calx, 5,86 argill, 1,4 magneſia, 0,074 iron, and 46,1 of fixed air.

Hence we ſee that the lime in this ſtone is united to a much greater proportion of fixed air than in other limeſtones; 100 parts lime in Carrara marble take up 86 of fixed air, but in this ſtone 100 parts lime take up above 100 parts of fixed air. Does not this proceed from its containing an exceſs of the carbonic principle?

Mr. Dolomieu has the merit of having firſt drawn the attention of mineralogiſts to this ſort of limeſtones. Hence Mr. Sauſſure, junior, has diſtinguiſhed it by the name of this juſtly-celebrated Geologiſt. His analyſis is replete with many new and important obſervations.

In 1 Bergm. I, for 1792, p. 218, we find alſo a yellowiſh ſpar mentioned, whoſe form is tabular and expanded, conſiſting partly of granular and partly lamellar diſtinct concretions, which efferveſce very ſlowly with acids. See alſo *Voight*, Mineralogiſch. Abhandl. 54.

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* Roz. 39, 5.

Second

Second Variety.

Elaſtic Marble *.

Colour ſomewhat yellowiſh white. Surface rough and uneven.

Luſtre 1. Tranſparency 1. Fracture verging from the compact to the granularly foliated. Hardneſs from 6 to 7, brittle. Spec. grav. 2,836.

When its length exceeds 10 or 12 times its thickneſs, it is ſlightly flexible and very perceptibly elaſtic.

It phoſphoreſces when ſtruck in the dark, or when laid on red hot iron.

It abſorbs about $\frac{1}{200}$ of its weight of water heated to 70° in $\frac{3}{4}$ of an hour; ſpec. grav. is then 2,850.

It efferveſces and diſſolves in acids ſtill more ſlowly than the former variety.

By the analyſis of Mr. Sauſſure, junior, it contains 0,322 of calx, 0,175 argill and iron, 0,03 mica, 0,0035 magneſia, and 0,4638 fixed air. Note, the iron ſcarcely exceeds $\frac{1}{400}$ of the whole. Here alſo we find the pure calcareous part highly ſuperſaturated with fixed air: for, as 32,2 : 46,38 :: 100 : 144.+

It was firſt obſerved in the Borgheſe palace at Rome, and lately on Mount Gothard in Swiſſerland.

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* 41 Roz. 86, by Mr. Fleuriau de Belvue.

Obſervations.

Any ſtone of a fine grain, conſiderable hardneſs, and which admits of a good poliſh, is in general called marble; but this denomination is now moſtly confined to aërated limeſtones.

White marbles, and tranſparent ſpars, are reckoned the pureſt of the aërated ſpecies, and among the former that of Paros and Carrara; but this laſt we have ſeen to contain a ſlight proportion of argill and mountain cryſtal; and ſome parts of its immenſe beds, I am informed, are remarkably replete with ſiliceous particles. Expoſed to a heat of 700° Fahr. for ſeveral hours, it loſes but $\frac{1}{6000}$ of its weight, therefore contains ſcarcely any water. 41 Roz. 96.

The white marble of Stannovai, near Catharinenburg in Siberia, contains, according to Mr. Georgi, 93 per ct. of mild calx, 6 of ſilex, and 1 of argill. It is the ſame as that brought to Paris by Abbé de la Chappe. Spec. grav. 2,7185, per Briſſon. Abbé Poda is ſaid to have diſcovered in it a portion of aërated barytes. 1 Raab, 287.

Black marble frequently contains iron; in that uſed in Paris, Mr. Bayen detected 5 per ct. of iron; but it derives its colour from bitumen moſt probably, for it affords a white lime, 11 Roz. 496. The ſpec. grav. of fine Italian marble is 2,712.

The Chineſe ſounding ſtone, called Hion Chè, or Calcophonos of Pliny, is of this ſpecies. The Duke de Chaulnes has ſhewn it to conſiſt of calcareous earth, with bitumen and iron. It has much

much the appearance of baſalt, 6 Mem. Chin. Thorough black marble is very ſcarce. Some black marbles will not melt even by the aid of pure air, others will. Ehrm. § 210.

Grey marbles, or limeſtones, appear to be the lighteſt. I found the ſpec. grav. of a grey marble from Saxony only 2,700. It contained 42 per ct. of an ill ſmelling fixed air.

Pale red limeſtones, I believe, are moſtly dolomites. One from Tiwdi in Finland afforded Mr. Georgi 96 per ct. of mild calx, 1 of ſilex, 1 of argill, and 1 of iron. It gave fire with ſteel, efferveſced with acids very ſlowly, and preſented a fracture like quartz. 1 Act Petrop. 1782, 276.

Yellow orange marbles are much lighter; the ſpec. grav. of that of Arragon is 2,678, of old Caſtile 2,691, of that of Loyola 2,709, of that of Lamancha, which ſeems compoſed of minute globules, 2,750, of the yellow marble of Sienna 2,677, *Briſſon.* It was found by Mr. Georgi to contain 93 per ct. of mild calx, 3 ſilex, 2 argill, 1 magneſia, and 1 calx of iron.

GREEN MARBLES are ſaid to be very ſcarce: according to Rinman, § 206, they derive their colour from ſhorl; hence they are generally fuſible, Ehrm. § 210. The ſpec. grav. of green campan is 2,741.

Blue, or deep blue, is certainly the rareſt colour among marbles; that of Carrara, called Bardiglio, has its ſpec. grav. 2,713. The *dove-coloured* or greyiſh blue is very common; that of Goroioctſchit, in the Ouralian ridge of Catharinenburgh, contains by Mr. Georgi's account 86 per ct. mild calx, 4 ſilex, 3 argill, 6 magneſia, and 1 calx of iron.

Violet marbles or limeſtones vary much in denſity; that of the violet marble of Valentia is 2,656, or 2,680; that of Maſſra, near Liſbon, 2,723; that of Rome 2,755.

The variegated marble of Florence owes its dentritical figures to manganeſe. 1 Chy. Ann. 1785, 57.

The marble called *Lumachelli*, found at Bleyberg in Carinthia, owes its ſplendour to ſhells agglutinated by a grey or brown calcareous matter with argill and iron.

Beſides the characters ariſing from texture and colour, there are other diſtinctions ariſing from compoſition, which are of conſiderable importance for œconomical purpoſes; for inſtance, the diſtinction of fat and meagre limeſtones, as the workmen call them.

The *fat*, or thoſe which being converted into lime take up the greateſt quantity of ſand, are much eſteemed by mercenary architects, as ſand is the cheapeſt ingredient.

Meagre lime takes up leſs ſand, yet forms a harder mortar even in water. Mr. Smeaton remarked, that all ſtones which afford a buff-coloured lime are of this ſort. Eddyſtone, § 171. So alſo are thoſe that afford a dark or blackiſh lime, according to Mr. Bergman, who firſt diſcovered that this property proceeded from the manganeſe contained in the lime, 2 Berg. 229. It is however ſaid, that a certain proportion of ſilex and iron pre-exiſting in the ſtone contributes not a little to this property, 2 Sauſſ. 115, 140; and much I believe depends on the ſtate in which the iron exiſts in it, as ſhall be ſeen in treating of Pouzzolana. Of the ſtones in which this property has been principally noticed, authors have

have given but a very imperfect deſcription. I muſt, therefore, repeat it in their own words.

1. The *Stone of Lena* in Upland, mentioned by Mr. Bergman, is grey, mixed with greeniſh white particles, and very hard; generally inveſted with the brown calx of manganeſe. It loſes 0,39 of its weight by calcination, and affords a brown lime. I believe all limeſtones inveſted with a brown cruſt are capable of producing the ſame effect. The preſence of manganeſe is diſcovered by melting theſe ſtones with double their weight of nitre; the manganeſe, if any there be, will leave a green trace on the ſides of the crucible.

2. A dark grey, compact, and exceeding hard ſtone, from Brion in Burgundy, preſenting in its fiſſures ſome brown friable matter. It loſes 0,39 of its weight by calcination. 2 Mem. Dijon, 1783, 93.

3. *A ſky-blue ſtone*, with ſhining particles, found at Aberthaw, in Glamorganſhire, gives a buff-coloured lime, and contains about 12 per ct. of a bluiſh clay, which reddens when calcined.

Meagre lime is reckoned the worſt for manure.

All limeſtones, as we have ſeen, contain fixed air. Fixed air is now known to conſiſt of pure air and charcoal, or the carbonaceous principle, moſt probably in the proportion of 72 of the former to 28 of the latter; but limeſtones are as antient as the creation; therefore, ſince they always contained fixed air, charcoal muſt alſo have been an original principle, and being ſo, it moſt probably enters into many compoſitions in which it has not been hitherto ſuſpected. Over and above that, combined with pure air, it certainly exiſts in ſhells with which compact limeſtones abound, and I believe in all limeſtones of the darker colours. It is certain that all theſe ſtones emit a bituminous ſmell by friction, and many of them contain other traces of bitumen; now bitumen eſſentially contains the carbonaceous principle; hence we ſee that lime, formed in cloſe veſſels, is never perfectly white, for the coaly principle remains unconſumed, that is, uncombined with pure air, with which in cloſe veſſels it cannot come in contact. Is it not from coal thus exiſting in lime that the mephitic air proceeds, which Dr. Prieſtley obſerved to ſucceed the production of fixed air? for charcoal is known to abſorb and retain mephitic air. 6 Pr. 226. Hence alſo Dr. Higgins found that $\frac{1}{38}$ part of the air yielded by limeſtones is mephitic air. *On Cements*, 8.

10*th Species.*

Combined with the vitriolic acid.

Gypſum. Selenite.

It is ſoluble in the temperature of 60° in about 500 times its weight of water; but to effect this ſolution in a moderate ſpace of time, it is requiſite that the gypſum be preſented in the ſtate of fine powder, otherwiſe it will be very ſlowly effected; but in boiling water much more of it may be diſſolved, which will precipitate on cooling ſo that no more than $\frac{1}{500}$ or $\frac{1}{450}$ will remain in ſolution The calcareous earth is precipitable therefrom by cauſtic fixed alkalis, but not by the cauſtic volatile; and the filtered ſolution affords tartar vitriolate, or Glauber's ſalt.

When pure, it does not efferveſce with any acid, and is ſcarcely ſoluble in any of them, except the concentrated vitriolic, which, when heated, and particularly when boiling, takes a large proportion of it*. Per Morveau, 18 Roz. 302.

Artificial gypſum, ſo far dried as to retain its glaſſy appearance, contains 34 per ct. of mere calx, 48 of the ſtrongeſt vitriolic acid, and 18 of water. Mr. Lavoiſier found 9 parts natural gypſum to afford by diſtillation 2 of water †, which agrees very nearly with my determination of that contained in the artificial: but ſome ſorts of gypſum contain a mixture of mild calx, which is foreign to their conſtitution, and therefore efferveſce with acids. This ſort of gypſum ſeems to have been formed by precipitation from ſome other acids, and its proportion of ingredients is different from that found in the former, as I have elſewhere ſhewn. Moſt gypſums alſo contain about 2 per ct. of iron, and ſeveral, more; beſides a ſmall proportion of ſilex and argill.

The eaſieſt method of decompoſing gypſum is to boil it in a ſolution of mild alkali.

In a clay crucible gypſum melts at about 130° Wedgewood, but it is infuſible on coal or in chalk crucibles. By a blow-pipe it may be reduced to a globular form, if the blue flame plays on the edges of the lamellæ, becauſe the acid is

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* Yet Beaumé ſays that dilute vitriolic acid diſſolves $\frac{1}{13}$ of its weight of gypſum, 1 Beaumé, 273; and that dilute nitrous acid, and marine acid alſo, and vinegar diſſolve it as water.

† Mem. Scav. Etrang.

then converted into ſulphur. Maquer found the pureſt gypſum invitrifiable by ſolar heat; that of Monmartre ſeemed to yield, but probably was not pure. Even the heat excited by pure air, if continued long enough to diſſipate the acid, cannot vitrify it; and as the experiments on its fuſion, by Mr. Lavoiſier and Ehrman, were made on gypſum lying on charcoal, it is probable its fuſibility even then proceeded from the converſion of the acid into ſulphur; yet Geier aſſerts it is fuſible by pure air when held in a tongs.

When powdered and heated a little below ignition, it undergoes a motion ſimilar to that of ebullition from the eruption of the water of cryſtallization; if taken up as ſoon as this motion ceaſes, and then ſprinkled over with water, it ſoon concretes and hardens by re-aſſuming and cryſtallizing with the water it had loſt.

Its hardneſs is from 4 to 5, and its ſpec. grav. according to Briſſon, from 2,167 to 2,311; if higher, it is impure: but he ſeems not to have ſeen a lighter ſort, which is called alabaſter, whoſe ſpec. grav. by the trials of the Philoſophical Society of Oxford, and of Mr. Ward, is 1,872. Mr. Briſſon applies the term alabaſter only to certain calcareous ſpars, following Mr. D'Aubanton, in Mem. Par. 1754.

Of this ſpecies I diſtinguiſh 4 families: The Farinaceous; The Compact; The Fibrous, or ſtriated; and The Foliated.

1ſt Family.

Farinaceous Gypſum.

White. Luſtre 0. Tranſparency 0. Of the conſiſtence of meal. Will not form an adheſive concretion,

concretion, as hair powder does, without being wetted. Feels dry and meagre. Is not gritty between the teeth. Scarcely ſinks in water, and, when it does, becomes ſlimy. Slightly efferveſces, but is ſcarcely diſſolved by nitrous acid. When heated a little below redneſs, becomes of a dazzling white. Lazius, 238.

2d Family.

Compact Gypſum. Dichter Gypſtein of Werner. Alabaſter.

Greyiſh or yellowiſh white, or yellowiſh grey, or bluiſh grey, or greeniſh grey, or olive green, or wine or honey yellow, or light or dark red. Theſe colours often meet in the ſame ſpecimen in ſpots, ſtripes, or veins; brown ſpots alſo often occur.

Luſtre 1 or 0. Tranſparency 2, 1, 0.

Fracture compact, moſtly ſplintery, ſometimes paſſing into the fine-grained foliated. Fragments 1 or 0. Hardneſs 4. Spec. grav. from 1,872 to 2,288. Feels dry, but not harſh. Does not decrepitate when heated. Often efferveſces, though ſlightly, with acids, probably from a mixture of aërated calx.

Mr. Nadault found 3lb. of gypſum to contain 36 grains of nitre beſide common ſalt, 2 Buffon, Minéralogie, 8vo. p. 70; but this is merely caſual.

The ſpecimen, Leſke, O. 1547, is white; its ſpec. grav. 2,347: but the ſpecimen, O. 1548, efferveſces ſmartly, though for a ſhort time: its ſpec. grav. is 2,315. Hence we ſee that the mixture of unſaturated calx renders it heavier.

The ſpecimen, Leſke, O. 1551, is hard as 6 or 7. Spec. grav. 2,939. It is ſaid that it is intimately mixed with ſwine-ſtone; but this does not explain the reaſon of its remarkable denſity; perhaps it contains ſtronthian inſtead of, or with, common calx; but as it does not efferveſce with acids, this is alſo doubtful.

3d Family.

Fibrous, or ſtriated.

White, or greyiſh, yellowiſh, or reddiſh white, often grey or fleſh red, or honey yellow. Sometimes theſe colours meet in ſtripes.

Luſtre 2, 3. Tranſparency 2, 1, 3. Fracture fine or coarſe, fibrous or ſtriated, the fibres, &c. generally ſtraight and parallel, yet ſometimes bent. Fragments long ſplintery 1. Hardneſs 4, brittle. Spec. grav. 2,300.

Does not decrepitate when heated; never efferveſces with acids; when poliſhed, becomes irideſcent. 1 Raab, 346.

The ſpecimen in Leſke, O. 966. is much harder; it does not yield to the nail.

4th Family.

Foliated.

Of this there are two varieties, the ſmall grained and ſparry, and broad foliated.

1ſt Variety.

Granularly foliated. Blattriger gypſtein of Werner.

Greyiſh or yellowiſh white, or yellowiſh, bluiſh, or greeniſh blackiſh grey, or light or dark fleſh red, or brown, or olive green.

Luſtre 2, 3. Tranſparency 2, 3. Fracture foliated, ſtraight, but moſtly ſomewhat curved. Fragments 0, 1. Preſents fine and coarſe grained, often ſtraight or curved diſtinct concretions. The fine grained eaſily crumble and ſeparate like ſandſtones.

Hardneſs 4, 3. Spec. grav. from 2,274 to 2,310. Feels ſoft.

This and the compact are frequently mixed, and paſs into each other, and (though rarely) the fibrous and foliated meet and interſect each other at right angles.

The ſpecimen, Leſke, O. 1552, varies much from this deſcription, for its hardneſs is from 6 to 7, its fragments 3, and its ſpec. grav. 2,900. It effervefces briſkly with acids. Its fracture partly fine ſplintery, and partly foliated. It is evidently impure, though its colour is nearly pure white.

Many ſtones of this family may eaſily be miſtaken for limeſtones without much attention. See the Specimen in Leſke, S. 620, 621.

2d Variety.

Broad foliated. Specular gypſum. Fraueneis of Werner. Glacies Mariæ.

Grey,

Grey, or yellowiſh grey, ſometimes falling into the pale yellow.

It is found amorphous, or cryſtallized into hexagonal priſms, terminating in an edge, or in rhomboids, or cuneiform, tabular, or lenticular.

In the cryſtallized, the planes which form the acute angles are ſtreaked longitudinally, thoſe that form the obtuſe are ſmooth.

Luſtre glaſſy, 4, 3, 2. Tranſparency 4, 3. Fracture ſtraight, or curved foliated.

Hardneſs 4. Spec. gr. 2,311.

It is often penetrated with ſwineſtone (as it is ſaid), which diminiſhes its tranſparency, and gives it a diſagreeable ſmell when rubbed. Kärſten on Leſke, 293. Maquart, 434.

It is found in great plenty, and of an extraordinary ſize, in Ruſſia, if we may credit Mr. Guettard, Mem. Par. 1762, p. 861, 8vo, and Mr. Maquart, p. 403, both of whom have travelled into that empire: it is there uſed inſtead of glaſs for window panes; nevertheleſs, Mr. Kärſten aſſures us this is *abſolutely falſe*.

Gypſum mixed with marl is often found in a ſlaty form. Of this ſort is the ſpecimen, Leſke, S. 259. Its colour is bluiſh grey, and greyiſh black. Luſtre and tranſparency 0. Fracture ſlaty. Fragments 3. Hardneſs 7. Spec. grav. 2,473. Heated to redneſs, it becomes reddiſh white. As the ſpec. grav. is ſo low, I preſume the gypſum predominates. Sometimes it is mixed with the ſmall foliated, as in Leſke, O. 26; the lamellæ are coarſe and more imperfect.

11*th Species.*

Combined with the ſparry acid.

Fluor.

Fluor. Flus of Werner.

This ſtone is nearly inſoluble in water. It does not efferveſce with any acid, except the concentrated vitriolic acid, and with that but feebly. The nitrous and marine acids, in the common temperature of the atmoſphere, are not abſolutely inert with reſpect to it, but ſcarcely diſſolve it without decompoſition. It is inſoluble in the acetous.

In a moderate heat, it decrepitates; and if pulverized, phoſphoreſces, particularly the blue or purple coloured; but, if heated to redneſs, it will never after phoſphoreſce. In a heat of 130° of Wedgewood it melts in clay crucibles, or, but leſs perfectly, in thoſe of chalk, but on charcoal very imperfectly. By concentrated ſolar heat, or that given out by pure air, it melts into a button, which is generally white and opake when cold; if that heat be long continued, it becomes leſs fuſible. Hence, in the heat of our furnaces, it does not part with its acid.

If it be diſtilled in glaſs or earthen veſſels with the mineral acids, it emits an acid air, which corrodes the veſſels, and depoſits a ſiliceous cruſt on the water in the receiver, which abſorbs this air; this is the moſt certain characteriſtic of the acid. The vitriolic concentrated, and taken in equal weight with the ſtone, is the acid moſt uſually employed; a gypſum then remains in the retort.

Hardneſs from 7 to 8. Spec. grav. 3,09 to 3,19.

100 Parts of this ſtone contain about 57 of calx, the remainder acid and water, in a proportion not yet accurately determined, and a ſmall proportion of argill, ſilex, and iron, with ſome traces of marine acid, and ſometimes of cobalt.

Againſt the exiſtence of the ſparry, as of an acid *ſui generis*, many difficulties were ſtarted ſoon after its diſcovery by ſome French chemiſts, diſguiſed under the name of Boulanger, and afterwards by Mr. Achard and Mr. Monnet. To remove theſe, Mr. Scheele inſtituted a new ſeries of experiments, which not only impreſſed the fulleſt conviction of the object they were meant to illuſtrate, but once more diſplayed the unrivalled abilities of the illuſtrious diſcoverer, and the infinite reſources of his art. Sorry I am to add, that, ſince the death of this admirable man, a man as eminent in the chemical as Newton in the mathematical branch of natural philoſophy, Mr. Monnet has thought proper to renew his attacks in a ſtyle of haughtineſs and acrimony that inſpires infinite diſguſt. The fallacy of his reaſoning is ſufficiently expoſed by Mr. Leonhardi, in the 6th volume of his late learned edition of Maquer's Dictionary.

Of this ſpecies we have 3 families: *The Sandy*; *The Compact*; and *The Foliated*, or *Sparry*.

1ſt Family.

In a ſandy or earthy form.

This has been found only at Kobola Poiana, in the diſtrict of Marmaros, in Hungary. It is of a light a light grey colour and looſe conſiſtence; when ſtrewed on an iron plate heated a little below redneſs, it diffuſes a blue or pale yellow phoſphoric light. According to the experiments of Klaproth and Gmelin, it contains the fluor acid ſingly, and not the phoſphoric *. Mr. Pelletier found 100 parts of it to contain 31 of ſilex, 21 of calx, 15,5 argill, 28,5 ſparry acid, 1 of phoſphoric acid, and 1 of iron. In an unconnected ſubſtance of this ſort, different ſpecimens muſt undoubtedly contain different proportions of ingredients, among theſe the ſilex is evidently adventitious, the phoſphoric acid, being in ſuch ſmall quantity, may be found in ſome ſpecimens, and not in others. Mr. Haſſenfratz diſcovered veſtiges of it in moſt fluors †.

2d Family.

Compact.

Whitiſh grey, and thence paſſing into the verdigris green. Luſtre 1, 2, 0. Tranſparency 2, 1. Fracture ſplintery or even. Hardneſs 8, very brittle. Spec. grav. from 3,12 to 3,165.

3d Family.

Foliated, or *ſparry*. Fluor ſpar.

Its colours are very numerous, pure and greeniſh white, or yellowiſh or reddiſh white, or grey

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* 1 Chym. Ann. 1787, 52. 1 Ditto, 1791, 197.
† 9 Ann. Chy, 225.

or bluiſh grey, or light or violet blue, or graſs, leek, or olive green, or dark red verging to purple, or purple inclining to black, or wine or honey yellow, or yellowiſh brown. Many of theſe occur often in ſpots, blotches, or veins pervading the maſs of one and the ſame ſpecimen.

It is found either amorphous or cryſtallized: the moſt uſual of the cryſtallized forms is that of a perfect cube, the angles or edges rarely truncated or bevilled; theſe laſt have ſometimes concave planes. The octohædral form is alſo ſometimes met with. See Mr. Romé's deſcriptions.

Its ſurface moſtly ſmooth, and froſted over with minute cryſtals.

Luſtre 2, 3. Tranſparency 2, 3, 4.

Fracture foliated, generally ſtraight, ſeldom curved; ſome parts, however, are found ſplintery, as if paſſing into the compact.

Fragments tend to the form of triangular or quadrangular pyramids, preſent coarſe or ſmall grained, ſeldom priſmatic, diſtinct concretions.

Hardneſs 8, very brittle. Spec. grav. 3,09 to 3,19; that of the ſpecimen, Leſke, O. 1613, is 3,154.

12th *Species.*

Combined with the phoſphoric acid.

Phoſpholite.

It is nearly inſoluble in water.

It is attacked by the concentrated vitriolic frequently with ſome efferveſcence, but it is rather decompoſed than diſſolved; and the ſelenite depoſited ſoon protects the greater part of the phoſpholite from the action of this acid.

It

It is ſoluble in the nitrous and marine acid, ſometimes with ſcarcely any effervеſcence. In the latter it often appears gelatinous. It is inſoluble in the acetous. If to a ſolution in theſe acids the vitriolic be added, a ſelenite will precipitate; and, the filtered ſolution being evaporated, and the ſelenite depoſited during evaporation removed, the liquor, farther evaporated, will aſſume the conſiſtence of honey; and, being mixed with as much charcoal as gives it the form of a powder, and diſtilled, a phoſphorus will paſs.

By a moderate heat or trituration it phoſphoreſces, but by a ſtronger heat it loſes this property. If reduced to powder it will not decrepitate, which it does when in larger grains. It is ſcarcely fuſible by the blow-pipe, even aſſiſted by alkali, microcoſmic ſalt, or borax.

It contains calx and phoſphoric acid nearly in the proportion of 2 to 1. It is commonly contaminated with ſilex, aërated calx, iron, muriatic ſelenite, fluor acid, and ſometimes manganeſe*. According to Mr. Hauſen, cryſtallized phoſphorite becomes electric by friction with woollen cloth†.

Its external characters are as follow.

1ſt Family.

Phoſphorite. Apatite of Werner.

Colour grey, pearl grey, or green of various degrees of intenſity, mountain, leek, Aſparagus,

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* 1 Bergm. I. 1788, 294. 2 Ann. Chym. 94.

† Berg. I. 1790, 254.

gus, or olive, or clove brown, or intermediate between the fleſh and roſe red, or light or deep blue, or purple or irideſcent; two of theſe colours often meet in the ſame ſpecimen. That found in Spain is generally grey; the other colours are more frequent in Germany.

In Spain, it is found in extenſive ſtrata forming intire mountains; theſe ſtrata offer vertical flatted ſtriæ heaped on each other, and often interſected with quartz*. Sometimes alſo cryſtallized in Germany, and of a greeniſh colour. In Saxony, it is found in low hexahædral priſms with truncated edges and angles, the planes of the ſides longitudinally ſeamed, or in hexangular tables heaped one on the other.

External luſtre 2, 3. Internal 3, 2. Tranſparency 3, 2, 4.

Its croſs fracture foliated; its longitudinal uneven, fine-grained, or tending to the conchoidal †. Fragments 2.

Hardneſs from 6 to 7, brittle. Spec. grav. of the *whitiſh ſort* found in Spain, before it has abſorbed water, 2,8249; after abſorption, 2,8684, 7 Ann. Chy. 82; of the greeniſh, found in Spain, 3,098, 2 Berg. I. 1790, 75; of that found in Saxony, 3,218, Ibid. 76. The greeniſh cryſtals have often been miſtaken for cryſolites, ſometimes for berylls, and ſometimes for aigue marines. Ibid.

The greeniſh cryſtals, whoſe ſpec. grav. is 3,098, do not phoſphoreſce when heated, nor decrepitate as ſpars do, and diſſolve in nitrous acid with a weak efferveſcence. Per Werner, 2 Berg. I. 1790, 75.

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* 37 Roz. 242.

† 1 Bergm. I. 1788, 89. 2 Bergm. I. 1790. 75.

I find he now calls them *ſpargel ſtein*; as the phoſphoric acid has not yet been found in them, it is not certain that they belong to this ſpecies. Do they not belong to that of ſtronthian?

13*th Species.*

Combined with the Tungſtenic acid.

Tungsten.

Inſoluble in water, and neither efferveſces nor diſſolves in acids.

Pulverized and digeſted in a moderate heat, either with the nitrous or marine acid, it aſſumes a yellow colour.

Expoſed to the blow-pipe, it decrepitates, but is infuſible. Mineral alkali attacks it with ſome efferveſcence, and borax without any; but with microcoſmic ſalt it runs into a bead of a blue colour, without that redneſs by refraction which is produced by cobalt.

It is decompoſed by ÆR formed of equal parts of nitrous and marine acids in a boiling heat. By repeating this proceſs with freſh portions of acid, the calcareous part is at length taken up. The tungſtenic acid, that then remains undiſſolved, aſſumes a blue colour when heated to redneſs, and loſes its uſual yellow colour, becoming white by the affuſion of cauſtic volatile alkali. It poſſeſſes, in a word, all the other properties of tungſtenic acid*.

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* 4 Berl. Beob. 321.

Sp. gr. 5,00 to 6,07. Hardneſs from 8 to 9. Of this foſſil there are a few varieties.

1ſt Variety.

Grey tungsten, Scheelium of Werner, white Zin-Graupen of many.

Colour, whitiſh or pearl grey, rarely yellowiſh grey.

It is found both amorphous and cryſtallized; the cryſtals cubic, or aluminiform octohædral.

Luſtre, 3. 2. Tranſparency, 2.—Fracture, foliated.—Hardneſs 8 to 9. Spec. gr. from 5,8 to 6,028, which is that of the ſpecimen Leſke O. 3261.

By the experiments of Mr. Scheele, who firſt diſcovered the nature of this ſtone, it contains about 30 per ct. of pure calx, a few grains of ſilex and iron, and the remainder tungſtenic acid. Scheele, §. 2. 3. Meſſrs. Eluyart have found nearly the ſame proportion in the tungſten of Schlackenwald in Bohemia. See their Memoir, § 5. in note.

2d Variety.

Brown tungsten *. Goſſan of the Corniſh Miners.

Reddiſh or yellowiſh brown, or grey mixed with reddiſh or yellowiſh brown.

Amorphous or forming a brittle accumulation of ſmall cryſtalline grains.

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* 4 Berl. Beob. 320.

Luſtre, 2.—Tranſparency, 0.—Fracture, uneven, granular, and partially ſplintery, ſometimes ſlaty.—Hardneſs, 8.—Sp. gr. 5,570.—Gives a powder of an iſabella yellow colour.

According to Mr. Klaproth, it contains 88 per ct. of tungſtenic acid, 11,5 of pure calx, and $\frac{1}{2}$ a grain of argill and calx of iron.

Note. The red or fleſh-colured ſtone of Rytterſhutte, which with Cronſted I ſuſpected to contain the tungſtenic acid, is now found to conſiſt only of calx, 24 per ct. of iron, and of ſilex 22. See *Ferricalcites.*

This ſpecies may perhaps more juſtly be conſidered as an ore of tungſtenical ſubſtance, of which we ſhall treat in the 4th part of this work.

SECTION VII.

Barytic Genus.

1ſt Species.

BAROLITE, or aerated Barytes. Witherite of Werner.

This ſubſtance, as found at Angleſark in Lancaſhire, is deſcribed by Mr. Watt, jun. nearly as follows:

Its colour greyiſh white, ſometimes inclining to milk white, and ſometimes with a ſlight tinge of yellow, from a mixture of iron; ſeldom greeniſh, often inveſted with a reddiſh ochry cruſt.

It is found in ſolid maſſes, ſometimes filling an intire vein, ſometimes interſperſed with baroſelenite, frequently rounded or affecting that form, ſeldom cryſtallized. Of the cryſtallized 4 forms have occurred. As 1°, ſmall cryſtals radiated as a ſtar, ½ an inch in length, and very thin, appearing to be hexangular priſms rounded towards the point; the other varieties were the ſix-ſided column, pointed with a pyramid of the ſame number of faces; alſo the double ſix-ſided and the double four-ſided pyramid.

Luſtre 2. Tranſparency 2.3.

Fracture, in one ſenſe conchoidal, in another fibrous or ſtriated, the fibres converging. Fragments, long ſplintery.

Hardneſs from 5. to 6. Sp. gr. from 4,3 to 4,338.

Effervesces with acids, and is ſoluble even in the concentrated vitriolic in a ſtrong heat, but precipitates into baroſelenite by the affuſion of water, Phil. Tran. 1784,301, and 18 Roz. 300.—It diſſolves in the nitrous acid 1,4 when diluted with 5 times its weight of water.—And in ſp. of ſalt whoſe ſp. gr. is 1,034,—It does not decrepitate when heated, but loſes its tranſparency, and, when viewed againſt the light, appears bluiſh green.—It will not loſe its air nor burn to lime in the ſtrongeſt heat, but is rather diſpoſed to melt where in contact with the crucible; whereas artificial barytes eaſily burns to lime, probably becauſe it contains more water. It will not melt even in the heat given out by pure air, as Mr. Lavoiſier atteſts.—Fourcroy found it ſoluble in 4304 times its weight of water in the temperature of the atmoſphere, but it required only 2304 times its weight of boiling water. 4 An. Chy. 64.—According to Dr. Withering 100 parts of it contain 20 of fixed air *; according to Fourcroy only 10.4. An. Chy. 65. Dr. Withering's determination however ſeems more exact, being ſupported by a double proof.

It has lately been found, as I am informed, in Argyleſhire; alſo on Schlangenberg in Siberia, and in the pit of Iſaacſund near Freyberg in Saxony.

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* Phil. Tranſ. 1784. 298.

Mr. Werner has beſtowed on this foſſil the name of *Witherite*, in honour of Dr. Withering, who firſt diſcovered it; and for the ſame reaſon I ſhould alſo follow his example, were it not already generally known under the name of *Aërated Barytes.* The ſp. gr. of artificial aërated barytes is, according to Bergman, 3,773. But he allows it a large proportion of water. Sciagr. § 88.

2d Species.

Barytes combined with the Vitriolic Acid.

Baroſelenite.

This ſubſtance requires 43000 times its weight of water to diſſolve it in the common temperature of the atmoſphere.

It is ſoluble in the concentrated vitriolic acid 1,87 in a boiling heat, and precipitable therefrom by the affuſion of water. Phil. Tranſ. 1784, 303.18. Roz. 300, per Sage 1 part requires 12 of acid for its ſolution. Mem. Par. 1788.

Hardneſs, from 4 to 5. Sp. gr. when perfectly pure, according to Afswelius, 4,865. But in general it reaches only from 4,40 to 4,43; in temp. 60° an impure ſort which contained only 55 per ct. of baroſelenite, the remainder being ſilex, argill, and iron, had its ſp. gr. 3,892. The Swediſh baroſelenites are yet the heavieſt, their ſp. gravity generally exceeding 4,5.

It is fuſible *per ſe* by the blowpipe, on charcoal it acquires an hepatic ſmell; and, when thus melted

melted by pure air it gradually diſſipates.—Mineral alkali melts it with effervеſcence, borax and microcoſmic ſalt with ſcarce any; the firſt decompoſes it, the two laſt extract no colour from it.

It does not form a plaſter, as gypſums do; yet Gerhard denies this.

It contains about 84 per ct. of barytes, the remainder vitriolic acid and water, per Bergman. But artificial baroſelenite contains 67 of earth and 33 of vitriolic acid and water, per Klaproth 2. Chym. An 1785.219. or 65 of earth and 35 of acid and water, per Fourcroy 4 Chem. An. 65. And Dr. Withering's experiments appear to me to prove, that 100 parts marmor metallicum contain 68,5 pure earth and 31,5 acid, as ſtrong as that contained in tartar vitriolate. See Phil. Tranſ. 1784, 304. According to Dr. Withering's own calculation, 100 parts of this ſtone contain 67,2 of pure barytes, and 32,8 of vitriolic acid, which agrees almoſt exactly with Klaproth's determination.

Baroſelenite is frequently contaminated with ſelenite, ſilex, iron, and aërated calx, and hence ſometimes ſlightly effervеſces with acids.

To analyze and purify it, Mr. Afswelius uſes the following proceſſes:

1ſt. After pulverization, it is mixed and calcined with 2,5 times its weight of aërated mineral alkali, perfectly pure and deprived of its water of cryſtallization, in a red heat for one hour and an half, avoiding fuſion. A double decompoſition thus takes place.

2d. Glauber's ſalt and the ſuperfluous alkali being then ſeparated by lotion and coction, the reſiduum is boiled for 3 hours in 10 times its weight of diſtilled vinegar, whoſe ſp. gr. is 1,033. This takes

takes up not only the barytic, but alſo the calcareous and muriatic earths if any, leaving only the argillaceous and ferruginous.

3d. To this ſolution vitriolic acid is added as long as any precipitation appears. This precipitate contains baroſelenite, and poſſibly gypſum: this laſt is ſeparated in 50 times as much water as the precipitate weighs, and the baroſelenite remains ſingle. When dried in a red heat, it contains 67 per ct. of pure barytes, which is ſeparated by calcining it again with mineral alkali, diſſolving it in nitrous or marine acid, and precipitating the ſolution with an aërated fixed alkali.

The whiteſt and heavieſt baroſelenite is the pureſt.

Of this Species we may diſtinguiſh 5 Families.

1ſt Family.

In an Earthy looſe form.

Yellowiſh or reddiſh white, rarely pure white, conſiſts of coarſe duſty particles, moſtly forming ſlight concretions, ſeldom in powder. Feels coarſe, rough, and harſh, but appears weighty.

2d Family.

Compact Baroſelenite. *Dichter Schwer Spath* of Werner.

Yellowiſh white, or yellowiſh, reddiſh, bluiſh or blackiſh grey, or pale red, or Iſabella yellow. Amorphous,

Amorphous, in nodules, or in half-rounded maſſes, or teſſular.

Luſtre, 0.1. Tranſparency 1.0.

Fracture generally ſplintery, not rarely paſſing into the granularly foliated.—Sometimes earthy.—Fragments, 2.1.—Hardneſs from 5 to 6, rarely 4.—Sp. gr. from 4,3 to 4.4.—Feels meagre.

It ſcarcely occurs without conſiderable impurities.

To this family belongs the baroſelenite of Wignäs in the province of Dalin in Sweden. Afſwelius § 10.—Colour reddiſh, form teſſular, fracture preſents indiſtinguiſhable particles; it is opake, and its ſp. gr. is 4,3. It contains 71 per ct. baroſelenite, 11 of ſelenite, 13,5 ſilex, ½ martial argill, and 4 of water. It decrepitates when heated.

Alſo the heavy ſtone of Ramelſberg is of this family; colour bluiſh grey, paſſing in ſome parts into the blackiſh grey. Dull, opake, and of a ſplintery fracture, ſometimes verging to the granularly foliated or ſparry. Sp. gr. 4,313. By Mr. Weſtrumb's Analyſis, it contains 83 per ct. baroſelenite, 65 ſilex, 4 calx of iron, 25 ſelenite, 1,5 alum, 2 of water and bituminous ſubſtance. 2 Bergbau 47.

At Wilicza in Galicia this ſtone is found beautifully waved and twiſted, it aſſumes a poliſh like alabaſter.

A compact baroſelenite, found at Waldſtein near Faiſtritz in Stiria, abounds ſo much in ſilex that it gives fire with ſteel. N. Act. Petrop. 1785. 263.

3d Family.

Foliated.

White, or bluiſh, reddiſh, or yellowiſh white, or yellowiſh, reddiſh or bluiſh grey, or fleſh red, or verging on the browniſh red, or Iſabella yellow, rarely greyiſh black; the cryſtallized ſort is often bluiſh grey, wine yellow, more rarely olive green, and ſtill more rarely azure, verging in ſome parts on the green.

It occurs either amorphous, or cryſtallized in ſuch various forms that even the patient Werner deſpairs of enumerating them; the moſt remarkable are the quadrangular priſm, the hexangular priſm, the double quadrangular pyramid, the quadrangular table bevilled at the edges; the ſurface of the cryſtals is generally ſmooth.

Luſtre 2.—That of the cryſtals commonly 3.—Tranſparency 2.1.3.—That of the cryſtals 4.3.

Fracture either granularly foliated, or broad foliated, ſeldom curved foliated.

It generally preſents thick lamellar diſtinct concretions, moſtly ſtreight, ſeldom curved, thicker commonly at one end than the other, owing to the accumulation of ſeveral lying on each other, and having a ſimilar direction, which often gives the ſtone a radiated appearance.

Its fragments tend often to a ſparry form.—Hardneſs from 5 to 6. Sp. gr. from 4,3 to 4,8.

It is generally the pureſt of the ſpecies.

The Derbyſhire caulk is of this family. Colour white, grey, or reddiſh, compoſed of rhomboidal laminæ ſet in different directions. Sp. gr. 4,330.—It contains, by Dr. Withering's account, 99,5 per ct. of baroſelenite and 0,5 of calx of iron.

Semitranſparent quadrangular priſms of this family, analyzed by Mr. Afswelius, afforded him 79 of baroſelenite, 6 of ſelenite, 3 of ſilex, 4 argill and iron, and 1,5 water.

White rhomboidal lamellar cryſtals from Kilpatrick hills near Glaſgow, whoſe ſp. gr. was from 4,402 to 4,44, contain by Dr. Withering's account the pureſt baroſelenite, 100 parts affording 67,2 of pure earth and 32,8 of vitriolic acid. His analyſis is a model of ſkill and accuracy *.

Foliated baroſelenite often bears a ſtrong reſemblance to Feltſpar, and I make no doubt has often been miſtaken for it. See Leſke K. 137.

4th Family.

Striated or Fibrous.

Yellowiſh white, or bluiſh grey, or browniſh or reddiſh yellow.

It occurs in ſomewhat rounded maſſes, of uneven ſurface.

Luſtre, ſilky, or waxy, 2. Tranſparency 2.1.

Fracture, ſtriated, converging to a common, center.

Hardneſs 5. Sp. gr. from 4,000 to 4,4409.

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* Mr. Weruer has of late diſtinguiſhed, and with great propriety, the lamellar, and granularly foliated. The granular differs from the foliated as granular limeſtone from calcareous ſpar.

The Cawk of Shropſhire, analyzed by Dr. Withering, is of this family: he found in it 97,7 per ct. of baroſelenite, and 2,3 of calx of iron.

Under this head we may alſo place the celebrated Bolognian ſtone, its ſp. gr. is 4,440 per Briſſon. According to Mr. Arvidſon, it contains 0,62 of baroſelenite, 0,10 ſilex, 0,15 argill, 0,06 ſelenite, and 0,02 water. 2 Chy. Ann. 1788. 205.

The Stalactitic baroſelenites may alſo be reckoned as of this family; for inſtance, the tubuliform, whoſe croſs fracture is fibrous, and their longitudinal foliated.

5th Family.

Acicular. Stangen ſpath of Werner.

Colour, white, or whitiſh grey, or pale blue.

It is found in the form of needles, heaped together ſometimes parallel, but often confuſedly. Moſt commonly inhering in other ſtones. The ſurface of theſe needles is longitudinally ſtreaked.

Luſtre 2.3. Tranſparency 2.1.

Hardneſs 5. Sp. gr. as of the foregoing families.

Mr. Bergman found theſe needles to conſiſt of pure baroſelenite. Schwed. Abhand. 1784 111. They much reſemble certain white-lead ores.

3d Species.

Liverſtone. Lapis Hepaticus, Leberſtein.

Colour, grey, greyiſh, or yellowiſh grey, or brown, or greyiſh black.

Luſtre 2. 1. Tranſparency 1.

Fracture, foliated and partly ſtriated.—Hardneſs from 5 to 6. Sp. gr. by my trial 2,666. It emits a ſmell of liver of ſulphur when rubbed or heated to redneſs.

It does not efferveſce with acids.

According to the analyſis of Mr. Bergman, a ſpecimen from Andrarum in Scania contains 0,38 of baroſelenite, 0,33 ſilex, 0,22 alum, 0,07 gypſum, and 00,5 mineral oil. Sciagr. § 90.

The ſpecimen, Leſke, O. 1519 efferveſces with acids, and therefore is not a liver-ſtone.

Neither is the ſpecimen O. 1518 free from a calcareous mixture.

SECTION VIII.

Muriatic Genus.

UNDER this head I include not only thoſe earths and ſtones in which magneſia predominates, but alſo thoſe in which the ſiliceous earth predominates, if magneſia be, next after this, the moſt copious ingredient, and the compound poſſeſſes the characters of the muriatic and not thoſe of the ſiliceous genus.

1ſt Species.

Magneſia mixed with Silex. Silicimurite.

1ſt Family.

Keffekill. Myrſen. Meerſchaum of Werner.

Neither pure nor aërated magneſia unmixed with any other ſubſtance have as yet been found. Of the magneſia, ſeparated by art from other combinations, 100 parts contain about 55 of mere earth, 30 of aërial acid, and 15 of water, when of the dryneſs poſſeſſed by that uſually found in the ſhops.

Keffekill or myrſen, which the Germans corruptly call Meerſchaum, is ſaid to be when recently dug of a yellow colour, and as tenacious as cheeſe or wax. By the lateſt accounts it is found near Burza in lower Aſia *. It is the ſubſtance of which the large Turkey tobacco pipes are formed. It is ſaid to be the earth called in Canada *terre à chalumeau*, but of this I doubt. When boiled with greaſe it is formed into pipes, and hardens in the open air. The ſcrapings of theſe pipes were examined by Mr. Weigleb, and found to conſiſt of $\frac{1}{2}$ ſilex and $\frac{1}{2}$ magneſia nearly; the magneſia did not efferveſce with acids, this was probably occaſioned by the expulſion of fixed air during the treatment with fat. To this alſo the hardneſs may perhaps be aſcribed, as magneſia and ſilex will not harden even in a porcelain heat. 3 Crell. N. Entdeck. 3.8. By the heat of pure air this ſubſtance is converted into a white porcelain maſs.

Note, Baron Born, 1 Raab 244, conſiders this earth as a ſemi indurated talc.

2d Family.

Martial Muriatic Spar.

Mr. Monnet, a mineralogiſt of conſiderable note, lately diſcovered this ſtone at *St. Marie aux Mines*, and called it *piſolites*; but, as a very different compound is generally denoted by this name, I have called it martial muriatic ſpar, a name which agrees better with its properties.

It is of a hard, ſolid, and ſparry texture, of a

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* N. Acta Petropol. 1785. 263.

grey, ochry, dull colour, but internally bright: it gives fire with ſteel, yet efferveſces with acids.

In a ſtrong heat it grows brown, but at laſt melts *per ſe.* Hence it muſt contain ſomething elſe than magneſia, ſilex, and iron.

100 Parts of it are ſaid to contain 50 of ſilex, the remainder mild magneſia and iron, but in what proportion is not mentioned. 13 Roz. Suppl. 416.

2d Species.

Magneſia mixed with a notable proportion of calcareous Earth and ſome Iron.

Calcimurite.

Colour, blue, or olive-green, of the conſiſtence of clay; the latter contains no argill, but merely calcareous earth and magneſia tinged by iron; the former contains a larger proportion of calcareous earth; both are found near Thionville; the former is uſed by Potters. 13 Roz. 60.

3d Species.

Mild Magneſia mixed with Clay and Iron.

Argillo-Murite.

Colour, greeniſh yellow; conſiſtence, earthy. Found in Sileſia, and by Mr. Margraaf's experiments

periments contains $\frac{1}{3}$ of its weight of magneſia. 2 Theile 18. Another ſort has been diſcovered in Italy by Mr. Fabroni, of which I have ſeen only the analyſis; it contains 0,50 of ſilex, 0,13 magneſia, 0,10 argill, 0,03 calx, 0,009 calx of iron, 0,08 water. Of it the ancients made bricks ſo light as to float on water. 12 An. Chy. 316. Its conſiſtence is very looſe.

4th Species.

Chlorite. Samt Erde. Peach of the Corniſh Miners.

1ſt. Family.

In a looſe Form.

Colour, graſs-green, or greeniſh-brown, or dark-green inclining to black.

It is found in ſcales either inveſting other ſtones or heaped together.

External Luſtre. 0,1 :—feels greaſy,—ſhews a white ſtreak,—gives an earthy ſmell when breathed on.

It melts into a dull black compact ſlag, and then becomes magnetic. By the analyſis of Mr. Hæpfner it contains 0,4375 magneſia, 0,375 ſilex, 0,0417 argill, 0,0166 calx, and 0,1292 iron. 2 Sauſſ. 133.

2d Family.

Indurated and cryſtallized.

Colour, dark green, almoſt black. Form oblong, quadrangular, and acuminated.

Luſtre, 1. Tranſparency, 0.

Fracture earthy, yet ſomewhat ſcaly. Hardneſs, 6. not remarkably heavy. Gives a mountain green ſtreak. Feels meagre. Does not effervesce with acids.

Ferb. Briefe 43.

According to Hæpfner, it contains 0,415 ſilex, 0,3947 magneſia, 0,0613 argill, 0,015 calx, 0,1015 iron, 0,015 air and water. 1 Chy. An. 1790. 56.

3d Family.

Slaty *.

Of this I have ſeen no authentic deſcription. It is ſaid to abound with garnets and magnetic iron ſtone. According to Baron Born, 1 Raab 247, its colour is greeniſh grey. According to others, dark green, inclining to black.

Internal Luſtre, 1.2. Tranſparency, 0.

Fracture, more or leſs perfectly ſlaty, ſometimes curved ſlaty, or paſſing into the ſcaly foliated; and then accompanied with more luſtre, and a darker colour. Fragments, flatted.

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* Lenz. 76.

Gives a mountain green ſtreak, feels ſmooth and ſomewhat greaſy.

Hardneſs, 5.4.

5th Species.

Talc.

Of this Species we have 3 Families.

1ſt Family.

In a looſe or ſemi-indurated form.

Talcite.

Colour, reddiſh or greeniſh white, or leek green.

Found in the form of ſmall ſcales, looſe, or ſlightly coherent.

Luſtre 3.4.

Feels ſomewhat greaſy, adheres to the fingers, and, when rubbed in, gives a gloſs to the ſkin.

Very light.

Does not efferveſce with acids.

The name *Talcite* has been beſtowed by Wallerius, Baron Born, and others, on a very different ſubſtance. But it is more properly applicable to this.

2d Family.

Talc. Or Common Talc. Venetian Talc.

Colour, generally greeniſh-white, or pale apple green, verging on the ſilvery white, more rarely reddiſh-white, by tranſmitted light it appears green.

Frequently occurs in oblong nodules of an irregular ſurface.

Luſtre, nearly metallic, 4. Tranſparency, 2. 3. or if very thin, 4.

Fracture, foliated, ſtreight, curved, or undulating. The lamellæ, eaſily ſeparable from each other, if ſtreight, but not if curved or wrinkled. The lamellæ flexible, but not elaſtic.

Hardneſs, from 4 to 5. Sp. gr. from 2,7 to 2,8 by my trial on the ſpecimen Leſke O.

Feels ſomewhat greaſy. Does not efferveſce with acids. Strongly heated, it becomes whiter, leſs tranſparent, and more brittle. Fixed alkalis ſcarcely flux it, borax and microcoſmic ſalt are more effectual. Pure air melts it into an opake greeniſh maſs, ſpotted ſlightly with red.

The few experiments I formerly made on this ſubſtance ſeemed to indicate the preſence of ſilex, magneſia, and argill, with a very ſmall proportion of iron; but they are too imperfect to be relied on. I am happy to find it has been ſince analized by Mr. Hœpfner; he found it to contain 0,50 ſilex, 0,44 magneſia, and 0,06 argill. 4 Helvet. Mag. 296.

The cryſtallized talc of Baron Born, 1 Raab 247, ſeems to me to be rather *chlorite*; and, though he wiſhes to confound this with talc, yet they muſt be diſtinguiſhed, ſince the one is fuſible by the blow-pipe, the other not.

3d Family.

Shiſtoſe Talc. *Schiefriges Talc*, Leſke O. 1154. 194.

Colour, whitiſh grey, or greyiſh green, or dark green, or bluiſh grey.

Surface, uneven and wavy, the lamellæ being in many parts broken or worn away.

External luſtre, 2. 3. Internal luſtre, 1. from a number of ſhining particles diſperſed through it, ſometimes in certain poſitions, 3.

Tranſparency, 0. except the whiter ſort, whoſe tranſparency is 2.

Fracture, hackly, long ſplintery, and irregularly ſlaty.

Hardneſs, from 4 to 6. Brittle. Sp. gr. from 2,7 to 2,8.

It becomes white and ſcaly by expoſure to the air. Feels ſoft, and eaſily crumbles when rubbed in the fracture.

6th Species.

Steatites.

1ſt Family.

Semi-indurated. Craie de Briançon. Specſtein of Werner.

Colour greyiſh, yellowiſh, or greeniſh white, rarely pure white, moſtly having a ſhade of green, particularly

particularly when moiſtened, (the white often contains black dentritical figures,) or yellowiſh white ſpeckled or veined with red, or mountain, olive, or leek green, or ſlate blue.

It is found in amorphous maſſes, rarely cryſtallized in hexangular priſms, terminated with an hexangular priſm *.

Luſtre, 0. Tranſparency, 0. or ſcarcely 1.

Fracture, earthy, or coarſe ſplintery. Hardneſs from 4 to 5. Sp. gr. before it has abſorbed water, is according to Briſſon from 2,61 to 2,79. And after abſorption from 2.66 to 2,794. But perhaps this laſt may belong to the next family, if ſo, the ſp. gr. of this will only reach to 2,66 or 2,69 when penetrated with water.

It abſorbes, but does not diffuſe itſelf in water.

It either does not adhere, or ſcarcely adheres to the tongue.

It feels ſoft and greaſy, and takes a poliſh from the nail.

Does not efferveſce with acids.

Hence we ſee it reſembles fullers earth; it differs chiefly in not being diffuſible in water, in poſſeſſing ſome ſlight degree of tranſparency, and being ſomewhat harder.

When heated, it hardens and whitens, but does not melt at 150°.

The ſteatites of Suartwick, examined by Mr. Bergman, ſeems of the kind we now treat; its colour green, felt greaſy, and might be ſcraped by the nail. Microcoſmic ſalt had not the power of fluxing it, but it yielded to borax, and with efferveſcence to mineral alkali. He found it to con-

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* Q.?

tain 0,80 of ſilex, 0,171 of aërated magneſia, 0,02 argill, and 0,009 calx of iron. 4 Bergman, 166. I ſuſpect however, from its hardening in fire, that it contains more argill.

The white ſteatites of Cape Lizard in Cornwall, which is ſtreaked with red and blue, of the hardneſs of cheeſe, and uſed for porcelain, ſeems alſo of this kind. Mr. Klaproth found it to contain 48,42 per ct. of ſilex, 20,84 magneſia, 14 argill, 1 of iron, and 16 of air and water. 1 Berl. Beob. 163. 192.

2d Family.

Indurated Steatites. Lardites of Wallerius. Schmeerſtein of Succow.

Colour, yellowiſh, or greeniſh grey, often veined or ſpotted with a deeper yellow or red.

External luſtre, 2.1. Internal, 0. Tranſparency, 2. 2,5.

Fracture, fine ſplintery, often mixed with imperfectly conchoidal. Fragments, 2.

Hardneſs from 5 to 6. Sp. gr. of a ſpecimen I tried was 2,784. That of a ſpecimen tried by Mr. Briſſon, which he calls pierre de lard, was before it had abſorbed water 2,583, and after abſorption 2,632.

Feels greaſy, and often reſembles ſoap.

This ſeems to be the ſtone analyſed by Mr. Weigleb, 2 Chy. An. 1784, 429, under the name of ſteatites of Bayreuth, for he refers to Margraaf, 2 Theile, p. 15, whoſe deſcription anſwers to that of this. He found it to contain per ct. 58,33 of ſilex,

ſilex, 39,16 magneſia, and 2,5 iron. It is remarkable that he found no argill.

The ſteatites of China, Leſke O. 1102, is of this family. Margraaf ſays it is often called Spaniſh chalk; it may therefore be the ſame as the Spaniſh chalk of Briſſon, whoſe ſp. gr. he found to be 2,790.

3d Family.

Foliated, or Striated. *Talcites* of Wallerius.

Colour, leek green, paſſing on the one hand into the mountain green, and on the other through the olive green, into the ſulphur yellow.

Generally found in independent amorphous maſſes, ſometimes inveſting or interſecting ſerpentines, &c.

External luſtre caſual, but commonly 3. Internal, metallic in the dark coloured, or waxy, in the higher 3. Tranſparency, 2.1.

Fracture, foliated, moſtly curved foliated; ſometimes ſtriated, particularly when inveſting, or interſecting. Fragments cuniform. Hardneſs from 6 to 7.

Brittle. Sp. gr. of the ſpecimen I tried, Leſke O. 1111 is 2,636. That of the *talcite* of Briſſon, (which he ſays is compoſed of white mica, whoſe layers are agglutinated, but ſeems to be the ſame as that now deſcribed), before it has abſorbed water, is 2,6325, and after abſorption 2,6496.

Gives a pale greeniſh grey ſtreak.

Feels greaſy. Does not adhere to the tongue.

This

This deſcription, is for the moſt part taken from Mr. Karſten, who very properly diſtinguiſhes this foſſil from common ſteatites.

Heated to redneſs, it becomes grey and harder, and at 147° forms a grey porous porcelain maſs.

7th Species.

Pot-Stone. Lapis Ollaris. Verharteter Talk, or Topfſtein of Werner.

Colour, light or dark greeniſh grey, or greeniſh and reddiſh grey, or yellowiſh grey, or ſpeckled with red, or leek green.

Luſtre, 2.1.3. Tranſparency, 1.0.2.

Fracture, undulatingly foliated, or the folia exceeding thin, and diſcovering rugoſities; often alſo ſlaty.

Fragments, long ſplintery, or plated.

The foliated preſent ſometimes groſs or minute diſtinct concretions.

Hardneſs, from 4 to 6. brittle. Sp. gr. of that of Como, the moſt famous of this ſpecies, is 2,8729. According to Sauſſure, that of Swiſſerland has its ſp. gr. 3,023. Some abſorb water, the ſp. gr. of the potſtone of Dauphiné, which is of ſlaty ſtructure before the admiſſion of water, is 2,7687; after admiſſion 2,8214; of the Swediſh, before the admiſſion of water, 2,8531; after admiſſion, 2,8629.

Feels greaſy.

This ſtone is often confounded with indurated ſteatites, which poſſibly may have been applied to the ſame uſe, but whoſe characters and compoſition are very different; it is more difficultly diſtinguiſhed from ſhiſtoſe talc, eſpecially where the potſtone

potſtone is ſlaty, yet their luſtre, ſpec. gravity, and feel, are different. The ſlaty abounds in common talc. See the ſpecimen, Leſke O. 1157.

By the analyſis of Mr. Weigleb, the potſtone of Como, contains about 0,38 ſilex, 0,38 magneſia, 0,07 argill, 0,5 iron, 0,01 aërated calx, and ſtill leſs of the ſparry acid[*]; but, as the quantity of air and water is not given, we can form no true idea of the proportion of theſe ingredients to the whole, but only of that in which they ſtand to each other. The fluor acid and calx are in too ſmall proportion to affect the eſſence of the ſtone. It differs therefore from ſteatites principally in this, that the magneſia and ſilex are in a larger proportion to each other, and the iron to both.

8th Species.

Serpentine[†].

Moſt commonly of a dark blackiſh, or leek, olive, or canary green, ſeldom ſulphur yellow, ſometimes blood, carmine, or peach bloſſom red, often bluiſh, or greeniſh grey, or browniſh red, or reddiſh brown, or greyiſh blue.

Theſe colours, are ſcarce ever ſingle, but 2, 3, or more accompany each other, (and hence the ſtone derives its name), one, or two, form the ground; and one, or more of the others, form ſpecks, veins, or dots therein; in theſe, not only the

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[*] 3 Helvet. Magaz.

[†] The Germans and French call it alſo *Serpentine*; but the latter call alſo a ſort of porphyry or variolite *Serpentin*.

the above colours occur, but alſo black, and more rarely the ſcarlet red, crimſon red, and canary green.

It is almoſt always found in an amorphous independent ſtate, ſeldom diſſeminated, and inherent.

Luſtre, 0. Tranſparency, 1.0.

Fracture, fine, or coarſe ſplintery, which ſometimes paſs into the uneven of a fine grain.

Fragments, between 2 and 3.

Hardneſs from 6 to 7. Somewhat brittle. Sp. gr. according to Briſſon, reaches, before it is penetrated with water, from 2,2645 to 2,709. It is only thoſe whoſe ſpec. gravity is beneath 2,6 that admit water. He indeed mentions one which he ſays is fibrous and ſemitranſparent, whoſe ſp. gr. is 2,9997; but this cannot be a ſerpentine, as neither of the three characters belong to it; nor do I believe that of Dauphiné, which he ſays is ſemitranſparent, to be a ſerpentine, but rather an indurated ſteatites. The ſp. gr. of the dark reddiſh brown ſerpentine of Zoblitz, Leſke O. 1137, to which a ſmall quantity of talcite adheres, I found to be 2,561 and that of the dark blackiſh green, alſo of Zoblitz, Leſke O. 1130, to which alſo ſome talcite adheres, 2,574.

Moſt give an earthy ſmell when breathed on.

It feels rather ſoft, almoſt greaſy.

Moſt ſerpentines diſcover in their fracture yellowiſh or canary green ſcales, particularly thoſe that otherwiſe reſemble trap. See Leſke G. 318, 319. 321. Theſe alſo often contain garnets, which trap never does. It is diſtinguiſhable from indurated ſteatites by its opacity, colour, hardneſs, feel, and generally by its ſp. gr. By reaſon of its earthy ſmell, I ſuſpect it has often been miſtaken for trap, from which it differs moſt widely.

When

When heated it hardens and reddens, but is infuſible by the blowpipe. By a heat of 136° I found the blackiſh green, Leſke O. 1130, hardened to 9, and turned to a reddiſh brown; at 150° it became greyiſh white, and formed a ſemicompact maſs of the nature of porcelain. Hardneſs 10. The dark reddiſh brown at 163° imperfectly melted, forming at the ſurface a grey opake enamel, but internally a porcelain maſs.

Mr. Knock found a ſerpentine, whoſe ſp. gr. was 2,684, to contain per ct. 45 parts ſilex, 33 magneſia, 14 magnetic iron, 6,25 aërated calx, $\frac{1}{4}$ argill, with a little ſalited magneſia and water. 2 Chy. An. 1790. 497. Meyer found a ſerpentine he examined, to contain ſilex and magneſia, with a little iron, and a ſuſpicion of calx. 1 Chy. An. 1790. 342. Klaproth found no argill in the ſerpentines of Saxony, 4 Berl. Beob. 187. Hence I am inclined to think, that ſerpentines contain no argill except accidentally, but merely ſilex, magneſia, and iron. The ſilex in the proportion of about 5 or 4 to 3 of magneſia. The proportion of iron variable from 4 to 15. The experiments of Mr. Bayen, though accurate, were not made with a view to preciſion; it was only by induction that I found the quantity which I formerly ſtated. In potſtone, iron ſeems alſo to be eſſential, but the ſilex and magneſia approach nearer to an equality. In ſteatites, iron is merely caſual, and never in any conſiderable proportion. The ratio of ſilex and argill to each other is not ſettled, but water ſeems eſſential to the ſemi-indurated.

9th Species.

Aſbeſtus. Aſbeſte non mur of the French.

Colour, generally leek green, often olive or mountain green, more rarely greeniſh grey, or dark, or light yellowiſh grey. Luſtre, 2.1. Tranſparency, 1. or, if very thin, 2.

Fracture, parallel, or divergingly, and generally ſomewhat curved ſtriated, or fibrous, the fibres coarſe or delicate; ſometimes inclining to, or intermediate between, the fibrous and ſplintery *. Fragments, for the moſt part long ſplintery.

Hardneſs from 6 to 7. The limits of its ſpec. gr. are, according to Buffon, pretty diſtant, one ſpecimen of a light grey colour which he calls *aſbeſte mur*, had its ſp. gr. before it had abſorbed water 2,577, and after abſorption 2,699. Another of the ſame colour, which he calls *aſbeſte non mur*, was before abſorption 2,9958, and after abſorption 3,0343. And that of divergingly fibrous aſbeſtus, which he calls aſbeſte étoilée, was before abſorption 3,0733.

I found that of the ſpecimen from Zoblitz, Leſke O. 1184, to be 2,547. I believe the heavy ſorts mentioned by Briſſon were actinolytes.

Feels ſomewhat greaſy. Gives a grey powder, and ſtreak.

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* See Pabſt's Catalogue, by Werner, No. 2730. Werner, in Cronſted, aſſigned it a ſtriated fracture, but now a fibrous. See Leſke's and Pabſt's Catalogues, and 1 Bergm. I. 1789. 162.

Does

Does not efferveſce with acids.

The ſpecimen Leſke O. 1184, which is of a yellowiſh green colour, was hardly diſcoloured by a red heat; at 160° it formed a grey, ſomewhat porous porcelain, whoſe ſurface was enamelled, and gave fire with ſteel, therefore it began to be fuſed. Mr. Sauſſure found the aſbeſte he tried affected in the ſame manner. 1 Sauſſ. 86.

Mr. Bergman comprehends ſtones of many different ſpecies under the name of aſbeſtus; and hence it is difficult to aſſign the numerous and exact analyſis he has made of them, to the different ſpecies to which they ſeverally belong; a clear proof of the neceſſity of exact deſcriptions of the external characters of foſſils. The aſbeſtus of Baſtnäs ſeems to be that of which we here treat, as he refers to Cronſted, § 105.2 this he ſays afforded him 67 per ct. ſilex, 16,8 aërated magneſia, 6 aerated calx, 6 argill, and 4,2 iron. 4 Bergm. 168.

Another from Grænge in Dalecarlia, Cronſt. § 106 contained 63,9 ſilex, 16 aërated magneſia, 12,8 aërated calx, 1,1 argill, and 6 calx of iron. Ibid 170.

Another from Pehrſberg in Wermeland, contained 62 ſilex, 13,7 aerated magneſia, 12 aerated calx, 1,7 argill, and 10,6 calx of iron.

Mr. Weigleb, in the leek green aſbeſtus of Zoblitz, found about 47 of ſilex, 48,5 mild magneſia, and 4 of iron. I tried this reſult ſynthetically, and found it to reſiſt fuſion at 148°.

Hence we ſee that few ſtones admit of a greater latitude of compoſition than this, as it admits ſome argill, and a pretty large proportion of aërated calx, into its compoſition; yet neither are eſſential to it. But the iron is in a calcined ſtate, which

which diſtinguiſhes this ſtone, in that reſpect, from ſteatites, potſtone, and ſerpentine.

10th Species.

Ligniform Aſbeſtus.

Colour, brown, approaching to Iſabella yellow.

Luſtre, 0. Tranſparency, 0.

Fracture, ſlaty, and, if broken acroſs, it diſcovers an irregular filamentous ſtructure, like wood.

I have not ſeen it, nor do I know whether it has any other ſimilitude to wood, or aſbeſtus. I place it here only by reaſon of its name.

Mr. D'Aubenton has propoſed a good criterion for diſtinguiſhing petrified wood. He obſerves, that mere concentric layers are not ſufficient, there muſt alſo be lines interſecting theſe layers, as the medullary prolongations from the center to the bark.

11th Species.

Amianthus.

Colour, moſt commonly greyiſh, or greeniſh white, more rarely yellowiſh or ſilvery white, ſometimes olive or mountain green, or pale fleſh red, or ochre yellow.

Luſtre, 1,2, ſometimes 3, and then reſembling the metallic. Tranſparency, 1,2,0.

Fracture preſents delicate, and moſtly ſtreight and parallel, rarely curved fibres, ſometimes cloſely compacted. Its fibres flexible.

Fragments, long ſplintery.

Hardneſs from 3 to 4. Sp. gr. before it has abſorbed water, is, according to Briſſon, from 0,9088 to 2,3134, and after abſorption from 1,5662 to 2,3803.

Feels ſomewhat greaſy.

I found a ſpecimen of the greyiſh white to melt at 162,5, into a greeniſh black, perfectly compact glaſs.

Mr. D'Arcet and Sauſſure found it to melt, and cryſtallize, at (I preſume) a much lower heat; and at a higher, to run into a greeniſh glaſs.

The ſnow-white amianthus, of Tarentaiſe, was found by Mr. Bergman to contain 64 per ct. ſilex, 18,6 aërated magneſia, 6,9 aërated calx, 6 baroſelenite, 33 argill, and 1,2 calx of iron. 4 Bergm. 163.

The ſtone from Suarwick, which he calls aſbeſtus, but which, from the flexibility of its filaments, I judge to be an amianthus, afforded him 0,64 ſilex, 0,172 aërated magneſia, 0,139 aërated calx, 0,027 argill, and 0,022 calx of iron. Ibid. 165.

That which he calls aſbeſtus of Corias, in Aſturias, I take alſo to be an amianthus, as he ſays it is very like that of Tarantaiſe, and refers it to Cronſtedt, § 105. 1; in this he found 0,72 ſilex, 0,129 aerated magneſia, 0,105 aërated calx, 0,033 argill, and 0,013 calx of iron.

Another from Crete contained 53 per ct. of ſilex, 28,8 aërated magneſia, 14,3 aërated calx, 1 argill, and 2 calx of iron.

Hence we ſee, that aſbeſtus and amianthus differ, not in their conſtituent parts, but in this, that amianthus contains them in a proportion more eaſily fuſible; hence alſo aſbeſtus paſſes into amianthus, when, by expoſure to the air, it loſes part of that ingredient, whoſe diſproportion to the remainder renders it more difficultly fuſible.

Note. Amianthus has been found in a farinaceous ſtate by Mr. Dolomieu, on the mountain St. Fiora, in Tuſcany. See his notes on 3 Bergm. 246.

Amianthus in a cryſtallized form, namely, in rhomboids or compreſſed parallelopipeds, of a grey or bluiſh colour, are ſaid to have been found in the neighbourhood of Bagneres; they are very ſoft and of a filamentous texture, but harden by expoſure to the air. 26 Roz. 429.

12th Species.

Suber montanum. Corium montanum.

Colour, white, or reddiſh white, or yellowiſh grey, or Iſabella, or ochre yellow, or yellowiſh brown.

It is found either in thick compact pieces, and then called mountain cork; or in thin flat pieces, then called mountain leather, or paper; or cellular, and then called caro montana, &c.

Luſtre 0, rarely 1. Tranſparency 0.

Fracture preſents fibres confuſedly interwoven with each other, ſometimes ſo ſubtile as to be difficultly diſtinguiſhed, and thus they give the fracture a compact earthy appearance.

Hardneſs,

Hardneſs, 4. takes an impreſſion, or yields like cork to the finger, and ſomewhat elaſtic.

Sp. gr. before it is penetrated by water, from 0,6806 to 0,9933: and after admiſſion of water, from 1,2492 to 1,3492. *Briſſon.*

If perfectly dry, and ſufficiently thick, it gives a ſound when ſtruck.

It feels meagre.

Bergman and Sauſſure found it fuſible, though difficultly, by the blow-pipe. 4 *Bergm.* 169. 2 *Sauſſ.* 124.

By Mr. Bergman's Analyſis it contains from 56 to 62 per ct. of ſilex, 22 to 26 aërated magneſia, from 2,8 to 12,7 argill, about 3 of calx of iron, and from 10 to 12,7 aërated calx.

13th Species.

Amianthinite. Aſbeſtartiger Strahlſtein, of Werner, in part. Leſke O. 1186. 1188.

Colour, aſh, or greeniſh or yellowiſh grey, often mixed with yellow, or red, or both, from decompoſition.

Form, amorphous.

Luſtre, of the grey part, ſilky, verging to the ſemimetallic 3. Tranſparency 0.

Fracture, preſents a confuſed appearance of the foliated and fibrous, the fibres ſo faint as to be ſcarcely diſtinguiſhed, preſenting diſtinct concretions, irregularly bundled, and in the groſs often obſcurely ſlaty.

Hardneſs from 2 to 4. Sp. gr. of the ſpecimen Leſke, O. 1186, that which was the pureſt was 2,584, that of another, Leſke, O. 1188, which was mixed with iron, ochre, and pyrites, 3,872.

The purer ſpecimen melted at 154° into a brittle porous opake black ſhining maſs; the heavier being heated to redneſs became partly purple, and partly browniſh red; and at 147° melted partly into a compact ſlagg, and partly agglutinated into a porous brittle maſs.

14th Species.

Aſbeſtinite. Gemeiner Strahlſtein of Werner.
Leſke, O. 1190, 1199, S. 374.

Colour, white with ſhades either of red, yellow, or green, or blue.

Amorphous.

Luſtre, ſilky, approaching to the ſemimetallic, 3. Tranſparency, 1, 2.

Fracture, ſhattered foliated, or broad ſtriated, ſometimes faintly ſeamed.

Preſents oblong diſtinct concretions, running in different directions.

Hardneſs, from 5 to 6. Sp. gr. from 2,806 to 2,880.

At 150° melts into a green glaſs.

It is ſometimes diſguiſed by a thin cruſt or illinition of black manganeſe, which exhibits the the ſame radiated appearance.

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15th Species.

Aſbeſtoid.

Of this I diſtinguiſh two Families.

1ſt Family.

Common Aſbeſtoid. Gemeiner Strahlſtein of Werner. Leſke O. 1191-2-3-5-7-8, and 1200, and S. 373.

Colour, olive or leek green, when decompoſing reddiſh brown.

Amorphous.

Luſtre, common 2, when glaſſy 3, when decompoſing 0. Tranſparency 0.1.

Fracture, ſometimes foliated, ſometimes broad-ſtriated, the ſtriæ diverging from one or more central points.

The foliated may even be conſidered as tending to, or departing from, a common center.

Hardneſs from 6 to 7. Sp. gr. from 3 to 3,31.

At 160° it melted into an opake, black compact glaſs.

This ſeems to be the ſtone analyzed by Mr. Weigleb, and in which he found 43 per ct. ſilex, 22 magneſia, and 34 of iron, and ſome traces the ſparry acid. 1 Chy. An. 1785, 21.e ſp

2d Family.

2d Family.

Metalliform Aſbeſtoid. Aſbeſtartiger Strahlſtein of Werner, in part. Leſke, O. 1187.

Colour, grey, or inclining to the reddiſh grey.

Amorphous.

Luſtre, ſemimetallic 3. Tranſparency 0.

Fracture, foliated, or what ſome would call broad-ſtriated; often ſeemingly converging to a common center.

Hardneſs from 8 to 9. Sp. gr. 3,356.

At 152° melts into a compact black glaſs.

16th Species.

Lamellar Actynolite. Aſbeſtartiger Strahlſtein of Werner. Leſke, O. 1189.

Colour, dark yellowiſh, or greeniſh grey.

Amorphous.

Luſtre, in ſome poſitions feeble, in others 3 and glaſſy. Tranſparency, 0, or ſcarcely 1.

Fracture, the ſhattered foliated, the edges of the broken lamellæ give, however, a ſtriated appearance.

Hardneſs 7, brittle. Sp. gr. 2,916.

By a red heat it becomes in ſome places whiter, in others redder, and upon the whole harder. At 168° it melts into a dark green compact glaſs.

It has a ſtrong reſemblance to hornblende.

17th Species.

Shorlaceous Actynolite. Gemeiner Strahlſtein of Werner, in part. Leſke, O. 1194, 1196, 1201.

Colour, leek or dark green. External luſtre, 3,4. glaſſy Internal 1,2. Tranſparency 2,3,1.

Cryſtallized generally in long, ſlender, quadrangular, hexangular, or (apparently) triangular, priſms, with perfectly ſmooth ſurfaces, or rather pyramids, being thicker at one end than at the other, and hence called *ſtrahl*, or *arrow ſtones*. Sometimes a ſmall pyramid adheres longitudinally, and, as it were, grows out of a larger; ſometimes many adhere together. In Siberia, it is ſaid, ſome are found 5 feet long, and 15 inches thick. 1 Chy. Ann. 1785, 265.

Fracture, hackly.

Hardneſs from 7 to 10. Sp. gr. from 3,023 to 3,45.

The ſpecimen, Leſke, O. 1196. whoſe ſp. gr. was 3,023 melted at 154° into a dark green compact glaſs.

18th Species.

Glaſſy Actinolyte. Glaſſartiger Strahlſtein of Werner.

Colour, leek green, or (from decompoſition) verging to the greeniſh white, or ſilvery white, or ſtained with yellowiſh, or browniſh red.

External luſtre, 3,4. ſometimes glaſſy, ſometimes ſilky. Internal 0. Tranſparency 2.

Cryſtallized in ſlender compreſſed quadrangular or hexangular pyramids, or fibres, cloſely and longitudinally adhering to each other, ſtreight or incurvated, or conſiſting of fibres undulatingly incurvated, and adhering in the ſame manner.

The face of the fracture of ſingle pyramids cannot be diſcerned, that of the collection is hackled; but the longitudinal fracture is fibrous, the fibres ſometimes parallel, ſometimes diverging, and often from many central points.

Fragments, long ſplintery, and exceeding ſharp, ſo as to be difficultly handled without injury.

Hardneſs, difficult to eſtimate, on account of their brittleneſs. Sp. gr. of ſome ſpecimens that had a glaſſy luſtre, I found to be 2,950, of the ſpecimen 1205 *Leſke*, O. which has a ſilky luſtre, 3,493.

The laſt mentioned ſpecimen melted at 149° into a compact dark green, almoſt black glaſs.

But the ſpecimens that were cryſtallized in needles, of great ſubtlety, but whoſe planes and angles were ſtill diſcernible as thoſe in Leſke, O. 1203, 1204, melted at 137° into a grey, ſomewhat porous maſs, and at 159° into a yellowiſh grey compact porcelain, with an enamelled ſurface, and began to act on the crucible.

The ſubſtance, called by Mr. Bergman, the *fibrous ſhorl of Grænge*, ſeems to be of the ſort of which we here treat. It is, he tells us, of a green, bordering on white, and conſiſts of ſlender parallel tranſparent fibres, brittle as glaſs; and melts into a ſcoriform maſs. In this he found 72 per ct. of ſilex, 12,7 of aërated magneſia, 6 of aërated

aërated calx, 2 argill, and 7,3 of calx of iron. 4 Bergm. 171.

The *fibrous ſhorl* (as he calls it) of Zillerthal, in Tyrol, ſeems alſo of this ſpecies; it contains by his analyſis 64 per ct. ſilex, 20 aërated magneſia, 9,3 aërated calx, 2,7 argill, and 4 calx of iron. *Ibid.* 172.

We may alſo vindicate to this ſpecies the ſtone called by Mr. Sauſſure *ſhorl en filets brillants et fragiles*, ſo ſharp as ſcarcely to be handled with impunity. In it he found 0,5525 ſilex, 0,3018 argill, 0,1087 unaërated magneſia, 0,0484 unaërated calx, and 0,0148 of iron. 2 Sauſſ. 470. Here not only the large proportion of argill is remarkable, Mr. Bergman having ſcarcely found any, but that magneſia and calx ſhould be *unaërated*, whereas Bergman in all the ſtones of this Genus found them *aërated**.

The great ſp. gravity of theſe ſtones, conſidering the moderate proportion of iron, found in them, alſo deſerves attention. May not the new earth, called ſtronthian, be found in them? and may it not have been miſtaken for calx?

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* Of the ſix foregoing ſpecies I have given the deſcriptions from my own obſervations; they are all comprehended by Mr. Werner, under the name of *ſtrahl ſtein*, and of them he makes three diviſions, the aſbeſtine, common, and glaſſy. The arrangement I have followed ſeems to me more exact, though not out of the reach of cavil.

19th Species.

Jade. Nephrit of Werner. Bitterſtein of Hoepfner, and others.

Colour, generally dark leek green, or verging to blue, or in ſome prominencies inclining to the greeniſh, or bluiſh white; and even the greener parts, when freſh broken, diſcover pale whitiſh ſplinters, ſometimes yellowiſh white, with a light ſhade of green.

Found in detached rounded maſſes, or inhering in rocks.

Surface, often ſmooth, often ſomewhat uneven.

External luſtre, 1, waxy. Internal 0, or ſcarcely 1. Tranſparency 2, 1.

Fracture, coarſe or fine ſplintery; yet often diſcovers here and there a few fibres ſomewhat incurvated. Fragments 3, 4.

Hardneſs 10, not brittle. Sp. gr. of the ſpecimen Leſke, O. 1116, which came from the Eaſt Indies, by my trial, 2,977. Briſſon found that of green Jade 2,9660; and that of whitiſh, or olive-coloured jades, from 2,950 to 2,9829. Mr. Sauſſure found thoſe of oriental jades from 2,970 to 3,041; but the jades of Swiſſerland he found ſtill heavier, namely from 3,31 to 3,389. He alſo found them harder.

It feels greaſy.

According to Dolomieu it becomes more tranſparent and brittle when heated. 40 Roz. 215.

But

But is ſaid to be infuſible in the ſtrongeſt heat of our furnaces.

According to the analyſis of Mr. Hoepfner, it contains 0,47 ſilex, 0,38 aërated magneſia, 0,04 argill, 0,02 aërated calx, and 0,09 iron.

20th Species,

Combined with the Boracic Acid, and boracited Calx.

Boracite *.

Colour, greyiſh white, ſometimes paſſing into the greeniſh white, or purpliſh.

Hitherto it has been found only in cubes, whoſe angles have been more or leſs deeply cut off.

Their ſize ſcarcely exceeds ½ an inch. The ſurfaces generally ſomewhat corroded.

The external luſtre, if the ſurface be ſmooth, 3; if rough 0. Internal, greaſy, 2.

Tranſparency (except it be covered with an opake rind) 2.3.

Fracture, compact, and of the ſmall flatted conchoidal kind. Fragments 3.

Hardneſs, 9, 10. Sp. gr. 2,566.

Expoſed to the ſtrongeſt heat, it contracts, and at laſt melts into a yellowiſh glaſs.

It does not efferveſce nor diſſolve in acids, unleſs heat be applied.

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* 2 Bergm. Journ. 1790. 234. 2 An. Chy. 102, 137. 3 Berl. Beobacht 1.

Abbé Hauy, has diſcovered that it becomes electric by heat, like Tourmaline; but the diſcovery of its component parts, one the moſt important and leaſt expected hitherto made in mineralogy, was reſerved for Mr. Weſtrumb; he found it to contain 0,68 boracic acid, 0,13 magneſia, 0,11 calx, 0,01 argill, 0,01 ſilex, and 0,01 iron. The three laſt he juſtly conſiders as caſual.

The mountain of Kalkberg, near Luneburg, is the only place that as yet affords it. It is there ſeated in a bed of gypſum.

SECTION IX.

Argillaceous Genus.

1ſt Claſs.

Argillaceous Earths.

THESE are for the moſt part diffuſible in water, and do not immediately ſink in it as ſands do; or if ſo compact as immediately to ſink, they ſoften, crumble, or moulder away in it, ſome ſooner, ſome later, either to a ductile viſcid pulp, or to a powder.

Hardneſs, ſcarce ever exceeds 6; they harden when heated; ſcarce ever effervеſce with acids, and are difficultly ſoluble in them.

As earths originally received their denominations from external and not from internal characters, they cannot now, without creating much confuſion, be arranged according to their real ſpecific properties, if any ſuch could be aſſigned. But in fact none ſuch can, except fuſibility or infuſibility, which depend on proportions and ingredients both mutable and caſual. Hence I ſhall ſort them under the title of different Tribes; marking the caſes in which theſe are found to be more or leſs fuſible, or adapted to various uſes.

1ſt Tribe.

Native Argill. Lac Lunæ of ſome. Reinethon Erde of Werner.

Colour, pure white.

Found in neſts, in compacted rounded kidney-form maſſes.

Luſtre, 0. Tranſparency, 0.

Fracture, earthy. Fragments, 0. Hardneſs, 4, brittle. Sp. gr. moderate.

Feels meagre, but ſoft.

Adheres very ſlightly to the tongue, ſtains very ſlightly.

Does not readily diffuſe itſelf in water.

Infuſible at 166°.

It ſometimes efferveſces with acids, being ſaturated with fixed air, a circumſtance which is rarely obſerved in earths of the argillaceous kinds; and to this union we may aſcribe its meagre feel, ſlight adherence to the tongue, and little attraction to water. It is not perfectly pure; for, it was found by Mr. Schreiber to contain a very ſmall proportion of aërated calx, and in ſome ſpecimens a little gypſum, alſo ſome feeble traces of iron; but (as it ſeems) no ſilex, which diſtinguiſhes it from *clays* properly ſo called.

It has been found at Halles, in Magdeburgh, and, as ſome ſay, at Verona.

Of Clays in general.

The conſtituent parts of clays are argill and ſiliceous ſtones, from the ſize of $\frac{1}{100}$ to $\frac{1}{1000000}$ of an inch. All other ingredients (except water), and there are many, are extraneous to its compoſition.

The proportion of theſe 2 ingredients to each other is variable; ſometimes the argill exceeds, but moſt commonly the ſiliceous ingredient predominates. When the argill exceeds, its proportion to ſilex ſcarce ever reaches, but ſometimes approaches, the ratio of 4 to 1; but more frequently ſubſiſts in the ratio of 3 to 1, or 2 to 1, or 1,5 to 1, or approaching ſtill nearer to equality. When the ſiliceous ingredient exceeds, which is by far the commoneſt caſe, it is found at moſt, and very rarely in the proportion of 6 to 1, more commonly in that of 4 to 1; and ſtill oftener in that of 3 to 1, or 2 to 1, more rarely it approaches an equality.

Theſe proportions produce different effects. Thus the clays, in which the ſiliceous ingredient enters in the proportion of from 3 or 4 to 1, are beſt for porcelain, thoſe in which the argill exceeds are beſt for coarſe pottery; and particularly for the glaſs-houſe crucibles, as being leſs acted on by alkalis *.

The kind of ſiliceous ſtone which conſtitutes the ſandy part of clay, ſhould alſo be attended to; I believe it to be more frequently quartz,

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* 14 Ann. Chy. 143. 3 Neu. Entdeck. 13. 35.

but it may alſo be hornſtone, or felſpar, or of various other ſpecies, which will much influence the internal properties of the clay. The nature of the ſand ſhould therefore be tried, after ſeparating it as much as poſſible by waſhing. If the ſand be of the quartz kind, it is beſt ſeparated by boiling the whole in oil of vitriol, which will take up the argill and leave the quartz; but if it be a comminuted felſpar, or other compound ſtone, this ſtone itſelf will be decompoſed by that acid; ſo that the trial ſhould rather be made on the part ſeparated by waſhing.

The colours that occur in clays are very numerous, and depend on metallic, or vegetable, or bituminous, or coaly particles, pure clay being always white. The colours ariſing from the particles of a vegetable, coaly, or bituminous nature, are deſtroyed by heat in an open fire, and therefore are no way prejudicial to the finer uſes to which clay may be applied; but thoſe ariſing from metallic particles are moſt obſtinate. Sometimes, however, the metallic particles are engaged only in the coarſer ſandy part, and may with it be ſeparated by elutriation; ſometimes they are picked out by the hand.

With reſpect to fuſibility, we may remark, that clays, which contain only argill and ſilex, will melt in no heat that can be produced by our furnaces, in whatever proportion theſe two ingredients may be to each other.

But calcareous earth, in the proportion of 10 or 12 per ct. will render any clay fuſible. Calces of iron, if united to the argill, will render the clay fuſible; but, if united to the ſiliceous part,

and

and if this part conſiderably predominates, the clay will not be fuſible.

It ſhould ſeem, therefore, that an addition of pure ſilex to any clay in ſuch proportion as not to deſtroy its ductility, would not render it fuſible; the addition of lime, or calces of iron, would, on the contrary, render any clay fuſible.

As the infiltration of water frequently conveys calcareous earth, and calces of iron, and as beds of coal obſtruct this infiltration, hence the clays found under coal are generally the moſt infuſible.

2d Tribe.

Porcelain Clay. Kaolin.

Colour, white, greyiſh white, or reddiſh, or yellowiſh white.

Luſtre, 0. Tranſparency, 0.

Friable and duſty, often compact.

Adheres very ſlightly to the tongue.

Feels ſoft but not greaſy.

Hardneſs ſeldom exceeds 4; but lately ſome much harder has been found in Siberia. Maquart 430. Sp. gr. (which is beſt taken when hardened by fire) varies with the proportion of its ingredients between 2,23 and 2,4. That of Limoges, which is worked without any mixture, has its ſpec gr. 2,341. Briſſon 273.

In water it immediately falls into powder. Thoſe of Japan, and St. Iriez in France, are perfectly white; thoſe of Saxony, reddiſh, or yellowiſh;

owiſh; thoſe of China, and Cornwall, are mixed with particles of talc and mica.

In general porcelain earth is infuſible in our furnaces, as Cronſted remarked; but, in manufacturing this earth, ſome fuſible ingredient is commonly added; however, nature ſometimes furniſhes theſe ingredients with the earth, and to this compound we cannot refuſe the name of porcelain earth. According to Mr. Haſſenfraz, to whom mineralogy, in all its branches, and the arts therewith connected, are much indebted, the porcelain earth of Limoges above mentioned contains, when dried, 0,62 ſilex, 0,19 argill, 0,12 magneſia, and 0,07 baroſelenite[*]. Mr. Wedgwood, in the porcelain clay of Cornwall, found on the contrary 60 per ct. argill, and only 20 of ſilex; this clay is therefore infuſible. When dried by a ſummer heat, or that of a room moderately warm, it loſes about $\frac{1}{100}$ of its weight; in the heat of boiling water as much more; in that of melted lead, and thence to a ſtrong red heat, in which copper melts $\frac{10}{100}$, in all $\frac{12}{100}$; after that no more. The matter thus loſt is common and fixed air, but no inflammable air. Hence it appears to differ from the firſt tribe only in containing ſilex.

3d Tribe.

Common Clays in various ſtates of Induration.

Of this tribe Mr. Werner diſtinguiſhes three ſorts, which I call families. Their ingredients

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[*] 14 An. Chy. 144.

may differ conſiderably, as they are denominated, from their external appearances only. They are all conſidered here in their pureſt ſtate, and *dry.*

1ſt Family.

Potters Clay.

Colour, generally greyiſh white, and then called *pipe clay*, or light yellowiſh, white, or grey, or dark bluiſh grey, more rarely browniſh black, or pale reddiſh, or greeniſh grey, or mountain green, or ochre yellow, and often ſpotted only with this.

Often found in large ſtrata.

Luſtre, 0. Tranſparency, 0.

Fracture, fine earthy, and, from a number of rifts, ſomewhat uneven.

It ſtains the fingers ſlightly.

It acquires ſome poliſh by friction.

It adheres to the tongue moderately.

It feels greaſy.

Hardneſs, 3 or 4. Sp. gr. from 1,8 to 2.

It is entirely diffuſible in water; and, when duly moiſtened, very ductile.

When unmixed with metallic particles (which may be known by expoſing it to a ſtrong heat, as already mentioned) it is infuſible at 160°; but it is not therefore fit for making porcelain; for this requires that the ſandy part ſhould be of the greateſt fineneſs, and alſo that it do not retain water with obſtinacy, which it always does when the argill is not combined with fixed air; and hence, I believe, we may derive the practice of expoſing clays to the air for a long time, before they are employed.

It does not efferveſce with acids, unleſs contaminated with mild calx or magneſia in a conſiderable proportion, and then is rather a marl. There are few clays, however, that do not contain ſome proportion of calcareous earth.

It is expoſed to many contaminations from iron and pyrites; if iron be united to the argillaceous part, it is fuſible.

The proportions of argill and ſilex vary conſiderably, as we have already ſeen.

2d Family.

Indurated Clay. Verharteter Thon of Werner.

Colour, grey, yellowiſh, bluiſh, or greeniſh grey, or brick or fleſh red, or mountain green, or reddiſh brown, or blackiſh brown.

It frequently contains the roots of vegetables.

Luſtre, 0. Tranſparency, 0.

Fracture, earthy, ſometimes participating of the even, and ſometimes of the ſplintery, and ſometimes tending to the ſlaty. Fragments, 1.

Hardneſs, from 5 to 6. Sp. gr. inconſiderable.

Slightly adheres to the tongue. Often feels ſomewhat greaſy; often not. In water it does not diffuſe itſelf, but gradually falls to pieces, or crumbles into powder, and diſcovers but little ductility. Some ſorts do not moulder in many days.

It hardens when heated.

Sturbridge clay ſeems of this ſort. Colour, dark grey; does not adhere to the tongue. I found 100 parts of it in the ſtate of dryneſs in which it comes to us to contain 12,5 per ct. of moiſture, 12 of coarſe ſand, partly white and cryſtalline, and partly brown and reddiſh brown, and 30 per ct. of a browniſh ſand, ſo fine as ſcarcely to be diſcerned through a lens. The argillaceous part was grey, and contained ſtill more ſand, which could not be ſeparated but by boiling in acids.

Water quickly acts upon it, a white argillaceous part ſoon diffuſes itſelf, and afterwards another part which is darker falls into powder; hence it ſhould ſeem there are two ſorts of indurated clay. The ſandy, and the clayey.

3d Family.

Shiſtoſe Clay.

1ſt Variety. Slate Clay, Shale.

Schiefer Thon of Werner.

Colour, generally bluiſh, or yellowiſh grey, more rarely dark blackiſh, or reddiſh grey, or greyiſh black, or greeniſh yellow. Often found in ſtrata, particularly in coal-mines, of which it is almoſt a ſure fore-runner; it commonly bears vegetable impreſſions. Its ſurface generally knobby.

Luſtre, externally it hath often ſome gloſs, but none in its fracture, or only preſents a few ſhining particles. Tranſparency, 0.

Fracture, ſlaty, ſometimes bordering on earthy. Fragments, 2.

Hardneſs from 4 to 6. Sp. gr. from 2,6 to 2,68.

Adheres ſlightly to the tongue.

Feels meagre or merely ſmooth. Gives a white or grey ſtreak.

Gradually moulders, and falls into powder in water; but the harder ſorts very ſlowly. The harder as that in Leſke O. 786, melted into a frothy maſs, partly lead coloured, and partly dark greeniſh yellow, between a porcelain and an enamel. Another ſpecimen, Leſke O. 784, melted at 151° into a frothy maſs, partly pearl grey, and partly liver-brown, between porcelain and enamel.

When it contains mica it is not ſo probable an indication of coal. Voight, Prack. Gebirg. 85.

2d Variety.

Bituminous Shale. Brandſhiefer of Werner.

Colour, browniſh black, or blackiſh brown, and looks like bad coal.

Found in conſiderable ſtratified maſſes.

Luſtre, 0, or 1. Tranſparency, 0.

Fracture, ſlaty; the ſlates moſtly thin, often thick. Fragments tabular.

Hardneſs, 5. Sp. gr. about 2,000.

Its ſtreak ſomewhat gloſſy.

It often efferveſces, though very ſlowly, with the mineral acids.

Feels rather greaſy.

Placed on burning coals, it burns with a weak flame, and ſulphureous ſmell; the reſiduum is then light grey. It thus loſes a conſiderable part of its weight. Some will hardly burn but with the aſſiſtance of bellows.

It ſeems to differ from the former variety, in containing bitumen.

The ſpecimen in Leſke O. 961, has its ſp. gr. 1,995; and that of Leſke, 959, has its ſpec. grav. 2,053. Both efferveſce, though very ſlowly, with acids.

It ſometimes bears the impreſſion of fiſh.

4th Family.

Fuller's Earth. Walkererde of the Germans, Smectis.

Colour, the foſſil ſo called, has almoſt always ſome ſhade of green, commonly light olive, greeniſh grey, or greeniſh white, or greeniſh brown, more rarely yellowiſh grey, or greyiſh white. The greeniſh ſhade is made viſible when the earth is breathed on, or moiſtened. Fleſh red has alſo been found in Saxony, but of an inferior quality.

Luſtre, 0. Tranſparency, 0.

Fracture, earthy, often inclining to the uneven, ſometimes to the ſlaty, ſometimes fine earthy, and ſlightly participating of the conchoidal. Fragments, 0.

Receives a poliſh from friction.

Does not adhere to the tongue.

Feels ſomewhat greaſy.

Hardneſs, 4, almoſt friable.

In water it readily falls into powder without conſiderable diffuſion, or forming a pulpy maſs. Some imagine theſe earths ſhould froth and lather with water, but though this poſſibly may ſometimes happen, yet certainly not generally; for Mr. Werner denies this property to the fulling-earths of Saxony, Mr. Bergman to that of Hampſhire, and Mr. Becker to that of Weſterwalds *.

Mr. Bergman has given an accurate account of the fuller's earth of Hampſhire; its colour is brown, with a ſcarce perceptible ſhade of green, and ſtreaked with pale yellowiſh veins, with ſome ſlaty appearance. Water boiled on it for half an hour, though filtered, ſtill retains ſo much of it as to diminiſh its tranſparency. In this water the ſolution of marine baroſelenite diſcovers nothing vitriolic; but the ſolution of ſilver does indicate ſome traces of marine acid. If this earth be heated to redneſs, it blackens; but this blackneſs vaniſhes in a higher heat, which ſhews it to proceed from ſome vegetable or coaly matter. When heated it ſlightly decrepitates, and in a ſtrong heat forms a brown ſpongy maſs. Heated with microcoſmic ſalt, it at firſt efferveſces ſlightly, but afterwards is ſcarcely acted on; borax corrodes it better, but conſumes it ſlowly. Soda attacks it with conſiderable efferveſcence. By his analyſis it contains 0,518 ſilex, 0,25 argill, 0,033 aërated calx, 0,037 calx of

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* Werner, Cronſt. 182. 4 Bergm. 155. 1 Berl. Beob. 20.

iron, 0,007 aërated magneſia, 0,155 moiſture, or volatile matter.

Though this earth contains 4 per ct. of ſubſtances that ſhould efferveſce, yet it does not efferveſce with acids; which induces Mr. Bergman to think, that the calx and magneſia may be chemically combined with the argill, and not merely mechanically mixed as in marls. Some fulling-earths, it is ſaid, efferveſce ſlightly with acids [*], but the beſt certainly do not; and it is plain from the ſmall quantity of effervesſcible matter found in that of Hampſhire, that neither the calcareous ingredient, nor the magneſia, do of themſelves contribute in the leaſt to the fulling property. The great uſe of this earth is to deprive the cloths of greaſy ſubſtances with which they are impregnated, before they are ſoaped; this advantage they evidently derive from the argillaceous ingredient; this, therefore, ſhould be ſufficiently copious, not leſs than 20 or 25 per ct. and not too unctuous, for it would not then readily diffuſe itſelf in water; perhaps, indeed, the union of the calx and magneſia contributes to this prompt diffuſibility. The ſiliceous ingredient ſhould be very fine, leſt it ſhould cut the cloth; this fineneſs is indicated by the poliſh the earth receives by rubbing it with the nail; hence any clay that poſſeſſes theſe properties may be uſed for fulling [†]; but a mixture of pyrites, or 3 or 4 per ct. of calx of iron, is hurtful.

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[*] 2 Gerh. Geſch. 350.

[†] 4 Bergm. 159. 2 Gerh. Geſch. 352. 1 Genſanne Hiſt. Nat. Langued. 158.

In Saxony this earth commonly lies under mould; in England under ſandſtone or ſand, and over ſandſtone or limeſtone; in Germany it has alſo been often found ſo ſituated; ſometimes too in the neighbourhood of Trap, or Baſalt. 1 Berl. Beobacht, 21.

4th Tribe.

The finer Clays in various States of Induration.

1ſt Family.

Lithomarga. Steinmarck of the Germans.

Theſe earths are principally diſtinguiſhed by their great fineneſs, and fuſibility into a frothy ſlagg.

1ſt Variety.

The friable or crumbling kind.

Colour, white, or yellowiſh, or reddiſh white.

Luſtre, 1 or 0. Tranſparency, 0.

Seldom looſe, moſt commonly moderately coherent, and formed of ſcaly or exceeding fine particles, and then adheres ſtrongly to the tongue. Scarcely ſtains the fingers.

Feels very ſmooth. Aſſumes a poliſh by friction with the nail, Fracture, earthy, often uneven, and groſly conchoidal. Hardneſs from 3 to 4. Sp. gr. exceedingly light.

In water it immediately breaks and falls into powder.

2d Variety.

Indurated Lithomarga.

Colour, greyiſh, reddiſh, or yellowiſh white, or pearl grey, or fleſh red, or browniſh red, or yellowiſh, or reddiſh, or liver-brown, or ochre, or Iſabella yellow, or bluiſh grey, or violet blue, or lavender blue, or ſpotted or veined with theſe different colours.

Generally found in neſts or veins of rocks, or entering into the compoſition of aggregate ſtones as a conſtituent part.

Surface, frequently very ſmooth, poliſhed, and fine and cloſe grained, having the aſpect of a ſtone.

Luſtre, external, often 2; internal, 0. Tranſparency, 0.

Fracture, earthy, often conchoidal, more or leſs perfectly, or inclining to the even; nay, ſometimes to the ſlaty. Fragments, 0; yet ſometimes, 2.

Hardneſs, from 4 to 6, or even 7. I found the ſp. gr. of the harder ſorts, 2,815.

The ſofter ſorts adhere ſtrongly to the tongue where newly broken, the harder ſorts very moderately *.

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* 2. Bergm. J. 1788, 520.

Commonly feels very greaſy, or at leaſt ſmooth, yet ſome feel dry and duſty. Does not ſtain the fingers. The ſofter acquire a poliſh by friction.

The coloured give a ſtreak, or powder of the ſame colour.

In water the harder ſorts do not eaſily yield; but the ſofter immediately crumble.

According to Cronſted, § 85, the characters of this earth are,

1ſt, A ſmooth ſoapy ſurface while dry.

2d, A gradual diſintegration in water; firſt into ſmall pieces, and afterwards into grains, but not into a pulp, as happens to potters clay.

3d, In a ſtrong heat, fuſion into a frothy maſs, which occupies more room than the crude earth had done.

4th, A lamellar, or rather, as Mr. Bergman quotes it, a conchoidal fracture.

The earth, called *mountain ſoap*, differs from this only in being ſofter, feeling more greaſy, adhering more ſtrongly to the tongue. Its colour is dark brown, or pearl grey; its fracture earthy, or participating of the earthy and conchoidal. Hardneſs, 4.

Mr. Bergman analyzed the grey Lithomarga of Oſmund; its ſurface feels greaſy, though ſomewhat uneven. It appears ſlaty, yet its fracture is conchoidal. Fragments ſharp. Hardneſs 5; it is acted on by water as above mentioned; does not lather, yet is deterſive, it melts into a white frothy maſs. It contains 60 per ct. ſilex, 11 argill, 5,7 aërated calx, 0,5 aërated magneſia, 4,7 calx of iron, and 18 of water and air.

The beautiful earth, called *terra miraculoſa Saxoniæ*, is by Mr. Werner reckoned of this family;

mily; but, if fuſibility be an eſſential property of lithomarga, this earth does not belong to it; for neither of the ſpecimens, 1080, 1081, Leſke O. are fuſible in a heat of 150°, but harden into a brittle blackiſh maſs, and ſeemed to me to contain charcoal. The ſpecimen 1080 poſſeſſes, indeed, all the other characters of the harder lithomargas; but the ſpecimen Leſke O. 1079, feels dry, and ſcarcely adheres to the tongue; ſo that I conſider it rather as an indurated clay.

A lithomarga phoſphoreſcing when ſcraped, of a pearl colour, and ſomewhat ſemitranſparent, was diſcovered in the Hartz by Baron Trebra. 1 Chy. An. 1784. Laſius, Hartz 313. Is it not rather a mixture of lithomarga and bole?

3d Family.

Bole.

Colour, dark Iſabella yellow, ſtrongly inclining to brown, or pale liver brown, ſometimes dotted or variegated with black ſpots, or dentritical figures, or reddiſh brown, ſeldom fleſh red.

Luſtre, 0. Tranſparency, ſcarcely 1.

Fracture, conchoidal. Fragments, 2.

Acquires a poliſh by light friction; ſcarcely adheres to the tongue; feels greaſy.

Hardneſs, 4. Sp. gr. from 1,4 to 2.

It immediately crumbles in water into powder, and not into pieces.

Mr. Bergman comprehends this earth under the head of Lithomarga, and gives the following account of Lemnian earth, which is one of the moſt noted boles. Colour, yellowiſh; ſurface, ſmooth and poliſhed like agate; fracture, conchoidal; fragments, angular; grain, cloſe and indiſcernible; hardneſs, ſuch as to admit being ſcraped by the nail. In water it falls to pieces, and theſe into powder; it does not froth like ſoap, but poſſeſſes a deterſive power, like fullers earth.

When heated to a ſufficient degree it melts into a frothy ſcoria.

By his analyſis it contains 47 per ct. ſilex, 19 argill, 5,4 aërated calx, 6 aërated magneſia, 5,4 calx of iron, and 17 of water and air. 4 Bergm. 157.

Hence we ſee, that all the ſofter ſorts of lithomarga are deterſive in ſome degree, and learn to value the *external characters* of Mr. Werner, which point out the beſt for the purpoſe of fulling.

4th Tribe.

Argillaceous Marls.

Colour, grey, yellowiſh, or greyiſh, or brown, or yellowiſh, or reddiſh brown.

Found in conſiderable ſtrata.

Luſtre, 0. Tranſparency, 0.

Fracture, earthy, ſometimes ſlaty, ſometimes conchoidal. Fragments, 0, 1, 2.

Hardneſs from 4 to 7. Often ſhattery. Sp. gr. from 2,4 to 2,6.

Feel ſomewhat unctuous, and adhere to the tongue.

Efferveſce with the mineral acids, but frequently refuſe to do ſo with vinegar.

Moulder and crumble by expoſition to the air, more ſlowly than calcareous marls, ſometimes requiring 5 or 6 years.

When heated they harden into an imperfect brick, which is ſlowly diſintegrated by water.

In a greater heat they form a ſlagg. However, if they contain a large proportion of ſand, the bricks formed by them are quickly diſintegrated by water.

They contain mild calcareous earth, in the proportion of, from $\frac{1}{10}$ to $\frac{1}{4}$ of the whole.

To Dr. Withering, of Birmingham, we are indebted for many well-directed experiments on theſe marls. He found,

1ſt, That a red compact marl, that was ſo plaſtic as to form and burn to a brick, contained $\frac{1}{10}$ of its weight of mild calx.

2d, A grey, in hard lumps, was alſo plaſtic, but gritty, and formed a ſoft brick; it contained $\frac{1}{6}$ of its weight of mild calx *.

3d, A red, with grey ſpots, and very hard, contained about $\frac{1}{4}$ of aërated calx; yet it was plaſtic and burned to a grey hard ſtone.

Mr. Andreas publiſhed a good diſſertation on marls in German, in the year 1769, in which he diſtinguiſhed marls as follows:

1ſt, Marl, properly ſo called, conſiſting of equal parts of clay and mild calx, that is, chalk.

2d, Calcareous marl, conſiſting of three parts chalk and one of clay.

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* Phil. Tranſ. vol. LXIII.

3d, Argillaceous marl, conſiſting of three parts clay and one of chalk. Again, if the marl contains coarſe ſand, gypſum, or mica, he makes the following ſubdiſtinctions:

1ſt, Sandy marl; 2d, Sandy calcareous marl; 3d, Sandy argillaceous marl.

Again, 1ſt, Gypſeous marl; 2d, Gypſeo-calcareous marl; 3d, Gypſeo-argillaceous marl.

And laſtly, Micaceous marl; Micaceous calcareous; and Micaceous argillaceous.

5th Tribe.

Colorific earths, or thoſe which ſtrongly ſtain the Fingers.

1ſt Family.

Red. Reddle. Rubrica fabrilis. Rothel, Leſke, O. 973.

Colour, dark cochenille red, or intermediate, between brick and blood red.

Luſtre, o. Tranſparency, o.

Fracture, earthy, ſometimes conchoidal. Fragments, 1. Hardneſs, 4. Sp. gr. inconſiderable. Adheres pretty ſtrongly to the tongue.

Feels rough; aſſumes a poliſh from the nail; ſtrongly ſtains the fingers.

In water immediately falls to powder; does not become ductile.

Does not efferveſce, nor eaſily diſſolve in acids.

When heated to redneſs it crackles and grows black; at 159° the ſpecimen, Leſke O. 973, melted into a dark greeniſh yellow frothy enamel.

It differs from red ochres only by containing more argill. The red colour proceeds from oxygenation and the abſence of acid. The more air and water is expelled by heat, the browner it grows.

2d Family.

Yellow. Gelbe Erde. Leſke, O. 1098.

Colour, ochre yellow.

Luſtre, externally often hath ſome gloſs; but internally none. Tranſparency, 0.

Fracture, earthy, often inclining to the conchoidal. Fragments, 0.

Hardneſs, 3. Sp. gr. inconſiderable.

Adheres ſtrongly to the tongue; feels ſmooth, or ſomewhat greaſy; takes a high poliſh from the nail; ſtrongly ſtains the fingers.

In water it immediately falls to pieces with ſome hiſſing; and afterwards to powder, but does not diffuſe itſelf through it.

It does not efferveſce with acids, nor is eaſily ſoluble therein.

Heated to redneſs it crackles, hardens, and acquires a red colour; gives a reddiſh ſtreak. At 156° I melted the ſpecimen, Leſke, O. 1098, into a liver-brown porous porcelain maſs.

This yellow earth differs from ochres only in containing a greater proportion of argill; the yellow colour proceeds from the calx of iron, highly oxygenated, and probably containing both water and acid. The earths that contain a larger proportion of iron have rather an orange colour.

According to the analyſis of Mr. Sage, of Paris, who has the merit of preſerving to his countrymen the immenſe gains the Dutch acquired by converting this yellow earth into what is there called *Engliſh red*, it contains 50 per ct. argill, 40 calx of iron, 10 of water, acidulated by vitriolic acid. Mem. Par. 1779, 313.

3d Family.

Black. Black Chalk. Schwartze Kreide, Zeichen Schiefer, Leſke, O. 972. Pierre noir, of Briſſon p. 163.

Colour, greyiſh black.

Luſtre, 0. Tranſparency, 0.

Fracture, imperfectly curved ſlaty. Fragments, 1; partly flat, partly long ſplintery.

Hardneſs, 5, ſp. gr. 2,114, by my trial; per Briſſon 2,186 before abſorption, 2,277 after abſorption of water.

Adheres ſlightly to the tongue, feels ſmooth, aſſumes a poliſh from a knife, gives a black ſtreak, and marks black.

In water does not readily moulder; but if taken out it cracks in a ſhort time.

Does not efferveſce with acids, or eaſily diſſolve therein.

Heated to redneſs it crackles and becomes reddiſh grey.

It contains ſomewhat vitriolic.

4th Family.

Green Earth. Leſke, O. 1013.

Colour, greyiſh green.

Found generally in lumps in the cavities of other ſtones, or externally inveſting them.

Luſtre, 0. Tranſparency, 0.

Fracture, earthy, ſometimes uneven; ſometimes verging to the conchoidal. Fragments, 2.

Hardneſs, from 6 to 7. Sp. gr. 2,637.

Sometimes feels ſmooth; but often ſcarcely; does not aſſume a poliſh from the knife, nor adhere to the tongue, nor ſtain the fingers, nor mark while dry, and when wet but lightly.

In water it often crumbles after ſtanding about half an hour.

Does not efferveſce with acids, nor is eaſily ſoluble therein.

Heated to redneſs it crackles and becomes of a dark reddiſh brown colour; at 147° the ſpecimen, Leſke O. 1013, melted into a black compact glaſs, reſembling that of Baſalt. This ſhews it to conſiſt of ſilex, argill, iron not much oxygenated, and calx of nickel, from which the green colour is derived, beſides water.

Of

Of Umber.

A brown or blackiſh ſubſtance, very light, which moderately ſtains the fingers, and ſtrongly adheres to the tongue; has long been taken for a ſort of clay. but Mr. Hupſch, in the Memoirs of Berlin for 1777 (and, long before that, Dr. Hill, p. 63) has ſhewn it to conſiſt chiefly of particles of decayed wood, mixed with bitumen. This name hath alſo been given to an ochre of the ſame colour, which becomes red when ſlightly heated; but in a ſtronger heat again becomes brown; and in a ſtill ſtronger melts into black glaſs. It is therefore a compound of clay and iron, but in which the iron is the prevalent ingredient. It does not effervſce with acids before torrefaction; but after that operation the martial part is eaſily acted on.

DIFFERENCES OF THE FOREGOING EARTHS.

As the diſtinctive characters of earths are found variouſly combined in the earths above deſcribed, their diſcrimination will be much aſſiſted by ſhewing the properties that diſtinguiſh each from all the others.

Native Argill is diſtinguiſhed,

From *Porcelain earth*, often by its colour, or effervſcing with acids, and its cryſtalline appearance when viewed through a lens, its

its more meagre feel; but beſt by its almoſt total ſolubility in vitriolic acid.

From *Potter's clay*, by the above properties, and a ſlighter adherence to the tongue.

—— *Indurated clay*, by its colour, coheſion, and abſence of ſand.

—— *Slate clay*, by its colour, coheſion, fracture, and infuſibility.

—— *Fuller's earth*, by its colour, meagre feel, and infuſibility.

—— *Friable lithomarga*, by its meagre feel, ſlight adheſion to the tongue, and infuſibility.

—— *Indurated lithomarga*, by its colour, coheſion, meagre feel, and often by its dulneſs.

—— *Boles*, by its colour, opacity, fracture, and meagre feel.

—— *Marls*, by its colour, fineneſs, coheſion, abſence of calx and ſand.

—— *Colorific earths*, by its colour, inadheſion to the tongue or fingers.

Porcelain Clay is diſtinguiſhed,

From *Potter's clay*, often by colour, always by its friability, inunctuoſity, fineneſs and lighter adherence to the tongue, and leſſer diffuſibility in water.

—— *Indurated clay*, by its colour, degree of coheſion and fineneſs.

—— *Slate clay*, by colour, degree of coheſion, fracture, and fineneſs.

—— *Fuller's earth*, by colour, degree of coheſion, and inunctuoſity.

From *Friable lithomarga*, by moderate adheſion to the tongue.

—— *Indurated lithomarga*, by its degree of coheſion, of adherence to the tongue, and by colour.

—— *Boles*, by its colour, fracture, inunctuoſity.

—— *Marls*, by colour, fineneſs, ineffervescence with acids.

—— *Colorific earths*, by colour, inadheſion to the fingers, fineneſs.

Potter's Clay is diſtinguiſhed,

From *Indurated clay*, by its degree of coheſion, adherence to the tongue or fingers, unctuoſity, and diffuſibility in water.

—— *Slate clay*, as from the laſt mentioned; and alſo in fracture.

—— *Fuller's earth*, by colour, adheſion to the tongue, unctuoſity, ſuſpenſibility in water.

—— *Friable lithomarga*, by its inferior fineneſs, ſmoothneſs, and adheſion to the tongue; and its ſuperior hardneſs and ſuſpenſibility in water.

—— *Indurated lithomarga*, by its inferior fineneſs, hardneſs, ſmoothneſs, luſtre, and fracture; and alſo by its greater diffuſibility in water, as well as ductility.

—— *Boles*, by its colour, adheſion to the tongue, inferior fineneſs; and alſo by fracture and diffuſibility.

—— *Marls*, by its fineneſs, hardneſs, and ineffervescence with acids.

From *Colorific earths*, by its colour and intinctivity.

Indurated Clay is diſtinguiſhed,

From *Slate clay*, by its fracture, and commonly by its colour.

—— *Fuller's earth*, by its hardneſs, fracture, inferior unctuoſity, and friability, and diſintegration in water.

—— *Friable lithomarga*, ſufficiently by its hardneſs.

—— *Indurated lithomarga*, by its inferior fineneſs, luſtre, adheſion to the tongue; and often in the fracture and unctuoſity.

—— *Boles*, ſufficiently by its ſuperior hardneſs and fineneſs; and alſo by its fracture.

—— *Colorific earths*, ſufficiently by its intinctivity.

Slate Clay is diſtinguiſhed ſufficiently,

From *All others*, by its fracture, form and colour.

Fuller's earth is diſtinguiſhed,

From *Lithomargas*, by its adheſion to the tongue, inferior fineneſs, (and often) hardneſs.

—— *Boles*, by its colour, fracture, opacity, and inferior unctuoſity.

—— *Colorific earths*, by its intinctivity.

Friable Lithomarga is diſtinguiſhed,

From *Boles*, by adhering to the tongue, by friability, and generally by fracture, colour, and hardneſs.

From *Marls*, by its fineneſs, adherence to the tongue, and ineffervеſcence.

—— *Colorific earths*, by its intinctivity.

Indurated Lithomarga is diſtinguiſhed,

From *Boles*, by adherence to the tongue, opacity, and generally colour; often by hardneſs.

—— *Marls*, by its fineneſs and ineffervеſcibility.

Theſe earths, however, are often mixed, and conſequently muſt exhibit mixed characters; but by an attentive conſideration of theſe the families ſo mixed may be inferred and diſcovered. The arbitrary impoſition of names, without any preciſe enumeration of the properties denoted by theſe names, has already introduced much confuſion in mineralogy; Mr. Werner has laboured very ſucceſsfully in removing it; the denominations ſhould therefore in future be taken in the ſenſe to which he has confined them.

6th Tribe.

Harſh and rough Earths.

Of theſe are two families. Tripoli, and Pouzzolana, or Terras.

1ſt Family.

Tripoli. Hill 67.

Colour, generally pale yellowiſh grey, or iſabella, or pale ochre yellow, or pale or reddiſh brown, or greyiſh, reddiſh, or yellowiſh white, ſeldom greeniſh white.

It is found in a looſe earthy, but oftener in an indurated, conſiſtence.

Luſtre, 0. Tranſparency, commonly 0; yet that of the harder ſorts, if wet, often 1.

Fracture, earthy; in the harder ſorts inclining to the flat conchoidal, ſometimes verging to the ſlaty. Fragments, 0, 1.

Hardneſs from 4 to 7. Sp. gr. of the harder ſort, after ſufficient abſorption of water, 2,529 *. Feels, harſh, dry, and frequently duſty; ſlightly, or ſcarce at all, adherent to the tongue; takes no poliſh from the nail; does not ſtain the fingers.

In water the ſofter ſorts ſoon crumble into powder; the harder ſorts imbibe it, but crumble ſlowly.

It does not efferveſce with acids, unleſs mixed with marl, as it frequently is.

It frequently reddens when heated.

Mr. Haaſſe found this earth to contain 0,90 ſilex, 0,07 argill, and 0,03 iron.

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* The ſpecimen, whoſe ſp. gr. I determined, was that in Leſke O. 981.

Another ſtone, ſeemingly of this kind, though differing in ſome reſpects, was annalyzed by Mr. Klaproth, its colour was whitiſh grey; its fracture, from a number of horizontal rifts, ſeemed ſlaty; to the touch it was meagre, and adhered ſtrongly to the tongue. Its ſp. gr. 2,080; it imbibed water ſtrongly. He found it to contain 0,665 ſilex, 0,07 argill, 0,025 calx of iron, 0,015 magneſia, 0,0125 calx, and 0,19 air and water. 2 Chy. An. 1790, 302.

It is often of pſeudo-volcanic origin, as appears from the Paris Memoirs, of 1769, 276; and perhaps alſo ſometimes really volcanic; but it alſo frequently ariſes from the decompoſition, or diſintegration, of other ſtones.

2d Family.

Pouzzolana, or Terras.

Of this I ſhall treat under the head of Volcanic Products.

Struvian Clay *.

This is a ſort of clay lately noticed, and deſcribed, by Profeſſor Struvius, and found in thoſe elevations that afford ſalt ſprings, and therefore worthy of particular attention.

Colour, dark bluiſh grey, inclining to black.

Found in conſiderable maſſes.

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* 2 Bergm. Journ. 1791, 244.

Luſtre

Luſtre 0, except in the rifts, and there 2. Tranſparency, 0.

Fracture, earthy, yet unequal, diſcovering thick curved laminæ irregularly compacted.

Fragments, obtuſe-angled.

Hardneſs from 4 to 5. Sp. gr. inconſiderable.

It ſtains ſlightly, adheres ſomewhat to the tongue, and feels ſomewhat greaſy.

Beſides argill, it contains ſome magneſia, and calcareous earth.

Miſcellaneous Obſervations.

Coloured clays of the common or coarſer kinds, which are by French writers called *glaiſe*, were found by Mr. Morveau to contain ſome contamination of the vitriolic acid; but in white clays he could diſcover none. 1 Encyclop. Chym. 122.

This acid is probably united to the ferruginous particles that are found in thoſe clays, and to which they owe their colour and fuſibility. The *yellow*, however, ſometimes derive their colour from Regulus of antimony, biſmuth, lead, ſilver, or zinc. Rinman, Hiſt. Ferri § 197.

Blue clays and marls ſometimes whiten when heated, and conſequently owe their colour to volatile matter, coal, or bitumen; but ſome redden, and contain pyrites. This trial ſhould be made before they are uſed as a manure; as the firſt are innocent, the laſt hurtful. Neither Beamé nor Woulfe could find any vitriolic acid in ſome blue clays, moſt probably in thoſe of the firſt kind, and poſſibly not even in the ſecond, as the barytic teſt, the

the niceſt of all, was not known when their experiments were made.

Mr. Bergman found copper and cobalt in ſome blue clays; from others Mr. Rinman extracted 13 per ct. of iron, and 4 of lead, beſides ſome traces of zinc. § 201.

Black clays are ſometimes bituminous, ſometimes pyritous.

Dr. Watſon, in his elegant and uſeful Tracts, vol. II. p. 288, mentions a ſingular clay, (or rather earth, ſince it contains no ſand,) which burns to a white brick. It contains 25 per ct. of aërated calx, 2,2 ſelenite, with a ſmall quantity of calx of iron, the remainder argill. However, as this clay was not treated with vitriolic or any mineral acids, which alone can ſeparate the argillaceous from the ſiliceous parts, it is probable, it ſtill contained ſand of great fineneſs. I alſo believe the ſelenite to have been formed during the drying.

Of *brick clay* the colours are various, reddiſh, bluiſh, brown, or yellowiſh; the beſt is that which, when burned, has the feweſt cracks, and this depends on the proportion of ſand it contains; if it contains too much, the clay will not be ſufficiently ductile; if too little, the bricks will be rifty; and in that caſe more fine ſand ſhould be added. Therefore, potter's clay, if ſufficiently ſandy, will ſerve; the beſt proportion is, I believe, 0,86 ſilex to 0,14 of argill. Argillaceous marls are alſo very proper, but they ſhould be well burnt to vitrify the calcareous part; but calcareous marls vitrify too eaſily, and therefore require an addition of clay. The coarſe martial clays, that contain ſcarce any calcareous particles, are beſt; when ſlightly burned they are reddiſh, when more, they become yellow, or browner. Salt thrown into the kiln when at its greateſt heat, will vitrify the ſurfaces of the bricks, and prevent their abſorbing water.

This clay often contains ſelenite, which is decompoſed by the common ſalt contained in mortar, and hence the glauber ſalt found effloreſcing on bricks. This is alſo decompoſed by the joint action of fixed air and lime; and hence the effloreſcence of mineral alkali.

Volatile alkali has often been found in clays and earths, particularly in thoſe that contain iron; a circumſtance which had long puzzled mineralogical writers; but which has of late been happily explained by Dr. Auſtin, whoſe premature death cannot be too much deplored. He has ſhewn, by well contrived experiments, that when inflammable air, in its naſcent ſtate, ſlowly and gradually meets mephitic air, they combine and form vol. alkali. Now iron in its metallic ſtate, ſojourning with water, always extricates inflammable air; which meeting with the mephitic part of the common atmoſphere, thus forms volatile alkali.

2d Claſs.

Stoney ſubſtances of the Argillaceous Genus not mouldering in water.

1ſt Species.

1ſt Species.

Argill combined with vitriolic acid, or ſulphur.

This forms ores of alum, and ſhall therefore be conſidered in the 2d part of this treatiſe.

2d Species.

Argill combined with the Phoſphoric Acid.

Phoſpholite.

The ſtones, commonly called *Valentia garnets*, are ſuſpected by Mr. Prouſt to be of this ſpecies. I have ſeen no deſcription of them; they may be the garnets of Spain, mentioned in 1 Raab's Catalogue, p. 155. Theſe are of the colour of Hyacinth, tranſparent, and of a dodecaedral figure; expoſed to the blowpipe they burſt; but in a moderate heat they ſwell like borax, whiten, and become ſo light as to ſwim on water, after which they are difficultly fuſible. 1 Ann. Chym. 196.

3d Species.

Lepidolite. Lilalite of ſome.

Colour, in the maſs, is violet blue, but in thin laminæ ſilvery white.

Luſtre, pearly, 3. Tranſparency, 1,5.

Fracture, ſtreight foliated. Fragments 2.

Preſents fine grained diſtinct concretions, eaſily ſeparable.

Hardneſs, from 4 to 5, brittle. Spec. grav. 2,816.

Before the blowpipe it melts with a moderate ſpumeſcence into a white ſemitranſparent enamel; with mineral alkali it ſlightly efferveſces, and affords a red and blue ſpotted maſs. Microcoſmic ſalt gradually diſſolves it; borax more readily; the firſt into a white, the laſt into a clear colourleſs pearl.

Expoſed to a red heat for half an hour, it acquires an iſabella yellow colour, and loſes about 1 per ct. of its weight; in a melting heat it forms an opake reddiſh grey enamel, glittering in the fracture, and loſes 25 per ct. of its weight.

By the analyſis of Mr. Klaproth it contains 54,5 per ct. of ſilex, 38,25 of argill, 00,75 of iron and mangane ſe, 2,5 of water and air. He found a loſs of four grains, which aroſe from the diſſipation of ſome unknown matter which cauſed its fuſibility.

4th Species.

Sappare. Cyanite of Werner.

Colour, bluiſh grey, or partly greyiſh blue, partly greeniſh or yellowiſh grey, ſtreaked with azure or deep blue, often in ſome ſpots reflecting a ſilvery white.

Luſtre, pearly, 2.3. Tranſparency, when thin, 3.

Fracture paſſes from the divergingly broad ſtriated, into the curved foliated.

Fragments 2, long ſplintery.

It is found of thin diſtinct lamellar concretions, which are in part accumulated in grains, feels ſomewhat greaſy.

Hardneſs from 6 to 9. Brittle. Sp. gr. from 3,092 to 3,517. That of the ſpecimen which I examined, which is the greyiſh blue, Leſke O. 1185, was 3,092; that of the ſpecimen examined by Mr. de Sauſſure 3,517.

Heated to redneſs it became whiter, and had a more talky appearance; 157° it became almoſt perfectly white, but looked duller, and betrayed not the ſmalleſt inclination to fuſion. It is difficultly fuſed by borax, ſcarcely by microcoſmic ſalt, and not at all by fixed alkalis. According to Mr. Sauſſure, jun. it is compoſed of 0,6692 argill, 0,1325 magneſia, 0,1281 ſilex, 0,0171 calx, and 0,0548 iron. The calx ſeems an adventitious ingredient.

Mr. Struvius, in Crell's Annals for 1790, gives a very different account of the compoſition of this ſtone; for, according to him, it contains 0,515 ſilex, 0,305 magneſia, 0,055 argill, 0,04 calx, 0,05 iron, 0,035 water or loſs. But his experiments not being detailed, nor his method known, I cannot ſet his analyſis in competition with that of Mr. Sauſſure, which appears to have been carefully and ſkilfully executed.

5th Species.

Mica, Muſcovy talc, Glimmer of the Germans.

Its colours are, grey, or yellowiſh, or greeniſh grey, or ſilvery white, or yellowiſh, or reddiſh brown, or copper red, or gold yellow, or mountain green, or greyiſh, or greeniſh black, or leek green; but blue it ſeems has not as yet been ſeen.

Generally found interſperſed, or aſſociated with other ſtones, as in granite, gneiſs, or, though rarely cryſtalized, in hexagonal plates.

Luſtre, commonly metallic, 3, 4. Tranſparency in thin pieces 3, 4, 2; in thicker 1.

Texture generally curved or undulatingly foliated, more rarely ſtreight foliated, ſtill ſeldomer ſtriated, chiefly broad ſtriated.

Fragments, flat, preſent ſometimes thick, ſometimes oblong granular concretions. Its lamellæ flexible, and in ſome degree elaſtic; feel ſmooth, but not greaſy.

Hardneſs 6. Sp. gr. various; that of muſcovy talc, which conſiſts of broad colourleſs leaves, is, according to Briſſon, 2,7917; moſt other ſorts abſorb water; the ſp. gr. of the white, before abſorption, 2,704; after abſorption, 2,749; that of yellow mica before abſorption, 2,6546; after abſorption, 2,7037; that of black, before abſorption, 2,9004; after, 2,9386; that of cryſtallized black mica, 2,9342. *Ibid.* Hence we ſee the coloured micas abſorb from $\frac{1}{154}$ to $\frac{1}{54}$ of their weight of water, which accounts for their decompoſition when expoſed to the influence and variations of temperature of the atmoſphere.

Mr. Sauſſure at firſt found all ſorts of mica fuſible into a ſemitranſparent glaſs, black, brown, or greeniſh, and ſlightly porous. 1 Sauſſ. 95. However, he afterwards found colourleſs micas convertible only into a white enamel. 2 Sauſſ. 136. Mr. Sage found muſcovy glaſs infuſible in the ſtrongeſt heat; in my trials ſome bits of muſcovy glaſs were barely agglutinated in a heat of 163°; though they had porcelain grain, and appearance, yet they were barely ſoftened, not melted; with the help of pure air, however, this ſubſtance forms a white glaſs. Hence we may infer, that even colourleſs tranſparent micas are not all homogeneous, ſome being more fuſible than others; coloured micas are fuſible in much lower heats; they are little affected by ſoda, but borax and microcoſmic ſalt effect their fuſion.

According to Baron Born the browniſh pellucid mica of Siberia contains 50 per ct. ſilex, 45 aërated magneſia, and 5 argill. 1 Raab. 238.

Mr. Werner alſo informs us, that the micas in gnieſs often afford ſteatites by their decompoſition; conſequently they muſt contain ſilex, argill, and magneſia.

I found 100 parts of the colourleſs kind to contain, 38 ſilex, 28 argill, 20 magneſia, and

20 of the moſt perfectly calcined iron; ſo I deemed it, from its colour and the great difficulty I experienced in diſſolving it. This proportion, however, may admit of ſome doubt, as I had not then deviſed the more accurate method of eſtimating the real contents of precipitates by the Pruſſian alkali; but as to the other ingredients I do not ſuſpect that any miſtake could have happened in eſtimating their proportion to each other.

6th Species.

Micarelle, Leſke O. 999.

Browniſh black.

Found in granite.

Luſtre, metallic, 3. Tranſparency, 0.

Fracture, broad foliated.

Hardneſs, 6. Sp. gr. 2,980 by my trial.

At 153° it melts into a black compact glaſs, its ſurface reddiſh.

By its external characters, except ſp. gr. this ſtone would be taken for mica; its analyſis, however, ſhews it not to be ſo, as the argillaceous ingredient too much exceeds the muriatic, which ſometimes is even entirely miſſed. Bergman found one ſpecimen to contain 0,46 argill, 0,40 ſilex, 0,05 unaërated magneſia, and 0,09 mangancſe and iron. Swed. Abhand. 1784, 113.

Mr. Klaproth found another to conſiſt of 0,63 argill, 0,295 ſilex, and 0,0675 iron. 2 Bergm. Journ. 1790, 229. Hence the preſence of magneſia is merely caſual; therefore it muſt be regarded

garded as a diſtinct ſpecies from mica, and hence I have given it the name of *micarelle*.

7th Species.

Hornblende. Pierre de Corne of the French.

Schorl en Maſſe, and Shorl Spathique of Briſſon.

Colour, black, or greyiſh black, or blackiſh green, or dark olive green, or leek green.

Luſtre, 2. Tranſparency, 0.

Fracture, ſometimes ſtreight, or curved, or divergingly ſtriated; ſometimes ſmall or broad, ſtreight or curved foliated *.

Commonly with long-grained, more rarely with curved lamellar diſtinct concretions.

Fragments, 2; thoſe of the lamellar variety affect a rhomboidal form.

Streak, greeniſh, or greyiſh green.

Hardneſs, from 5 to 9, ſcarcely reaching nine.

Sp. gr per Briſſon, from 2,922 to 3,3852, that of Leſke O. 1027, I found 3,41.

At the heat of 89° a piece of the above ſpecimen melted into a black ſolid glaſs with grey ſpots; at a lower heat it baked into a greeniſh grey maſs, between a porcelain and an enamel.

In the year 1783 I analyzed a piece of the foliated kind, and found it to contain 0,37 ſilex, 0,22 argill, 0,16 magneſia, 0,02 calx, (both the laſt aërated,) and 0,23 of iron, not much oxygenated.

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* Its croſs fracture, conchoidal, Leſke G. 297 Anmerk.

In 1787 Mr. Weigleb found another ſpecimen to contain 0,4083 ſilex, 0,175 magneſia, 0,1666 calx, 0,175 iron *. Here is a deficit of ſeven grains; but, what is moſt remarkable, he found no argill.

To diſcover which of thoſe analyſes approached neareſt to truth, I made compounds of the ingredients given as the reſult of each; and in the proportion ſet forth in each. I found Weigleb's to give a glaſs ſimilar to that of hornblende at a heat of 136°; the calx of iron I employed was thoroughly oxygenated. My own compound gave alſo an equally juſt reſult when I uſed ruſt of iron; but then it got a much higher heat, viz. 156°; when I uſed metallic iron inſtead of ruſt, I obtained only a ſlagg, and a great part of the iron ſeparated itſelf from the earths.

Mr. Herman found black hornblende to contain 37 per ct. ſilex, 27 argill, 5 calx, 3 magneſia, and 25 iron. 5 Berl. Beob. 79.

This is the ſtone which, in conformity with the moſt eminent Swediſh and French mineralogiſts, I denoted by the name of *hornſtone* in my firſt treatiſe on mineralogy. The deſcription I gave of it was ſuch as candour could not miſtake for that of petro-ſilex; but as I ſince found that writers, who apply this name to ſtones abſolutely different from the ſort of ſtones called petroſilices, extended it too far, as will preſently be ſeen, I now, in conformity with Mr. Werner, apply it ſolely to thoſe ſtones of the ſiliceous genus called *Petroſilices*; ſince, however, it is ſtill applied in various ſenſes by writers of great merit, it may be

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* 2 Chy. Ann. 1787, 15.

proper to trace its origin. This name took its riſe from common working miners; they obſerved that a ſort of ſtone, of a duſky colour, was cut through with great difficulty by reaſon of a tenacity which reſembled that of an horn or horſe's hoof *; now, a horſe's hoof, when in thin pieces has alſo a ſlight degree of tranſparency, this ſort of ſtone they therefore called *hornſtone.* Mineralogical writers obſerving this combination of properties not to meet together in the ſame ſtone, diſtinguiſhed two ſorts of hornſtone, both of a duſky colour, one that had the ſemitranſparency, but not the tenacity of a hoof or horn, and another which reſembled that ſubſtance only in colour and tenacity. This diſtinction I find in Henckel on the origin of ſtones †. Since that time the German writers in general have confined this name with ſome modification to ſtones of the firſt kind; that is, to the ſtones that all writers had indicated by the name of *petroſilices*, and the Engliſh in particular by that of *chert*. But the Swedes and French ſtill apply it in the latter ſenſe ‡. The great weight of the ſtone called *hornblende* made the miners at firſt imagine it contained ſome metal, but finding none except iron they called it *blind*, in the ſame ſenſe as the vulgar do nuts without a kernel. Hence the name *hornblende*.

Wallerius deſcribes what the Swediſh writers call *hornſtones*, thus:

" Their colour is always dark, their ſurface ſmooth, with a greaſy luſtre, their texture ſtri-

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* Vogel Mineral. p. 130.

† P. 400 of the French Tranſlation.

‡ Wallerius.

ated, lamellar, fibrous, or ſparry, eaſily ſcraped by a knife, preſenting a greyiſh ſtreak or powder, and an earthy ſmell while ſcraping or powdering; when heated they aſſume a browniſh red colour and harden; in a ſtronger heat they melt into a black ſlagg, or compact glaſs. They do not effer veſce with acids, though partially ſoluble by them in a boiling heat. Their ſp. gr. from 2,8 to 3,2."

This is almoſt an exact deſcription of our hornblende. It is, he tells us, by the Swedes called *Hornberg*, and by the French *Roche de Corne*, and by the Germans *Hornfelstein*. Of this ſtone he diſtinguiſhes four varieties. 1ſt That which is obſcurely lamellar which he calls *Corneus ſolidus nitens durior*. 2d That which is of a ſlaty texture, which he calls *Hornſchieſer*, and is what I call *Hornblende ſlate*. 3d That which is of a ſparry and ſtriated texture, which he calls *Hornblende*, or *Strahl ſkimmer*, or *Shorlblende*, *Roche de Corne ſtrié*. And 4th That which breaks into cubes, or rhomboids, which he calls *Corneus trapezius* and *Trap*; yet he tells us, that when broken in another direction it preſents conchoidal ſurfaces. Here he evidently confounds hornblends with traps.

Mr. Sauſſure, though well aware of the double ſenſe of the term *hornſtone*, yet relying on the authority of Wallerius, and unwilling to multiply denominations, wiſhed to reſtrain its ſignification to the ſpecies we here deſcribe; but, in following Wallerius too implicitly, he unwarily comprehended ſtones under this name which are of a different ſpecies. Thus he reckons among corneous ſtones ſome which preſent no idea of cryſtalliza-

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tion, are deſtitute of luſtre, and of an earthy texture; namely, Traps *. Thoſe whoſe fracture is lamellar or ſtriated, he tells us, are by many called *Hornblendes*; the ſp. gr. of theſe he found inferior to that of ſhorl, viz. 2,973, which certainly is not always the caſe. He thinks hardneſs the external character which chiefly diſtinguiſhes them from ſhorls, and therefore calls all thoſe that are compoſed of rectangular laminæ, and which are hard enough to give fire with ſteel, ſhorls; but, aſſuredly, the diſtinction between them is grounded on more numerous differences, as will be ſeen in the article *ſhorl*; and the difference in their compoſition muſt be conſiderable, ſince they are completely fuſible at 89°, and ſhorls only at 127°.

Romé de Liſle denotes the ſtone of which we here treat, ſometimes by the name of *ſhorl en maſſe*, or continuous ſhorl, les ſhorls en maſſes informes lamelleuſes déſignés par les Allemands ſous le nom de hornblendes †, ſometimes by the name of *argillaceous ſhorl* ‡; and under theſe denominations alſo he comprehends *hornblende ſlate*, and hornblendes of a ſtriated or fibrous texture.

Mr. Sauſſure applies the term *ſhorl en maſſe* in another ſenſe, which is not eaſily diſcovered, as the only mark by which he diſtinguiſhes it from other ſhorls is its hardneſs, intermediate between that of ſilex and limeſtone; and its ſpecific gravity, which he does not determine; perhaps alſo he means (and this ſeems the moſt obvious ſenſe of his

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* 1 Sauſſure, 69. 75.

† 2 Cryſtallogr. 309.

‡ Ibid. p. 338. 348. 377. 425.

his expreſſions) that theſe criteria diſtinguiſh it from *other* ſtones; but ſurely not from trap or hornblende? with which, however, by treating them apart, he would ſeem to wiſh not to confound it.

The argillaceous ſmell, by which Mr. Sauſſure and I myſelf formerly ſought to diſtinguiſh this ſpecies of ſtone, is a very fallacious teſt; for, I have ſince found the ſame ſmell emitted by various traps after breathing on them, by ſerpentines, and even earthy limeſtones. Mr. Deſmaretz, in the Mem. of Paris, 1773, denotes hornblende by the names of *Shorles en grandes maſſes*, *Black Baſalt*, *Gabbro en maſſes confuſes*, indicating ſhorls in general by the name *Gabbro*. This laſt appellation was grounded on a miſtake, ſince detected by Mr. Sauſſure.

Baron Born, in the deſcription of Miſs Raab's Mineral Cabinet, calls our ſtone *foliated ſhorl*, and under the ſame name comprehends alſo Thumerſtein, though its compoſition, as well as external characters, are very unlike. With him Mr. Gerhard, of Berlin, alſo agrees; becauſe both ſhorls and hornblendes are fuſible per ſe into a black ſlag; but ſo alſo are baſalts; muſt they alſo be confounded with the former? I ſhould imagine that, until we are much better acquainted with the compoſition and formation of minerals than we are at preſent, they can ſcarce be too minutely diſtinguiſhed from each other. Wallerius was very pardonable for confounding many which were little known at the time he wrote; but to take him as a guide, after the numerous illuſtrations and diſtinctions furniſhed by Mr. Werner, ſeems to ſavour of prejudice.

Mr.

Mr. Lenz mentions ſome cryſtallizations of hornblende diſtinct and different from baſaltic hornblende; but neither Werner's Catalogue of Mr. Pabſt's foſſils, nor Leſke's, mention any; hence I ſhould ſuſpect it a miſtake.

8th Species.

Baſaltine. Baſaltic Hornblende, or Cryſtallized Hornblende, of Werner. Shorl Spath, of Ferber. Shorl priſmatique hexagone, of Sauſſure.

Colour, black, or greeniſh black, or dark green, or yellowiſh green.

It is moſtly found in baſalts, wacken, and lava; in the former it is generally black, or greeniſh black; in the latter, of the lighter hue *; hence I have called it baſaltine. Mr. Sauſſure has alſo found it in granite †. It is found cryſtallized in rhomboidal, hexahædral, or octohædral ſhort thick priſms generally mutilated, terminated by flatted three-planed pyramids. The cryſtals not ſeamed or ſulcated.

Luſtre, 3. Tranſparency, in very thin pieces, 1; and tranſmits a reddiſh yellow colour.

Fracture, foliated, if broken in the direction of the laminæ, its croſs fracture uneven, and often conchoidal; but in that found in lavas the foliated texture is more difficultly diſcernible.

Hardneſs from 9 to 10. Brittle. Sp. gr. 3,333, by my trial.

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* 4 Hevet. Magaz. 242. 251.

† 1 Sauſſure. 67.

It gives a white ſtreak.

At 119° it melts into a glaſs partly grey, and partly greeniſh black.

This ſpecies, which the French, Swediſh, and Italian mineralogiſts have indicated by the name of ſhorl, or hexangular ſhorl, ſeems to be that which was analyzed by Mr. Bergman under the appellation of black ſhorl of St. Albano, deemed an antient extinct volcano, near Verletri, in the neighbourhood of Rome; he found it to contain 0,58 ſilex, 0,27 argill, 0,04 calx, 0,01 magneſia, and 0,09 iron. 3 Bergm. 207.

The degree of hardneſs I have attributed to this ſtone is ſuch as I have obſerved in the ſpecimen of Leſke O. 1043, and in Voight's Collection, No. 46. It is ſaid, however, that ſome are ſofter. 2 Bergm. Journ. 1788, p. 509. 1 Noſe Orogr. Briefe 119, 120. Hence this laſt writer, a man of great ſagacity, and who has beſtowed much attention to this ſort of ſtone, thinks that the ſofter kinds ſhould alone be called *hornblende cryſtals*, and the harder ſorts rather *garnets*, which often agree with them in colour and form; but I think the much greater fuſibility of baſaltines, whether hard or ſoft, ſufficiently diſtinguiſhes them from garnets.

The great luſtre of theſe ſtones, when ſet in baſalts, frequently occaſions them to be taken for mica; their quadrangular ſhape, however, may always ſerve to diſcriminate them.

9th Species.

Reſplendent Hornblende.

Of this there are two varieties.

1ſt Variety.

Labradore Hornblende.

Colour, in moſt directions, greyiſh black, or blackiſh grey; but in other poſitions it reflects a ſtrong iron grey, either ſingly or mixed with dark copper red.

Luſtre in the firſt caſe, 0; in the ſecond, 3 or 4, and metallic. Tranſparency, 0.

Fracture, moſtly curved foliated.

Hardneſs from 8 to 9; ſome are ſaid to be ſofter. Sp. gr. by my trial, from 3,35, to 3,434.

2d Variety.

Schiller Spar.

Colour, yellowiſh, leek or apple green, or golden yellow, reflecting a white, grey, or yellow, in certain ſituations, and ſome even in all ſituations.

Generally found ſhooting out of ſerpentine.

Luſtre, metallic, 4. Tranſparency, in thin pieces, 1.

Fracture, foliated. Hardneſs from 8 to 9, often only 7. Sp. gr. by my trial, 2,882; it would have been higher if I could have ſeparated the ſerpentine perfectly.

At 141° a part of the ſpecimen Leſke O. 1041, hardened and formed a porcelain maſs.

I had not a ſufficient quantity of the firſt variety to examine its fuſibility; but the infuſibility at ſo high a heat of this variety at leaſt ſhews it to be ſpecifically different from common hornblende. By the analyſis of Mr. Gmelin, it contains 0,437 ſilex, 0,179 argill, 0,112 magneſia, and 0,237 iron. 1 Bergbau. 92.

10th Species.

Shiſtoſe Hornblende. Hornblende Slate. Hornblende Schiefer of Werner. Roche de Corne feuilletées. 1 Sauſſ. § 166. p. 119.

Colour, greyiſh, or greeniſh black, or dark bluiſh grey, or greyiſh blue; ſeldom dark leek green.

Found in large maſſes.

Luſtre, 2, ſometimes ſilky. Tranſparency, 0, rarely 1.

Fracture, in the great ſlaty; but of the ſlates themſelves, ſtriated, generally ſtreight and interwoven, rarely diverging.

It gives a greeniſh grey ſtreak.

Hardneſs

Hardneſs from 7 to 9, difficultly frangible. Sp. gr. from 2,909 to 3,155, by my trial.

Heated to redneſs it becomes ſometimes reddiſh grey, ſometimes reddiſh brown. At 80° I melted the ſpecimen Leſke O. 1037, into a black compact glaſs; a ſure ſign that it is not of volcanic origin. The ſpecimen Leſke O. 1038, melted at 108° into a greyiſh black, ſomewhat porous Slagg, whoſe ſp. gr. was 2,308 from the number of air holes. The ſpecimen Leſke G. 135, melted at 130° into a browniſh black, almoſt compact glaſs. Hence we need not be ſurprized that it was often miſtaken for trap (called baſalt). Voight Prack. Gebirg § 21.

11th Species.

Wacken.

Colour, dark greeniſh, or blackiſh, or yellowiſh, or reddiſh grey, or greyiſh black, or liver brown.

Found in conſiderable maſſes.

Luſtre, 0. Tranſparency, 0. It feels merely as a ſand ſtone.

Fracture, even, earthy; ſeldom uneven, and then fine-grained *.

Fragments, 2. It never preſents ſeparate diſtinct concretions.

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* According to Hoffman, 2 Bergm. Journ. 1788, its fracture is *uneven*, and fine grained, approaching the ſplintery. According to Karſten, it is commonly *even*, ſeldom *uneven*. 3 Helvet. Mag. 234.

Hardneſs from 6 to 9 *. Sp. gr. by my trials, from 2,535 to 2,893; that of the ſpecimen Leſke O. 1047, is 2,535; that of O. 1045, is 2,622: and that of O. 1046, is 2,893. This laſt is blackiſh green, gives an earthy ſmell, and pounds tough, ſo that it would undoubtedly paſs for a *pierre de corne* among the French. Mr. Succow found that of a wacken, near Frankford, 2,576. 2 Chy. An. 1786, 430.

The greeniſh grey, Leſke O. 1045, melted at 124° into a yellowiſh grey, very porous, opake ſlagg; that of Leſke O. 1046, melted at 130° into a true compact black glaſs; and ſo did that of Leſke O. 1047. Hence theſe two laſt do not ſeem truly to belong to this ſpecies.

It withers by expoſure to the atmoſphere, and then becomes more grey.

Its tranſition is into trap or baſalt.

It muſt not be confounded with the Grauwaken of the Hartz. which is a very different ſpecies.

This ſtone has not as yet been analyzed; but moſt probably conſiſts of ſilex, argill, calx, in a fuſible proportion, and iron in a ſmaller proportion than the foregoing, and alſo than traps or baſalts.

It frequently contains black mica and baſaltine, but never olivin.

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* Noſe alſo remarked, that it ſometimes gives fire with ſteel. 1 Noſe, 148.

12th Species.

Mullen Stone.

Colour, aſh, or bluiſh grey, often mixed with ochry yellow, from the decompoſition of its ferruginous parts.

Found in conſiderable maſſes, and frequently contains baſaltine; it alſo often inclines to a regular form moſtly quadrangular, like baſalt. Noſe 1, 250.

Surface, where expoſed to the air and moiſture, covered with a greyiſh white rind, ſometimes ſlightly ochry.

Luſtre, 0, except ſome ſhining particles of baſaltine. Tranſparency, 0.

Fracture, uneven, and fine ſplintery.

Hardneſs, from 7 to 9. Sp. gr. from 2,6 to 2,738.

It frequently occurs in our Northern counties and is by the pump-ſinkers called *Mullen*; it is evidently the grey baſalt of Ferber, mentioned in Leſke's Cabinet, S. 351. It ſeems to be the third variety of trap, mentioned by Mr. Faujas, p. 88.

At 130° it melts into a black compact glaſs.

See alſo the ſpecimen Leſke S. 95.

13th Species.

Kragg-Stone. Leſke S. 661, (and 1695 Q.)

Colour, greyiſh red, or reddiſh grey; exceeding porous, the pores often filled with various cryſtallizations.

Luſtre, 0. Tranſparency, 0.

Fracture, uneven and earthy. Fragments 2. Hardneſs from 5 to 7. Sp. gr. 2,314.

Feels rough and harſh, gives a yellowiſh grey ſtreak.

At 138° it melted into a reddiſh brown porcelain maſs.

It is found in the neighbourhood of Belfaſt, and there called Kraggſtone; it reſembles the ſtone mentioned by Leſke S. 661, by him called a baſalt. It ſeems alſo to be that mentioned by Mr. Faujas as the 5th variety of trap, p. 91.

This ſtone is often mixed with globules of magnetic iron ſtone, which adds conſiderably to its ſpecific weight, as in the ſpecimen Leſke S. 1233, whoſe ſp. gr. amounts to 2,910.

Theſe three ſpecies, viz. Wacken, Mullen, and Kragg, have been by moſt writers confounded with trap, but their colour, ſp. gr. and fuſibility, ſhew they muſt be diſtinguiſhed.

14th Species.

Trap.

Of this I diſtinguiſh two families, the common, or amorphous, and the figurate.

1ſt Family.

Common Trap. Baſalt of Werner.

Its moſt uſual colours are the greyiſh or bluiſh, or purpliſh black; more rarely blackiſh, or reddiſh brown (as in the baſis of mandelſtein or toadſtone) or greeniſh grey; traps of the laſt colours ſeem to me to be mixed with other ſpecies.

Found in large maſſes, and frequently containing baſaltine, quartz, calcareous ſpar, calcedony, zeolite, hyalite, felſpar, (trap porphyry,) and olivin.

Hence it is frequently found porous, cellular, and cavernous, from the decompoſition and falling out of theſe ſtones.

Externally it has frequently a brown or reddiſh brown rind, from decompoſition.

Luſtre, 0; or from ſhining particles of baſaltine diſperſed through it; ſee Leſke S. 102, 835. Tranſparency, 0.

Fracture, earthy, or fine ſplintery, often uneven. Fragments 2,3, often tending to a quadrangular form.

It often preſents ſmall or coarſe-grained diſtinct granular concretions.

Hardneſs from 8 to 9, and difficultly broken, except when in a ſtate of decompoſition, and then often only 5 or 6. Sp. gr. when ſound lies between 2,78 and 3,021 excluſively, by my trials; the ſpecimen that exhibited the laſt is that in Leſke S. 1695, whoſe colour is reddiſh brown, and has ſeveral red grains in it. The ſpecimen Leſke 1223, which is greyiſh black, has its ſp. gr. 2,728, but then it is not pure; for, at 148°, it melted only into a ſomewhat porous liver-brown maſs, between a porcelain and an enamel. The ſpecimen Leſke G. 264, which is bluiſh or greeniſh black, has its ſp. gr. 3,478; but then, as Mr. Karſten obſerves, it contains a quantity of magnetic iron ſtone. The ſp. gr. of the ſtone called trap by Mr. Briſſon is 2,745, and of that which he calls baſalt of an irregular form or touchſtone, 2,4153; but this moſt probably is that ſort of ſiliceous ſchiſtus, called lydian ſtone, of which hereafter. The ſp. gr. of this ſtone muſt undoubtedly vary with its ſtate and degree of decompoſition, and with the quantity and ſort of foreign ingredients contained in it, as well as the proportion of its own conſtituent parts; but we may ſtate that of the pureſt at a medium 2,87 or 2,88.

By expoſure to the influences of the atmoſphere, and often by mere moiſture, this ſtone is frequently decompoſed, and inveſted with a brown, yellowiſh, or reddiſh brown rind.

Expoſed to a heat of from 120° to 130° it melts into a black compact glaſs.

According to the analyſis of Mr. Bergman, the trap of the mountain Hunneberg, in Weſt Gothland, contains 0,50 ſilex, 0,15 argill, 0,08 aërated calx, 0,02 magneſia, 0,25 iron, though in the dry way it would yield but 0,10 of iron. 3 Bergm. 213. The magneſia is evidently of little importance, but we may obſerve that the quantity of iron exceeds that of argill, and is very ſlightly oxygenated. It is probable the iron is ſometimes mixed with manganeſe and ſometimes with nickel, from which laſt the green colour, may probably originate, which is ſometimes obſerved in traps, though moſt commonly it proceeds from the iron itſelf.

In England, three varieties of trap have been obſerved; namely, toadſtone or rather its baſis; rowley ragg; and whinſtone. Mandelſtein.

Toadſtone is of a dark browniſh grey colour, abounding with cavities filled with cryſtallized ſpar, which, with the brown colour of the baſis, gives the whole the appearance, from which it derives its name. The cavities, from the deſtruction or decompoſition of the ſpar (originating from the iron contained in it) are frequently empty. The ſp. gr. of a toadſtone, free from calcareous matter, was found by Dr. Watſon, 2,921; and of another 2,85; but that of another, in a ſtate of decay, 2,68; and of one ſtill more decayed 2,558. By the analyſis of Dr. Withering, this ſtone contains 0,63 ſilex, 0,14 argill, 0,07 mild calx, and 0,16 calciform iron.

Rowley ragg, or *Ferrilite*, is of a black colour, with numerous white dots, and black lamellæ of baſaltine, which give it a dark browniſh grey appearance. It is found in large maſſes, which affect a rhomboidal form; ſome of theſe incloſe rounded pebbles of the ſame ſubſtance. By expoſure to the air it acquires an ochry cruſt. Internally it hath ſome luſtre from a number of minute ſhining particles. Fracture, nearly even, and fine ſplintery, yet often inclining to the flat conchoidal. Opake. Hardneſs 9. Sp. gr. 2,748, by my trial.

Heated in an open fire it becomes magnetic, and loſes about 3 per ct. of its weight. It does not redden; but at 98° melts into a ſomewhat porous black maſs, partly porcelain, and partly an enamel.

According to the analyſis of Dr. Withering, it contains 0,475 ſilex, 0,325 argill, 0,20 calx of iron. Here we may obſerve, 1ſt, that it contains no calx; 2d, that it contains leſs iron than argill; and, 3d, that the iron is in a calciform ſtate. In theſe reſpects then it differs from many traps, and from baſalts; hence I call it *ferrilite*.

Whin-ſtone is a name uſed in England, Scotland, and the North of Ireland. It is of a blue, or greyiſh black colour, whoſe hardneſs is from 8 to 9. Sp. gr. from 2,4 to 2,88, is often a *trap*. It is found in detached fragments, or forming dykes in mines; of theſe a curious account, by Mr. Mills, may be ſeen in the Phil. Tranſ. for 1790, p. 73.

The baſis of the cellular ſtone, called amygdaloid, the mandelſtein of the Germans, is alſo frequently a trap, generally of a greyiſh, blackiſh or reddiſh brown, or yellowiſh black, or greeniſh grey; and has its holes filled with quartz, ſpar, or calcedony, often with bole, &c. or empty; and the ſides of an ochry, or bluiſh grey colour, derived

derived from the ſtones that fell out of them. That mentioned in Leſke G. 296, had its ſp. gr. 2,443, and gives a reddiſh ſtreak. It melted at 130° into a black compact glaſs; that in Leſke G. 300, had its ſp. gr. 2,354, gives a white ſtreak, and melts into a maſs ſimilar to the former. The hardneſs of both is 8.

It is the poroſity of this ſtone that renders it ſo light.

Its tranſitions, and thoſe of kragg and mullen ſtones that are nearly allied to it, are into each other, or into wacken, or argillaceous marl, or ſandſtone, or ſhiſtoſe porphyry, or amygdaloid.

Such of theſe ſtones as are ſpecifically lighter than 2,78 ſeem to contain wacken, or ſome other of thoſe ſpecies, that border on the genuine traps.

2d Family.

Figurate Trap, Baſalt. Baſalt of Werner.

Colour, greyiſh black, ſometimes bluiſh, or browniſh black; when withered, the ſurface is greyiſh, or reddiſh brown.

Found in conſiderable maſſes.

Luſtre, properly, 0; but from ſome ſhining particles intermixed with it, 1. Tranſparency, 0; yet ſometimes in very thin pieces, 1.

Fracture, compact, moſtly fine ſplintery; ſometimes approaching to the even, or flat conchoidal. 1 Bergm. J. 1792, 300. Fragments, 2.

Generally of a columnar form, ſtreight or curved, perpendicular or inclined, rarely parallel;

lel; and when erect generally diverging beneath; their diameter from three inches to three feet, ſometimes with tranſverſe ſemiſpherical joints, in which the convex part of one is inſerted in the concavity of the other; the angle of the concave often prolongated where it receives the convex; theſe joints are called *articulations.* The forms of the columns are pentangular, hexangular, or octangular, more rarely triangular, or quadrangular. Sometimes the columns are irregular.

It is alſo ſometimes found in rounded thick laminar maſſes, either ſpherical or compreſſed, and lenticular, ſometimes of a tabular form; both theſe and the columns when broken preſent thick laminar concretions incruſted with ochre.

Hardneſs, from 8 to 9. The pillars of the Giant's Cauſeway, expoſed to the rougheſt ſea for more than 20 centuries, have their angles as perfect as thoſe more diſtant from it, a complete refutation of Buffon's Theory.

Sp. gr. of ſome baſalts 3,000, according to Bergman; of that of the Giant's Cauſeway, according to Briſſon, 2,864; or, according to Dr. Hamilton, 2,900; of that of Fairhead, according to Mr. Mills, 2,95. He mentions ſome of leſs denſity, but they are probably traps; for, though both are of the ſame ſpecies, yet baſalt is known to have moſt commonly a ſmaller and cloſer grain. Mr. Succow found a baſalt from Fulda 3,123, but this was in the temperature of 65°, 75. I found that of another from Saxony, of a pentagonal form, 2,979.

It is ſometimes magnetic, ſometimes not; Baron Veltheim tells us, that among 100 ſpecimens of the baſalt of Stolpe, he ſcarcely met one that moved

moved the magnetic needle. 1 Chy. An. 1788, 412.

Frequently ſonorous when ſtruck.

Gives a grey ſtreak.

When heated reddens. I melted that of Saxony into a black glaſs at 100°, ſo compact that its ſp. gr. was ſtill 2,859; at 130° its glaſs is ſtill more compact.

According to Mr. Bergman, it conſiſts of the ſame principles as trap, and in the ſame proportion. It almoſt always contains particles of baſaltine, ſometimes alſo hornblende, the German baſalts contain alſo olivins; but theſe laſt are not found in the Iriſh; alſo, though more rarely, felſpar, quartz, zeolytes, ſhorl, and ſpar. Micas are ſcarce ever found in it, though ſometimes upon it. Wacken, on the contrary, never exhibits olivins.

15th Species.

Calp, or black quarry ſtone of Dublin.

Colour, bluiſh black, or dark greyiſh blue, variouſly interſected with veins of white calcareous ſpar, and often inveſted with the ſame.

Found in large maſſes.

Luſtre, 0, except a few ſhining particles of ſpar. Tranſparency, 0.

Fracture, exceeding fine ſplintery, paſſing into the even, and ſometimes into the imperfect, conchoidal. Fragments, 2. In the direction of its ſtrata it eaſily ſplits into large flaggs.

Hardneſs,

Hardneſs, from 6 to 7. Sp. gr. from 2,646 to 2,70.

It gives a white ſtreak.

It efferveſces with mineral acids.

Gives an earthy ſmell when breathed on.

At 130° melts into a black compact glaſs.

Contains 50 per ct. mild calx, the remainder ſilex, argill, and iron. The argill ſeems, however, to preponderate.

It ſeems to be the calcareous trap of Laſius, Hartz 170; at leaſt, this agrees with it in colour, ſp. gr. and in containing calcareous matter.

16th Species.

Argillite, or argillaceous Shiſtus or Slate. *Thon Schiefer* of Werner *.

Colours, the moſt uſual are bluiſh, greeniſh, or blackiſh grey, or the greyiſh blue, or greyiſh green, or greyiſh, bluiſh, or reddiſh purple. More rare are the yellowiſh grey, browniſh red, reddiſh brown, greyiſh black, bluiſh black, or mountain green. Sometimes with ſtripes or ſpots of a darker colour.

Found in conſiderable ſtrata.

Luſtre, ſeldom 0, oftener 1, from ſome diſperſed glimmering particles, frequently 2, and ſilky, rarely 3. Tranſparency, 0,1.

Fracture, ſlaty, commonly ſtreight, ſometimes curved, or undulating; ſometimes thick, fre-

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* Werner's Cronſted 203. 3 Helvet. Magaz. 185 per Karſten. Leſke, Muſeum, &c.

quently thin, more or leſs difficultly ſeparable, ſometimes approaching to the foliated. Fragments, 2, frequently tabular; ſometimes long ſplintery, rarely trapezoidal, or rhomboidal.

Hardneſs, from 5 to 8. Sp. gr. from 2,67 to 2,88; but generally from 2,7 to 2,8. Laſius mentions one of a pearl grey colour, whoſe ſp. gr. is but 2,500; Hartz 109. The heavier contain an exceſs of iron.

It gives a white or grey ſtreak, ſometimes a reddiſh grey.

It does not adhere to the tongue.

It does not ſtain, yet Laſius mentions one ſo ſoft as to leave a white line, on harder ſtones. Ibid.

It is compoſed of ſilex, argill, calx, magneſia, and iron with ſome bituminous particles; the proportions nearly in the order I have mentioned, when the mean of all the varieties is conſidered; but, in the different varieties, the proportion varies conſiderably; and hence the numerous varieties of this ſpecies: with theſe, mica or talc is often intimately incorporated.

Its tranſitions are into ſandſtone, ſiliceous ſhiſtus, jaſper, hornſtone, grau-wacken, ſyenite, ſhiſtoſe hornblende, ſhiſtoſe porphyry.

Very commonly it imbibes water, but different varieties abſorb it in various proportions.

It ſometimes bears impreſſions of vegetables, ſometimes of ſhells.

It differs from ſlate clay, in the form of its ſurface, hardneſs, ſpec. gravity, relation to water, and inadheſion to the tongue, as well as in compoſition, containing more magneſia and iron. The

The curved ſlaty argillites have their croſs fracture hackly, and opake.

1ſt Variety.

Angleſey Slate.

Purple, or reddiſh purple. Internal luſtre 1. Opake. Hardneſs, from 7 to 8. Sp. gr. from 2,84 to 2,876. It does not imbibe water, gives a reddiſh white ſtreak. Does not efferveſce with acids, unleſs powdered, and then weakly. Gives a greeniſh colour to nitrous acid after ſtanding ſome days. Becomes browniſh red when heated. Slightly detonates with nitre. Melts into a black ſpongy maſs. Contains 0,38 ſilex, 0,26 argill, 0,08 magneſia, 0,04 calx, 0,14 iron perhaps mixed with nickel, or perhaps the green colour of the nitrous acid may proceed from the bituminous ſubſtance contained within it, this ſeems moſt probable.

2d Variety.

Weſtmoreland Slate.

Many ſorts are found in that county; but that which paſſes for the beſt has its colour, bluiſh grey; when moiſt, greeniſh grey. Luſtre, ſilky, 2, opake. Hardneſs, 6. Sp. gr. 2,752; gives a white ſtreak; does not imbibe water; ſlightly efferveſces with acids; by heat becomes reddiſh brown;

brown; and at laſt, melts into an opake gloſſy ſlagg.

The pale grey ſlates of Weſtmoreland have their ſp. gr. 2,732, the purple 2,797, according to Dr. Watſon. Some of the former afforded him a ſtrong lime water after calcination. The ſilky gloſs intimates the preſence of magneſia.

Aſh grey Slate of France.

According to Briſſon its ſp. gr. before it abſorbs water is 2,6718, and after abſorption 2,6905; it conſequently abſorbs $\frac{1}{143}$ of its weight of water. Of other ſlates, uſed for roofs, he found the ſp. gr. before abſorption 2,8535, and after abſorption 2,8592. The beſt are thoſe that abſorb leaſt.

3d Variety,

Killas.

Pale bluiſh grey, or red, or whitiſh yellow. Luſtre, ſilky, opake. Its ſurface undulated. Fracture, long ſplintery, and imperfectly ſlaty. Hardneſs, from 4 to 5; the whitiſh yellow ſtill ſofter, but that of a dark grey, I am informed, is 9. The ſp. gr. of the bluiſh grey I found in different ſpecimens from 2,63 to 2,666; it contained by my analyſis 0,60 ſilex, 0,25 argill, 0,09 magneſia, and 0,06 iron, and ſome petrol or bitumen, as appeared by the greeniſh hue which it gave to the nitrous acid. As it wants calx it can ſcarce be deemed a true argillite.

4th Variety.

4th Variety.

Argillite of Ditters Back. Leſke O. 954.

Greyiſh black. Luſtre, ſtrong and ſilky. Opake. Fracture, undulatingly ſlaty, which gives it a ſtriated appearance. Fragments, tending to the rhomboidal. Hardneſs, 6. Sp. gr. 2,727. At 140° it melted into a yellowiſh green porous glaſs.

5th Variety.

Grapholite.

Black, or bluiſh black. Hath ſcarce any luſtre. Opake. Splits eaſily into ſmooth plates. Its croſs fracture long ſplintery. *Gives a white ſtreak, and is generally uſed to write upon.* Hardneſs, 5. Sp. gr. 2,701. When powdered it efferveſces with acids.

17th Species.

Novaculite. Turkey hone. Shiſtus Coticularis of Wallerius. Pierre Raſoir. Wetzſtein of Werner.

Colour, greeniſh grey, or inclining to mountain green, or pale greyiſh yellow; rarely ſpotted. Found

Found in large maſſes.

Luſtre, 0, 1. Tranſparency, 1 or 1,5.

Fracture, ſlaty, but inclining ſtrongly to the ſplintery; ſometimes alſo to the conchoidal, and earthy.

Hardneſs, from 7 to 8, rarely 9. Sp. gr. from 2,609 to 2,955, by my trial. According to Briſſon, hone-ſtones for razors of a dirty white abſorb water, before abſorption the ſp. gr. of one of them was 2,8763, and after abſorption 2,8830; ſo that it abſorbed $\frac{1}{428}$ of its weight. He mentions another whoſe ſp. gr. was 3,1398, whoſe colour was black and white.

Some feel ſomewhat greaſy. Efferveſce ſlightly with acids; and ſome not.

There are other ſtones alſo uſed as hones, as ſome argillites and ſandſtones; theſe laſt form the coarſer whet-ſtones.

Some at leaſt are decompoſed by expoſure to the atmoſphere, and form a white earth.

From all this it appears that this Species contains many varieties of compoſition.

I ſhall here mention a few of thoſe varieties I have met with.

1ſt, That of Leſke O. 976, whoſe colour is mountain green. Hardneſs 7. Sp. gr. 2,722, and does not efferveſce with acids, melted at 120° into a ſomewhat porous hard greyiſh black, porcelain maſs, whoſe ſurface was vitrified.

2d, Another which I bought in London: could not hear whence it came; but it is uſed for ſetting razors; was of a greyiſh yellow colour. Luſtre, 0. Tranſparency, 1,5. Fracture ſplintery. Fragments, 1. Hardneſs from 7 to 8. Sp. gr. 2,609. And efferveſces very ſlightly with acids.

acids. Heated to 120°, it hardened ſufficiently to give fire with ſteel, and grew perfectly white, the outſide had a glazed ſemivitrified appearance, but the inſide a more diſtinct unvitrified grain.

3d, Another from the ſame ſhop, whoſe colour was iſabella yellow. Luſtre, 0. Tranſparency, ſcarcely 1. Hardneſs, from 7 to 8. Sp. gr. 2,955. Did not efferveſce with acids. At 120° it melted into a yellow porous enamel.

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SECTION X.

Siliceous Genus.

1ſt Species.

Mountain Cryſtal and Quartz.

THESE form two families, the only difference being in their fracture and tranſparency.

1ſt Family.

Mountain or Rock Cryſtal.

When pureſt it is colourleſs, but it is alſo found greyiſh, and yellowiſh white, or pale yellow, otherwiſe called *Citrine*, and impure topaz; or pale or dark brown, or brown falling into black, then called *Morion*, or, though very rarely, pale roſe red, or white, or brown, and irideſcent.

Its luſtre glaſſy, 3. Tranſparency, 4. It cauſes a double refraction.

The forms of its cryſtals are various, the moſt uſual is that of hexangular priſms, ſurmounted with hexagonal pyramids on one or both ends, the angles of the priſm correſponding with thoſe of the pyramid; ſometimes the pyramids are joined baſe to baſe, and frequently it exhibits but one pyramid, or a priſm without a pyramid. The priſms are generally ſeamed perpendicularly to their axis, the pyramids ſcarce ever. For other forms I muſt refer to Mr. de Liſle.

Fragments rounded by rolling in water are alſo frequent.

Its fracture is *conchoidal*, but frequently ſo flatly as to reſemble the foliated.

Its fragments, 4 or 3. Its hardneſs, 11. Its ſp. grav. 2,653, when colourleſs; that of the red 2,67.

2d Family.

Quartz.

Its colours are various, white, grey, yellowiſh, reddiſh, or greeniſh white, or yellowiſh, bluiſh, or pearl grey, or yellow, or ſwarthy brown, or pale or blood red.

Its external luſtre caſual, the internal, 3, 2, or 1. Its tranſparency, 2, 3, rarely 1.

Commonly amorphous, frequently cryſtallized, as mountain cryſtal. The priſms have ſometimes been found crooked. N. Act. Petrop. 1785, p. 265. Cubic cryſtals of quartz have alſo been diſcovered. 1 Leſke O. 418[*]. Alſo in quadrangular plates heaped together; and frequently in the form of ſand, and ſometimes in columnar diſtinct concretions adhering together or to each other.

Its fracture fine or coarſe *ſplintery*, very rarely ſtreight fibrous. The ſplinters are ſometimes ſo groſs and rounded as to reſemble the conchoidal form.

Its fragments, 3, indeterminate; yet ſometimes rhomboidal. Leſke O. 429.

Its hardneſs, 10, brittle. Sp. gr. from 2,64 to 2,67.

It does not wither by expoſure to the air. Nor yield to any acid but the ſparry.

When heated to redneſs it loſes its tranſparency, which mountain cryſtal does not, and generally decrepitates. It is infuſible *per ſe* in any heat but that of pure air, which barely ſoftens it. But it yields to alkalis with efferveſcence; to borax ſlowly and without any.

Its tranſitions are into hornſtone, flint, cornelian, opal, calcedony, ſiliceous ſhiſtus and ſandſtone.

By the niceſt teſt that could be employed Mr. Brugman could not diſcover the ſmalleſt degree of magnetiſm in mountain cryſtal[†]. Mr. Bergman in one ſpecimen found 6 per ct. of argill, and 1 of calx; but Mr. Meyer in another found only 2 per ct. of argill [‡]; and Mr. Gerhard frequently found none at all. By long digeſtion in acids, both he

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[*] It has been found alſo in quadrangular priſms. Ferber Briefe, 41.

[†] De Magnetiſmo, p. 73. 101.

1 Chy. An. 1785. p. 63.

and Mr. Dorthes imagine they diſcovered ſome traces of iron. Yet as they employed the Pruſſian alkali, which by long digeſtion in acids always betrays its own ferruginous contents, I think this experiment inconcluſive. The coloured cryſtals, however, undoubtedly contain ſome metallic particles.

Varieties of this Species.

1ſt *Variety*. *Glaſſy*, otherwiſe called fat quartz, of a greyiſh or bluiſh white, or red, yellow, brown, bluiſh or violet, or brown or black. Its luſtre that of greaſe, more or leſs ſemi-tranſparent. Its fracture groſs ſplintery and thence bordering on the conchoidal, on that account it feels ſmooth, and as if it were greaſy. Its hardneſs, 10. Its ſp. gr. 2,6459.

2d *Variety*. *Arid*, or meagre quartz. White, grey, brown, or greeniſh, has leſs luſtre than the former, and feels more harſh; its fracture more ſplintery. Its ſp. gr. 2,640.

3d *Variety*. *Lamellar*, by ſome called foliated, or ſparry quartz, not from its fracture, but from its form, as it conſiſts of plates either ſuperimpoſed on each other, or more generally placed at various angles with each other, and thence it is called *cellular*, ſometimes alſo in the form of a cock's comb, and thence called *criſtated*. According to Baron Born, thoſe found in Hungary are frequently partially ſoluble in nitrous acid, without effervescence, as they contain a conſiderable portion of calx, and ſometimes alſo of barytes. 1 Raab. 48.

4th *Variety.* *Stalactitic* in the form of ſolid or hollow cones, or in that of roſes, cauliflowers, grapes, &c.

5th *Variety.* *Fibrous*, this is exceeding rare.

6th *Variety.* *Granular*, conſiſting of grains compacted together, often reſembles ſandſtone, ſometimes cloſe and ſometimes looſe. Mr. Ferber mentions ſome of this kind that reſemble pumice, being ſo light as to float on water; whole mountains he ſays are formed of it. N. Act Petrop. 1785. p. 265. Some are criſtated and often contain calcareous earth.

Of the granular variety the moſt remarkable is that called aventurine, which contains ſome mica interſperſed betwixt its grains, and hence reflects a metallic luſtre. Of which Baron Born mentions five ſorts. 1ſt, The white and ſemitranſparent, with lamellæ, that reflect a ſilvery luſtre. 2d, The red or browniſh red, which reflects a gold colour. 3d, The grey. 4th, The green, both of which reflect a ſilvery colour. 5th, The black, reflecting a golden luſtre.

7th *Variety.* *Roſy red* quartz, found in Bohemia and Bavaria; is diſtinguiſhed by its luſtre, tranſparency, and fracture, which is imperfectly conchoidal. It is ſaid to derive its colour from mangancſe.

8th *Variety.* *Honey yellow*, otherwiſe called *citrine*, or impure topaz; in Carinthia this is found in pellucid hexahædral priſms, and perfectly tranſparent; but near Catharinenberg, in Siberia, Mr. Bindheim found a cryſtal of this ſort with very ſingular properties, in form and tranſparency it agreed with that of Carinthia, but its hardneſs was, 12. Its ſp. gr. 2,755*. When heated it attracted aſhes and other light bodies like tourmaline; it even became electric by friction, and when ſo attracted fine iron filings. It was infuſible *per ſe*, nor had borax, or microcoſmic ſalt any effect on it, but mineral alkali fuſed it into an opake opaleſcent maſs without efferveſcence. By his experiments it appears to conſiſt chiefly of ſilex, with a few particles of calx of iron and lime. 2 Berl. Beob. 256.

2d Species.

Amethyſt.

Its moſt uſual colour is *violet blue* of different degrees of intenſity, alſo milk white, grey, and very rarely olive or graſs green; often ſtriped with two colours.

Its ſhape is generally that of hexahædral pyramids, yet often occurs in blunt-edged pieces.

Its internal luſtre, ſometimes ſtrong, ſometimes weak and very weak.

Its tranſparency, 2 to 4. It cauſes a double refraction.

When its luſtre is ſtrong, its fracture is conchoidal, when weaker ſplintery, when weakeſt intermediate between the ſplintery and the coarſe diverging fibrous.

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* The book ſays 1,755, but I believe this muſt be a miſtake of the preſs, otherwiſe the author would have noticed a circumſtance ſo remarkable.

It often preſents irregularly columnar diſtinct concretions approaching to the granular, whoſe planes are obliquely ſeamed acroſs.

Its fragments, 3. Indeterminate.

Its Hardneſs, 10 or 11. Its ſp. gr. from 2,651 to 2,657.

It is infuſible *per ſe* at 160°, but loſes its colour in a ſtrong heat and becomes ſhivery; it is ſaid to derive it from manganeſe. By the heat of pure air, it is reduced to an enamel.

Mr. Achard attributes to 100 parts of this ſtone 60 of argill, 30 of ſilex, 8,22 of lime, and 1,66 of iron *. Yet as its external characters, and particularly its ſp. gr. is ſo low, I think it ſhould be placed immediately after the quartz, at leaſt until the analyſis be repeated, for its infuſibility render this ſomewhat ſuſpicious.

3d Species.

Emerald.

Its colour is from the perfect to the pale graſs green.

Its luſtre, 3 to 4. Its tranſparency, 3, 4, 2. Gives a double refraction.

Its ſhape hexangular priſms, truncated at the ſides or angles.

Its fracture conchoidal inclining to the uneven.

Its fragments, 3. Indeterminate.

Its hardneſs, 12. Its ſp. gr. 2,775.

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* Quoted in 6 Leonhardi, 398.

Heated to 120°, it becomes blue, but recovers its colour when cold; at 150° it melts *per ſe* into an opake diſcoloured maſs.

It is ſcarcely fuſed by mineral alkali, rather better by microcoſmic ſalt, and tolerably well by borax, when expoſed to the blowpipe.

One hundred parts of it contain by Bergman, 60 argill, 24 ſilex, 8 calx, and 6 of iron; and by Achard 60 argill, 21,66 ſilex, 8,33 calx, and 5 of iron. Neither of theſe reſults is improbable. Mr. Quiſt obſerved, that the addition of lime renders emeralds more fuſible, which is very conſiſtent with its properties and compoſition.

Emeralds are now found only in Peru; the Braſilian are in reality actinolites.

This ſtone cannot be placed among the precious, by reaſon of its low ſp. gr. and double refractive power; and, as it agrees in moſt reſpects with cryſtal, it may as juſtly be placed in the ſame claſs with it as amethyſt is by many mineralogiſts, the only reaſon that could prevent it is the fuſibility of the emerald, which induces me to ſeparate them.

4th Species.

Berryll *. Aigue Marine of many.

Its colour is greyiſh green, often verging on the apple green, more rarely bluiſh green. Its internal luſtre is variable. Tranſparency, 2,3,4.

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* 1 Bergm. Journ. 1788, p. 253. 1 Chy. An. 1790, p. 491. 2 Lempe Magaz. p. 60.

Cryſtallized in equiangular hexahædral priſms longitudinally ſtreaked.

Its longitudinal fracture is rather conchoidal, its croſs really foliated, though it appears only uneven.

Its hardneſs is at leaſt 12. Its ſp. gr. from 2,65 to 2,722.

It decrepitates when heated and generally is diſcoloured; but does not melt in a heat of 150°. Mineral alkalis affect it moſt, borax very little, and microcoſmic ſalt ſcarce at all.

It becomes electric by friction; but one of its poles is attractive whilſt the other is repulſive.

According to Mr. Bindheim's analyſis, 100 parts of it contain 64 of ſilex, 24 argill, 8 calx, and 1,66 iron.

It ſeems alſo to be the ſtone which Mr. Heyer analyzed under the name of Siberian aigue marine, and in which he found 0,67 ſilex, 0,32 argill, 0,01 calx, and 0,002 of iron [*].

Mr. Herman, 61 ſilex, 29 argill, 2 calx, and $\frac{1}{2}$ iron, 7 parts loſt. 1 Chy. An. 1792, p. 295.

5th Species.

Praſium.

Generally of a dark browniſh, ſometimes yellowiſh green.

Its luſtre, 2. Tranſparency, 2.

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[*] 4 Berl. Beob. p. 154.

It is found either in irregular maſſes, or cryſtallized in hexahædral pyramids, or ſmall hexahædral tables, ſuperimpoſed one on the other, and forming hexahædral priſms, ſometimes in ſlender needle like cryſtals.

Its fracture, coarſe ſplintery. Its fragments ſharp.

Its hardneſs, 10. Its ſp. gr. 2,580.

It is capable of a fine poliſh, but, after ſome time, is ſaid to become turbid.

It ſeems to conſiſt of a mixture of quartz, and ſhoerlaceous actinolite, both are even ſometimes diſtinguiſhable.

6th Species.

1ſt Family.

Oriental Ruby.

Its colour is carmine red, ſometimes verging to violet, or intermediate between carmine and hyacynth red; but the ſame ſtone is in various parts, ſometimes red and white, or red and blue, and thence called ſapphire ruby, or orange red, by ſome called vermeille or rubicelle.

It is found cryſtallized in elongated hexagonal pyramids joined to, and oppoſed baſe to baſe; its ſize ſeldom an inch. Its luſtre, 3, 4. Tranſparency, 3, 4.

Its fracture, foliated. Its fragments, 3.

Its hardneſs, 17. Its ſp. gr. 4,288.

It

It retains its colour and is infuſible in a heat of 170°, ſomewhat diſcoloured and barely ſoftened by the heat of pure air.

When finely powdered, borax melts it though with difficulty into a greeniſh glaſs, it yields alſo to microcoſmic ſalt, but not to fixed alkalis.

By Mr. Bergman's analyſis, 100 parts of the vermeille kind contains 40 argill, 39 ſilex, 10 aërated calx, and 10 of iron.

By that of Mr. Achard, 41,66 ſilex, 36,66 argill, 8,33 calx, 10,83 of iron.

However, I found a compound of 39 parts ſilex, 40 argill, 10 aërated calx, and 10 oxygenated calx of iron, to melt at 140°, into a greyiſh black porous ſlagg. I therefore believe that the proportion of calx ſet forth in theſe analyſes too great. The high ſpecific gravity of the ſtone prevents me from judging that of the iron too high.

2d Family.

Oriental Topaz.

Its colour golden yellow.

Luſtre, 3, 4. Tranſparency, 4. Gives a ſingle refraction.

Its ſhape as that of the ruby.

Its fracture, foliated. Fragments, 3.

Hardneſs, 15. Sp. gr. 4,0106.

It is infuſible *per ſe*, and loſes its colour, only in a very high degree of heat. Reſiſts alkaline fluxes,

fluxes, and yields only to borax and microcoſmic ſalt, with which it yields a clear glaſs.

3d Family.

Oriental Sapphire.

Its colour, Berlin blue, but often decreaſes ſo much in intenſity as to become almoſt white, and then called *lux ſapphire*.

Its internal luſtre, 3 or 4. Tranſparency, 3, 4, 2. Cauſes ſingle refraction.

It is found cryſtallized in the ſame form as the preceding families, and often in rounded maſſes, the angles being worn off by friction.

Its fracture foliated.

Its hardneſs, 17. Its ſp. gr. 3991.

It is infuſible at 168°, and generally preſerves its colour. It is affected by the uſual fluxes, as the preceding gems. By the heat of pure air it forms an enamel.

The ſapphires, found amidſt the ferruginous ſand of Expailly, near Puys in Velay, ſeem of this ſpecies. Their colour, hardneſs, and tranſparency being ſimilar, and their ſp. gr. 4,076. They are very ſmall, their form ſomewhat irregular from the friction they muſt have encountered.

According to Mr. Bergman, this ſtone contains 0,58 argill, 0,35 ſilex, 0,5 aërated calx, and 0,02 of iron. By Mr. Achard, 0,5833 argill, 0,3333 ſilex, 0,0666 calx, 0,0333 of iron.

To

To this family we may alſo annex the ſtone called *Gyraſale*, of which we have as yet no analyſis, and but an imperfect deſcription.

Its colour is white with a ſlight tinge of red, and a ſtill lighter of blue, which gives it ſome reſemblance to calcedony.

Its luſtre, 3, 4. Tranſparency, 3; gives a ſingle refraction.

Its hardneſs, 15. Its ſp. gr. 4,000.

7th Species.

Spinell and Balaſs Rubies.

The colour of the former a deep, of the latter a pale red, or inclining to orange.

Luſtre, 3. Tranſparency, 3, 4. Gives a ſingle refraction.

Its form octohædral, conſiſting of two pyramids, each of four planes, and joined baſe to baſe; or triangular, or trapezoidal plates bevilled on the edges.

Its hardneſs, 13. The ſp. gr. of the ſpinelle, 3,76, of the balaſs, 3,645.

By Mr. Klaproth the ſpinelle which he analyzed, and whoſe ſp. gr. was only 3,5700, contained, 0,7635 argill, 0,1568 ſilex, 0,0263 of iron, and 0,0128 calx. The remainder was loſt in the operation *. It ſhould be obſerved, that what is here called ſilex melted in fixed alkali without effervescence, and therefore it may be doubted whether it be genuine ſilex.

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* 3 Berl. Beob. 336.

The

The ſtone imported from Ceylon, called *ruby ſpar*, whoſe ſp. gr. is 3,454, is an irideſcent ſort of ſpinell ruby.

8th Species.

1ſt Family.

Occidental or Braſilian Ruby.

Red inclining to yellow.

Luſtre, 3. Tranſparency, 3.4. Produces a double refraction.

Shape quadrangular rhomboidal priſms, ſometimes with and ſometimes without pyramids, often difficult to determine.

Fracture foliated.

Hardneſs, 16. Its ſp. gr. 3,531.

It is infuſible *per ſe*, even by pure air it is barely reduced to a fine-grained porcelain maſs.

2d Family.

Occidental Topaz.

1ſt Variety, Brazilian.

Golden yellow, but paler than the oriental and even white.

Luſtre, 3.4. Tranſparency, 3.4. Produces a double refraction.

Shape, as that of the former family, the priſms often longitudinally ſulcated.

Fracture, foliated. Hardneſs, 16. Sp. gr. 3,536.

Expoſed to a moderate heat, it is ſaid to become *red*, and then becomes ruby of Brazil; in a ſtronger, it loſes its colour; however, it is fuſible at 160°; by borax it may be vitrified, and by the heat of pure air converted into an enamel.

2d Variety.

Saxon.

Its moſt uſual colour is pale wine yellow, rarely a purer yellow, often yellowiſh grey, or greyiſh white.

Its external luſtre caſual, internal, 3.2. Tranſparency, 2.3.4. Gives a double refraction.

Its uſual form, that of an octangular priſm. Four of the angles very obtuſe.

The planes longitudinally ſtreaked, and cuneiform pyramids. Often in blunt rounded fragments. Fracture, foliated.

Hardneſs, 14. Sp. gr. 3,564. The paleſt called white topaz, 3,553.

When ſtrongly heated it becomes white*, and cracks at 160°. By pure air it is converted into an enamel.

According to Mr. Bergman, it contains, 0,46 argill, 0,39 ſilex, 0,08 aërated calx, and 0,06 of iron.

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* 4 Berl. Beob. 15, 16.

By Mr. Weigleb[*], 0,5229 ſilex, 0,4459 argill, 0,025 calx, 0,0031 of iron. This appears the moſt exact; for a ſtone, compounded as Mr. Bergman's, ſhould be more fuſible; in effect I found a compound, formed exactly as Mr. Bergman's reſult, to melt at 144° into a greyiſh black porcelain maſs ſomewhat porous.

3d Variety.

Topaz.

Aigue marine, by ſome called oriental aigue marine.

Its colour bluiſh or pale green.

Its luſtre, 4. Tranſparency, 3.2. Double refraction.

Found either in rounded or ſharp-edged fragments, or cryſtallized in hexahædral priſms, as topaz, furrowed lengthways.

Fracture, foliated. Hardneſs, 12. Sp. gr. from 3,47 to 3,548.

It is infuſible *per ſe*.

3d Family.

Occidental or Brazilian Sapphire.

Its colour of all ſhades of blue; often white.

In other reſpects, it agrees with the preceding.

Its hardneſs, 15 or 16. Sp. gr. 3,1307.

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[*] 1 Chy. An. 1786, p. 111.

It is infuſible *per ſe*, but loſes its colour in a heat of 130°.

9th Species.

Hyacinth.

Yellowiſh red, mixed with brown; one of theſe colours ſometimes predominates, and ſometimes the other, but generally the red. Hence we have the dilute red, and ſometimes the blood red; theſe are often miſtaken for garnets; but theſe have generally a bluer tinge, and are ſpecifically heavier.

Its luſtre, 3. Tranſparency, 3.4. Double refraction.

Its form may be conſidered as that of a rectangled quadrangular priſm, terminated by two rhomboidal pyramids; but it generally occurs only in blunted fragments.

Its ſurface ſmooth.

Its fracture foliated.

Its hardneſs, 12 or 13. Sp. gr. from 3,687 to 3,76.

According to Mr. Quiſt, the reddiſh yellow hyacinth, which he calls true hyacinth, being packed in ſand, acquires a pink colour in a moderate heat; in a ſtronger it loſes its colour, but retains its tranſparency, and does not melt at 160°; neither can alkalis flux it; but borax and microcoſmic ſalt are more effectual.

The yellowiſh brown, though it retains its colour in a ſtrong heat, yet melts at 150° or 160° *. Hence theſe two appear to differ.

Mr. Bergman attributes to the yellower ſort, 0,40 of argill, 0,25 of ſilex, 0,20 aërated calx, and 0,13 of iron; and Mr. Achard, 0,4133 argill, 0,2166 ſilex, 0,20 calx, and 0,1333 of iron.

I found a compound, formed as Mr. Bergman's reſult, to form a grey maſs not well melted at 144°, yet glazed at the ſurface; which ſhews that a few degrees more would effect its fuſion, or, perhaps, the ſame degree, if longer continued.

10th Species.

Garnet.

Of this we have three varieties.

1ſt Variety.

Oriental Garnet. Carbuncle.

This is ſo called, not from its being found only in the eaſtern countries, but from its greater perfection; viz. hardneſs, luſtre, and tranſparency.

Its colour, deep or blood red, yet inclining to violet.

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[*] Mem. Stock. 1768.

Its internal luſtre, 3 or 4. Tranſparency, 4. Double refraction.

Cryſtallized, and preſenting either 12 rhomboidal planes, or 24 trapezoidal, or 36 planes, of which 12 are rhombs, and the 24 others elongated hexagons, interpoſed between theſe rhombs, and ſome other variations.

Fracture, conchoidal.

Hardneſs, 14 or 13. Sp. gr. from 4,000 to 4,188.

2d Variety.

Common Garnet.

Deep red, inclining to violet, or verging to black, or olive, or leek green, or brown, ſeldom yellow.

Its external luſtre caſual, internal 2.3. Tranſparency, 2.3.1. Of the browniſh and blackiſh, moſt frequently, 0. Of the green at moſt, 2.

Cryſtallized as the former variety, the ſurface of the cryſtals often diagonally ſeamed, frequently found alſo in rough rounded grains, or fragments.

Fracture uneven, inclining to the conchoidal, flat or imperfect, often to the ſplintery.

Hardneſs, from 10 to 11. Yet ſometimes only 9.

Specific gravity, of the red, from 3,941 Werner, to 4,000 Briſſon; of the green, from 3,75 to 3,800.

I have found that of ſome ſmall garnets 3,63.

Both varieties exert moſt commonly ſome action on the magnetic needle.

According to Mr. Bergman, they are fuſible, *per ſe*, by the blowpipe, ſometimes into a tranſparent green glaſs, but moſt commonly into a black ſlagg. Alkalis flux them with great difficulty, borax and microcoſmic ſalt convert them into a green or black glaſs *. Mr. Gerhard tells us, that in a ſtrong heat they form a grey glaſs †; yet Mr. Fourcroy, in a ſtrong heat of eleven hours, found garnets powdered, barely ſoftened and agglutinated ‡. Obſerving theſe different reſults, I expoſed 35 grains weight of ſmall Bohemian garnets, whoſe ſp. gr. was 3,63, to a blaſt heat for a few minutes, and found them melted into an opake dark grey, fine grained porcelain, by a heat of 136°.

By Mr. Bergman's account this ſtone contains more ſilex than argill, and more argill than calx; of iron it contains from 0,02 to 0,20.

By Mr. Achard, red Bohemian garnet contains 0,483 ſilex, 0,30 argill, 0,116 calx, and 0,10 iron.

Mr. Wiegleb found the green garnets of Saxony to contain 0,3645 of ſilex, 0,3083 calx, and 0,2875 of iron §. If ſo, the green garnets being alſo ſpecifically lighter, we may ſuſpect them to be ſpecifically different from the red. In another experiment, however, Mr. Wiegleb found the argillaceous ingredient alſo in the green; and ſo did Mr Merz; for, in that of Ehrenberg, he ſound 0,40 ſilex, 0,20 argill,

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* 2 Bergm. 105.

† Grundriſſ. 111.

‡ 6 Buff. Mineralogy 251. in octavo.

§ 1 Chym. Ann. 1788. p. 201.

0,08 calx, and 0,20 of iron. The 12 grains miſſing muſt have been air and water, and perhaps a caſual loſs; but it appears the calx is aërated, as Mr. Wiegleb found alſo a conſiderable *deficit* *.

It is commonly found in ſhiſtoſe mica, or gneiſs, more rarely in argillites or granites.

3d Variety.

Amorphous Garnet.

Its colour, browniſh or blackiſh red.

Its luſtre, 2. Tranſparency, 2.1.

Fracture, foliated and ſlaty.

Hardneſs, 11 or 12. Sp. gr. 3,89. Leſke O. 83.

Found in Sweden, and the Eaſt Indies. See Leſke, 50 and 83, O; and alſo in Swiſſerland by Mr. Sauſſure.

Mr. Maquart mentions another variety, which he calls the ſubſtance of which garnets are formed; it conſiſts of ſtreight fibres, diverging from a common center. Eſſaies de Minéralogie, p. 373.

11th Species.

Chryſoberyll †.

Its colour is a dilute yellowiſh green, but like an opal it reflects, ſeemingly from its inſide,

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* 1 Voight Abhandl. 15, and 22.

† 2 Bergm. Journ. 1790, p. 84, 90. Leſke, O. 9. Gmel. Grundr. p. 22.

a mixed colour of bluiſh green and golden yellow.

Its luſtre, 3.4. Tranſparency, 3.4.

Its fracture conchoidal.

Its hardneſs, 10. Sp. gr. 3,698 to 3,719.

12th Species.

Chryſolite.

Its moſt uſual colour is yellowiſh green, mixed with brown, ſometimes verging to the olive green, and ſometimes to pale yellow, mixed with grey, ſeldom allied to reddiſh brown, or graſs green.

Its internal luſtre, 3.4. Tranſparency, 4.3.

It is found partly in ſharp uneven indented fragments, often rounded grains, and partly in mutilated cryſtals, which ſeem to derive from right-angled quadrangular priſms, whoſe angles were truncated.

Its ſurface has a fine ſplintery or ſcaly appearance; but ſuch of the cryſtals as have not been injured by friction have their broadeſt ſides ſtreaked lengthways. Where the ſurface has not ſuffered by attrition, it has a conſiderable luſtre.

Its fracture, in every direction, is conchoidal. Fragments, 3.

Its hardneſs from 9 to 10. Brittle. Sp. gr. from 3,340 to 4,410. Mr. Werner adds, that no ſtone, whoſe denſity is inferior to 3,300, or ſuperior to 3,450, is a chryſolite.

It is infuſible at 150°, but loſes its tranſparency and becomes blackiſh grey. By pure air it it is converted into an enamel. Borax and microcoſmic ſalt effect its fuſion, but alkalis have ſcarce any action on it.

The above account is taken, with little alteration, from Mr. Werner's maſterly treatiſe on this ſtone, in the ſecond part of the Miner's Journal, for 1790. He there ſhews that this ſtone hath been frequently miſtaken, and that olivins, greeniſh tourmalines, chryſoberylls, olive green amethyſts, prehnites, yellowiſh green garnets, and dark green cryſtals, found near Veſuvius, have been taken for it by different writers; nay, that Mr. Rome de Liſle had been ſo far deceived as to deſcribe cryſtals of phoſphorite, and Saxon topaz, under the appellation of chryſolites. Baron Born, in Raab's Catalogue, fell into ſimilar miſtakes.

According to Mr. Achard it contains 0,64 argill, 0,17 calx, 0,15 ſilex, and 0,0166 of iron *.

13th Species.

Olivin †.

Its colour, light browniſh green, often inclining to the yellowiſh and greyiſh green; and, when withered, to browniſh or ochre yellow. Lately alſo, ſome has been found of a bluiſh or mountain green. 1 Bergm. Journ. 1792, p. 290.

Its internal luſtre, 2.3. Tranſparency, 3.2,

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* 2 Bergm. Journ. 1790, p. 69.

† 2 Bergm. Journ. 1790, p. 55.

It is found generally in roundiſh grains, moſtly inſerted in other ſtones; but ſometimes in large maſſes, never yet cryſtallized.

Fracture, conchoidal, approaching to the uneven, ſeldom imperfectly foliated; and then it is not certain that it is not different ſtone; or, perhaps, a variety of the ſame *.

When large, it preſents ſmall-grained diſtinct concretions eaſily ſeparable.

Its hardneſs, 9. Brittle. Sp. gr. from 2,96 to 3,225.

It eaſily withers by expoſure to the open air.

By the experiment of Mr. Voight and Mayer, it is fuſible into an enamel in a heat of 150° or 160°.

Hitherto it has been found only in baſalts or traps, and not in wacke, or amygdaloids; yet Mr. Lievre aſſures us, he detected it in ſome potſtones on the Pyrenees. 30 Roz. 397.

This ſtone is attacked by digeſtion in nitrous acid; and its ferruginous part taken up; but chryſolites are not affected by this acid; and thus we have a ſufficient criterion whereby to diſtinguiſh them.

14th Species.

Obſidian.

Icelandic agate of ſome, lux ſapphire of Hungary.

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* 1 Bergm. Journ. 1792, p. 242.

Its colour, black or greyiſh black; in very thin pieces dark green.

Its internal luſtre, 3. Tranſparency, 1.

It is found in detached maſſes, or inherent in gneiſs, granite, or porphyry; generally inveſted with a grey opake cruſt. Fichtel ſays it has been found in the form of a twelve-ſided pyramid *.

Its fracture, perfectly conchoidal, ſometimes irideſcent.

Hardneſs, 10. Sp. gr. 2,348.

It melts into a grey opake maſs.

According to Mr. Bergman, Icelandic agate contains, 0,69 ſilex, 0,22 argill, 0,09 iron.

We have no reaſon to ſuſpect it of volcanic origin, as it is found in Hungary, inhering in gnieſs, and diſintegrated granite. Gerh. Miner. Syſt. 283.

15th Species.

Shorl. *Schwartzer Stangen Shorl* of Werner.

Its colour is black.

Its luſtre 2, common. Tranſparency, 0.

It is found either in maſſes of an indeterminate form, or cryſtallized in three or nine ſided priſms, which, when intire, are terminated with three-ſided ſummits.

The ſurface of the cryſtals is longitudinally ſtreaked.

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* Beytr. Zur. Mineral Geſch. Siebenburgh, Theile. 1, p. 143.

The amorphous ſort preſents thin, ſtreight, diſtinct, columnar concretions; ſometimes paralell, ſometimes diverging or ſtelliform, ſtreaked, and eaſily ſeparable from each other; very ſeldom irregular granular concretions.

Its fracture conchoidal, verging to the uneven; and hence often reſembling the ſtriated.

The longitudinal fracture, foliated.

Its fragments, 3. Gives a grey ſtreak.

Its hardneſs, 10. Its ſp. gr. from 2,92 to 3,212.

When heated to redneſs, it alters its colour in cooling, to a browniſh red; at 46°, it becomes redder; at 65°, it does not melt; but at 127°, it is converted into a browniſh black compact enamel; at 147°, it becomes more porous, and its ſurface ſomewhat redder. I found its ſp. gr. after expoſure to that heat 2,143, from the number of ſmall pores.

The word ſhorl ſo frequently occurs in mineralogical writings, and has been ſo often applied to ſtones of various ſpecies, not only by different, but often even by the ſame author, that it becomes neceſſary to point out the different ſenſes in which it occurs amongſt the moſt eminent of thoſe writers.

The term itſelf is derived from the Swediſh *ſkorl*, brittle, and was firſt uſed by Cronſtedt to denote a claſs of ſtones of a columnar form and conſiderable hardneſs and denſity; their ſp. gr. being from 3 to 3,4. But it unfortunately happened, this claſs of ſtones comprehended many of different ſpecies, ſuch as baſalts, actinolites, &c. And, as he tranſlated this word into Latin by by the baſalt, the confuſion was thereby increaſed.

He does not, however, pretend it is always cryſtallized; for, he diſtinguiſhes four ſorts, the the laſt of which only is, he ſays, cryſtallized.

1ſt, *The amorphous martial ſhorl, or ſkorlberg*; this, Wallerius tells us, is his own 148th ſpecies, of a green or yellowiſh green colour; its ſp. gr. 3,200, difficultly, if at all, giving fire with ſteel. This is what is now called the Gemeiner, or Common Actinolite, of Werner, as far as this takes in the amorphous ſort only.

2d, *The ſhorl ſpar* of a green, and ſometimes of a white colour; this is the *baſaltes ſpathoſus* of Wallerius, and probably denotes the green foliated hornblende and ſhorlite.

3d, *The fibrous, or ſtrahl ſhorl*; black, green, and white; the *baſaltes fibroſus* of Wallerius, which is the cryſtallized common actinolite of Werner.

4th, *The ſhorl cryſtal*, which he tranſlates *baſaltes cryſtalliſatus*, of which he diſtinguiſhes three colours, the black, green, and reddiſh brown; as does Wallerius, who, deceived by the name, comprehends alſo the pillars of the Giants Cauſeway under this ſpecies. The black, however, is the real ſhorl; the other colours probably comprehend actinolites and tourmalines.

Mr. Bergman alſo diſtinguiſhes three ſorts of ſhorl, the *fibrous*, which he mentions in his treatiſe on aſbeſtos, the cryſtallized, and the ſcaly; this laſt he alſo calls hornblende *; but the firſt melts, *per ſe*, into a grey porcelain maſs, and

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* 2 Bergm. 107.

therefore

therefore does not belong to this ſpecies; the cryſtallized is ſoftened indeed by the blowpipe, but is ſcarcely melted into a bead, whereas hornblende melts eaſily, and therefore they are not of the ſame ſpecies; he alſo owns, that the cryſtallized ſort emulates the hardneſs of cryſtal, whereas hornblende may be ſcraped by a knife. Again he diſtinguiſhes the cryſtallized into tranſparent and opake; the tranſparent are yellow, or brown, but moſtly green; the opake, alſo, black or green.

Thus the tourmalines alſo, to ſay nothing of baſaltic hornblendes, will be comprehended under this denomination.

Mr. Sauſſure's definition of the characters of this ſtone is alſo too comprehenſive; it is, he tells us, " a hard bright cryſtallized ſtone, partially ſoluble without effervеſcence in acids, and fuſible *per ſe*. Its hardneſs, 10; its fracture, vitreous; its ſpecific gravity, far exceeding that of cryſtal; its colours, green, yellow, or black;" to which he afterwards adds white, and alſo baſaltic hornblende.

Mr. Romé de Liſle conſtantly confounds ſhorls, actinolites, tourmalines, and baſaltic hornblendes; yet he owns that he long heſitated whether he ſhould not conſider theſe laſt as a diſtinct ſpecies; he calls them volcanic ſhorls.

To Mr. Werner's ſagacity we owe the preciſe characters by which theſe different ſpecies are now accurately diſcriminated; and which we have enumerated in treating of each.

From the indiſcriminate application of this name to ſtones of different ſpecies, we are at a loſs to know

know to which of them the few analyſes we have of ſhorls ſhould be particularly applied.

Mr. Bergman, in his Treatiſe on Gems, tells us, that ſhorl contains a larger proportion of ſilex than garnet does (and in garnet the ſiliceous is the moſt copious ingredient); next to that the argillaceous; and next to that the calcareous is the moſt prevalent. In black ſhorls, he tells us, iron is in the proportion of 20 per ct. however, as he mentions yellow, brown, and green ſhorls, it is uncertain to which of them this gradation of ingredients ſhould be attributed.

Mr. Wiegleb, indeed, ſeems to have analyzed the genuine ſhorl of which we here treat; yet his account differs in many circumſtances from that of all other chemiſts; for, in the firſt place, he found that unleſs the union of its conſtituent parts were weakened by calcination with an alkali, ſpirit of nitre, even by long digeſtion, could diſſolve no part of it *. And again he tells us, it contains no calx, but only 0,3416 ſilex, 0,4125 argill, 0,20 iron, 0,0541 manganeſe †.

Mr. Chaptal, on the other hand, relates, that he found, in the black priſmatic ſhorl of Gevaudan, 0,52 ſilex, 0,37 argill, 0,05 calx, 0,03 manganeſe, and 0,03 of iron. 2 Chaptal, p. 123.

Mr. Sauſſure alſo informs us, that the ſhorls he examined were in great meaſure ſoluble in nitrous and all the mineral acids without any previous operation, and contained both magneſia

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* 1 Chym. An. 1785. p. 246.

† 1 Crell Beytrage. 4 Stuck. p. 33.

and

and calx, as well as argill, ſilex, and iron. ‡ Sauſſ. p. 64, 65, &c.

Mr. Bergman even thinks calx an ingredient eſſential to ſhorl [*]. In the analyſis he gives us of the black cryſtallized ſhorl of Mount Albano, he found both calx and magneſia, but this was moſt probably a baſaltic hornblende.

Mr. Bindheim alſo found 21,6 per ct. in what he calls priſmatic ſhorl diſcovered in limeſtone in the Carpathian Mountains; but it is not clear, as no deſcription is given, what ſtone it really was. Mr. Bergman thinks it was a zeolyte [†].

I tried Mr. Wiegleb's reſult ſynthetically, and found a compound exactly formed as his reſult, omitting only the mangañeſe, ſcarcely fuſible at 148°; it formed only a greeniſh black porous ſlagg.

To comprehend in one view the different ſignifications of this term, we may obſerve, that what are called,

White Shorls, are ſhorlites, or acicular baroſelenites;
Yellow, baſaltic hornblendes;
Reddiſh brown, baſaltic hornblendes, and ſometimes tourmalines;
Green, if fibrous, ſhorlaceous, or vitrous actinolites; if groſſer, prehnites; ſometimes even hornblende is called green ſhorl [‡];

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[*] Schwed. Abhand. 1784, p. 113.

[†] 2 Chy. Ann. 1784, p. 396.

[‡] For inſtance, by Mr. Beſſon, ſee Eſtner Freymuth Gedanken, p. 37, 38.

Violet,

Violet, thumerſtein;

Blue, ſappare;

Black, and *hexagonal*, or *volcanic*, are alſo baſaltic hornblende;

Red ſhorls, longitudinally ſtreaked, have been lately found in Hungary. 1 Raab. 168. I have alſo obſerved one in Leſke's collection O. 171; but ſo ſmall, and ſo firmly ſtuck in quartz, that I could make no experiments upon it. Rubellites are alſo ſo called.

16th Species.

Tourmaline.

The uſual colour is brown, often ſo dark that, when not held to the light, it ſeems black, yet often ſo light as to approach to the hyacinth red; ſometimes it verges to the olive green, or dark green; it is even found blue. Mr. Bergman tells us, that of Ceylon is dark brown, or yellowiſh; that of Brazil, greeniſh, bluiſh, reddiſh, or yellowiſh brown; that of Tyrol, by reflected light, blackiſh brown; but, by tranſmitted light, yellowiſh, or, in thin pieces, greeniſh. That of Switzerland blackiſh.

Its internal luſtre, 2.3. Tranſparency, 3.4.2. and 1, when black.

It is found in detached blunt-edged pieces, or grains, or cryſtallized in ſlender three or nine ſided priſms, with a tetrahædral ſummit.

The ſurface of theſe cryſtals is often ſmooth, but often alſo longitudinally ſeamed.

Its fracture conchoidal, yet ſometimes diſcovers ſome tendency to the foliated.

Fragments, 3. The detached amorphous pieces diſcover columnar concretions.

Its hardneſs, from 9 to 11. Sp. gr. from 3,05 to 3,155.

But its moſt remarkable character is the electrical power it acquires when heated to about 200°, of Fahr. ſo that it attracts and repels aſhes, and other light bodies; yet this property is ſaid to have alſo been found in opake ſhorls. 2 Bergm. p. 124.

It reddens when heated, and is fuſible *per ſe*, the cryſtalized with intumeſcence; and that from Ceylon or Tyrol forms a *whitiſh* ſpungy enamel; the uncryſtallized, that of Brazil, melts more difficultly.

Hence we ſee that tourmalines differ from ſhorls generally in colour and tranſparency; but chiefly in the reſults of their fuſion.

Neither microcoſmic ſalt, nor mineral alkali, readily flux it; nor borax, though its action is more ſenſible.

The mineral acids extract both calx and iron from it when barely pulverized, and after long digeſtion or diſtillation; but do not decompoſe it perfectly without particular management.

The proportion of ingredients in the tourmalines of Ceylon, Tyrol, and Brazil, according to Mr. Bergman, and in that of Mount Gothard, in Swiſſerland, according to Struvius, is as follows:

	Ceylon.	*Tyrol.*	*Brazil.*	*St. Gothard.*
Silex	37	40	34	37,5
Argill	39	42	39	38,5
Calx	15	12	11	10
Iron	9	6	5	9

17th Species.

Thumerſtone [*]. Shorl Violet de Dauphiné, Glaſs Shorl of ſome.

Its colour is clove brown, often very light, or inclining to red, greeniſh, or pearl grey; or inclining to violet, or black.

Its luſtre, 2. Tranſparency of the amorphous, 2.1; of the cryſtallized, 3.4.

It is found either amorphous or cryſtallized; the amorphous is lamellar, and nearly foliated.

The cryſtallized forms flat rhomboidal cryſtals, whoſe angles are truncated.

The faces, except where truncated, generally longitudinally ſtreaked; the grey are often cellular, and the cells filled with the brown variety.

The fracture, minute conchoidal, inclining to the uneven. Fragments, 3.

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[*] 1 Bergman, Journ. 1788, p. 55, and 262. 1 Helvet. Magaz. 180.

Its hardneſs, 10, 9. Brittle. Specific grav. 3,2956.

When heated little above redneſs, it ſwells and foams like zeolyte, which proves it to be ſpecifically different from ſhorls, and at laſt melts into a hard black enamel.

According to Mr. Klaproth, it contains 0,527 ſilex, 0,256 argill, 0,094 calx, 0,096 calx of iron, and ſome manganeſe.

It is found cryſtallized in Dauphiné, and near Bareges, and amorphous in Saxony, near Thum, whence Mr. Werner calls it Thumerſtein.

18th Species.

Prehnite *.

This ſtone has been denoted by various names. By ſome it has been called green ſhorl; by others, emerald, or praſium, or chryſopraſium; and even feltſpar, and chryſolite, and zeolite of the cape.

Its colour is apple green, or greeniſh grey, of various degrees of intenſity.

Its external luſtre, 2. Its internal leſs, and of the pearly kind. Its tranſparency, 3.2.

It is found both amorphous and cryſtallized. The amorphous preſents either a foliated or ſtriated texture; the foliated conſiſts of large or ſmall-grained diſtinct concretions, and the ſtriated forms imperfect, ſlender, columnar concretions.

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* 1 Bergman's Journal, 1790, p. 110. 32 Roz. Journ. 82. 1 Ann. Chy. 202.

The cryſtallized forms either low, ſmall, compreſſed, flat, quadrangular priſms, or tables; and ſome with truncated angles, and heaped together, or in groups.

The principal fracture is foliated, ſeldom ſtriated; the croſs fracture uneven, and fine grained. Its hardneſs from 9 to 10. Brittle. Its ſp. gr. 2,9423.

Expoſed to the blowpipe, it ſwells and foams when heated to redneſs ſtill more than zeolites do, and melts into a brown enamel, ſmooth on the outſide, but ſpungy and porous underneath.

Of the uſual fluxes borax is the moſt effective; with alkalis it forms only an enamel, but microcoſmic ſalt forces it into an opaleſcent glaſs.

By the analyſis of Mr. Klaproth, it contains 0,4383 ſilex, 0,3033 argill, 0,1833 calx, 0,0566 iron, and 0,0183 of water and air.

By that of Mr. Haſſenfratz, 0,50 ſilex, 0,204 argill, 0,233 calx, 0,049 iron, 0,009 water, and 0,005 magneſia.

This ſtone was firſt found near the Cape of Good Hope by Capt. Prehn, hence Mr. Werner calls it prehnite. Lately, it has been diſcovered near Dumbarton, in Scotland, by that accurate obſerver Mr. Grotſche. It has alſo been found in Dauphiné.

In luſtre, texture, and intumeſcence, it reſembles zeolites, but differs in hardneſs, ſpecific gravity, colour, relation to fluxes, and alſo in conſtitution, for it contains iron; neither does it gelatinate with acids as zeolites do. On the other hand, it differs from ſhorls, by its fracture, intumeſcence when heated, greater fuſibility, and the poroſity of its enamel. Hence Mr. Werner juſtly conſiders it as a particular ſpecies, but nearly allied to zeolite.

19th Species.

Ædelite, or Siliceous Zeolite *.

Its colour is light grey, ſometimes with a tinge of red, or yellowiſh brown, green, or yellowiſh green.

Its luſtre, 0.1.

Its form, tuberoſe, or knotty.

Its fracture, ſtriated, but ſometimes ſplintery, like quartz.

Its hardneſs from 9 to 10. Sp. gr. 2,515, when penetrated with water, of which theſe ſtones abſorb about $\frac{1}{80}$ of their weight, and ſometimes more.

The external characters are but imperfectly given, as I neither poſſeſs any ſpecimen, nor have ſeen any juſt deſcription of it.

Treated by the blowpipe it intumeſces, and gives a frothy maſs.

It contains from 0,62 to 0,69 ſilex, 0,18 or 0,20 argill, 0,08 or 0,16 calx, and 0,03 or 0,04 of water. Per Bergman, Mem. Stock. 1784, p. 114.

Theſe ſtones have hitherto been found only in Sweden, at Adelfors, and Meſſeberg, and muſt not be confounded with zeolites mixed with ſilex or calcedony, which are much more common,

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[*] Schwed Abhandl. 1784, p. 114.

and

and abound in Auvergne. They have hitherto been claſſed with common zeolites, becauſe they conſiſt of ſilex, argill, and calx, in a proportion progreſſively diminiſhing, and anſwer to Mr. Bergman's formula *ſac*, as he himſelf tells us, and becauſe they contain water, and ſwell or froth before fuſion, and have a ſtriated texture. But, if theſe reaſons were valid, prehnite ſhould alſo be reckoned a zeolite; for, its compoſition correſponds with the formula *ſac*; it contains water, intumeſces before fuſion, and has a ſtriated texture; yet moſt mineralogiſts conſider it as a diſtinct ſpecies; the proportion of ingredients muſt be conſidered, and in this caſe the *proportion* of water, which I look upon to be eſſential to zeolites, is wanting; for this ſtone contains only 3 or 4 per ct. a proportion not exceeding that in ſeveral other ſpecies of ſtones, and merely accidental; indeed, any quantity below 5 per ct. (except a metal) makes no alteration in the notable properties of any ſtone, as I have before remarked.

On the other hand, a hardneſs, not ſufficient to give fire with ſteel, is a property laid down as one of the criteria of zeolites by Cronſtedt, otherwiſe ſufficiently careleſs of external characters; and, in effect, is found in all thoſe that poſſeſs the true conſtituent parts of zeolite, and in due proportion; beſides, its ſpecific gravity is conſiderably greater than that of zeolites. The abſence of iron is not a ſufficient reaſon to annex it to zeolites; for even Bergman allows that zeolites may contain 1 per ct. of iron.

Hyalites approach much nearer, and yet are a diſtinct ſpecies.

The red zeolite of Adelfors is generally reckoned among the zeolites that ſtrike fire with ſteel [*]; yet Mr. Bergman expreſſly tells us it gives no ſparks. Schwed. Abhandl. 1784, p. 115. And Swab. 2 Mem. Swed. p. 434.

20th Species.

Zeolite [†].

Its colour is white, yellowiſh, or reddiſh white, brick red, greeniſh, or blue.

It is found both amorphous and cryſtallized, the latter in cubes, or hexahædral paralelopepids, or tables, or cuneiform, or capillary, or in triangular pyramids [‡]; ſometimes with 24 or 26 faces, &c. [§]. the former frequently in a mealy or ſandy form.

Its luſtre, ſilky or pearly, 2.3.1. Tranſparency, 2.3.4.1.

Its texture, fibrous or ſtriated, often both in the ſame ſpecimen; either ſtelliform, or ſcopiform; rarely foliated, and only when cryſtallized in hexahædral priſms. Fragments, 2.

Its hardneſs, from 6 to 8; rarely 4. It abſorbs from $\frac{1}{36}$ to $\frac{1}{74}$ of its weight of water.

Its ſpecific gravity before abſorption is from 2,07 to 2,214; and, after abſorption, from 2,13 to 2,3; but ſometimes it is mixed with quartz or calcedony, and then may riſe to 2,4.

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[*] Briſſ. p. 142. 2 Berl. Beob. 221.

[†] Born. Phyſ. Arbeitung 2 Stuck. p. 72.

[‡] Chy. Ann. 1790, p. 432.

[§] Dolom. on 3 Bergm. 245.

It is partially and ſlowly ſoluble in the three mineral acids without effervеſcence, and, if they be not in too great quantity, it *gelatinates* moſt commonly. The acetous acid, at leaſt the common, does not affect the gelatination. The ſiliceous part, being undiſſolved, is that which forms a jelly. Radical vinegar diſſolves the calcareous part. Sometimes an inſtantaneous effervеſcence may be produced, as in the red foliated zeolite of Adelfors. 2 Mem. Swed. p. 436. But this ariſes from a ſlight quantity of calcareous ſpar, with which it is contaminated. Van Troil, p. 375. Mem. Swed. 454.

When heated, moſt zeolites froth and foam nearly as alum, before fuſion emit a blue phoſphoric light, and finally melt into a white ſemitranſparent frothy enamel, not hard enough to cut glaſs, and which is itſelf ſoluble in acids *. Mineral alkali promotes their vitreſcence moſt, next borax, microcoſmic ſalt leaſt. 3 Bergm. 226.

The zeolites analyzed by Mr. Bergman, Mayer, and Pelletier, contained as follows:

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* 2 Born, Phyſic; Arbeit, p. 73.

	Silex.	Argill.	Calx.	Water.	
Bergman	0,48	0,22	0,14	0,16	Zeolite of Iceland.
Ditto	0,80	0,095	0,065	0,04	Red of Adelfors Van Troil, p. 368. 370. and 374.
Mayer	0,583	0,172	0,06	0,175	A ſtriated. 4 Berl. Beſchaft. 330.
Ditto	0,41	0,31	0,11	0,15	A do. 2 Berl. Beſchaft, 475.
Pelletier	0,50	0,20	0,08	0,22	Of Feroe.
Rinman	0,55	0,025	0,262	0,17	Zeolite of Hælleſtadt. Swed. Abhand. 1784. 66.
Bergman	0,55	0,025	0,247	0,17	And fixed air; 0,003 iron, and 0,005 magneſia, in the ſame ſtone. Ibid. 115.

Hence we ſee that any proportion of ſilex, argill, calx, and water, is ſufficient to conſtitute a zeolite, ſo that the ſilex exceeds, and that the compound is fuſible to an enamel. For, the zeolite of Hælleſtadt poſſeſſes the properties of a zeolite, though the proportion of argill be ſmaller than that of calx, contrary to what happens in all the other zeolites.

Hence Mr. Bergman's formula ſhould here be *ſca*, and not *ſcam*, as the proportion of magneſia is abſolutely inſignificant, and iron is ever accidental in this ſpecies. Pure zeolite neceſſarily excludes it. I muſt alſo add, that the ſpecific gravity of zeolite of Hælleſtadt exceeds that of other zeolites, being 2,417.

Zeolites generally poſſeſs two properties, viz. gelatination with the mineral acids, and intumeſcence before fuſion; neither of which is peculiar to them, but one or other of them ſeems eſſential to them; and both, I believe, are poſſeſſed by no other ſubſtance, except lapis lazuli, which intumeſces only in a very high heat, and gelatinates only after calcination.

1ſt, As to gelatination. Mr. Swab obſerved, that a mixture of equal parts, fine clay and lime, forms a glaſs which gelatinates with acids. So does a melted maſs of equal parts, lime and quartz. 2 Mem. Swed. p. 443. The clay in the former experiment alſo contains ſilex. Mr. Pelletier found the ſiliceous ore of zinc, alſo to gelatinate, but does not intumeſce.

On the other hand, all zeolites do not gelatinate, per Mr Swab, 2 Mem. Swed. 455. 3 Bergm. p. 228. The zeolites of Hælleſtadt alſo gelatinate, but not, until previouſly calcined, per Mr. Swab, Swed. Abhandl. 1784, p. 60. The zeolites of the Hartz do not gelatinate; neither do the cryſtallized of Iceland, or Feroe, as ſome ſay *.

Again, as to *intumeſcence*, ſeveral ſtones intumeſce before fuſion, as prehnite, thumerſtein, &c. Lilalite, and ſeveral zeolites, do not intumeſce, per Bergman, Swed. Abhandl. 1784, p. 115. or only very ſlightly.

As zeolites imbibe water, they frequently effloreſce by expoſure to the air; and as they exiſt in a rounded form in traps, the cavities in theſe frequently ariſe from the falling or waſhing out of the mouldered zeolites.

This ſtone often paſſes into calcedony.

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* Laſius Hartz. p. 335. 2 Lempe Maga. p. 59.

21ſt Species.

Staurolite, or croſs ſtone of St. Andreaſberg, in the Hartz *. Kreutz Cryſtal of the Germans. Hyacinth Blanche of 2 Romé, p. 299.

Of this ſtone there are two varieties. The ſecond is very ſcarce, having occurred but once.

The colour of the firſt is milk white; of the ſecond, browniſh grey.

Their ſhape is that of two quadrangular tables, or flat quadrangular priſms, bevilled at the edges, and interſecting each other at right angles. Some difference may take place as to the form of the edges, and the angle of interſection.

The cryſtals of the 2d variety are moſt commonly ſulcated.

The luſtre, both external and internal, is variable. Of the firſt generally 2; and of the waxy kind, that of the ſecond pearly; and ſomewhat ſtronger than that of the firſt.

Tranſparency, 1.2.3. The fracture of both is foliated. Fragments, 3.

Hardneſs, 9; brittle. Sp. gr. of the firſt, 2,355; of the ſecond, 2,361.

Gradually heated, both decrepitate and loſe 0,15 or 0,16 of their weight, and as ſome ſay, ſlightly intumeſce †, and then fall in powder. This powder is infuſible at 150°, but by pure air is converted into a white enamel.

Mineral alkali fluxes both varieties into a frothy enamel; that of the firſt is white, that of the

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* 2 Bergbau. p. 23.

† 2 Lempe Mag. p. 59.

ſecond purpliſh, and yellowiſh. Borax and microcoſmic ſalt efferveſce, but ſcarcely unite to them, yet reduce them to a porous greeniſh opake maſs.

Acids do not ſenſibly efferveſce with them, yet they have ſome action on them; as the concentrated vitriolic takes up a little argill, and the nitrous and marine, alſo argill and barytes; but, after calcination, aqua regia, ſlightly efferveſces with them, and takes up ſome argill and barytes.

According to Mr. Weſtrumb, the firſt variety contains 0,44 ſilex, 0,20 barytes, 0,20 argill, 0,16 of water. The ſecond variety contains 0,475 ſilex, 0,20 barytes, 0,12 argill, 0,16 water, and 0,045 iron and manganeſe.

According to Mr. Heyer, the firſt variety contains 0,44 ſilex, 0,24 barytes, 0,20 argill, and 0,12 of water.

This ſtone is commonly conſidered as a zeolite; but we ſee that its compoſition is totally different.

22d Species.

Lapis Lazuli.

Its colour is of different ſhades of blue, moſtly light, or deep azure, with white ſpots of quartz, and often with bright yellow ſpecks, or veins of ſulphur pyrites.

Its ſhape amorphous.

Its luſtre, 0. Tranſparency, 0.1.

Fracture uneven, nearly earthy. Fragments, 2.

Hardneſs,

Hardneſs, from 8 to 9. Sp. gr. from 2,76 to 2,945 Briſſon.

A ſpecimen of my own collection, very pure, 2,896.

It retains its colour in a heat of 100°, which diſtinguiſhes it from cupreous ſtones, but in a higher heat it intumeſces, and melts into a yellowiſh black maſs, and in a ſtill higher, to a whitiſh enamel. 2 Margra. p. 323, 324.

If pulverized, and treated with acids, it gives ſome ſigns of efferveſcence; if calcined it does not efferveſce, but gelatinates with the mineral acids. Magr. Ibid. p. 319.

It has not as yet been properly analyzed. Margraaf's inquiries were chiefly directed to the inveſtigation of copper. He found none but barely iron, ſilex, calx, and gypſum. Mr. Rinman detected the ſparry acid, § 201.

It is found only in the confines of Siberia and Tartary, or China; and, lately, as is reported, in America.

23d Species.

Chryſopraſium *.

Generally of an apple, or light leek green, ſometimes approaching to the graſs green, or to the olive green, or pale greeniſh grey.

Always amorphous.

Luſtre 1, almoſt 0. Tranſparency 2.3.

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* Werner's Cronſt. p. 99.

Fracture, even, or inclining to the ſplintery. Fragments, from 2 to 3.

Hardneſs, from 10 to 12. Sp. gr. 2,479, by my trial.

Heated to 130°, it loſes its colour, whitens, and becomes opake. It is infuſible at 168°; by pure air it gives a white compact enamel. Powdered and heated with two parts vegetable alkali it gives a violet glaſs; with mineral alkali or borax, it gives a brown glaſs; with microcoſmic ſalt, a honey yellow *.

By the analyſis of Mr. Klaproth, in which the moſt conſummate ſkill and accuracy are diſplayed, it contains 0,96 of ſilex, 0,01 calx of nickel, 0,0083 lime, 0,0083 Argill, and 0,0083 calx of iron.

It often paſſes into calcedony.

24th Species.

Veſuvian, or white Garnet of Veſuvius.

Its colour, white or greyiſh white.

Always cryſtallized, either with 12, 18, 24, 36, or even 56 faces, ſometimes pentagonal, trapezoidal, or triangular, &c. from the ſize of a pin's head, to that of an inch; and moſt frequently decompoſed. Found principally in the lava of Veſuvius, or other ancient lavas, particularly in Italy, and in the primordial ſtones of Veſuvius. Gioeni. 37. But lately alſo in ſome granites of the Pyrenees, and among the gold ores of Peru. 40 Roz. Journ. p. 393.

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* 2 Berl. Beob. 2 Stuck. p. 39, and 40.

Luſtre, 3; but, as they are commonly in a ſtate of decompoſition, 0.

Tranſparency, when freſh, 3.2; but generally from decompoſition, 0.

Fracture foliated, inclining to conchoidal.

Hardneſs when intire, from 8 to 9; when mouldering, 5 or 6. Sp. gr. 2,4648.

Fuſible *per ſe* by the blowpipe, but difficultly. Mineral alkali ſcarcely fluxes them, borax and microcoſmic ſalt, very ſlowly.

Mr. Bergman found them to contain 0,55 ſilex, 0,39 argill, and 0,06 lime, but no iron, or ſcarce any. 3 Bergm. p. 206.

The decompoſed ſtate of this ſtone does not proceed merely from the action of the air, nor expoſure to ſulphureous vapours, but principally from the heat to which it was expoſed; for it is found opake, and mouldering even in the midſt of ſolid maſſes of lava, as Mr. Werner has obſerved. 4 Helvet. Magaz. p. 241.

25th Species.

Shorlite *. Shorlartiger Beryll of Werner's Mineral Syſtem. Stangenſtein of Leſke.

Its colour, greeniſh white, ſometimes inclining to yellowiſh, or ſulphur yellow.

Moſtly found in irregular oblong maſſes or columns, inſerted in a mixture of quartz and mica, or granite. Mr. La Peyrouſe tells us, he

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* Werner's Cronſt. p. 169. Weiſſen ſtangen ſhorl. 1 Chy. Ann. 1788, p. 390.

found ſome in ſmall lamellar maſſes on the Pyrenees *.

Luſtre, 2. Tranſparency, 2.1.

Its fracture, uneven, and, ſeemingly, ſomewhat foliated.

Hardneſs, from 9 to 10. Sp. gr. 3,530, per Klaproth. 1 Chy. Ann. 1788, p. 390.

Infuſible at 168°, and no way altered by heat.

Mr. Ferber mentions a white ſhorl found in the Bannat, which phoſphoreſces when ſcraped in the dark. Nov. Acta Petrop. 1785, p. 264.

By the analyſis of Mr. Klaproth it contains 0,50 ſilex, and 0,50 argill; by that of Mr. Bergman, 0,52 argill, 0,46 ſilex, and 0,02 water.

This ſubſtance was called *ſhorlite* by Mr. Klaproth, than whom we cannot have a better guide. It cannot be the ſubſtance called *white ſhorl* by the French; as Abbé Hauy thinks this rather of the feltſpar ſpecies; and Mr. D'Arcet found it fuſible in a porcelain heat, and ſo did Mr. Chaptal; and accordingly it contains 0,55 ſilex, 0,25 argill, 0,13 magneſia, and 0,07 lime. By his analyſis, 2 Chaptal, p. 124. But that called white ſhorl by Mr. La Peyrouſe is moſt probably our ſhorlite; for, he found it infuſible in the ſtrongeſt heat.

The *white ſhorl* of the French, at leaſt of Mr. Chaptal and Abbé Hauy, is moſt probably that ſent to Saxony by Mr. Shreiber from Dauphiné,

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* 26 Roz. 434.

of which Mr. Hoffman gives the following deſcription *:

Its colour is greyiſh white, but being covered with iron ochre, it ſeems of a ſmutty yellow. Cryſtallized in quadrangular thin tables, whoſe edges are ſomewhat convex, and heaped on each other.

Its external luſtre, 2. Internal, 1. Tranſparency, 3.

Its fracture compact, approaching to the even. Its fragments, 3.

Its hardneſs, 10. Its ſpecific gravity he could not determine.

Shorlite paſſes into feltſpar.

26th Species.

Rubellite, Red Shorl of Siberia †.

Its colour, crimſon, blood, or peach red.

It occurs in accumulated groups, of a middle or large ſize, with ſtreight tubular-like ſtria. Its ſurface rough.

Its external luſtre, 2. Internal, 2,5. Tranſparency 2, at the edges 3; tranſmitting a yellowiſh colour.

Its longitudinal fracture delicately fibrous, with ſlender diſtinct concretions.

Its croſs fracture even, inclining to the conchoidal.

Fragments, 3. Hardneſs, 10. Brittle. Sp. gr. 3,100.

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* 1 Bergm. Journ. 1788, p. 57.

† 2 Chy. Ann. 1792, p. 320.

Heated to redneſs, it becomes ſnow-white, and ſeems to phoſphoreſce, but loſes no part of its weight. In a higher heat it is infuſible. Mineral alkali is tinged blue by it, but ſcarcely fluxes it; neither does borax, nor microcoſmic ſalt, effect its fuſion.

By the analyſis of Mr. Bindheim it contains 57 per ct. of ſilex, 35 argill, 5 calx of iron and manganeſe.

27th Species.

Of this I diſtinguiſh four families; opal, ſemi opal, pitchſtone, or pechſtein, and ligniform.

1ſt Family.

Opal Edler, Gelber Opal of Werner.

Its colour is generally of a light bluiſh white, ſometimes yellow or green. The white often emit a yellowiſh, greeniſh, or reddiſh effulgence, reſembling a flame, when placed between the eye and the light; as do the yellow, a fiery; and the green, a purple, red, or yellow. Thoſe that poſſeſs this varying ſplendor are called *oriental opals*, though they are not found in the eaſt; and thoſe that preſent but one colour are called common, or vulgar opals *.

Amorphous, interſperſed, or in ſharp fragments.

Its luſtre, 3. Glaſſy. Tranſparency, 3 2.

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* 2 Bergm. Journ. 1788, p. 487.

Its fracture perfectly conchoidal. Fragments, 3.

Its hardneſs, from 6 to 8. It is ſaid to have ſometimes occurred in a ſoft ſtate, and to have hardened by expoſure to the air. Its ſp. gr. from 1,700 to 2,144.

It frequently contains a drop of water. A ſpecimen of this ſort occurs in Leſke's Collection O. 841.

It is infuſible *per ſe* at 150°; it yields moſt readily to mineral alkali, next to borax, but ſcarce at all to microcoſmic ſalt.

By Mr. Bergman's analyſis it contains 0,85 ſilex, 0,13 argill, contaminated with iron. By that of Klaproth, the white opal of Koſemitz contains 98,75 ſilex, 0,01 argill, and 0,01 of iron. The green derives its colour from calx of nickel *.

It is often decompoſed by expoſure to the atmoſphere.

I found the opal 844. Leſke O. Infuſible at 151°; and ſo are all opals found to be.

2d Family.

Semi Opal †.

Its colours are, bluiſh, pearl, reddiſh, greeniſh, or yellowiſh grey; greyiſh, reddiſh, or yellowiſh white, or honey, or wax yellow; or fleſh, or hyacinth red; or reddiſh brown, or yellowiſh, or liver brown; or graſs, leek, or verdegris green, or many of theſe in the ſame maſs.

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* 2 Berl. Beob. p. 45.

† Werner's Cronſt. p. 123.

Amorphous or in ſharp fragments.

Its luſtre, 2. Glaſſy. Tranſparency, 2.1.3. Its fracture conchoidal, ſometimes imperfectly. Fragments, 3.2.

Hardneſs from 7 to 9. Brittle. Sp. gr. 1,7 to 2,118.

Some adhere to the tongue by reaſon of the rifts they contain; theſe admit water, and are often hydrophanous, as we ſhall preſently ſee.

It is infuſible as the former family.

It differs from opals always in luſtre, and often in tranſparency, fracture and hardneſs.

Its tranſitions are into hornſtone, calcedony, chryſopraſium, jaſper, and quartz; and, when decompoſing, into porcelain clay.

The ſemi opal of Leſke S. 658. much reſembles flint, but does not give fire with ſteel.

There is a variety of the ſemi-opal called a *Pyrophanes*; becauſe, being heated on a ſpoon, it becomes tranſparent, but returns to its opake ſtate when cold, as Mr. Landriani has diſcovered*. Mr. Sauſſure, jun. renders common hydrophanes tranſparent, and of a topaz colour, when heated by digeſting them in melted wax.

It is ſaid that ſome pyrophanes are found in Armenia, which are tranſparent while expoſed to the ſun, and opake at night †.

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* 1 Chy. Ann. 1791, p. 483.

† 1 Chy. Ann. 1792, p. 35.

3d Family.

Pitchſtone*.

Its colours, greyiſh black; bluiſh grey; mountain leek or olive green; greeniſh brown; brick or blood red, or yellowiſh colour; ſometimes many in the ſame maſs. Found in large maſſes; and, lately, alſo cryſtallized in ſix-ſided priſms, with triangular pyramids. Luſtre of the greaſy kind, 3.2.1. Tranſparency, 2.1., rarely 0.

Fracture, imperfectly conchoidal, and uneven, often approaching to the ſplintery, the longitudinal fracture ſometimes ſlaty. Fragments, 2.3.

Hardneſs, from 8 to 10; and exceeding brittle. Sp. gr. from 2,049 to 2.39. It is true, Mr. Briſſon found that of a brick red from Saxony, 2,6695, but it was probably impure. I found another of them, Leſke 251 G. to be 2,720.

It frequently preſents either large or ſmall grained diſtinct concretions.

It often much reſembles ſemi opals and jaſpers, but differs from the former always in the *kind* of luſtre, and often in fracture; from the latter always in brittleneſs, and moſtly in tranſparency. The brick red of Saxony, whoſe ſpecific gravity was 2,720, had ſcarce any luſtre or tranſparency, and rather ſeems a jaſper, or between a hornſtone and jaſper, and pitchſtone, for it had ſeveral ſeparate concretions divided by white ſeams.

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* Werner's, Cronſt. p. 124.

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As to fuſibility, there ſeems a great difference in different ſpecimens.

1ſt, The pitchſtone, Leſke O. 870. Of a leek, partly inclining to an olive green, whoſe ſpecific gravity is 2,298, melted at 165° into a white frothy enamel.

2d, Another of the ſame collection, O. 873, which had ſcarce any luſtre, and no tranſparency, or, ſcarcely, 1, and whoſe ſpecific gravity was 2,267; its colour between a mountain and an olive green, and exhibiting curved lamellar concretions, melted at 130° into a fine ſmall-pored white enamel. This ſeems allied to felſpar.

3d, Another of Leſke G. 251, brick red from Miſnia, in Saxony, which had but little luſtre, and ſcarce any tranſparency, whoſe ſpecific grav. was 2,720. Its fracture uneven and ſplintery, did not melt at 160°, but remained a looſe browniſh red powder. Is it not rather an iron ſhot quartz?

4th, Another of Leſke S. 295, pearl grey, much reſembling porcelain jaſper, its luſtre being ſilky, whoſe ſpecific gravity was 1,970, decrepitated ſtrongly when heated, then whitened, but at 149° it remained a looſe powder.

5th, Another of Leſke S. 949, yellowiſh brown, and ſemi-tranſparent. Its ſpecific gravity, 2,266, at 152° melted into a white ſmall-pored porcelain maſs.

The different degrees of fuſibility ariſe from the different proportion of its ingredients, or its mixture with extraneous ſubſtances.

Mr. Wiegleb found in that of Saxony, of a dull brown colour (probably 873 O. of Leſke), 0,73 ſilex, 0,18 argill, 0,058 iron, the remainder of water and air. 11 Neu. Entd. p. 18. Mr.

Mayer, of Stetin, found the ſame ingredients, and nearly in the ſame proportion, in the greyiſh black, beſides water, and ſome traces of ſal-ammoniac. 2 Crell. Ann. 1784, p. 125.

Mr. Gmelin, in a kind of pitchſtone ſtuck in baſalt, found 0,90 ſilex, 0,07 argill, and 0,026 of iron. 1 Chy. Ann. 1791, p. 301.

Mr. Klaproth, in that of Meſnilmontant, which was of a reddiſh yellow colour, and whoſe ſpecific gravity was 2,1685, found 0,855 of ſilex, 01 argill, and 0,005 of iron, of calx and magneſia 0,005, water, inflammable matter, and air 0,11.

The greyiſh black of Hungary were found infuſible by Mr. Ruprecht: they decrepitated and whitened like that of Leſke, 295 S. above mentioned, and afforded him 0,91 ſilex, 0,08 argill, and ſome traces only of iron and inflammable matter alſo, for they ſlightly deflagrated with nitre, and render the vitriolic acid ſomewhat brown *.

Another pitchſtone, found near Frankford on the Maine, whoſe colour was nut brown, and which was in ſome degree magnetic, and infuſible in a porcelain heat, Mr. Wiegleb found 0,8958 ſilex, 0,05 iron, 0,0333 calx, and 0,0041 argill. 1 Chy. Ann. 1788, 398.

From all theſe analyſes it is plain, that opals and pitchſtones conſiſt eſſentially of ſilex, with about from $\frac{1}{6}$ to $\frac{1}{10}$ of argill, and ſome water and inflammable matter. If to theſe, when the argill is about $\frac{1}{12}$ of the whole, 5 or 6 per ct. of iron, be added, they become fuſible, otherwiſe

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* Phyſ. Arbeits 2 Stuck. p. 55.

not.

not. The opals ſcarcely contain any iron, and therefore are infuſible at 168°.

It is remarkable that theſe ſtones difficultly give fire with ſteel, and yet are more difficultly ſcratched than many that do.

They are often found in a ſtate of decompoſition.

Their tranſitions are into hornſtone, jaſper, and I believe ſometimes into felſpar.

4th Family.

Ligniform Opal or Pitchſtone.

Its colours are, milk white, reddiſh or yellowiſh white, or yellowiſh grey, nut or yellowiſh brown, or ochre yellow, or hyacinth red, or greyiſh black; theſe colours are ſcarce ever ſingle, but generally in different ſtripes in the ſame maſs.

It occurs in large maſſes.

Luſtre, 2.3, waxy. Tranſparency, 1.0; ſeldom, 2.

Longitudinal fracture, fibrous; croſs fracture, conchoidal; fragments, oblong.

It will not give fire with ſteel, and yet can ſcarcely be ſcratched. Brittle.

Its ſp. gr. from 2,08 to 2,1.

Of Hydrophanes.

Such opake ſtones, as become tranſparent by placing them in water, are called *Hydrophanes*. Theſe are for the moſt part ſemi opals or pitchſtones, and particularly thoſe that are ſomewhat withered by expoſure to the atmoſphere; they generally adhere to the tongue.

Mr. Klaproth, having diſtilled ſome of thoſe of Saxony, obtained from them 5 per ct. of water, inflammable matter and air, 93 per ct. of ſilex, 1 of argill, and no iron [*].

Mr. Wiegleb's analyſis gives pretty nearly the ſame contents [†]; but Mr. Mayer found ſome that contained a much larger proportion of argill, and ſome iron [‡], as did Mr. Gerhard [||]. It ſeems alſo certain that ſome of theſe ſtones attract moiſture when expoſed to a moiſt atmoſphere, for, they increaſe in weight [§], and ſome even burſt. Other ſtones are often hydrophanous, as ſteatites and calcedony. 2 Bergm. p. 70.

28th Species.

Hyalite, Muller's Glaſs of the Germans. Lava Glaſs of Many.

Its colour, pure white.

Its luſtre, 2.3. Glaſſy. Tranſparency, 2.3, rarely 0. Voight Fulda. 171.

It occurs moſt frequently in baſalt, or trapps; either in grains, or in maſſes inclining to a rhomboidal form, or in filaments.

Its fracture even, inclining to the conchoidal; but, on the whole, often lamellar.

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[*] 1 Chym. Ann. 1790, p. 52.
[†] 1 Chym. Ann. 1789, p. 402.
[‡] Naturforſch 19 Stuck. p. 220.
[||] 2 Geſch. p. 400.
[§] 2 Chym. Ann. 1784, 183.

Hardneſs, 9. Sp. gr. by my trial, 2,110.

It is infuſible at 150°, but yields to mineral alkali.

By the analyſis of Mr. Link it contains 57 per ct. ſilex, 18 argill, 15 calx, and very little iron; he does not tell us what were the other ten parts.

In compoſition then it nearly agrees with thoſe ſtones which Mr. Bergman and others have called zeolites, and I have called ædelites; and yet no one has hitherto conſidered Muller's glaſs as zeolite; but many have taken it for calcedony, though it wants the bluiſh colour of this ſort of ſtone; many alſo for an opal, but its luſtre is very different, and many, particularly when it is rhomboidal and foliated, for felſpar, from which, when buried in other ſtones, it is difficult to diſtinguiſh it. Mr. Werner, as I hear, now conſiders it as a middle thing between opal and calcedony, and calls it Hyalite.

It has lately been found in Serpentine, near Swentick, in Sileſia; Ferber Briefe. 40. 1 Noſe. 251; and therefore cannot be a volcanic production, as many, notwithſtanding its infuſibility, have ſuppoſed it.

29th Species.

Calcedony.

Of this ſpecies I diſtinguiſh two families; common calcedony, or calcedony ſimply ſo called, and carnelian.

1ſt Family.

1ſt Family.

Calcedony, or Common Calcedony *.

Its colours are various, but moſt generally greyiſh; as yellowiſh, greeniſh, bluiſh, and pearl grey; or bluiſh white. This laſt often paſſes into blue, or violet blue, as the firſt does into honey yellow, or blackiſh brown. It is alſo found *milk white*, and then called *cacholong*, very rarely graſs green, or mountain green, or fleſh red, or dotted with red; often with many colours in the ſame piece, either in ſtripes, or ſpots, and with arborizations; when the white and black or brown ſtripes alternate, it is called *onyx*, or *camehuya*; if the white and grey alternate, *calcedonyx*. The grey when they preſent arborizations are called *mochos*. The blackiſh or dark brown, being held againſt a ſtrong light, appear dark red.

It occurs, in amorphous pieces, often flat, oftener blunt, and ſomewhat rounded, or ſtalactitic, or in nodules, or cellular, and lately alſo cryſtallized in hexahædral or quadrangular pyramids with convex planes, or in hexangular priſms with a pyramidal apex, or even, as is pretended, cubic or rhomboidal †. But ſome aſſert that theſe are only inveſtments of other cryſtallized ſtones that have ſince decayed; or filiform, tubular, or ſpiky.

The ſurface of this ſtone is generally rough and uneven, often tuberoſe and botryoidal or inveſted

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* Werner's Cronſt. p. 130.

† 1 Chy. Ann. 1785, p. 480. Nov. Act. Petrop. 1785, p. 266.

with druſy quartz, yet ſometimes even and ſmooth.

Its external luſtre fortuitous. Its internal, 1. Tranſparency 2.3, rarely 1.

Its fracture even, often inclining to the conchoidal, more rarely to the ſplintery. Sometimes the intermediate between the even, ſplintery, and uneven. Fragments, 3. Commonly without any ſeparate concretions, ſometimes with thin, or thick, curved, and moſtly concentric lamellar diſtinct concretions.

Its hardneſs from 10 to 11. Sp. gr. from 2,60 to 2,665. Mr. Bergman was induced by Muſchenbroek to ſuppoſe it might extend to 4,36, which is impoſſible; but it is frequently found much lower than 2,6; namely, when the calcedonies are hydrophanous. Hence Mr. Briſſon found one of theſe 1,0942, and others 2,29. This is the ſtone called *oculus mundi*. This difference ariſes only from the ſmall pores into which water cannot penetrate.

The blue he found to amount to 2,5867.

It is infuſible *per ſe*, even by a burning glaſs, but by pure air it is, though with difficulty, converted into a white ſemi tranſparent enamel.

Mineral alkali melts it with efferveſcence, borax without any, and microcoſmic ſalt ſcarcely affects it.

By Mr. Bergman's analyſis, the calcedony of Feroe contains 84 per ct. of ſilex, and 16 of argill, ſlightly contaminated with iron. 2 Bergm. p. 60. By that of Mr. Bindheim, 83,3 ſilex, 11 calx, 1,6 Argill, and a minute portion of iron. 3 Naturforſch. Freunde. p. 429

It ſometimes decompoſes by expoſure to the air; I have often ſeen its ſurface fretted and porous, with an earthy and ochry powder.

Its tranſitions are into opal, flint, quartz, jaſper, cryſopraſium, and felſpar.

2d Family.

Carnelian.

Its colours are of various ſhades of red, from the deep blood red, to the lighter, almoſt white, or reddiſh brown, or honey or wax yellow, or yellowiſh brown, and often theſe colours or ſhades occur in the ſame maſs, either in gradation, or ſtripes, or ſpots.

Amorphous, or in blunt or ſomewhat rounded maſſes, with rough or uneven ſurfaces, or ſtalactitic.

Its luſtre ſcarcely 1. Tranſparency 3.2.1, often cloudy.

Its fracture, conchoidal. Fragments, 3.

Hardneſs, 10. Sp. gr. from 2,597 to 2,63.

It is infuſible, but loſes its colour at 160°, nor even by pure air is it melted as perfectly as calcedony is, nor in a chalk crucible in thoſe parts that touch the chalk as calcedony is. 2 Gerh. Geſch. 10. But by the uſual fluxes it is affected nearly as common calcedony.

Some conſider it as a compound of jaſper and calcedonian.

Some are found partly withered by expoſure to the air, particularly the ſtalactitic.

It ſometimes graduates into quartz.

30th Species.

Cat's Eye.

Its colour is generally of a greeniſh or yellowiſh grey, or light, or dark yellowiſh brown, or reddiſh brown, or ſtriped with theſe colours; and, in certain poſitions, particularly when poliſhed, emitting a ſilvery or yellowiſh movable effulgence.

It is found in blunt or rounded fragments, and comes from Ceylon.

Its luſtre, 2. Tranſparency, 3.2.

Its fracture imperfectly conchoidal, ſometimes approaching to the ſplintery.

Fragments, 3. Hardneſs, 10. Sp. gr. from 2,56 to 2,66.

31ſt Species.

Flint. Feuer Stein of the Germans.

Commonly of a yellowiſh, or bluiſh grey colour; the latter, however, often paſſes into the greyiſh black, and the former into the ochre yellow, or brown. Several of theſe often meet in the ſame ſpecimen, either in veins, ſtripes, clouds, or dots.

Amorphous, interſperſed in other ſtones, or in nodules, or rounded lumps, often perforated, very rarely cryſtallized, in double triangular pyramids; often alſo forming the ſubſtance of petrefactions, particularly of echinites. Its ſurface generally uneven and wrinkled, either ſmooth or rough, often covered with a rind, either calcareous or argillaceous. Its external luſtre, 0 or 1. Internal, 1. Tranſparency, 2.1, ſometimes nearly 3. Fracture conchoidal, ſeldom imperfectly. Fragments, 3.

Hardneſs, from 10 to 11. Sp. gr. from 2,58 to 2,63.

Heated, it decrepitates, whitens, becomes brittle, and opake, is infuſible at 168°, and is barely ſoftened by pure air; the uſual fluxes affect it as they do quartz.

The impreſſions of marine ſhells, and even of leaves, are frequently found in flints, which leaves no doubt of their having been produced in the moiſt way, and even that ſome are of modern formation *.

According to Mr. Wiegleb's analyſis, they contain about 0,80 ſilex, 0,18 argill, and 0,02 calx †.

Its tranſitions are into quartz, calcedony, carnelian, and hornſtone.

It is frequently intimately mixed, not only with quartz or calcedony, but even with calcareous earth, or calcareous ſpar, as may be ſeen in Leſke's Catalogue, S. p. 116.

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* Charpent. Min. Geograph. p. 40. 66. Leſke Reiſe durch Sacks. Ferb. Oryctogr. von Derbyſh. p. 16. 1 Naturfor. &c.

† 6 N. Acta. Natur. Curioſa, p. 408.

32d Species.

Hornſtone. Hornſtein of the Germans, Petroſilex, Chert.

Its colour commonly dark blue, yellowiſh, or pearl grey, ſometimes yellowiſh white, fleſh, or browniſh red, or mountain blue, or blackiſh brown, or greeniſh brown, or dark green, or olive green, often variegated.

Amorphous for the moſt part, but lately found cryſtallized by Mr. Beyer on Schneeberg, either in hexahædral priſms, ſome with, ſome without, a pyramid, or barely rounded at both ends, or in double triangular pyramids, or cubes or hexahædral plates, the ſurface of theſe cryſtals moſtly rough and uneven, ſome hollow, ſome ſolid, ſometimes as thin as paper [*].

Its luſtre, 0. Tranſparency, 1.2. The cryſtallized, ſometimes 0.

Its fracture generally ſplintery, more rarely conchoidal, ſometimes from the fine ſplintery, paſſing into the even, but of a coarſer grain than flint. Fragments, 2.3.

Hardneſs, from 7 to 9. Sp. gr. from 2,532 to 2,653.

Though Mr. Bergman counts this ſtone among thoſe that are fuſible *per ſe*, even by a blowpipe, yet, in the many trials I have made in a much ſuperior heat, I found but one which gave any ſign of fuſion; but moſt frequently decrepitate and whiten.

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[*] 2 Crell. Beytr. p. 191. 3 Helvet. Maga. p. 251.

1ſt,

1ſt, The blackiſh grey, Leſke K. 48, with ſome mixture of arſenical pyrites, whoſe fracture is ſplintery; its ſp. gr. 2,744, probably from the pyrites, and opake, barely concreted at 140°, but ſhewed no other ſign of fuſion at 163°.

2d, The grey hornſtone, Leſke K. 383, whoſe fracture is fine ſplintery; its ſp. gr. 2,654, whitened, and barely coaleſced at 143°.

3d, The yellowiſh white hornſtone, Leſke O. 441, whoſe fracture is fine ſplintery, and its ſp gr. 2,563, whitened, but gave no ſign of fuſion at 155°.

4th, A bluiſh, and partly a yellowiſh grey hornſtone, mixed with jaſper, Leſke O. 442; its fracture, partly ſplintery, and partly inclining to the flat conchoidal, whoſe ſp. gr. is 2,626, whitened, but did not yield in the leaſt at 151°.

5th, A dark purpliſh red iron ſhot hornſtone, Leſke G. 61; fracture, fine ſplintery, and uneven; ſp. gr. 2,638, barely agglutinated into a dark grey maſs at 147, 5.

6th, But a greeniſh white hornſtone, with reddiſh ſpots, from Lorraine (given to me by Mr. Woulfe), whoſe ſp. gr. is 2,532; fracture, conchoidal, ſemitranſparent at the edges; luſtre, 0; fragments, remarkably ſharp; hardneſs, 10; whitened, and became brittle at 127°; and at at 144°, melted into a ſemitranſparent compact enamel. Mr. Sauſſure found the hornſtones of Switzerland in general infuſible; and only thoſe lying in calcareous ſtrata, to be fuſible in a high degree of heat.

7th, I found alſo another hornſtone fuſible, but it is iron ſhot, Leſke S. 831; outſide it has a browniſh red rind, but inſide, its colour bluiſh grey; its fracture, uneven and ſplintery; its ſp.

gr. 2,813. At 146°, it melted into a black compact glaſs.

The hornſtone I formerly analyzed is that mentioned at No. 6. It contained 72 per ct. ſilex, about 22 argill, and about 6 of mild calcareous earth, or rather more; and, I believe, rather leſs argill, if this were ſufficiently dried. The infuſible hornſtones probably contain no calx, or leſs.

Hornſtones are frequently found in a ſtate of decompoſition.

Its tranſitions are into flint, calcedony, cryſopraſium, jaſper, quartz, opal, ſiliceous ſhiſtus, argillite, ſandſtone, and even into granular limeſtone, and indurated clay.

Hornſtone differs from jaſpers, often by its ſplintery fracture; always by its tranſparency, though imperfect, and want of luſtre; from flints, by its fracture, dulneſs, and hardneſs; but when its fracture happens to be conchoidal, by its dulneſs, leſſer tranſparency, and hardneſs; from quartz, by its dulneſs and inferior hardneſs; from ſerpentine, generally in hardneſs, ſpecific gravity, and fuſibility; from heliotropium, by the aggregate of its properties.

2d Family.

Schiſtoſe Hornſtone. Schiefriges Hornſtein. Voight Abhand. p. 81.

Of this I diſtinguiſh three varieties; ſiliceous ſhiſtus, lydian ſtone, and hornſlate.

1ſt Variety.

Siliceous Shiſtus, Gemeiner Kieſel Schiefer of Werner.

Dark bluiſh grey, or greyiſh black, moſtly interſected with reddiſh veins from iron. The bluiſh grey often intercepts a whitiſh earth between its laminæ. Luſtre, 0. Tranſparency, 1 or 0.

Fracture, in the groſs, ſlaty; of the ſingle plates, fine ſplintery. Fragments, 2.3.

Hardneſs, from 9 to 10. Sp. gr. from 2,596 to 2,641, by my trial.

The greyiſh black, Leſke O. 601, whoſe ſp. gr. was 2,641, became grey when heated, but was not otherwiſe altered by a heat of 156°. The bluiſh grey, Leſke O. 602, whoſe ſp. gr. was 2,596, grew whiter, coaleſced, but did not melt at 141°.

The greyiſh black is that which was analyzed by Mr. Wiegleb, as it ſeems, (though he calls it coal-black), and found it to contain 0,75 ſilex, 0,10 calx, 0,046 magneſia, 0,035 iron, and 0,052 inflammable matter, which appears to be genuine coal*.

This ſtone cannot be the ſlaty petroſilex mentioned in 2d Sauſſure, as it contains no argill.

Its tranſitions are into quartz, hornſtone, argillite, and coticular ſlate. Sometimes it is ſo

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* 1 Chym. Ann. 1788, p. 50, 140.

mixed with argill as to ſeem to paſs into it, as in Leſke G. 154.

It ſeems to be nothing more than a ſlaty, and at the ſame time rifty, hornſtone; the rifts lined with calx of iron.

2d Variety.

Baſanite. Lydian Stone of Werner. Black Jaſper of Some.

Its colour, dark greyiſh black, frequently interſected with veins of quartz.

It is generally found in blunted fragments in the beds of rivers.

Luſtre, ſcarcely 1. Tranſparency, 0.

Fracture, moſtly even, ſometimes inclining to the conchoidal. Fragments, 3.

Hardneſs, 10. Sp. gr. 2,596.

When pounded, its powder is black.

Heated to 164,5°, it remained black, and ſhewed no ſign of fuſion.

3d Variety.

Hornſlate, of Charpentier and Voight. Schiſtoſe Porphyry of Werner.

Its colour is *grey*, of different ſhades, from the aſh, to the bluiſh, or olive green. As this *grey* conſiſts of two colours, the white and blue, the ſtone itſelf is looked on by Mr. Werner as an aggregate, and the white he conſiders as denoting felſpar; and hence he calls it a porphyry; and, becauſe it is ſlaty, ſchiſtoſe porphyry. However, the felſpar is ofen ſo minute, that it can ſcarce be diſtinctly perceived; and in ſuch caſes the ſtone may be placed here, and not among aggregate ſtones, and may be called hornſlate.

In the *bluiſh* the diſtinction of blue and white is moſt perceptible.

Generally amorphous, and in large maſſes, ſometimes columnar.

Its luſtre, moſtly 0; yet in a ſtrong light a few ſhining particles may ſometimes be perceived. Its tranſparency, 1.0.

Its fracture, on the whole, ſlaty, but of the ſingle laminæ, which are often very thick; the fracture is uneven, ſplintery, and ſometimes approaching to the conchoidal.

Its fragments, 2.3. Hardneſs, nearly 10. Sp. gr. from 2,512 to 2,700, by my trials.

The ſpecimen in Voight's Catalogue, marked 55, and in Leſke's S. 645, which is aſh grey, and whoſe ſp. gr. is 2,5122, melted at 145°, into a dark grey, almoſt compact enamel. The ſpecimen, Leſke S. 973, which is bluiſh grey, and in the form of a quadrangular priſm, its ſp. gr. 2,693, melted at 166°, into a greeniſh yellow ſpongy maſs.

By Mr. Wiegleb's analyſis, the aſh grey, Voight 55, contains 0,73 ſilex, 0,239 argill, and 0,035 iron *.

As the term hornſlate, or *hornſchiefer*, has been applied to various ſorts of ſtones, Mr. Hoepfner, of Switzerland, generouſly offered a premium to the perſon who ſhould clearly aſcertain its preſent ſignification: ſatisfactory anſwers were accor-

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* 1 Chym. Ann. 1787, p. 302.

dingly given by Meſſrs. Karſten and Voight. By theſe it appears,

That *Wallerius* applied this name to hornblende ſlate, or ſhiſtoſe hornblende.

Ferber, partly to micaceous argillite, and partly to ſchiſtoſe mica, in which he is followed by Baron *Born* and *Haidinger*.

Leſke in his voyage through Saxony often calls our ſtone *hornporphyry*.

Werner firſt called it as Charpentier and Voight do, but afterwards beſtowed this name on lydian ſtone, as ſome others had done before him; but now he drops this name intirely, and calls our ſtone ſchiſtoſe porphyry. See Leſke S. 1763, and 1811.

It ſeems alſo the ſtone mentioned. 2 Sauſſure §. 672, is our hornſlate.

The bluiſh grey often paſſes into trapp, or baſalt, or into argillite, as in Leſke S. 1639.

Its chief diſtinction from ſiliceous ſhiſtus conſiſts in its fuſibility.

33d Species.

Jaſper.

Of this ſpecies I diſtinguiſh four families, common jaſper, Ægyptian pebble, ſtriped jaſper, and ſinople.

1ſt Family.

Common Jaſper.

Its colours are milk white, or greyiſh white, or yellowiſh white, citron, iſabella, honey or ochre yellow, browniſh yellow, brick, cochenille or blood red, browniſh dark red, yellowiſh or reddiſh brown, liver brown, or blackiſh brown, or olive, canary, or dark green (blue or black it ſeems have not occurred *), or variegated, ſpotted or veined with many of thoſe.

It is met with either in large maſſes, or blunt detached fragments. Mr. Gerhard tells us, he has found ſome irregularly cryſtallized in hexahædral priſms, among the foſſils ſent to him by Mr. Beyer from Schneeberg. Gerh. Grundriſs. 285. And Baron Born mentions ſome found in the Palatinate. 1 Raab. 126.

Its luſtre, 2.1. Its tranſparency 0, or nearly 1.

Its fracture, conchoidal, ſometimes imperfectly, ſometimes flatly. Fragments, 3.

Its hardneſs from 9 to 10. Sp. gr. from 2,58 to 2,7. Mr. Briſſon, indeed, mentions ſome whoſe ſp. gr. is but 2,358, and others, whoſe denſity extends to 2,76 or 2,8; but, as he tells us, jaſper ſcarce ever diſcovers any luſtre in its fracture, it is probable he does not always comprehend in his idea of jaſper, the ſtone here deſcribed. The heavier ſort ſeems evidently contaminated with metallic particles.

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* That mentioned by Laſius, Hartz. 106, ſeems not to be true jaſper, its ſp. gr. being only 2,059.

It does not decrepitate when heated; nor in my experiments did it harden. The dark cochenille red, mixed with brick red, Leſke O. 822, whoſe ſp. gr. was 2,6288, and its hardneſs 10, being heated to 157,5°, gave fire more weakly, and thence ſeemed leſs hard, loſt its colour, having turned to greyiſh black, and ſhewed no ſign of fuſion. Another ſpecimen of a lighter red, ſomewhat mixed with quartz and calcedony, whoſe ſp. gr. was 2,597, being heated to 156°, acquired the ſame colour as the former, did not harden, nor in the leaſt incline to fuſion. Alkalis and microcoſmic ſalt difficultly flux it; borax better, and without efferveſcence.

Even by pure air jaſper is ſcarcely, and but imperfectly, melted, as appears by the experiments of Mr. Lavoiſier. It diſcovers no metallic mixture; its colouring matter is rather volatile; and its low ſp. gr. ſhews it contains no iron. As, however, Mr. Gerhard found it to yield in a chalk crucible, in the parts that touched the chalk, it is probable it contains a ſmall proportion of argill, with a much larger of ſilex. Unleſs very impure, it does not wither by expoſure to the air.

Its tranſitions are into hornſtone, opal, argillite, and lithomarga; it is often intimately mixed with calcedony.

The liver brown ſtone of Leſke O. 836, being deſtitute of luſtre, I reckon a hornſtone. No. 817 O. of Leſke, is by Karſten reckoned a jaſper, yet it has all the appearances of pitchſtone; its ſp. gr. is only 2,442, which marks it deciſively a pitchſtone.

2d Family,

Ægyptian Pebble.

This ſtone preſents various colours together in the ſame ſpecimen, either in regular, or irregular concentric and alternating ſtripes, or layers, or in dots and dendritical figures. The moſt uſual colours are the yellowiſh, and liver brown, reddiſh brown, iſabella yellow, yellowiſh grey, greyiſh, or reddiſh white, milk white, leek green, and black; this laſt only in dots and dendritical figures. It is found in ſpheroidal, or flat rounded maſſes, which are inveloped in a coarſe rough cruſt.

Its internal luſtre, 1. External, 0. Its tranſparency, 0.

Its fracture conchoidal.

Its hardneſs, 10. Its ſp. gr. 2,564. Briſſon.

Found principally in Ægypt, ſometimes in Europe, particularly in Lorraine.

3d Family.

Striped Jaſper. Band Jaſper of Werner.

This ſtone alſo preſents different colours in the ſame ſpecimen, generally in ſtreight, more rarely in curved concentric ſtripes or layers. Seldom in oblong ſpots.

The moſt uſual colours are yellowiſh, or greeniſh grey, ochre, and iſabella yellow, browniſh

iſh red, pale or dark fleſh red, mountain or dark green.

It occurs in large maſſes. Luſtre, 0. Tranſparency, ſcarcely 1.

Its fracture imperfectly conchoidal, or nearly even.

Its hardneſs, from 9 to 10. Sp. gr. from 2,5 to 2,82.

4th Family.

Sinople.

Its colour dark red.

Its luſtre, 0. Tranſparency, 0.

Its fracture, imperfectly conchoidal.

Its hardneſs from 9 to 10. Sp. gr. 2,691. Briſſon. p. 120.

It is ſaid to contain 18 per ct. of iron. 1 Raab. p. 125. Yet, if ſo, it ſhould be much heavier.

A red hornſtone is ſometimes known under this name in Hungary.

34th Species.

Porcellanite, Porcelain Jaſper, of Werner.

Its colours are pearl grey, lavender blue, pale blue, pale yellow, greeniſh yellow, brick red, with pearl grey, or greyiſh black *.

It is found in large maſſes, frequently rifty.

Its luſtre from 1 to 2. Tranſparency 0.

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* 1 Bergbau. p. 358.

Its fracture, imperfectly conchoidal, inclining to the even. Fragments, 2.3.

Its hardneſs, 9. Its ſp. gr. 2,33, by my trial.

The ſpecimen of Leſke K. 33, melted at 151°, into a ſpongy, yellowiſh grey tumefied ſemitranſparent maſs. Hence I conſider it as ſpecifically different from jaſpers. The colour of that I employed was lavender blue, and ſeemed perfectly pure.

Mr. Peithner called it porcellanite, which name ſhould be continued, not to confound this ſtone with genuine jaſpers.

35th Species.

Heliotropium.

Its colour is generally intermediate between graſs and leek green, ſometimes dark mountain green, ſometimes lighter, or approaching to a blackiſh green, and moſtly dotted or ſpotted with olive green, ochre yellow, or blood red ſpots of jaſper.

Amorphous.

Luſtre, 1.0. Tranſparency, 2.1, ſometimes ſcarcely 1.

Its fracture conchoidal, ſometimes flat or imperfect, or mixed with the coarſe ſplintery.

Fragments, 3.

Its hardneſs from 10 to 11. Its ſp. gr. 2,62 to 2,7.

In Mr. Lavoiſer's experiments, it was ſcarcely melted even by pure air. In mine the dark green of Leſke O. 580, whoſe ſp. gr. was 2,681, became

became reddiſh brown at 114°; at 142°, its fragments ſlightly agglutinated.

This ſpecies is evidently nearly allied to jaſper, and often differs only by the aggregate of its properties; its fragments ſharper, and its tranſparency often much greater.

36th Species.

Woodſtone. Holzſtein of Werner. Lithoxylon of others *.

Its colour is generally blackiſh, or bluiſh grey; the former frequently paſſes into the greyiſh black, and the latter into the greyiſh white; and this, from the light reddiſh grey, into the blood or cochenille red. Seldom ochre yellow, or mountain green; ſometimes reddiſh, or yellowiſh brown.

Theſe colours moſt commonly appear together, in ſpots, blotches, or ſtripes, in the ſame ſpecimen.

It always manifeſts its priſtine ſtate, either by its branchy form, or its knots or roots. Its ſurface, like that of the wood from which it originates, ſometimes rough, ſometimes uneven, ſometimes coarſely ſtreaked in the direction of its length.

Its internal luſtre, 1. Its tranſparency, 1.2.

Its fracture, conchoidal; ſometimes imperfectly, or approaching to the fine ſplintery, ſometimes ſlaty; and generally, by its interlaced fibrous ſtructure, diſcovers its origin. Its fragments, 3. Often ſplintery.

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* 1 Bergm. Journ. 1788, p. 289.

Its hardneſs, 10. The ſp. gr. of different ſpecimens which I tried extended from 2,045 to 2,675.

It is commonly (not always) the ſubſtance of petrified wood. A ſtump of a tree ſix feet in length, and as many in diameter, with roots and branches thus petrified, was lately found near Chemnitz, in Saxony.

It often withers by expoſure to the atmoſphere.

Its tranſitions are into quartz, calcedony, and, as ſome ſay, into pitchſtone or opal.

37th Species.

Elaſtic Quartz.

Its colour is greyiſh white, covered with thin ſcales of grey, or browniſh mica.

Its luſtre, 0, or 1, from a few micaceous particles diſperſed through it. Tranſparency, 1.

Its fracture I could not well diſcern, as I was not at liberty to break the ſpecimen; but from a ſmall accidental fracture, it ſeems earthy.

Its hardneſs, 9. Brittle. Specific gravity, according to Mr. Gerhard, Mem. Berl. 1783, p. 107, is 3,750; but his ſtone muſt be very different from that poſſeſſed by the Royal Iriſh Academy; the ſpecific gravity of this being only 2,624.

Flexible and elaſtic in a moderate degree in every direction.

Phoſphoreſces when ſcraped with a knife in the dark.

According

According to Mr. Gerhard, it is no way altered by a heat of 140°; but by fixed alkalis it is eaſily fuſible. According to Mr. Ehrman, it is by the heat of pure air converted into a ſemitranſparent glaſs. But Mr. Gerhard tells us, he expoſed his to that heat for ſeven minutes without any effect.

By the analyſis of Mr. Klaproth it contains 0,965 ſilex, 0,025 argill, and 0,01 iron.

By that of Mr. Gerhard, 0,92 ſilex, 0,03 argill, 0,02 calx, and 0,01 iron.

Baron Trebra found a flexible ſandſtone in Thuringia.

38th Species.

Felſpar.

Of this foſſil there ſeems to be three families; common felſpar, moonſtone, and continuous felſpar.

1ſt Family.

Common Felſpar, or Felſpar ſimply ſo called [*].

Spath fuſible of Deſmaretz, Spath Etinulant, Spathum Pyromachum.

Its colour is moſt commonly fleſh red, ſometimes bluiſh grey, oftener yellowiſh white, or milk

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[*] This name ſeems to me derived from *fels*, a rock; it being commonly found in granites, and not from *feld*, a field; and hence I write it thus, felſpar.

milk white, or browniſh yellow, rarely blue, or olive green; and lately, in one inſtance, black. 2 Sauſſ.

Amorphous and interſperſed, ſometimes cryſtallized in rhomboids, or ſix or eight ſided priſms; ſeldom right angled; very ſeldom in pellucid needles, tables, or polygons.

Its luſtre when broke acroſs, 0; in other directions, 2.3 1. Its tranſparency, 2.1.

Its fracture diſcovers a ſtreight foliated texture. The lamellæ poliſhed, and ſhining, often on four ſides, croſs fracture uneven.

Its fragments rhomboidal, or tending to that form.

It generally preſents granular diſtinct concretions, either large or ſmall.

Its hardneſs from 9 to 10. Its ſp. gr. from 2,437 to 2,600; the greeniſh ſeem to extend to 2,70.

The yellow felſpar of Port François, in North America, is ſo brittle as not to bear the ſlighteſt friction; when heated it becomes red. 31 Roz. Journ. p. 156.

When heated, the cryſtallized frequently decrepitate, a quadrangular priſm of cryſtallized felſpar of Baveno, of a reddiſh white colour, and whoſe ſp. gr. was 2,437, melted at 130°, into a grey ſemitranſparent porous glaſs, and at 154° into a compact ſemitranſparent glaſs. Another from Sileſia, which was not cryſtallized, and whoſe ſp. gr. was 2,554, and of a grey yellowiſh white colour, melted at 119°, into a grey ſmooth, almoſt compact, ſemitranſparent glaſs; and being mixed with an equal weight of Carrara marble, it melted at 105°, into a white opake, almoſt compact

compact maſs of a ſilky luſtre. The green becomes pale reddiſh when heated.

Alkalis flux this ſtone with great difficulty; microcoſmic ſalt (and particularly borax) is more effectual.

According to Mr. Gerhard, the pureſt felſpar found in granites contains 0,46 ſilex, 0,30 argill, and 0,06 calx. Here 0,18 parts are miſſing, a loſs too great to be imputed to the eſcape of air and water. Mem. Berl. 1783, p. 119.

Mr. Wiegleb, in 100 parts of the reddiſh felſpar of Geyer, found 65 ſilex, 32 argill, 1,66 calx of iron, and 0,0062 of fluor acid. 1 Chy. Ann. 1785, p. 392. This compound I found infuſible even at 155°, therefore it could not form a felſpar.

Mr. Heyer, in white felſpar, detected 0,74 ſilex, 0,30 argill, and a minute portion of iron; the amount exceeds 100. In a red felſpar he found 0,64 ſilex, 0,31 argill, 0,06 of iron, and a minute portion of calx. 2 Chym. Ann. 1788, p. 147. Both theſe compounds are infuſible at 150°.

Mr. Meyer, in *white felſpar*, 0,74 ſilex, 0,24 argill, 0,06 calx, and 0,01 of iron; and in red felſpar, 0,79 ſilex, 0,16 argill, 0,023 of iron. Theſe compounds I found infuſible at 145°. Mr. Sauſſure, from a ſemitranſparent greeniſh *felſpar*, ſeparated 0,43 ſilex, 0,37 argill, 0,017 calx, and 0,04 of iron. This compound is alſo infuſible at 145°.

Not one of theſe reſults exhibits a fuſible compound; or, at leaſt, one that would yield a white or grey ſemitranſparent enamel.

I found cryſtallized reddiſh white felſpar, whoſe ſp. gr. was 2,542, to contain 0,67 ſilex, about

14 argill, 0,11 of barytes, and 0,08 magneſia. Though this reſult ſeems leſs improbable, abſtractedly conſidered, than any of the foregoing, yet Mr. Dolomieu thinks I muſt have been miſtaken, as (according to him) barytes cannot exiſt in the felſpar of granites, and no other analyſis had diſcovered it. Mr. Hoepfner, however, diſcovered barytes in granite. 1 Chym. Ann. 1788, p. 134. And, ſhortly after, Mr. Haſſenfraz, in the felſpar of St. Yrieux, found 0,70 ſilex, 0,12 argill, 0,09 magneſia, and 0,08 of barytes. 14 Ann. Chym. p. 14. Mr. Weſtrumb alſo found baroſelenite in the pureſt felſpar.

Magneſia was indicated in felſpar by Mr. Bergman, Sciagr. §. 130. Though not found by many of the ſubſequent analyſts; it did not, however, eſcape Mr. Monnet, who found it jointly with ſilex, argill, and calx, in the felſpar he examined. 13 Roz. Suppl. p. 54. Nor Mr. Chaptal, who obſerved it to exiſt in greater plenty in the red than in white felſpar.

Mr. Fabroni, who, happily for Italy, has lately directed his attention to mineralogy, diſcovered, in the felſpar of Ægyptian granite, 0,55 ſilex, 0,36 argill, 0,02 barytes, 0,04 magneſia, and 0,03 of iron. See Mr. De La Metherie's late edition of the Manual of Mr. Mongez.

Mr. Scopoli, in felſpar of Baveno, found 0,63 ſilex, 0,17 argill, 0,06 magneſia, 0,02 calx, and 0,07 of iron, loſs 0,05. With reſpect to iron, it is highly improbable that this felſpar, which is of the pureſt kind, ſhould contain any. That which appeared may moſt probably be aſcribed to the Pruſſian alkali he employed in the analyſis.

From theſe different analyſes it appears that any compound of ſilex and argill, in which ſilex predominates, and to which a ſufficient but ſmaller proportion of calx and magneſia, or of calx, magneſia, and barytes, is added to render the whole fuſible in a heat not exceeding 140°, *may* form a felſpar, and will undoubtedly be ſo called, if at the ſame time it preſents a foliated texture; but iron appears to be a foreign ingredient.

The felſpar, both in granites and porphyries, is frequently found, or at leaſt ſuſpected to be the part that is found, in a decompoſed or diſintegrated ſtate, and is ſaid to conſtitute in ſuch caſes, when free from iron, a porcelain clay. But as this clay is infuſible, whereas felſpar is eſſentially fuſible, and as ſome felſpars are not in the leaſt injured by expoſure to the air, it ſhould ſeem that the ſtones, ſo diſintegrated as to be converted into porcelain clay, were not originally felſpars, but ſome other ſpecies of ſtone. I do not, however, deny, that in the neighbourhood of volcanos, real felſpars may be converted into porcelain clays by vitriolic fumes, as the ſalts, that have magneſia or calx for their baſis, may be waſhed away.

Felſpar may alſo be decompoſed when mixed with iron, or when its texture is looſe, but then the reſulting clay will not be fit for porcelain. To remove all doubt, I ſeparated part of the white earth of a decompoſed felſpar, Leſke O. 907ª. And found it refuſed to melt at 130°, but formed a porous white enamel at 140°. Hence it is really an earth from felſpar, though not true porcelain earth.

Its tranſitions are obſcure, and difficultly traced, but ſeem to be into ſhorlites, calcedony, quartz, Labradore ſtone, Labradore hornblende, and, perhaps, into pitchſtone. By diſintegration it paſſes into clay.

2d Family.

Moon Stone, Adularia of Pini *.

Its colour white, yellowiſh, or greeniſh white, ſomewhat irideſcent, ſometimes reddiſh. Found either in blunt amorphous maſſes, or cryſtallized either in truncated rhomboidal priſms, ſingle or coalited, or in rectangular tables, or in hexahædral priſms bevilled at both ends, ſingle or reunited. The ſurface often ſulcated.

Its external luſtre pearly, 3. Its internal the ſame. Tranſparency, 2.3.

Its fracture ſtreight foliated, and ſometimes appears ſtriated. Fragments, 2. Poliſhed on four ſides, and rhomboidal. Its hardneſs, 10. Its ſp. gr. by my trial, 2,559.

At 130°, it melted into a white ſemitranſparent maſs, with a vitreous ſurface; but internally between a porcelain and an enamel.

By the analyſis of Mr. Weſtrumb, it contains 0,625 ſilex, 0,17 argill, 0,065 calx, 0,02 baroſelenite, 0,06 magneſia, 0,014 iron, and 0,0025 of water. 2 Chym. Ann. 1790, p. 221.

Another ſpecimen, leſs tranſparent, and ſomewhat yellowiſh, afforded him 0,63 ſilex, 0,19 argill,

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* Wern. Cronſt. p. 151. 34 Roz. p. 262. 1 Bergm. Journ. 1790, p. 272.

gill,

gill, 0,06 calx, 0,0325 magneſia, 0,04 calx of iron, 0,015 baroſelenite, and 0,005 water.

Mr. Morell, in another ſpecimen, found 0,62 ſilex, 0,19 argill, 0,11 ſelenite, 0,055 magneſia, and 0,0175 water. 2 Helv. Mag. p. 95. Neither of theſe analyſts found the ſparry acid.

3d Family.

Continuous Felſpar. Felſpar en Maſſe.

Its colour reddiſh grey, or pale reddiſh yellow, or fleſh coloured.

It is found in large maſſes, and generally mixed with mica or hornblende, and ſometimes forms the baſis of porphyries.

Its luſtre, 0. Its tranſparency, 1.

Its fracture, unequal and earthy, ſometimes fine ſplintery. Fragments, 2. Indeterminate, and without any poliſh.

Its hardneſs, 10. Its ſp. gr. 2,609, in the ſpecimen I tried.

It frequently conſiſts of granular concretions, eaſily ſeparable.

A ſpecimen of this ſort, Leſke G. 233, melted at 150°,5, into a porous porcelain maſs, glazed on the ſurface.

It ſeems to be the ſtone called earthy felſpar. 2 Sauſſ. p. 136, 322, and 596.

It differs from the amorphous ſtones of the firſt family in this, that the laſt has a foliated texture, and more luſtre, and the fragments tend more to the rhomboidal ſhape; and alſo in fuſibility.

39th Species.

Labradore Stone. Labradore Felſpar of Werner *.

Its colour is of a light or dark grey, or bluiſh, or blackiſh grey; but, in certain poſitions and ſpots, reflecting blue, purple, red, green, &c.

In blunted fragments it chiefly occurs.

Its luſtre, 2.3. Its tranſparency, 1.2.3.

Its fracture, ſtreight foliated.

Its fragments, 2. Rhomboidal, with four poliſhed faces, or tending to that ſhape.

Sometimes without diſtinct concretions; ſometimes with large or coarſe grained, rarely with thick lamellar.

Its hardneſs, 10. Its ſp. gr. from 2,67 to 2,6925.

At 130°, a ſpecimen of the bluiſh grey, whoſe tranſparency was barely 1, and its ſp. gr. 2,672, which I had from Mr. Woulfe, was barely glazed on the outſide; and at 155° the white part ſeparated itſelf from the brown, and was melted. The brown was alſo imperfectly melted into an opake porous brown porcelain.

From this difficult fuſibility, I conclude Labradore to be ſpecifically different from common felſpars; the nature of the brown matter is not known, this ſtone having never been analyzed.

The green felſpar of Siberia, deſcribed by Mr. Bindheim, 5 Berl. Beob. p. 107, is evidently a variety of this ſpecies. It differs only in the following

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* Wern. Cronſt. p. 149.

lowing particulars. Its colour is apple green, and from that paſſes into the verdegris green, with white ſtripes. Its luſtre is often pearly and irideſcent. 2 Chym. Ann. 1792, p. 234.

Its ſp. gr. 2,583; in every other reſpect it reſembles the above. When heated it loſes its green colour, hardens, becomes fleſh red, but refuſes to melt before the blowpipe. Nor have the uſual fluxes much effect on it. Hence I conſider both as ſpecifically different from common felſpar and its varieties.

Mr. Bindheim found 100 parts of it to conſiſt of 69,5 ſilex, 13,6 argill, 12 gypſum, 0,7 calx of copper, 0,036 calx of iron, and about four grains were loſt. 5 Berl. Beob. p. 111.

40th Species.

Petrilite, or Cubic Felſpar of Karſten [*].

Its colour is reddiſh brown, or browniſh red.

Amorphous.

Its luſtre, 2. Its tranſparency, partly 2, partly 1.

Its fracture participates of the ſplintery and foliated; but inclines more to the former.

Its fragments, 2; cubic, or inclining to that form, and without poliſhed faces.

It ſeems to conſiſt of thick, indiſtinctly ſeparate ſtreight lamellar concretions.

Its hardneſs, 9. Brittle. The ſpec. gravity of the ſpecimen I tried, which was that in Leſke O. 907^{c}, was 3,081.

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[*] 2 Bergm. Journ. 1788, p. 809.

At 160°, it whitened, and barely concreted, without any farther ſign of fuſion.

Hence it is plain it is ſpecifically different from the other ſtones hitherto called felſpars; on this account, to avoid confounding it with them, I call it petrilite.

41ſt Species.

Felſite, or compact Felſpar of Widenman *.

Its colour is azure blue, or in ſome parts bluiſh white, or pale, or deep browniſh, or blackiſh green, or greeniſh white.

It is found amorphous, aſſociated with quartz and mica; in larger or ſmaller maſſes in granite; the green chiefly in porphyries. The blue was lately diſcovered near Krieglach, in Stiria, by Mr. Widenman.

Its luſtre, 1. Its tranſparency, ſcarcely 1.

Its fracture uneven, yet often approaching to the fine ſplintery; in ſome ſpecimens a fine foliated texture may, though with ſome difficulty, be perceived.

Its fragments, 2. Indeterminate.

Gives a white ſtreak.

Its hardneſs, 9. Its ſp. gr. not conſiderable, that is, does not amount to 4.

Expoſed to a blowpipe it whitens and becomes rifty, but is infuſible *per ſe*.

This ſtone I have not as yet ſeen, or at leaſt diſtinguiſhed.

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[*] 1 Bergm. Journ. 1791, p. 345. And the note in p. 346.

42d Species.

Argentine Felſpar, or Oculus Piſcis *.

Its colour white, two oppoſite faces ſilvery white, two others dead white, or yellowiſh; when decompoſing irideſcent, when farther decompoſed ochre yellow.

It is found amorphous in rounded fragments, or cryſtallized nearly as common felſpar, or in detached plates, or in ſhining ſtriæ.

Its internal luſtre, 4. Its tranſparency, 2; or 1 when decompoſing.

Its fracture in one direction foliated, in another ſtriated.

Its fragments rectangular. The lamellæ inflexible.

Hardneſs of the ſilvery laminæ, 6; of the others, 9. Brittle. Sp. gravity, when not much decompoſed, 2,500; when more advanced in this reſpect 2,300 or 2,212.

When decaying, if breathed on, it gives an earthy ſmell.

Expoſed to the blowpipe, and ſtuck on glaſs, if the flame be directed to the edges, it eaſily melts into a clear compact glaſs; but, if the flame be directed on the faces, they ſtill preſerve their luſtre, and only the edges ſlowly melt.

This ſtone was diſcovered in the black mountain of Languedoc, by Mr. Dodun, one of the moſt eminent French mineralogiſts; by its exter-

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* 37 Roz. Journ. p. 49. 36 Roz. Journ. p. 405.

nal characters it is nearly allied to common felſpar, but, by the quantity of calx of iron which it eſſentially contains, it muſt be deemed ſpecifically different from them.

By the analyſis of Mr. Dodun it contains 0,46 ſilex, 0,36 argill, 0,16 calx of iron.

43d Species.

Of the Redſtone of Rawenſtein.

This ſtone is thus deſcribed by Count Razoumouſky. 3 Mem. Lauſane, p. 129.

Its colour, by reflected light, is roſe red, and ſomewhat irideſcent; by refracted, blue.

It is found amorphous, and in large maſſes.

Its luſtre, 2. Its tranſparency, 2.3.4. Its fracture thick foliated.

Its fragments tending to the cubical form. Conſiſts of numerous diſtinct concretions.

Its hardneſs from 9 to 10. Brittle. Its ſp. gr. conſiderably approaching to that of baroſelenite.

It decrepitates when ſuddenly heated, and in the ſtrongeſt heat of a ſmith's forge it melts but imperfectly. The uſual fluxes have no very ſenſible effect on it.

It ſeems nearly allied to petrilite.

44th Species.

Siliceous Spar. *Saulen Spath* of Bindheim.

Its colour, white, ſtraw yellow, or ſea green, mountain green, or light blue. Red ?

Its luſtre ſilky, 2.

It is found cryſtallized in quadrangular or hexangular priſms, tranſverſely ſtreaked, and generally heaped together.

Its fracture fibrous, or ſtriated.

It effervesces with acids.

According to the analyſis of Mr. Bindheim, it contains 61,1 ſilex, 21,7 calx, 6,6 argill, 5 magneſia, 1,3 calx of iron, and 3,3 water. 3 Schrift. Naturforch. Freunde. p. 452.

The deſcription above given is imperfect; yet from that, and the analyſis, we may infer that it is nearly allied to zeolites. Mr. Bergman indeed * conſiders it as of the ſame ſpecies as the zeolite of Hælleſtadt; but the ſmall proportion of water it holds diſcriminates it too ſtrongly from that foſſil to allow them to be of the ſame ſpecies.

Mr. Hoffman, on the contrary, conjectures it may be the ſame as the *tremolite* of Hœpfner, which Mr. Ferber † informs us is of a *red* colour, and fibrous, or ſtriated, and in which Mr. Klaproth found 0,65 ſilex, 0,18 calx, 0,103 magneſia,

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* Schwed. Abhand. 1784.

† Drey Briefe Miner. Inhalt. p. 21.

magneſia, 0,065 fixed air and water, and 0,005 calx of iron. 1 Chym. Ann. 1790, p. 54*.

Of Agates.

Agates, as Mr. Werner juſtly remarks, do not form a diſtinct ſpecies of ſtone, but conſiſt of quartz, cryſtal, hornſtone, flint, calcedony, amethyſt, jaſper, carnelian, heliotropium, jade, aggregated in binary, ternary, or more numerous combinations, and ſuſceptible of a good poliſh; even one of theſe, if it preſents two or more colours and aſſumes a good poliſh, is called an agate. Theſe mixtures preſent either dots, veins, zones, filaments, figures of various kinds, ramifications, or arborizations.

They are found either in rocks, as in Saxony, near Kunmerſdorf, or in angular fragments, or in nodules, or contained in ſmall rounded lumps called *Geods*, or, though ſeldom, ſtalactitic.

Their colours are, the clear yellowiſh, reddiſh, milk, or greyiſh, or bluiſh white, or pearl grey, or honey, ochre, or orange *yellow*, fleſh, blood, or brick *red*, or reddiſh *brown*, violet *blue*, or browniſh *green*.

The clear pellucid white	denotes	Cryſtal or quartz,
The yellowiſh white		Amethyſt, calcedony,
The greyiſh white		Quartz,
The milk white		Jaſper, amethyſt,
The yellowiſh grey		Quartz, flint,
The ſmoke grey		Calcedony, flint,

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[*] 1 Bergm. Journ. 1790, p. 82.

The pearl grey denotes	Calcedony,
The greeniſh grey	Calcedony, jaſper,
The bluiſh grey	Calcedony,
The honey yellow	Flint, jaſper,
The yellow	Jaſper,
The ochre yellow	Calcedony,
The orange yellow.	Calcedony,
The yellowiſh brown	Carnelian,
The reddiſh brown	Hornſtone, carnelian,
The fleſh red	Carnelian,
The blood red	Jaſper, carnelian,
The brick red	Jaſper,
The violet blue	Amethyſt,
The browniſh green	Heliotropium,
The leek green, and feeling ſomewhat greaſy	Jade.

Amethyſts are diſtinguiſhed alſo by their diſtinct columnar concretions.

The figures contained in agates are various, ſome repreſenting the polygon lines of a fortification, ſome perſpective views, or arborizations, or moſs, and called mochos; ſome contain real moſs, or other herbs, as Mr. D'Aubenton has ſhewn. Mem. Paris. 1782, p. 668.

The ſpecific gravity of agates is generally from 2,58 to 2,666. If they contain jade they may be heavier. Their hardneſs from 10 to 12.

The finer kinds are called oriental, they are ſemipellucid.

SIXTH GENUS.

Stronthian Earth.

1ſt Species.

Combined with fixed air, Stronthianite.

ITS colour is light, or whitiſh green.

It is found in large ſhapeleſs maſſes.

Its luſtre, from 2 to 3. Its tranſparency, 2.

Its fracture, thick ſtriated, ſometimes preſenting diſtinct columnar concretions.

Its hardneſs, 5. Its ſpec. grav. from 3,4 to 3,644.

It burns to lime in a heat of 140°, and eaſily vitrifies with the clay of the crucibles.

It efferveſces with the nitrous and muriatic acids, and forms with them eaſily cryſtallizable ſalts, but which are precipitable by barytic lime water.

SEVENTH GENUS.

Jargon. Zircon of the Germans.

THE only ſpecies, of this genus hitherto known, is the ſtone called Jargon of Ceylon, or Zircon, which exhibits the following characters *:

Its colour is grey, or greeniſh white, mountain or olive green, inclining more or leſs to yellow, yellowiſh brown, reddiſh brown †, and violet.

It is found either in ſmall irregular grains, or cryſtallized. The cryſtallization preſents either right-angled quadrangular priſms ſurmounted with pyramids; or octohædrals, conſiſting of double quadrangular pyramids; the ſurface ſomewhat ſmooth and poliſhed.

The external luſtre is caſual, but the internal is ſtrong and inclining to the metallic.

The fracture is intermediate between the thin curved foliated, and the flat conchoidal, and ſome ſmall-grained diſtinct concretions.

The fragments, indeterminate and very ſharp.

Strongly ſemitranſparent. Sometimes Opake. Briſſon 73.

Its hardneſs from 10 to 16. Its ſp. gravity according to Briſſon, 4,416. And according to

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* 4 Lempe Magaz. p. 99. 2 Berl. Beob. p. 147.
† Briſſon p. 73.

Mr. Klaproth, 4,615. According to Werner, 4,7. 2 Bergm. Journ. 1790, 90.

Heated to redneſs, and quenched in water, it becomes rifty, and troubled.

According to Mr. Geyer, it is ſcarcely fuſible, even by the help of pure air.

It is inſoluble in acids, except by particular management.

By the analyſis of Mr. Klaproth *, 100 parts of it contain, 31,5 ſilex, 5 of ferruginous nickel, and 68 of a new earth.

EIGHTH GENUS.

Sydneia.

OF this no ſpecies has as yet been found; nor has it been detected in any other ſtone.

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* Briſſon, p. 73.

NINTH GENUS.

Adamantine Earth.

1ſt Species.

Adamantine Spar.

THIS earth hath hitherto been diſcovered only in adamantine ſpar, though its exiſtence may be ſuſpected in ſome felſpars.

Of this ſtone we are acquainted with three varieties; the firſt is found in China; the ſecond in India, near Bombay, and there called *Corundum*; and the third, in France.

1ſt Variety *.

Its colour is grey, with various ſhades of brown, or green.

Its form, when moſt regular, is that of an hexangular priſm, two ſides large and four ſmall (Briſſon), without any pyramid. Its ſurface ſomewhat ſtriated, and covered with a thin rind of ſilver white mica, with here and there particles of red felſpar, and ſometimes with ſulphur pyrites.

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* 2 Berl. Beob. p. 295.

Its internal luſtre, when broken croſsways, 0, or 1; diagonally, 3.

Its fracture, more or leſs, perfectly foliaceous, and ſparry.

In thin pieces, and at the edges, ſemitranſparent.

Its hardneſs, 15. Others ſay it is a little harder than cryſtal. 30 Roz. p. 13. Brittle.

Its ſpecific gravity, according to Klaproth, 3,710; according to Briſſon, 3,8732.

Some grains of cryſtallized magnetic iron are diſſeminated through it, which are eaſily ſeparated by a magnet when the ſtone is pulverized. They amount to about $\frac{1}{5}$ of the whole.

It is infuſible in a porcelain heat, and Mr. Lavoiſier found it ſo even by pure air; yet Mr. Ehrman aſſures us, he melted it into a dark brown button ſpotted with white in one minute. 2 Chy. An. 1788, p. 143.

2d Variety.

This differs from the former only in this, that it is whiter, its texture more manifeſtly foliaceous; and that the ferruginous particles barely adhere to it, and are not diſperſed through it.

3d Variety.

This was found by Mr. Morveau, in Poitou. Its colour reddiſh brown, and its hardneſs ſuperior to that of cryſtals. Its ſp. gr. was 4,183. 1 Ann. Chy. p. 188. Hence he preſumes it to be adamantine ſpar.

After theſe we may perhaps place the heavy felſpar mentioned by Mr. Briſſon, called in Rome *Verde di Corſica Duro*; its colour is dead white, with large blotches of green, and its hardneſs extraordinary. Its ſp. gr. 3,105. And another, mentioned by Mr. Morveau, found in Le Ferez, of great hardneſs, whoſe ſpecific gravity was 3,075; but, as it yielded a little to the heat of a furnace, it is probable it contained ſome mixture of common felſpar.

SECTION XI.

Of Aggregated Stones.

THESE conſiſt of either grains (angular maſſes) of ſtones ſimply compacted together, and forming either uniform or ſlaty maſſes; or of ſtones of one or more ſpecies, inhering in another ſtone, which may be conſidered as their baſis or cement; or of rounded ſtones of different ſorts, adhering to or inhering in ſome other; or of maſſes of different aggregates inhering or adhering to each other. All theſe, though ſuſceptible of infinite variety, might at leaſt, in general be diſtinguiſhed by appropriate names, if a claſſification were now for the firſt time to be attempted; but unhappily various combinations have already been denoted by particular names, under which they are now known by mineralogical writers ſo narrowed and reſtrained in their ſignification as to be incapable of being brought under general diviſions; and to introduce new names would produce confuſion. Hence, I ſhall confine myſelf to the explanation of the denominations already in uſe, as they are underſtood and applied by the moſt exact writers on this ſubject.

Granite.

This name in the ſtricteſt ſenſe denotes an aggregate of quartz, felſpar, and mica; all in very variable proportions, not only in different, but often in the ſame mountain; the felſpar generally amorphous, ſeldom cryſtallized, very frequently in the greateſt proportion, and the mica in the leaſt.

The ſize of the grains is alſo variable, from that of a pin's-head to that of two or three feet; but this laſt is very rare*. 2 Bergm. Journ. 1789, 932. The largeſt uſual ſize is that of a nut. Some are ſo ſmall as not to be diſtinguiſhed without a ſtrong lens, and are often taken for ſimple ſtones. See Voight, *Ilmenau* 29.

The colour of granites is infinitely diverſified; it depends chiefly on that of the felſpar, this being generally the moſt copious ingredient, this is generally reddiſh, more rarely greeniſh, or bluiſh, or greyiſh; the mica more generally black, more rarely yellowiſh or grey; the quartz commonly greyiſh white.

Granites are moſt commonly very hard; ſome, however, inclining to diſintegration are very brittle.

The felſpar found in granite, though generally of the common kind, yet may be of the ſorts I have called petrilite or felſite.

Hence the ſp. gr. of granite is variable, from 2,5388 the loweſt I have met with to 2,9564, that of the blue granite of Carinthia, which Briſſon tells us is the moſt beautiful of the ſpecies. Here the felſpar is blue, and moſt probably the compact felſpar of Weidenman, which I have called *Felſite*. But the moſt uſual ſp. gr. of granites is from 2,56 to 2,66 or 2,76, if we admit that it may contain a ſmall proportion of ſhorl,

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[*] Renovanz 7.

or rather hornblende, which Briſſon conſtantly mentions; he may, however, miſtake ferruginous or black mica for this. That of the red Ægyptian granites, of the obeliſks of Rome, is 2,654, that of the grey 2,7279.

Steatites is alſo ſometimes a component part of granite; but Mr. Werner deduces it with great probability from the decompoſition of mica. However, Hœpfner ſays, it is ſometimes an eſſential component part. 4 Helvet. Mag. 267.

Porcelain earth is alſo ſometimes found in granites, and ſaid to ariſe from the decompoſition of felſpar; but as this earth is infuſible, but common felſpars on the contrary very fuſible, it is not from theſe, but moſt probably from continuous felſpar, that its origin muſt be deduced.

Shorl (I mean true priſmatic ſhorl) is alſo ſometimes found in granites, but only caſually, that is to ſay, not as a conſtant ingredient in extended maſſes in the rock, except perhaps in a few countries. Werner, Claſſif. §. 6. Garnets have alſo been ſound in it, but very rarely. Ibid. Alſo ſhorlaceous actinolyte, and chlorite. 4 Helvet. Mag. 266. See alſo Renovanz 7.

It has lately been obſerved, that, when granites are traverſed by conſiderable veins of quartz or felſpar, rubies and other precious ſtones are frequently contained in thoſe veins. 1 Chy. An. 1792, Voight Prack. Gebrig. Kunde §. 18.

Mr. Hacquet found, that granite reduced to powder is eaſily melted into a whitiſh green homogeneous glaſs. Crell Beytrag. 34.

That granite may be produced, at this day, from the agglutination of its own ſand, we have an evident proof in the mole conſtructed in the Oder in the year 1722; it is 350 feet in length, 54 in height, of that breadth at top, and 144 at bottom; the walls were made of blocks of granite, faſtened with iron cramps, the chinks ſtopped with moſs, and the ſpace between the walls filled with granite ſand; this ſand, by the oozing of the water impregnated with iron, or other cauſes, is now at laſt rendered ſo hard and compact as to prevent any more water from traverſing it, and cannot be diſtinguiſhed from natural granite. Laſius, *Hartz*. 91.

Granites ſeem to paſs into ſandſtone, Leſke, S. 967.

Sienite.

An aggregate of quartz, hornblende, and felſpar, or of quartz, felſpar, hornblende, and mica, appears to Mr. Werner to be of later formation than the mere aggregate, of which hornblende is not a conſtituent part; hence he diſtinguiſhed it at firſt by the name of *Grunſten*; afterwards, however, he found the name of *Sienite* more proper, it having been already uſed by Pliny to denote a ſimilar ſubſtance; and Chevalier Napion, having diſcovered in Sweden a ſubſtance which correſponds with the grunſten of Cronſted, Mr. Werner applied this term, as Cronſted had done.

Mr. Hacquet found ſienite fuſible into a black glaſs in a moderate heat. Crell Beytr. 34.

Sienite in a ſlaty form, has been found in the Altaiſchan Mountains; it conſiſted of ſandy quartz, hornblende, and felſpar. Renovanz 5 and 8.

The ſienite, Leſke S. 1063, is worthy of particular attention; its colour is greeniſh; and where decompoſing, whitiſh, and yellowiſh grey, it preſents large patches of brown mica with ſmall grains of white quartz, and a large quantity of greeniſh black hornblende, with ſome felſpar.

The quartz is generally by far in the ſmalleſt proportion.

The granites which contain hornblende are the hardeſt. Mem. 1773, p. 824, in 8vo. They ſhould alſo be the heavieſt, particularly if the hornblende be in a conſiderable proportion.

Granatine.

Beſides the aggregates already mentioned, various other triple compounds have been diſcovered in Swiſſerland, by the indefatigable induſtry of Mr. Sauſſure and Mr. Hœpfner, which may be denoted by the name of *Granatines*; of theſe the following are the moſt remarkable *:

Quartz	Quartz	Quartz	Quartz	Quartz	Quartz
Felſpar	Felſpar	Felſpar	Mica	Mica	Mica
Jade	Shorl	Garnets	Shorl	Jade	Garnet

Quartz	Quartz	Quartz	Quartz	Quartz
Shorl	Shorl	Shorl	Hornblende	Hornblende
Hornblende	Jade	Garnet	Jade	Garnet

Quartz	Quartz
Jade	Hornblende
Garnet	Hornſtone †

Felſpar	Felſpar	Felſpar	Felſpar
Mica	Mica	Quartz	Quartz
Shorl	Hornblende	Serpentine ‡	Steatites §.

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* 1 Sauſſ. 107, &c. 1 Helvet. Mag. 281.

† Renovanz, p. 5.

‡ 5 Bergm. 128.

§ Renovanz, 5.

The

The ſhorl may be either the common, or tourmaline, or ſhorlaceous actinolyte.

Even calcareous ſpar, fluor, zeolyte, and baroſelenite, have been found in ſome granites in Swiſſerland. 1 Chy. An. 1788, 133. Haiding. 52. See alſo Leſke's Catalogue G. 55, and S. 528. And 2 Sauſſ. 407.

According to Dolomieu, ſeveral Ægyptian monuments at Rome are formed of black trap, felſpar, and mica. 37 Roz. 195.

The aggregate of quartz, mica, and garnet, is called *Norka*, or *Murkſten*, by Cronſted.

Of Binary Aggregates

of the Granitic kind.

Grunſten, Granitell.

Binary aggregates of quartz, felſpar, mica, ſhorl, hornblende, &c. are called by Mr. Hœpfner, *Simple Granites*. Wallerius beſtowed this name on the aggregate of quartz and felſpar. Mr. D'Aubenton calls the aggregate of quartz and ſhorl, or of quartz and hornblende, *Granitell*. Mr. Briſſon by this term underſtands the aggregate of felſpar and ſhorl. To avoid all ambiguity, I would propoſe to denote all theſe duplicates in general by the name granitell; ſpecifying, when neceſſary, the peculiar conſtituent parts of each.

Mr. Werner, and his ſchool, at preſent denote only the aggregate of hornblende and felſpar, or mica, by the name of *Grunſten*, as Cronſted had done before. Werner uberdie Gange, 79. It were not amiſs that every other combination, not merely accidental, but of which mountains or large tracts actually conſiſt, were alſo diſtinguiſhed by a peculiar name.

The granitells hitherto noticed by Sauſſure, Hœpfner, and Haidinger, are,

Quartz	Quartz	Quartz	Quart	Quartz	Quartz
Felſpar	Mica	Shorl	Hornblende	Jade	Garnet

Quartz
Steatites

Felſpar	Felſpar	Felſpar	Felſpar	Felſpar
Mica	Shorl	Hornblende	Jade	Garnet

Mica	Mica	Mica	Mica
Shorl	Hornblende	Jade	Garnet

Hornblende	Hornblende
Jade	Garnet

Jade	Indurated Steatites
Garnet	Shorl. 1 Sauſſ. 104.

The aggregate of *quartz and mica*, is, by the Swedes called *Stellſtein*, whether compact or ſlaty. Mr. Werner, when it is ſlaty, calls it *Glimmer Schiefer*, that is, *Slate Mica*, or *Shiſtoſe Mica*, or *Slaty Mica*; when compact, it may perhaps be proper to call it *Stellſtein*; when ſlaty, *Shiſtoſe Mica*. When its coherence is moderate, and the mica diſperſed through its ſubſtance, it has often the appearance of a ſandſtone, and is called by the French *Micaceous Grit*, or primitive micaceous ſandſtone.

Stellſtein is found either grey, green, or red; its appearance is variable according to the proportion of its ingredients. The mica often runs in veins or ſtripes; it is uſed as a fire-ſtone.

The ſtone called *Aventurine*, of which we have already ſpoken, may be conſidered as of this ſpecies.

The aggregate of *felſpar and mica* is called *Rapakivi*, its colour is brown, or browniſh red, it moulders by expoſure to the air, but that is only when the mica exceeds; when the felſpar exceeds, it forms a durable ſtone called in Italy *Granitone*. Ferber *Italy*, 118.

The aggregate of *hornblende and mica* is generally dark green, and hence called *Grunſtein*.

In fact, however, the addition of mica to any ſtone cannot, with propriety, entitle it to be placed in the granitic order; as mica does not form a grain, but attaches itſelf indifferently to many ſorts of ſtones. Thus we have micaceous limeſtones, micaceous potſtones, micaceous argillites.

The aggregate of *quartz and ſteatites* is called *Saxum molare* by Wallerius; its colour he tells us is grey, green, or red. Mr. Mongez tells us it is alſo found in Dauphiné.

Mr. D'Aubenton calls the aggregate of *quartz and felſpar*, granatin.

In ſome aggregates of *quartz and ſhorl*, ſlender capilliform needles of red ſhorl traverſe the quartz, and croſs each other in various directions. This ſtone is in ſome eſtimation, and is by the Germans called *Hairſtone*. It is found in Siberia.

Granilite.

Granites Indeterminatus of Hœpfner.

Under this denomination, we may comprehend all granites that contain more than three conſtituent parts.

Of this ſort many are mentioned by Hœpfner, Sauſſure, Haidinger, and in 2 Chym. Ann. 1785, 22.

Quartz
Felſpar
Mica
Shorl

Quartz
Felſpar
Mica
Steatites

Quartz
Mica
Shorl
Garnet

Quartz
Felſpar
Mica
Garnet

Quartz
Baroſelenite
Mica
Shorl

Quartz
Baroſelenite
Mica
Hornblende.

The two laſt aggregates were found forming a whole mountain in Swiſſerland, by Mr. Hœpfner. 1 Chy. An. 1788, 134. the baroſelenite was of a fleſh red colour.

Gneiſs*.

Roche feuilletée of Sauſſure, in part.

To Mr. Werner we are indebted for a preciſe deſcription of this ſtone. According to him gneiſs, like granite, conſiſts of quartz, felſpar, and mica.

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* Werner, Kurze Claſſification, §. 8. Bergm. Kalendar, 1790, 202.

Of *a thick, ſlaty, continuous, or fibrous texture,* and not of a granular, as when they form granite. And hence a ſlaty granite is not on that account to be called a gneiſs, as it is ſtill granular.

In gneiſs alſo mica is in the ſmalleſt proportion, and felſpar generally is nearly an equal in proportion with the quartz, except the gneiſs approaches to granite, for in that caſe the felſpar predominates, as does the quartz when gneiſs paſſes into *ſkiſtoſe mica.* If the gneiſs be ſplit longitudinally, the mica will appear in the largeſt proportion, becauſe the layers of mica are the moſt fiſſile. Voight §. 20. But, if broken acroſs, it will appear otherwiſe.

The felſpar in gneiſs is often decompoſed and paſſes into clay, and the mica ſometimes into ſteatites, particularly near veins.

Garnets are often found in gneiſs, but of no value; ſo alſo is ſhorl, and tourmaline; and, in Swiſſerland, alſo ſhorlaceous actinolyte, hornblende, and talc. Per Hœpfner. 4 Helv. Mag. 268. Voight Prack. Geb. §. 20.

The tranſitions of gneiſs are into granites, ſhiſtoſe mica, and ſhiſtoſe hornblende.

The hardneſs of gneiſs is as variable as that of granite; its ſlaty texture is often only perceptible to the eye, for it refuſes to ſplit, though it breaks more eaſily in that direction than in any other. 1 Sauſſ. 114.

The quartz grains are generally more blunt in gneiſs than in granite; the felſpar, often thin, and flatted in the direction of the laminæ; yet ſometimes thick, and placed obliquely to their direction. The mica often runs in veins parallel to each other. Sauſſ. 117. The plates or laminæ are

are often of unequal thickneſs, ſtreight, or variouſly bent.

Withered gneiſs has ſometimes the appearance of a grey ſlaty mortar, as in Leſke O. 68; or of a reddiſh and yellowiſh mortar intermixed with mica, as in O. 371.

Sometimes it abounds ſo much in hornblende, as to reſemble hornblende ſlate, as in S. 768.

Shiſtoſe Mica.

Glimmer Schiefer of Werner. Roche feuilletée of Sauſſure §. 160.

This conſiſts of quartz and mica more or leſs intimately mixed, and of a ſlaty or ſhiſtoſe texture, ſtreight, or curved, it contains more mica than gneiſs does; ſometimes the quartz is not diſtinguiſhable. I doubt even, whether talc, rather than mica, be not often one of its conſtituent parts. Sometimes the quartz and mica are found ſtratified with each other.

It frequently contains garnets (and then, as the compact ſort already mentioned, is called murkſten) and according to Heidinger alſo ſhorl, actinolyte, and ſappare.

Sometimes granular limeſtone holds the place of quartz, as in Leſke S. 1520. The ſpecimen 1512 is of a bluiſh grey colour, with an uneven ſhiſtoſe fracture, and, worthy of particular notice; it alſo contains granular limeſtone.

Its tranſitions are into gneiſs, argillite, ſhiſtoſe chlorite, and porphyry.

Sometimes it is ſo decompoſed as ſcarcely to be diſtinguiſhed, its colours yellowiſh, or reddiſh grey,

grey, or brown, ſometimes nearly black, however it always retains its fiſſile texture.

Murkſtein is remarkably heavy. See Leſke S. 293.

When the mica is dark blue, or lead coloured, or nearly black, this ſtone much reſembles hornblende ſlate, or at leaſt an argillite mixed with hornblende; but the ſoftneſs of the mica, and the ſpecific gravity, ſufficiently diſtinguiſh them. See Leſke G. 131.

Porphyry *.

Any ſtone which in a *ſiliceous* or *argillaceous* ground, or baſis, contains ſcattered ſpecks, grains, or dots of felſpar, viſible to the naked eye, is at preſent denominated a *porphyry*. But with felſpar it may, and generally does, contain quartz, hornblende, and mica; theſe inhering ſtones are generally of a different colour from the ground; in which, as in a cement, they are ſtuck and cryſtallized; nay, of late this name has been given to ſtones which do not contain felſpar, at leaſt viſibly. See Leſke G. 233, 236.

I do not ſee any reaſon why calcareous or muriatic ſtones, containing felſpar, ſhould be excluded; hence I diſtinguiſh four ſorts of porphyry, the *ſiliceous*, *argillaceous*, *muriatic*, and *calcareous*; moſt of which may be *compact*, or *ſhiſtoſe*, or *ſlaty*.

The felſpar contained in porphyries is commonly diſtinguiſhed by its oblong quadrilateral ſhape, though it is often in rounded grains. 2

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* Kurze Claſſif. §. 12.

Chy. An. 1790, 16. Very frequently it is diſintegrated or decompoſed. It is ſaid to differ in hardneſs and fuſibility from common felſpar; thoſe moſt uſual in granites poſſeſſing theſe properties in a higher degree; it may therefore be, if *grey*, the labradore; if *browniſh red*, the petrilite; if *greeniſh*, the felſite; porphyries containing large cryſtals or fragments of felſpar, from 0,4 to 0,9 of an inch, are by the French called ſerpentines; their baſis is ſuppoſed to be a jaſper, but commonly, I believe, it will be found to be a hornſtone. Briſſon, p. 126. 35 Rozier 128.

The ſpecific gravity of porphyries is neceſſarily different with the nature and proportion of eir baſes.

Of Siliceous Porphyries. Leſke S. 1090.

Siliceous porphyries have either jaſper, hornſtone, pitchſtone, obſidian, ſiliceous ſhiſtus, ſhiſtoſe hornſtone, or felſpar itſelf for their baſis.

Jaſper Porphyry.

The exiſtence of this has lately been called in queſtion. Mr. Werner, expreſſly ſays, he never met any. 1 Bergm. Journ. 1789, 600, in a note. Mr. Faujas, from the great fuſibility of the porphyries, that were preſumed to have jaſper for their baſis, thinks that it muſt be of a different nature. This point, however, is not yet perfectly aſcertained; ſee Leſke G. 212. and 2 Chy. An. 1790, 19. nor perhaps can, in particular inſtances, without examining the fuſibility of the ſpecimens in queſtion.

Hornſtone

Hornſtone Porphyry.

Theſe are diſtinguiſhed by their hardneſs, and a conchoidal fine ſplintery fracture, their ſlight tranſparency, and want of luſtre; they are alſo not difficultly fuſible; of this ſort is the porphyry. 1 Sauſſ. §. 150, 156, and 157. And many more in Leſke G. p. 25, &c.

Sometimes the felſpar is decayed, and ſometimes the hornſtone alſo, while the quartz and hornblende remain entire; this gives the whole the appearance of indurated volcanic aſhes, though the quartz might prove the contrary; if the felſpar alone be decayed, the hornſtones will appear porous, and may be taken for a lava. See Leſke G. p. 26, &c. Its tranſitions are into granite and ſandſtone.

Pitchſtone Porphyry. Leſke S. 1779.

Its colour, black, grey, green, red, or yellow, of various ſhades, generally many colours at once in the ſame ſpecimen. Luſtre, greaſy 2.1. Tranſparency, 2.1. Fracture, imperfectly conchoidal. Hardneſs, 8, 9, 10. The felſpar often blue. See Liebenroth Beobacht 42. Of this ſee a remarkable ſpecimen, Leſke S. 950. Its hardneſs, 10. Luſtre, 1.

Of ſome the fracture is ſlaty, as for inſtance, that in Leſke S. 1779. Its colour, yellowiſh grey. Luſtre, ſcarcely 1. Tranſparency, 1. Hardneſs, ſcarcely 9. Sp. gr. 2,452.

Obſidian Porphyry.

Black, or greyiſh black. Luſtre glaſſy, 3.2. Tranſparency, 0 or 1. Fracture, perfectly conchoidal. Hardneſs, 10.

Horn Porphyry.

Porphyry Schiefer of Werner. Leſke S. 1130, 971, 973.

This has ſiliceous ſhiſtus, or hornſlate for its baſis; but, as other porphyries may have alſo a ſlaty or ſhiſtoſe texture, Mr. Noſe juſtly propoſes to diſtinguiſh this we now treat of by the name of hornporphyry. 2 Noſe 432. It frequently contains hornblende and quartz much more apparently than felſpar.

The ground is generally bluiſh, or greeniſh, and the felſpar white, and often exceeding minute; this gives the whole a bluiſh or greeniſh grey appearance, ſometimes alſo a yellowiſh grey, and theſe laſt ſtrongly reſemble wacken porphyry. See Leſke S. 1015.

Luſtre, 1. Tranſparency, 0 or 1. Fracture uneven, coarſe, or fine ſplintery; ſometimes tending to the conchoidal; frequently ſlaty in the groſs.

Hardneſs, 9, 10.

It is often found decompoſed, or diſintegrated.

The grain of this ſtone is often as fine and cloſe as that of hornſtone; but then it does not give fire with

with that ſmartneſs, that hornſtone of that fine grain does.

It paſſes into argillite and trap.

The baſis of the horn-porphyry, Leſke S. 1041, ſeems a middle thing, between ſiliceous ſhiſtus, and argillite; its colour bluiſh grey, with ſome reddiſh and whitiſh ſpecks; fracture, thin ſlaty; hardneſs, 10; ſurface ſhews a whitiſh brown cruſt from decompoſition.

Petunſe Porphyry.

Porphyry that has felſpar for its baſis is called by this name.

Its colour is generally yellowiſh brown, or reddiſh brown, or browniſh red, or reddiſh grey, or fleſh coloured, or yellowiſh red.

Luſtre, 0. Tranſparency 0, or ſcarcely 1. Fracture unequal, or earthy, or fine ſplintery, or preſenting ſmall folia or lamellæ, often preſents diſtinct concretions. Hardneſs, 10.

The rock, mentioned in 2 Sauſſ. §. 728, ſeems different, being much more fuſible,. See Leſke S. 1158.

Of Argillaceous Porphyries.

Theſe may have indurated clay, hornblende, trap, wacken, mullen, kragg, or argillite, for their baſis.

Clay Porphyry, Leſke S. 1094, 1096,

Its colour is generally of ſome ſhade of grey, or greeniſh grey, or brown, or blackiſh, or reddiſh brown, or Iſabella yellow.

Luſtre, and tranſparency, 0; fracture, earthy; hardneſs, from 5 to 7. It ſometimes adheres to the tongue.

Of this ſtone is the *metalliferous ſtone* of Born or *Grauſtein* of the Germans, ſo celebrated in Hungary; its colour is ſome ſhade of green, moſtly dark, even inclining to black, rarely reddiſh; it conſiſts of indurated clay, in which hornblende, felſpar, mica, and quartz, are found. 1 Bergm. Journ. 1789, 606. Haid. 42. See the ſpecimen Leſke S. 289.

This porphyry is much ſubject to decay; the felſpar either moulders, or loſes its luſtre; the hornblende alſo; and the whole has then been often miſtaken for volcanic traaſs.

The reddiſh porphyry of the Hartz, mentioned by Laſius, whoſe ſp. gr. is ſo low as 2,405, is probably of this ſpecies. Alſo the porphyry of the Pottchapel, deſcribed by Mr. Weiſs, 6 Lempes Magaz. p. 52. which conſiſts of quartz, felſpar, and mica, held together by a grey clay, and there called a white ſandſtone.

The Iſabella yellow clay-porphyry, Leſke S. 1221, is remarkable, it has the earthy aſpect of a marl. Its luſtre, and tranſparency 0; fracture, earthy; hardneſs, 9; ſp. gr. 2563. At 148° melts into a greyiſh glazed porcelain. The felſpar in this ſtone is ochre yellow, and eaſily diſtinguiſhed while the ſtone is undecayed, but it is very ſubject to moulder.

Hornblende Porphyry. Ophites of Briſſon.

Maſſes of ſienite, in which the hornblende abounds, may deſerve this name. The colour of the

the baſis is black, or greyiſh black, or dark green, or yellowiſh green; the fracture ſtriated, or foliated. Sp. gr. when the proportion of hornblende is conſiderable, 2,972.

Trap Porphyry.

Its colour is greyiſh, or bluiſh black, or blackiſh, or reddiſh brown, or greeniſh grey; luſtre, and tranſparency 0; fracture, earthy, or fine ſplintery; hardneſs, from 7 to 9; its ſp. gr. exceeds 2,7.

Of this ſort is that of Montelimar, deſcribed by Faujas, on trap. p. 130. Sometimes it abounds ſo much in quartz and felſpar as to have its hardneſs 10. See Leſke S. 895.

Wacken Porphyry. See Leſke S. 894.

Greeniſh, blackiſh, reddiſh, or yellowiſh grey, or greyiſh black, or liver brown.

Luſtre, and tranſparency, 0. Hardneſs, from 6 to 9. Fracture, even, earthy, ſeldom uneven. Feels ſomewhat ſandy.

Mullen Porphyry.

Bluiſh grey, light or dark. Luſtre, and tranſparency, 0. Fracture uneven, and fine ſplintery. Hardneſs, from 7 to 9. Sp. gr. from 2,6 to 2,728. Of this ſort are the porphyries mentioned, 2 Chy. An. 1790, 18.

Kragg Porphyry. See Leſke S. 1078, 1079 893, and 941.

Greyiſh red, or dark purpliſh red. Luſtre, and tranſparency, 0. Exceedingly porous.

Fracture, uneven and earthy. Hardneſs, from 5 to 7. Feels rough and harſh; gives a yellowiſh grey, or reddiſh ſtreak.

It often verges to ſandſtone.

Argillitic Porphyry.

This is diſtinguiſhable from the foregoing not merely by its ſlaty fracture, but alſo generally by its luſtre; and often by its ſlight tranſparency. It is found in the Bobrouſki Mountains. Renovanz 5.

Novaculite Porphyry.

Greeniſh grey, or greyiſh yellow. Luſtre, 0. Tranſparency, 1 1,5. Fracture, fine ſplintery, earthy, or ſlightly conchoidal; but, in the groſs, often ſlaty. Hardneſs, from 7 to 8, rarely 9.

Feels ſomewhat greaſy.

Muriatic Porphyries.

Theſe have either potſtone or ſerpentine, for their baſis.

Potſtone Porphyry.

Greeniſh, reddiſh, or yellowiſh grey, or ſpecked with red, or leek green.

Luſtre, 2. 1. Tranſparency, 1. 0. Fracture undulatingly foliated; the folia very thin; its hardneſs, from 4 to 6. Sp. gr. exceeds 2,7.

Serpentine Porphyry.

Dark or olive green, or greeniſh grey, or browniſh red, or greyiſh blue, or yellowiſh, and yellowiſh green.

Luſtre, 0. Tranſparency, 1.0. Fracture fine ſplintery, often paſſing to the uneven. Hardneſs from 6 to 7. Sp. gr. not exceeding 2,7. Feels rather ſoft. Found near Florence.

Granitic Porphyry.

When porphyry is over-loaded with felſpar, it is often difficult to ſay whether it be a granite, or a porphyry which hath a granitell for its baſis. Thus the porphyry, in 1 Sauſſ. §. 154, may be conſidered either as a granite, ſince it conſiſts of quartz, ſhorl, and felſpar, or as a porphyry, as the quartz and ſhorl cryſtals are very minute, and the felſpar, on the contrary, is eaſily and fully diſtinguiſhable. See alſo Leſke G. 45 and 214; and 35 Roz. 126.

To this ſort we may alſo annex porphyries of which the ground makes by far the ſmalleſt part as that deſcribed by Herman. 2 Chy. An. 1790, 21, and which he calls a *porphyrite*. It conſiſts of ſmall ſparks of felſpar, grains of quartz, ſplinters of hornblende, and fragments of ſhorl cemented together by a ſcarcely diſcernible jaſpidean cement. Its Luſtre, 0. Fracture, fine ſplintery. Hardneſs, 9. Tranſparency, 0. Colour greyiſh, black, or red, or white. Alſo Leſke S. 1090.

Sandſtone Porphyry.

The yellowiſh grey argillaceous ſandſtone, which contains large grains of felſpar and quartz. Laſius, p. 158, is of this ſpecies. Sp. gr. 2,564. It readily moulders by expoſure to the air.

Of Porphyries with a *derivative baſis*. Leſke S. 459.

Derivative ſtones (of which more in the ſequel) are alſo frequently the ground of porphyries, of this ſort is the *earthy hornſtone porphyry*, Leſke S. 459. Colour, dark reddiſh brown. Luſtre, 0. Tranſparency, ſcarcely 1. Fracture, fine ſplintery. Fragments, nearly 3. Hardneſs, 9. Sp. grav. 2,617. The felſpar is ſcattered ſmall and white.

Amygdaloid.

Mandelſtein of Werner.

By this name I underſtand any ſtone, of the argillaceous claſs, which contains as in a ground, or baſis, rounded, or eliptic maſſes of calcedony, agate, zeolite, calcareous ſpar, lithomarga, ſteatites, green earth, often alſo garnets, hornblendes, and opal; with ſome or other of theſe, though very rarely, felſpar has alſo been found. Leſke G. 314.

This baſis is generally indurated clay, trap, wacken, mullen, kragg. Sometimes it is ſo decompoſed as to reſemble mortar, as in Leſke O. 634, 1016; the ſpecimen S. 236, is a kragg containing olivin.

Its colour is grey, or blackiſh, or greeniſh, or reddiſh grey, or brown, or browniſh red, reddiſh brown, or pale, or mountain green. Luſtre, 0. Tranſparency, 0.

Fracture, uneven, or ſplintery, or conchoidal; often earthy.

Some give a white, ſome a reddiſh ſtreak.

Hardneſs, from 6 to 9. Sp. gr. variable, not only from the difference of its contents, and of its baſis, but alſo from the ſtate of integrity, or of diſintegration, in which it may exiſt. Some I have found at 2,354, as that in Leſke G. 300; ſome at 2,443, as that in Leſke G. 296. The *toadſtone* of Derbyſhire comes under this denomination.

Laſius remarks of that found in the Hartz, that the calcareous concretions, contained in it, often wither by expoſure to the air; and then the baſis acquires the fallacious appearance of a lava. The deeper the ſtone lies in the earth, the larger the cavities it contains. Laſius, *Hartz* 259. The formation of the various concretions found in it is moſt ingeniouſly explained by him. Its tranſitions are into trap.

Pudding ſtone.

Under this name Mr. Werner comprehends a collection of ſmall rounded pebbles, partly of quartz, partly ſiliceous ſhiſtus, or flints bedded in an argillaceous ground, or in jaſper, or quartz, or even in ſandſtone. According to Haidinger, Pudding ſtones conſiſt of flints of various colours, cemented by a ſubſtance of the ſame nature; and, according to Sauſſure, this name is applied to a collection of ſmall flints compacted together. As this name was invented by Engliſh Lapidaries, we muſt apply it as they do; and they certainly acknowledge no other ground or cement than a ſiliceous, or ferruginous as hard as flint; hence we may define it a collection of rounded pebbles, of the ſiliceous genus, cemented by a ſubſtance of the ſame genus, or a ferruginous compound of equal hardneſs. The colour of the cement is whitiſh, or yellowiſh grey, or yellowiſh, or reddiſh brown, or red, or browniſh red; its fracture, generally conchoidal.

The pebbles are of various ſizes, from the bigneſs of rape ſeed to that of an egg, they are always rounded, or elliptical, and frequently compreſſed; the finer ſorts take a fine poliſh, the coarſer are uſed for mill-ſtones

The nature of the ground, and its ſuperior hardneſs, ſufficiently diſtinguiſh this aggregate from amygdaloids; beſides its pebbles are always ſiliceous, whereas ſpar, &c. is found in amygdaloids.

Sandſtones.

Sandſtones.

Theſe conſiſt of grains, not exceeding $\frac{1}{3}$ of an inch, of quartz, flint, hornſtone, ſiliceous ſhiſtus, felſpar, or ſometimes mica imbedded in a calcareous, argillaceous, ſiliceous, or ferruginous cement; the ferruginous is indeed very frequently intermixed alſo with the foregoing.

Sandſtones are either fine grained, or coarſe grained, and of various degrees of coherence and hardneſs, moſt of them feel rough and ſandy, the leaſt coherent break into ſand.

Their fracture is generally earthy.

Almoſt all ſandſtones abſorb water in various proportions, from $\frac{1}{10}$ to $\frac{1}{257}$ of their weight; as appears by Mr. Briſſon's Experiments, thoſe uſed for filtering abſorb $\frac{1}{10}$ of their weight.

Calcareous Sandſtones.

Are thoſe which have a calcareous earth for their baſis or cement, and this earth may be pure, or nearly ſo, or marly, or marlitic; both may be either coarſe grained, or fine grained, compact or ſlaty.

Their colour is generally white or grey, or yellowiſh white, or yellowiſh grey, or brown, or reddiſh brown. Their ſurface rough; fracture earthy or ſlaty. Hardneſs, from 6 to 7. They are frequently burned for lime, and when free from argill they harden when expoſed to the air. They are often ſprinkled over with mica.

These

Theſe ſandſtones have been found cryſtallized in rhomboidal tables ſuperimpoſed one upon the other, and thus forming a ſort of pyramid, or in rounded maſſes. The ſandſtone of Fontainbleau is a remarkable ſpecimen of this kind, its colour is grey for the moſt part, though ſome yellowiſh and reddiſh are found from a ſmall contamination of iron. Hardneſs, 9. Sp. gr. before penetration with water, is 2,5739; and after penetration, 2,6111. It contains by the experiments of Mr. Laſone 62,5 per ct. ſilex, and 37,5 mild calx; he remarked that it gave out very little air by heat. The Cos, Quadrum, of Wallerius, ſeems to be of this ſort.

Another cryſtallized ſtone of this ſort was found in the territory of Juliers, its colour reddiſh grey, but inveſted with a red ochry duſt. Its fracture ſmall grained foliated. Sp. gr. 2,555. Its form quadrangular and tabular. By the analyſis of Mr. Weſtrumb, it contains 70 per ct. of ſilex, 15 of mere calx, 4 of fixed air, and 10 of calx of iron. 2 Chy. An. 1789, 31. Here it is remarkable that the calx contained nearly more by the one half fixed air than it uſually does.

Baron Born mentions a fleſh-coloured ſpar viſibly mixed with quartz, whoſe fracture preſents a ſurface concentrically ſtriated, and whoſe denſity is conſiderable; it effervеſces with acids, and gives fire with ſteel. It contains manganeſe, to which both its colour and denſity are owing. 31 Roz. 22.

Calcareous marls that contain leſs than 33 per ct. of mild calx, the remainder being either wholly ſiliceous, or at leaſt containing ſo little argill as not to form a brick when burned, may be annexed to this claſs. Of this ſort is the light grey

grey marl of Dr. Withering, Phil. Tranſ. 1773, 161, No. 6. It contains but 0,26 of mild calx, withers by expoſure to the air, and will not burn to brick.

Thoſe of a ſlaty texture generally have a marl or marlite for their baſis, their colour moſt frequently is iſabella yellow, or brown.

Argillaceous Sandſtones.

Theſe have argill or clay for their ground or baſis, none effervеſce with acids, ſome are fuſible and ſome not. Their hardneſs is from 6 to 8, rarely 9. They are often ſhot through with mica. They are compact or ſlaty, coarſe or fine grained.

Of the coarſer ſort are formed various millſtones conſiſting of minute fragments of quartz, felſpar, and flints, in an argillaceous cement. Theſe may alſo be conſidered as porphyries, filtring ſtones, and the coarſer whetſtones.

They often contain impreſſions of marine ſhells. Sometimes appear cellular, the quartzy particles having fallen out; but ſometimes they contain neſts of porcelain clay. Baron Born mentions a grit of this kind found in Bohemia, whoſe grains were oblong, and ſo interwoven, as to be in ſome degree flexible and elaſtic. 1 Raab. 403.

The greeniſh grey often reſemble wacken. See Leſke S. 62.

The ſlaty ſandſtones of this ſort are either grey, or yellowiſh grey, or brown, or browniſh red. Of this kind is the red ſandſtone, called *Rothe todt liegendes*, or the *red deadlier*, from its being found under ſtrata of coal, and generally denoting that under it no more coal is to be expected. It is commonly micaceous, and often contains lumps of porphyry, or granite imbedded in it.

Siliceous Sandſtones.

Theſe in a ſiliceous ground may comprehend grit or ſands of a calcareous nature, or one ſpecies of the ſiliceous genus, may ſerve as a cement for grains of a different ſpecies of the ſame genus. Or even grains of the ſame ſpecies ſlightly compacted together and eaſily breaking into ſand may be thus denominated. See Leſke S. 1773. Its luſtre and tranſparency, variable.

Salindre is a ſandſtone of this kind, conſiſting of calcareous grains inſerted in a ſiliceous cement, of which Abbé Sauvage treats in Mem. Par. 1746.

Mr. Roſler mentions a ſandſtone found in Bohemia, conſiſting of grains of quartz in a flinty cement, 1 Bergb. 357; and various others occur in the Cabinet of Leſke G. 783 &c. and 1 Raab. 401, &c.

Theſe ſandſtones frequently paſs into granite. See Leſke S. 1079, 1080.

Siliceous ſandſtones, when the ſiliceous matter is much debaſed, as in ſome earthy quartz or hornſtone, has often the appearance of an argillaceous ſandſtone, but its hardneſs often ſerves to prevent any miſtake. Of this we have an inſtance in Leſke S. 1275 whoſe colour is yellowiſh, and reddiſh grey, and looks like mortar; but its hardneſs is 10. Luſtre, 0.

Ferruginous Sandſtones.

Their colour is generally of a deep ſhade of red, yellow, or brown, or greyiſh black; ſometimes they exhibit a kind of network.

The agglutinating power of moiſt ſemi-oxygenated calces of iron has been well aſcertained. Mr. Edward King deſcribes a ſtony concretion, found enveloping a maſs of iron long buried in the ſea. Phil. Tranſ. 1779, 35. And Mr. Gad informs us of another, diſcovered by Mr. Rinman. Mem. Stock. 1770. He alſo ſhews by his own experiments that calces of iron much oxygenated do not poſſeſs this power, which is farther confirmed by the experiments of Dr. Higgins, in his valuable Treatiſe on Cements. Hence it appears that ſtones, whoſe cement is ferruginous, are leſs magnetic after torrefaction than before. Brugman 93. As they acquire, inſtead of loſing air, and as moſt ſpecies of ſtone contain ſome proportion of iron, intimately diffuſed through their whole maſs, it is probable, 1ſt, that their coheſion in many inſtances proceeds from it. 2d, That their iron, at the time of the formation of ſtones, was in a ſemi-metallic ſtate. 3d, That their decompoſition, by their expoſure to the air, proceeds from its oxygenation.

Of this kind is the ferruginous ſandſtone, mentioned by Mr. Stutz, 2 Bergbau 398, it afforded 19 per ct. of iron.

The ferruginous part is in general ſomewhat mixed with argill.

Rubble Stone.

Grauwacke of Werner. Gres Gris of the French.

This is a particular kind of ſandſtone, containing not only grains of quartz, ſiliceous ſhiſtus, or hornſtone, but alſo ſcraps of bluiſh argillite in a clayey cement, and of this there is often no more than is barely ſufficient to hold the grains together, ſometimes with, and ſometimes without mica; commonly compact, ſometimes ſlaty in the groſs.

Its colour is yellowiſh, or bluiſh grey, or dark reddiſh brown mixed with grey.

Fracture, in the ſmall, fine ſplintery or earthy. Hardneſs, from 7 to 9, rarely 10. Sp. gr. from 2,64 to 2,685, but when withered, only 2,60 *. See Leſke O. 1278, and S. 474, 607.

Breccias.

Theſe are either ſimple or compound; ſimple breccias conſiſt of angular fragments of ſtones of the ſame genus, agglutinated or compacted together; or of ſtones of one ſpecies imbedded in a cement of the ſame genus, whether the ſpecies be different or not.

Thus a *Calcareous Breccia* conſiſts of fragments of marbles, of different colours, held together by a calcareous cement. This is often ſimply called

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* Laſius mentions ſome whoſe ſpec. grav. is 3,457. But the 3 ſeems an error of the preſs. Hartz. 143.

a *Breccia*, as the term was originally applied only to aggregates of this ſort.

A *jaſper breccia*, conſiſts of jaſpers of different colours, ſtuck in a jaſper ground, &c.

Some apply the term breccia, to aggregates which contain rounded fragments as, Gerhard, Cronſted, and Haidinger, who comprehend pudding-ſtones under this appellation.

Compound breccias conſiſt of fragments of ſtones, or aggregates of various ſpecies, or genera, ſtuck in a cement of a different genus; thus trap in which fragments of granite are ſtuck, or a trap in which granite, argillaceous ſhiſtus, and limeſtone fragments, are found, form breccias. Faujas *Trap* p. 115. So alſo the *ſandſtone breccia*, mentioned 2 Crell. Beytr. 63. which contains argillite, quartz, and mica, in a cement of ſandſtone. Similar to this is the *Nagel Fluke* of the Swiſs, formed of a compacted ſand, in which rounded maſſes of quartz, or flint with black, green, reddiſh brown, or grey limeſtone, and black argillite are firmly imbedded. Ferb. 3 Briefe Miner. Inhalt. p. 5.

Beſide thoſe aggregates which have been generally noticed, a few others are mentioned by ſome ſyſtematic authors of note, which deſerve particular attention, as they are frequently mentioned without any explanation.

1ſt, *Anomalous or compound grits.* Of this ſort is that of Julian near Geneva. 41 Roz. 99. Which is compoſed of quartz, felſpar, mica, ſteatites, and ferruginous calcareous marls; while moiſt, it is ſoft, but when dry ſufficiently ſolid. When heated it hardens, by reaſon of the clay and ſteatites it contains. Houſes are built of it.

2d, *Horn rock*, *kieſel fels*, or *hornfels* of Haidinger, *Saxum ſiliceum* of Brunich, has for i ground a hornſtone baſis, in which quartz, or indurated clay, or limeſtone, or garnets, are found either cryſtallized or in veins. Its fracture is compact, moſtly ſplintery.

3d, *Serpentine rock*, *ſerpentine fels*, of Haidinger; it is formed of ſerpentine, in which quartz, mica, limeſtone, or garnets ſingly, or collectively, are found.

4th, *Topaz rock* of Werner; this preſents a compound of topaz, quartz, ſhorl, and lithomarga, confuſedly compacted together. It has hitherto been found in Saxony only.

5th, *Garnet rock* of Karſten, found by him near Winneburgh; it conſiſts of amorphous garnet, in which trap, quartz, calcareous ſpar, and a very ſmall quantity of blackiſh brown mica are found.

6th, *Steatitic rock*, *Schneideſtein* of Haidinger, *Telgsten* of Cronſted; it conſiſts of indurated ſteatites mixed with mica, or talc, or mica, and felſpar (and then forms muriatic porphyry) or ſhorl, or tourmaline.

7th, *Variolites*. The French naturaliſts denote by this name ſtones that have rounded protuberances, of a different nature from the common maſs of the ſtone, from their reſemblance to *variolæ*. However, it is applied to thoſe alſo whoſe protuberances have been worn off, and particularly to rounded ſtones, of this kind, found in the beds of rivers.

Variolites of Durance conſiſt of a baſis, of a black or dark green colour, called by the French *Shorl en maſſe*, probably hornblende, containing according to Briſſon, grey felſpar. Its hardneſs, 9 or 10. Its ſp. gr. from 2,933 to 2,988. Some native ſilver has been found in it. It is evidently a porphyry. Briſſon calls it *Serpentine of Dauphiné*.

Variolites of *Drae* have trap for their baſis, or kragg, or mullen, and contain rounded maſſes of limeſtone, or ſteatites, or of both.

Still many aggregates are daily met, which cannot be arranged under any general denomination now in uſe. Hence I would propoſe to call them, if any of their conſtituent parts can be conſidered as a baſis or cement, *Porphyroids*; if none can be conſidered as a baſis, *Granitoids*.

SECTION XII.

Of Mixed Earths, and Derivative Stones.

With Supplemental Obſervations.

EARTHS, reſulting from the union of earths, or ſands, are called *mixed*, becauſe the ingredients united are, at leaſt for the moſt part, viſibly diſtinct, and may in great meaſure be mechanically ſeparated.

Stones, reſulting from the coalition of ſtones of different ſpecies, are called *derivatives*; they differ from *aggregates* in this, that the aſſociated ingredients are not viſibly diſtinct, or, at leaſt, require microſcopes to render them ſo. The coaleſcing *ſtones* may differ either by their ingredients, when both are compoſed of many, or by the proportion of ſome ingredient or ingredients common to both ſpecies.

If the coaleſcing ſpecies differ by one or more ingredients, the coalition is formed by the addition of theſe, or ſome of them, to the ſpecies that had them not, or by their ſubtraction from the ſpecies that had them.

So alſo, if the coaleſcing ſpecies differ in the proportion of their ingredients, the coalition is formed by augmenting that proportion in the one, and leſſening it in the other.

In either caſe the reſulting derivative ſtone is denominated from the ſpecies that ſtill predominates; if it participates equally of both it may be denominated from either.

Though this term be originally and moſt properly applied to ſtones that are intermediate between, and form the tranſition or gradation of one ſpecies to another, yet we may alſo apply it to ſtones which receive a ſuperabundance of one of the ſimple earths, or calx of iron; or even of another compound ſtone, without any connection of vicinity with ſtones of another ſpecies which contain it in a larger proportion.

The ſimple earths that moſt generally coaleſce with other ſtones are ſilex and argill, to which we may add calx of iron. Calcareous earth and magneſia coaleſce more rarely; but mica or talc, very often.

Derivative ſtones are exceeding common, and if their origin be not attended to, may exceedingly perplex young mineralogiſts. They are known and diſtinguiſhed by their mixed characters, participating of thoſe ſpecies from whoſe union they reſult. Moſt of the disjunctive characters that occur in the deſcription of the original ſpecies proceed from unnoticed coalitions. But if a character be perceived that is not found in either of the ſuppoſed originals, the ſtone cannot be deemed a *derivative*.

Of Mixed Earths.

The only mixed earths, to which peculiar names have been aſſigned, are *loam* and *mould*.

Loam,

Loam, according to Mr. Woodward, conſiſts of clay, mixed with fine ſand, that is, in other words, of clay, with a ſuperabundance of ſand *; and in effect, Mr. Bergman, having analyzed ſome found in the neighbourhood of London, and conſidered as very excellent, found it to conſiſt of 87 per ct. of a reddiſh grey ſand, as fine as meal, and 13 of argill. Now if we ſuppoſe clay to conſiſt, as it moſt frequently does, of 30 per ct. of argill, and 70 of fine ſand, we ſhall find that loam of the beſt kind contains an exceſs of ſand amounting to 17 per ct; if the exceſs of ſand be greater it will form what is called a *ſandy loam*; if ſmaller *clayey loam*.

Mr. Bergman found nothing calcareous in the loam; when it contains any, it ſo far inclines to the nature of marl, and this *marlaceous loam* may be either *ſandy* or *clayey*, according as the proportion above indicated is exceeded on either ſide; of ſandy loam, ſee a ſpecimen in Leſke S. 1061. But loams moſt frequently contain alſo a portion of calx of iron, and this calx is more or leſs oxygenated, a circumſtance which produces a conſiderable variety in the colours, and probably alſo in the vegetative powers of this earth; if its proportion be conſiderable, namely, 4 or 5 per ct. they often contain alſo ſome proportion of vitriolic acid; the colour of loam frequently proceeds from that of the calces of iron contained in it, but more frequently from its ſandy part.

Gravel, is a coarſer ſort of ſand, either of a calcareous or ſiliceous nature, is often mixed with loams, and alſo pebbles, from whence new diſtinctions ariſe of importance to agriculture.

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* Being derived from the German word *Leime*; it ſignified in ancient times a viſcid earth. See Johnſon's Dictionary.

Moulds

Moulds are loams mixed with animal and vegetable remains, particularly from putrefaction; generally of a black, brown, yellowiſh, or greyiſh brown colour; the proportion of theſe is highly intereſting to agriculture; it can be pretty nearly determined by comparing their weight when dried at 140° of Fahr. with that which they loſe by being heated to redneſs in an open fire, continued as long as any coaly ſubſtance remains in them; yet not exactly, without ſome nicer operations, as the animal earths will ſtill remain undetermined, and alſo the vegetable aſhes.

Of the Calcareous Genus.

Limeſtones are frequently intimately mixed, not only with ſiliceous particles, and calces of iron, as we have already ſeen; but alſo with argillite in various marbles, ſee Leſke G. 328. When mixed with ſiliceous particles in conſiderable proportion, they effervesce with acids, but ſlightly, and ſlowly, and their fracture tends to the conchoidal, but often alſo to the earthy; of this we have a remarkable inſtance in Leſke S. 229. Its luſtre, 0. Hardneſs, ſcarcely 9. Fragments, 3; which indicates the ſiliceous ingredient. Its ſp. gr. only 2,254, which ſhews it to be of the nature of ſandſtone. Heated to 141°, it did not form a lime, nor did it melt. When the limeſtone is of the granular kind it has more luſtre and is much heavier, ſee Leſke S. 1098. But when the particles of ſilex are in a ſmaller proportion, or not purely ſiliceous, the limeſtone preſents a different appearance; thus the limeſtone, Leſke S. 1769, ſeems as if paſſing into hornſtone, and is of a yellowiſh grey colour. Luſtre, 0. Tranſparency, 1. Fracture fine ſplintery.

Fragments, 1. Hardneſs, 9. Sp. gr. 2,640. It efferveſces briſkly with acids, but melts into a greeniſh grey compact enamel.

Efferveſcence with acids is not therefore a ſufficient proof that a ſtone will burn to lime; thus the dark bluiſh grey ſtone, Leſke O. 1229, whoſe luſtre is 0; tranſparency, 0; fracture, uneven and ſplintery; fragments, 2; ſpecific grav. 2,740; hardneſs, 9. and which contains the impreſſions of various ſhells, and efferveſces very briſkly with acids, yet melts into a black compact glaſs. It has an earthy ſmell when breathed on.

Calces of iron in a particular ſtate, not as yet perfectly known, (perhaps highly oxygenated, or combined with argill), not only communicate a yellowiſh or reddiſh colour to limeſtones, but ſeem to corrode them; of this we have one inſtance in in the ſpecimen, Leſke S. 1324. Its colour is reddiſh iſabella yellow; luſtre, 0; tranſparency, 0; fracture, earthy; hardneſs, 7; ſp. gr. 2,601; gives a white ſtreak, at 141°, it hardens into a purpliſh red porcelain maſs, and where in contact with the crucible becomes greeniſh. The porcelain gives fire with ſteel. As the ſtone is ſo light, notwithſtanding the quantity of iron it contains, it is plain it muſt be internally corroded. See alſo Leſke S. 1325.

Spars, even ſlightly contaminated with metallic ſubſtances, are much altered in their appearance, and acquire a more granular texture; thus the ſpar, Leſke O. 1425, from a ſlight contamination of lead and pyrites, acquires an earthy uneven fracture; its colour is greyiſh white; its luſtre, 0; its tranſparency, where thin, 2; ſp. gr. 2,822; hardneſs, 9; efferveſces with acids.

Marls alſo are much diſguiſed by iron; the ſpecimen, Leſke S. 453, is dark reddiſh brown, and reddiſh black; luſtre, 0; tranſparency, 0; fracture, partly even, partly ſplintery; fragments, 0 or 1, hardneſs, from 7 to 8; ſp. gr. 3,398; gives a red ſtreak; efferveſces with acids.

Gypſum is frequently penetrated with marl, calcareous ſpar, ſwineſtone, ſandſtone, and perhaps with ſtronthian, &c. theſe mixtures cauſe a change both in its hardneſs and ſpecific gravity; its colour is then either blackiſh grey, or a mixture of whitiſh and blackiſh grey in layers or ſpots and veins; luſtre, either 0 or 1, from interſperſed ſhining particles; ſee the ſpecimens in Leſke O. 1589 and S. 510; and this compound is itſelf often mixed with foliated gypſum, which may eaſily be taken for mica, as in the ſpecimen, S. 621.

All the varieties of gypſum are often met in veins in indurated clay. See Leſke S. 250, &c.

Sometimes this impure gypſum aſſumes a ſlaty form; and this often contains an exceſs of vitriolic acid, as the ſpecimen Leſke S. 259, which is internally black, and externally dark bluiſh grey; its hardneſs, 7; ſp. gr. 2,473; heated to redneſs it becomes reddiſh white.

The ſpecimen O. 1552 is very remarkable; its colour, pure white; luſtre, 2.3; tranſparency, 2; fracture, partly granular, partly foliated; hardneſs, 8; ſp. gr. 2,725. It ſeems a mixture of granular limeſtone and foliated gypſum.

Muriatic Genus.

Potſtone is often intermixed with quartz, or ſome other ſtone of the ſiliceous genus; of this ſort is the ſpecimen, Leſke S. 148, and often with quartz and mica, as in O. 195. Colour of the firſt, light bluiſh grey, mixed with yellow; luſtre, 2; tranſparency, 2.1; fracture, coarſe ſplintery, ſomewhat ſlaty; fragments, 3; hardneſs, 9; ſp. gr. 2,748. Perhaps alſo this ſtone is rather an indurated ſteatites, penetrated with ſiliceous matter, heated to redneſs it becomes browniſh white, inclining to red. The colour of the ſecond is greeniſh grey, enlivened by a quantity of talc or mica.

Siliciferous Potſtone.

The ſpecimen, Leſke O. 1158, is bluiſh black, mixed with white; its luſtre, 2; tranſparency, 0; its fracture, uneven, partly ſplintery, partly imperfectly curved ſlaty; hardneſs, 9; ſp. gr. 2,759. The quartz in many parts viſible in the veins. It is much more imperfectly ſlaty than argillites are; its grain and luſtre approaching more to thoſe of plumbago.

In Leſke S. 342, a greyiſh green ſtone occurs, covered with a whitiſh earth, that ſeems formed of *ſteatites*, intimately penetrated with *argill* and ſome *talc*; its luſtre and tranſparency, 0; hardneſs, 6; ſp. gr. inconſiderable; does not feel greaſy; its fracture, fine ſplintery, and imperfectly ſlaty; heated to redneſs it hardened to 9, and diſcovered ſome glimmering particles; it does not efferveſce with acids.

Steatites is much diſguiſed; when penetrated by *calces of iron* it generally aſſumes a bluiſh colour, increaſes in weight, but is never ſo hard as argillaceous ſtones become by a ſimilar mixture. See the ſpecimen in Leſke S. 882, whoſe hardneſs is 6, and gives a whitiſh ſtreak.

Calciferous aſbeſtinite, Leſke O. 626. Its colour is partly greyiſh, partly greeniſh white, ſometimes mixed with ſhades of pale red; its luſtre, 2.3; tranſparency, 2, in thin pieces; form amorphous; fracture, partly granularly foliated, partly radiated; hardneſs, 5.6, brittle; ſp. gr. 2,863; efferveſces partially with acids, melts at 146° into a yellowiſh green glaſs. Karſten and Leſke term it a zeolite; but its ſp. gr. and vitreſcence forbid this denomination.

Serpentine is ſometimes intimately intermixed with *hornblende*, and thus becomes almoſt black, increaſes in ſpec. grav. and diſcovers ſomewhat of a foliated or ſtriated fracture. See the ſpecimen Leſke O. 1041.

Serpentine is alſo ſometimes penetrated with trap, and in that caſe alſo its colour is black, and its fracture ſplintery. Of this ſort is the ſpecimen Leſke S. 864. It is full of ſeparate concretions, lighter than genuine trap, and leſs fuſible.

In the Argillaceous Genus.

Trap is frequently blended, or intimately mixed with hornblende ſlate, wacken, mullen, or kragg, ſingly, or with two or more of them in various proportions,

proportions, and hence the variety of its colour and ſpecific gravity often ariſes.

The greener ſorts, if they have more luſtre than ordinary, and if their denſity exceeds 2,8, may be ſuppoſed to contain a large proportion of hornblende ſlate; but, if deſtitute of luſtre, and if their denſity be below 2,78 and eaſily fuſible, they probably contain a proportion of wacken; if more difficultly fuſible, moſt probably ſerpentine.

The *light grey* traps, when their denſity is under 2,78, may be ſuſpected to contain mullen.

The *reddiſh brown* moſt probably are mixed with kragg.

Mr. Karſten ſuppoſes trap to be formed of an intimate mixture of hornblende, quartz, and felſpar; and in effect if we ſuppoſe it formed 0,60 hornblende, 0,30 quartz, and 0,10 felſpar, we ſhall have a ſtone whoſe ſp. gr. ſhall be 2,829; but this ſtone will not contain the proportion of iron that Bergman found in trap, and which, by the various analyſes mentioned by Mr. Faujas in his Treatiſe on Traps, appears to be never leſs than 20 per ct.; for, hornblende, by my analyſis contains 23 per ct. of iron, and by Mr. Wiegleb's ſtill leſs; conſequently a ſtone containing 60 parts of it can contain but 13,8 of iron at moſt, nor can we obtain by this means a ſtone whoſe ſp. gr. amounts to 2,98, as that of trap often does.

Siliciferous Trap. Leſke G. 173.

This ariſes from an intimate mixture of trap with ſome ſtone of the ſiliceous genus. The ſpecimen

cimen in Leſke S. 1230 preſents the following characters:

Colour, blackiſh grey, or dark iron grey, with numerous rounded white ſpecks as ſmall as the point of a pin; it is moreover full of rifts, and theſe exhibit a bluiſh, or reddiſh ferruginous illinition.

Luſtre, 1.0. Tranſparency, 0,5.1.

Fracture, uneven, fine ſplintery. Fragments, 3.

Hardneſs, 10. Sp. gr. 2,668.

At 140°, it melts into a whitiſh grey, exceeding porous, ſpongy, tumified, porcelain maſs glazed on the ſurface.

Mr. Karſten thinks it a compound of trap and lydian, but the effect produced by heat does not countenance this ſuppoſition. I call it ſiliciferous, merely from its external characters; it has a cloſer and more flinty grain than trap.

It ſeems to be the *hornartiger trap* of Laſius No. 27, which is ſpeckled as this is, and whoſe ſp. gr. is alſo 2,680.

Of this mixture there are various gradations. The changes it undergoes from heat clearly diſcriminate it from hornſtone, into which, however, I believe, it often paſſes on the one hand, as it may to common trap on the other.

Another ſpecimen of this ſort occurs in Leſke S. 1232, in which the grey and black parts are more diſtinctly ſeparated from each other, it is covered with a yellowiſh grey rind.

The luſtre of the grey part is 1, from a few interſperſed glimmering particles; of the black part 0. Fracture of the grey, uneven, and partly fine ſplintery; of the black imperfectly conchoidal.

Hardneſs of the black 8, of the grey 9 to 10. Sp. gr. 2,705.

At 130°, this ſtone melted into a black compact, and partly into a porous dark greeniſh yellow enamel.

Trap intimately mixed with Kragg.

Of this Leſke S. 1223 ſeems a ſpecimen.

Colour, greyiſh black, yet with a ſhade of red, and externally it is inveſted with a whitiſh grey rind from decompoſition.

Luſtre, 0. Tranſparency, 0.

Fracture, uneven, and fine ſplintery. Fragments from 2 to 3.

Hardneſs from 8 to 9. Sp. gr. 2,728.

At 148°, it melted into a ſomewhat porous, liver brown porcelain maſs, whoſe luſtre approached to that of an enamel.

Hence it is plainly a diſtinct foſſil from common trap.

Trap intimately mixed with Hornblende.

Of this ſort is the ſpecimen Leſke G. 264.

Colour, bluiſh or greeniſh black. Luſtre 1 from ſome glimmering particles. Tranſparency, 0. Fracture, fine ſplintery. Fragments, 3.

Hardneſs, 9. Sp. gr. 3,472.

It contains ſome grains of magnetic ironſtone, which raiſes its ſp. gr. ſo high.

Laſius, *Hartz*, mentions a trap of a duſky green colour, which does not give fire with ſteel; is ſprinkled over with black ſpots, offers an uneven fracture, and whoſe ſp. gr. is 2,850; moſt probably mixed with hornblende.

Trap intimately mixed with Serpentine.

Lommer is ſaid to have found a ſtone of this ſort; but I can find no deſcription of it.

Siliciferous Argillite. Leſke G. 153.

This with the appearance of an argillite ſeems at the ſame time intimately penetrated with ſome ſtone of the ſiliceous genus; generally ſiliceous ſhiſtus, or ſand, or jaſper, or baſanite, or quartz.

Colour, dark, blackiſh, or bluiſh grey, or grey with black or deep blue blotches, or reddiſh, or yellowiſh grey, more rarely greeniſh grey.

Luſtre, 1.2. Tranſparency, 1.

Fracture, in the groſs, ſlaty; but of ſingle laminæ, often ſplintery, or conchoidal.

Hardneſs, from 8 to 9. Sp. gr. from 2,615 to 2,67.

Sometimes the quartz ſeems the moſt conſiderable part of the compound, but ſtill preſerves the ſlaty appearance; and the ſeams are of a darker colour, as in the ſpecimen, Leſke S. 747.

Sometimes the ſiliciferous argillite is alſo ferruginous, which renders it much heavier, as the ſpecimen, Leſke O. 774, which is alſo micaceous. Its colour is dark bluiſh grey, with veins of red, and ſome of white quartz; its luſtre 1, from diſperſed mica; hardneſs, 9; it is but imperfectly ſlaty.

Trapiferous Argillite. Leſke G. 149.

This is mentioned, but inſufficiently deſcribed, by Laſius. Hartz 104.

Its colour, bluiſh black.

It ſplits difficultly.

Hardneſs, 8. Sp. gr. 2772.

Talcoſe Argillite.

Colour, whitiſh, or bluiſh, or greeniſh grey, often inveſted with foliated ſteatites.

It is found in large maſſes.

Luſtre, 3. Tranſparency, 0.

Fracture, ſlaty, moſtly thin, and very thin, curved ſlaty. Hardneſs, from 4 to 6. Sp. gr. 2,717.

It often involves quartz between its laminæ.

This is the ſtone mentioned in Leſke G. 133, and which Karſten ſtyles a middle thing, between mica and argillite; it is, indeed, hard to diſtinguiſh whether the minute ſhining ſcales it preſents are mica or talc; but as this ſtone is found in great plenty at Holyhead, and there often inveſted with a cruſt of foliated ſteatites, and ſometimes includes maſſes of pure talc and amianthus, I preſume theſe foliaceous ſhining ſcales are alſo of the muriatic genus.

Calciferous Argillite.

The ſpecimen Leſke S. 1104. efferveſces ſmartly with acids. Its colour, greyiſh and reddiſh

diſh purple; luſtre, 1,5, ſcarcely ſilky, with minute glittering particles; tranſparency, 0; fracture, ſlaty, but does not ſplit eaſily into very thin lamellæ; hardneſs, 7; ſp. gr. 2,721; gives a purpliſh grey ſtreak.

Hornblende Slate, penetrated with Talc or Mica.

Colour, greeniſh grey.

Luſtre, 2. Tranſparency, 0.

Fracture, ſlaty, and thin ſlaty, the laminæ not eaſily ſeparable, Fragments, 3.

Hardneſs, from 8 to 9. Sp. gr. of the ſpecimen I tried, which had exceeding thin layers of quartz between its laminæ, 2,815.

Feels very rough.

It is found in great plenty at Holyhead, and has for the moſt part thick layers of quartz intercepted between its laminæ.

Hornblende penetrated with Garnets.

Its colour is dark greeniſh red, or reddiſh dark green, according to the proportion of garnet. Its luſtre is only derived from the garnet mixture; fracture, earthy, or fine ſplintery; Hardneſs, 9; Sp. gr. exceeds 3; if mica be ſuperadded, it is generally ſhiſtoſe.

Hornblende Slate penetrated with an exceſs of Quartz.

Of this we have a remarkable ſpecimen, Leſke S. 1087; its colour is ochre yellow, with black ſhining ſtreaks of hornblende; fracture ſhiſtoſe; it feels ſandy; hardneſs, 10. The yellow colour ſeems to proceed from a ferruginous quartz. It has ſome reſemblance to gneiſs.

Mullen penetrated with Aſbeſtinite.

Of this we have a ſpecimen, Leſke S. 100. Its colour is reddiſh grey when freſh broken, ariſing from a mixture of reddiſh brown and aſh blue particles; of the reddiſh, ſome poſſeſs little, ſome no luſtre; but the aſh grey have all ſome, and even a conſiderable luſtre. Its ſurface appears decompoſed, and of a ruby brown; fracture, uneven and earthy; hardneſs, from 6 to 7; ſp. gr. 2,586. the aggregate being coarſely compacted. The moſt gloſſy of the reddiſh particles, reſemble the faces of felſpar.

Trap paſſing into granite.

We often meet with ſtones which have ſo great a reſemblance both to trap and granite, that it is hard to know to which of them they ſhould be referred; of this ſort are, 1. The ſtone in Leſke S. 988; its colour greyiſh blue, or black, with a number of diſtinct white particles, and alſo of oblong

oblong ſhining black particles, which ſeem to be hornblende; and others black and opake which may be trap.

Its hardneſs, is 9; ſp. gr. 2,916. The white parts do not ſeem to me to be quartz; the ſpec. gravity of the ſtone is incompatible with ſo large a quantity of this.

Ferruginous Argillite.

Of theſe ſome are ſo penetrated with calces of iron, as ſcarcely to indicate a ſlaty texture; of this ſort is the ſpecimen, Leſke O. 948.

Its colour is bluiſh brown; externally, it has ſome luſtre; internally, none.

It has ſomewhat of a ſtriated as well as of a ſlaty appearance.

Its hardneſs, 7. Sp. gr. 3,188. It rapidly imbibes water.

Argillite with an exceſs of Argill.

Theſe are generally ſofter and lighter than genuine argillites.

Of this ſort is the ſpecimen, Leſke O. 949.

Its colour is greyiſh blue, its luſtre and tranſparency 0. Its fracture, fine ſplintery and ſomewhat ſtriated, but in the groſs ſlaty. Its hardneſs, 6. Sp. gr. 2,668.

The lighter and ſofter kinds, mentioned by Laſius, are probably of this ſort.

Of the Siliceous Genus.

Iron ſhot Quartz.

Quartz is ſingularly diſguiſed by iron, ſcarcely retaining any of its characters, except its peculiar hardneſs. Its colour, brown, yellowiſh, or reddiſh brown, or browniſh purple. Its form variable, ſometimes ſhiſtoſe, ſometimes of the texture of moſs.

Luſtre, 0.1. Tranſparency, 0.1.

Fracture, ſplintery; earthy; or in the groſs, ſlaty; often diſcovering granular diſtinct concretions.

Hardneſs from 8 to 10. Sp. gr. variable.

The ſpecimen Leſke S. 1716, is of an Iſabella yellow. Its luſtre, 0. Tranſparency, ſcarcely 1. Fracture in the groſs, ſlaty; but of the ſingle laminæ, earthy; with minute reddiſh ochry ſpots. Hardneſs nearly 9. Sp. gr. 2,602. It ſeems debaſed by a mixture of ochry argill.

The ſpecimen O. 322, is reddiſh brown, with whitiſh ſtriæ, and red veins. Its luſtre 1; tranſparency, 0; hardneſs, 10.

Sometimes it ſhews a metallic luſtre, yellowiſh, reddiſh, or greeniſh, from the decompoſition of pyrites lying on its ſurface, as in Leſke O. 344.

Sometimes it hath an open ſpongy moſs-like ſtructure, deſtitute of luſtre and tranſparency, as in Leſke S. 783, which is partly blackiſh, and partly yellowiſh-ochry brown.

Sometimes it is ſo porous and earthy, as well as ferruginous, as to reſemble porous lava, as in Leſke 744, deſtitute of luſtre and tranſparency, but hard as 10.

Sometimes it is ſo cariated by calx of iron and argill that penetrates, as to reſemble ſlightly compacted ruſt, as in S. 28. Its colour is reddiſh brown. It is friable between the fingers.

Sometimes overlaid by calx of iron, as in Leſke O. 355, which exhibits quadrangular impreſſions of fluor cryſtals antiently contained in it.

Sometimes it has the appearance of a reddiſh grey, or greyiſh red, or yellow mortar, as in O. 1021 and 1733; or yellowiſh red, as in S. 270.

Sometimes it appears as if paſſing into ſandſtone, as in Leſke S., whoſe colour is greyiſh red; its luſtre, 1; tranſparency, 0; hardneſs 10; fracture, fine ſplintery, nearly even. See Leſke S. 1120.

Earthy Quartz.

This is often ſo diſguiſed as to be eaſily miſtaken.

The ſpecimen, Leſke O. 360, is almoſt perfectly white. Its luſtre ſcarcely 1; tranſparency, 1; its ſtructure as looſe as that of moſs, which it reſembles; exceedingly brittle, and light as pumice.

2d, The ſpecimen, O. 414, is dark grey; luſtre and tranſparency, nearly 0; conſiſts of minute grains compacted together with numerous minute interſtices; yet its hardneſs is 10; reſembles ſandſtone, and N. 434 ſtill more.

3d, In the ſpecimen, O. 1383, we find quartz deſtitute of luſtre and hardneſs, and of a yellowiſh grey colour, and ſplintery fracture; it differs from ſiliceous ſhiſtus in having no tendency to a ſlaty ſtructure.

4th, The olive green quartz, Leſke 744, hath very little luſtre, but ſome tranſparency; its fracture, ſplintery, ſeems paſſing into hornſtone, but its texture is ſtill too granular to ſuit this ſpecies.

5th, The ſpecimen, Leſke S. 800, preſents thin plates or laminæ variouſly heaped together, deſtitute of luſtre and tranſparency; but their hardneſs proves them to be quartz.

6th, In the ſpecimen, S. 1235, we may obſerve a yellowiſh white quartz, with diſtinct groſs granular concretions, almoſt entirely deſtitute of luſtre; but its tranſparency unhurt, being 2.

The earthy quartz, Leſke S. 1267, is of a grey colour, with a ſlight tinge of red and yellow; its luſtre is ſcarcely 1; fracture, ſplintery, in the groſs, ſlaty, with minute diſtinct granular concretions, reſembling a cloſe-grained ſandſtone; its hardneſs 10.

The ſpecimen, S. 1272, reſembles the foregoing, but its grain is more open, and has more the appearance of ſlate.

Sometimes it hath a ſtrong tendency to a laminar ſtructure, as if paſſing into felſpar, as in Leſke O. 422.

Sometimes it hath the luſtre, and ſomewhat of the appearance of pitchſtone, as in Leſke O. 422.

Sometimes its fracture approaches to the earthy, as in Leſke S. 1156, whoſe colour is bluiſh grey. Karſten calls it a ſiliceous ſhiſtus paſſing into quartz.

Earthy Quartz penetrated with yellowiſh green Actinolite. S. 1310.

Greeniſh grey with yellowiſh green lumps, and ſpecks and blotches of red.

Luſtre, 1. Tranſparency, 1 or 0,5.

Fracture,

Fracture, ſplintery and uneven.

Hardneſs, 10. Sp. gr. 2,883.

It has numerous rifts, the ſides of which preſent ferruginous illinitions.

Earthy Hornſtone.

It ſcarce differs from earthy quartz, but, in poſſeſſing a finer and cloſer grain, it often contains ſome glimmering particles which are thought to be felſpar. Hardneſs, from 7 to 10. Of this ſort is the ſpecimen, Leſke O. 454, which is of a reddiſh grey colour, mixed with green; its luſtre and tranſparency, 0. Fracture, fine ſplintery. Structure thick ſlaty. Hardneſs, 10.

The ſpecimen S. 239, is nearly black, or browniſh black. Its luſtre and tranſparency, 0. Fracture, tending to the conchoidal, with a cloſe grain. Hardneſs, 7.

When hornſtone is in ſome meaſure decompoſed, it diſcovers, in the ſame ſpecimen, the character both of an earth, and thoſe that belong to its ſtony ſtate. Thus in that, Leſke S. 417, which is pale grey, mixed with red and yellow, we ſee, both a conchoidal and earthy fracture. Its luſtre and tranſparency, 0. Hardneſs, 9.

Sometimes it hath the appearance of mortar, mixed with compact parts of a cloſer grain than quartz, as in Leſke S. 494, which is of an aſh-grey colour, the hardneſs of the more compact parts is 10.

The dark greeniſh grey is often the baſis of porphyry, ſee Leſke S. 457.

Mountain green hornſtone is often debaſed, apparently by green earth, of this ſort is the ſpecimen

cimen, Leſke K. 83. Its luſtre and tranſparency o. Hardneſs from 7 to 8. Its fracture imperfectly conchoidal. Gives a white ſtreak.

Ferruginous Hornſtone.

The peculiarities of theſe ſtones will beſt appear from the deſcription of a few of them.

1. The ſpecimen Leſke S. 238, is reddiſh brown. Luſtre and tranſparency, o. Fracture, flat conchoidal. Very cloſe grained. Hardneſs, 7. Gives a pale red ſtreak.

The iron ſhot hornſtones are more prone to melt than others; thus the greeniſh grey hornſtone, Leſke S. 831, whoſe luſtre, o; tranſparency, o,5. fracture, uneven and fine ſplintery; hardneſs, 9; ſp. gr. 2813; melted at 146°,5 into a black compact glaſs. When decompoſed it has frequently the appearance and fracture of an ill-burned brick, as in Leſke O. 1105, which is pale yellowiſh red; hardneſs 9 or 10.

The greeniſh grey hornſtone, Leſke S. 1255, is at once earthy and ferruginous. Its luſtre and tranſparency, o; fracture, coarſe ſplintery; in the groſs, ſlaty; hardneſs, 10; it is covered with a red ferruginous cruſt, which in ſome places ſinks pretty deep into its ſubſtance.

But the reddiſh calces of iron give no tendency to fuſion. Thus the purpliſh red hornſtone, Leſke G. 61, whoſe luſtre and tranſparency are o; fracture, uneven, but fine ſplintery; hardneſs, 9; Sp. gr. 2,638, refuſed to melt, but barely hardened at 147°,5 into a dark grey maſs.

Siliceous ſhiſtus penetrated with Argillite.

Colour, light bluiſh grey, or purpliſh grey.

Luſtre, 0. Tranſparency, 0.

Fracture, fine ſplintery; in the groſs, ſlaty.

Hardneſs, 9 or 10. Sp. gr. 2,689, but may vary with the kind of argillite.

Of this ſort is the ſpecimen, Leſke S. 993, whoſe colour is bluiſh grey; alſo that in Leſke G. 174[b], which is purpliſh grey, ſtreaked in the fracture with yellowiſh grey, and has ſome reſemblance to a ſandſtone. The ſpecimen, S. 993, had its ſp. gr. 2,689, and at 148°, melted into a greyiſh white porcelain, which was glazed at the ſurface. Leſke calls this a ſlaty hornſtone. Karſten a ſiliceous ſhiſtus. Its fuſibility, texture, and grain, induce me to ſuſpect it contains grey argillite.

Siliceous Shiſtus, penetrated with Mullen. Leſke S. 1246.

Bluiſh grey, its ſurface often ſtained reddiſh and yellowiſh brown.

Luſtre, 0; tranſparency, 0.

Fracture, fine ſplintery, and uneven.

Hardneſs, 8; Sp. gr. 2,739.

At 148° the ſpecimen, Leſke S. 1246, melted into a yellowiſh black, and ſomewhat porous porcelain.

Siliceous Shiſtus, penetrated with Limeſtone. Praſiform Porphyry of Karſten, Leſke S. 1811,

Dark, ſomewhat yellowiſh grey.

Luſtre, 0, except a very few particles; tranſparency, 0.

Fracture, ſplintery; the grain very fine and cloſe.

Hardneſs, from 9 to 10; ſp. gr. 2,578.

Though Karſten reckons it a ſhiſtoſe porphyry, I can perceive no traces of felſpar. The whiter ſpots are evidently nothing elſe than ſemi-tranſparent ſplinters.

Pitchſtone, penetrated with Opal. Leſke S. 295.

Pearl grey, ſomewhat reſembling porcelanite.

Luſtre, ſilky, 2; tranſparency, 1.

Seams penetrated with lumps of opal.

Hardneſs, 8. brittle. Sp. gr. 1,970.

Imbibes water ſlowly.

Heated, it decrepitates ſtrongly, and then whitens; at 148°,5 it remained a looſe powder.

Granite, penetrated with Argillite. Leſke S. 1883.

Whitiſh and purpliſh grey.

Luſtre, 1. Tranſparency, 0 or 0,5.

Fracture, partly ſplintery, and partly obſcurely foliated.

Hardneſs, 8. very difficultly broken; ſp. gr. 2,670.

The mica and purpliſh argillite are very perceptible.

FIRST APPENDIX.

Diamond.

ITS colour is moſt commonly pale grey, which often paſſes into the yellow, ſometimes citron yellow, ſeldom roſy red, ſtill more rarely green or blue, but very often pale brown, or colourleſs.

It occurs moſt commonly in rounded grains, ſeldomer in double quadrangular pyramids, or flat double triangular pyramids, whoſe edges are convex, &c.

Its external luſtre caſual, internal, 4. Its tranſparency, 2.3.4.

Its fracture foliated. Fragments, 4.

Its Hardneſs, 20. Its ſpec. gravity from 3,44 to 3,55.

It gives but a ſingle refraction.

In a heat of 35° or 40°, it conſumes and burns like an inflammable ſubſtance; hence ſome think it a very pure ſpecies of coal. No acid has any effect on it.

SECOND APPENDIX.

Of Stones and Earths that owe their Origin to Fire.

THE fires from which many minerals derive their form and aggregation are either volcanic or pſeudo-volcanic; of each of which we ſhall ſucceſſively treat.

CHAP. I.

§. I.

Of Volcanos in general.

A volcano is a mountain that ejects ſmoke, flame, and heated ſtony ſubſtances, partly in a looſe, partly in a ſolid, and partly in a liquified form.

Theſe mountains generally ſtand ſingle and detached; yet we are told, that in Peru, and frequently in Kamſchatzka, they form part of an extenſive chain. With theſe, however, we are as yet but imperfectly acquainted, and it is not clear, that moſt of thoſe that are ſo called are not rather pſeudo volcanos.

Every

Every volcano hath therefore neceſſarily an aperture, or mouth, through which this fiery matter is diſcharged; this aperture is called its *crater*, generally it is placed in the ſummit of the mountain, but ſometimes on its ſides. The aperture on the ſummit is, however, moſt frequently ſo called, as it is more commonly open, and is formed of materials that, after having been ejected, have fallen on the borders of the aperture, and in ſucceſſion of time have formed a ſort of chimney all around. The lateral aperture is commonly blocked up by the laſt portions of the liquified matter that have flown through it. The crater is always of conſiderable extent, often of many miles in circumference.

The ejective power of volcanos is now generally believed to proceed partly from air, paſſing from a concrete into an elaſtic ſtate; partly, and indeed principally, from water and bitumen, converted into ſteam; and often alſo from the decompoſition of ſteam, the cauſe of this decompoſition is eaſily underſtood by thoſe who are acquainted with the diſcoveries of Mr. Lavoiſier and Dr. Prieſtley.

The liquified matter that iſſues from volcanos is in general called *lava*, from the Gothic *Löpa*, or *Lauffen*, to run. The heat communicated by volcanic fire, to the immenſe maſs of materials on which it operates, ſcarce ever equals 120° of Wedgewood, and ſtill more rarely exceeds that degree; this is evident from its effects; for, limeſtones are frequently ejected from volcanos uncalcined[*], and yet their calcination requires only a heat of 120°, and ſhorls, which are fuſible

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[*] Dolom. Notes on 3d Bergm. p. 77.

at 95°, are ejected, unfuſed, and unaltered; ſo alſo are ſtones of the nature of trap, which yet vitrify in a heat of 120°, or leſs.

The moſt diligent and exact obſervers of volcanic eruptions agree in teſtifying this fact. Deſmaretz Mem. Par. 1771, p. 830, in octavo, tells us, "The experiments of Mr. D'Arcet "prove the fire of volcanos to be commonly "much too weak to produce perfect vitrifac"tions."

Mr. Dolomieu, in the Preface to his Obſervations on the Pontian Iſlands, p. 8, ſays, "vol"canic fires have no intenſity, they cannot vi"trify even the moſt fuſible ſubſtances, ſuch as "ſhorls." And, in his Notes on Bergman's Treatiſe on Volcanic Products, he affirms, that, "vol"canic heat neither alters the texture, colour, "denſity, or hardneſs, of many of the ſubſtances "that are expoſed to it." p. 162. Others give in effect the ſame teſtimony, by atteſting the ſlowneſs with which lava commonly flows. Thus, in the famous eruption of 1636, the lava of Ætna moved only at the rate of 3 miles in 24 hours, or about 3,6 feet in a minute, though ſeveral feet in height, and one of the quickeſt, of which we have any account *. The lava of Veſuvius has often continued in motion for years; and that of Ætna has continued to flow for ten years, and not more than at the rate of ſix feet in a day †. Now there are but three ſorts of fuſion, with which we are acquainted; that which produces porcelain, that which produces enamels and ſemi-vitrifications, and that which produces

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* 2 Phil. Tranſ. Abridg. p. 387.

† Dolom. *Ponces*, 12. 66.

glaſs; by inſpecting lava, we ſhall find that very little of it has been in any of theſe ſtates; ſince therefore, it has flowed, it is plain, it has derived its liquifaction not from the fuſion of its own materials, but from that of ſome foreign ſubſtance mixed with it. This fact is ſo plain, that it has even ſtruck Mr. Dolomieu, in the midſt of his prepoſſeſſions in favour of ſome ſtrange inconceivable power which he attributes to volcanic fire, of melting earthy ſubſtances without effecting any alteration in their ſenſible qualities. "I hope," ſays he, "to prove that "lavas contain in their interior a combuſtible "matter, which burns and conſumes in the ſame "manner as other inflammables." *Iſles Ponces*, 10. Yet he neglects telling us what this matter is; though it plainly appears to be no other than *ſulphur and bitumen*, of which an immenſe quantity is found in all volcanos, which liquifies in a low degree of heat, and cauſes all the ſtony ſubſtances to flow, that are immerſed in it. Mr. Fabroni, in his maſterly Treatiſe on Coal, p. 3, tells us, that recent lavas are, as if it were, anointed with petrol. Mr. Bergman, indeed, denies that any ſign of it appears on lavas, §. 9. But Dolomieu, in his notes on that ſection, eſtabliſhes the fact. "Recent ſcoriæ, which cover lavas, "often give unequivocal indications of petrol; "they are greaſy, ſooty, unctuous, and detonnate with nitre, but theſe indications ſoon "vaniſh."

Mr. Fougeroux made the ſame obſervation; Mem. Par. 1766, p. 42, in octavo. Mr. Guethard; Mem. Par. 1752, p. 76, concurs. Von Salis, in his account of Sicily, publiſhed in the year 1790, tells us, that he found in it whole mountains

mountains of bitumen, coal, and bituminous wood; p. 68 and 69; and ſome under beds of baſalt, which he calls lava.

Hence we have all the proof that can be expected, that lavas owe their liquidity to melted bitumen, and ſulphur; which at once explains why they are ſo little altered from their primitive ſtate, why they are magnetic, as their iron is in contact with inflammable matter, and the reaſon of their uncommon fertility when in a ſtate of decompoſition, as they retain much of the carbonic principle, which is the food of plants, and is ſet looſe by their decompoſition.

To preſent a clear idea of volcanic eruptions, I ſhall quote the deſcription given by Mr. Dolomieu, *Ponces*, 278, who has obſerved more of them in various circumſtances than perhaps any other perſon. " After repeated concuſſions and " ſubterraneous thunders have announced the la" bour of a volcanic mountain, the ſmoke iſſuing " from its ſummit augments; it is ſometimes " black, ſometimes white, and ſo thick as to " appear almoſt compact." (Here I muſt remark, that this black ſmoke, ſuch as we ſee iſſuing from glaſs-houſes, is an evident proof of the accenſion of coal and bitumen laid on freſh). " It riſes in perpendicular columns, to a great " height, then becoming too heavy to be ſup" ported in ſo rare a part of the atmoſphere, it " ſpreads and forms a head like the ſummit of a " pine; flame appears ſoon after, and this is ſuc" ceeded by projections of aſhes, ſcoriæ, and in" flamed ſtones; at laſt, from the bottom of the " crater, a liquid matter riſes reſembling melted " metal, whoſe ſurface is in a ſtate of com" buſtion." Here the bitumen expoſed to the open

open air burns off, and hence ſcarce any traces of it are afterwards found. It even appears doubtful to me, that there exiſts any flame at the bottom of the volcano, as the air is generally too impure to ſupport it. "This matter flows down "from the loweſt border of the crater, and is "covered with a quantity of ſcoriæ, which float "on its ſurface, being very thick, it flows ſlowly "ſcooping a cavity in the light ſcoriæ, that "form the exterior of the cone, and, attaching "thoſe ſcoriæ to itſelf, it deſcends gently, and "then ſpreads. Its farther progreſſion is made "either by rolling on itſelf, the upper part be-"coming the lower, or by iſſuing from under the "ſcoriæ which cover it; this laſt mode is the "moſt uſual; for, the ſurface of the current be-"ing covered with ſcoriæ, and congealing with "them, and with the earth on both ſides, forms "a kind of cruſt, under which, the lava flows "as under a bridge. An eruption of this kind "may flow for a long time and furniſh nothing "but porous lava. Rarely there are any cur-"rents of compact lava. In Ætna the lava ſel-"dom iſſues from the ſummit, but generally "from the ſides of the mountain, in rivulets "which afterwards unite in one common tor-"rent. Sometimes theſe lateral ejections are "made with immenſe force, and project enor-"mous ſtony maſſes half a league. The currents "that iſſue from the ſides of a mountain are "generally more compact than thoſe that iſſue "from the ſummit; they would even be exempt "from ſcoriæ, and porous lava, had it not been "for an internal efferveſcence, which takes place "in them. After the excavation of the ground "by the firſt ejection, the progreſſion becomes "ſlower,

" flower, and the lava is covered with a white and
" bluiſh flame. Sometimes it flows like an ex-
" panding ribband, and then the upper part be-
" comes loweſt, and conſequently buries the
" ſcoriæ and cellular lava; at other times a new
" head iſſues from under the hardened ſurface.
" Thus the lavas invelope and carry with them
" the bodies they meet; and thus they are aſſo-
" ciated with the porous lava."

§ II.

Of Volcanic Productions.

1ſt, Of Lavas in general.

Any matter that has iſſued out of a volcano in a liquified ſtate, or that has accompanied, or been inveloped in ſuch liquified matter, is in general ſtyled a *lava*; and of this three ſorts have been remarked, the vitreous, the cellular, and the compact.

2d, Of Vitreous Lavas.

Vitreous lavas are formed of ſuch matters as have been expoſed to the greateſt heat, or which, from their compoſition, were moſt ſuſceptible of vitrification in a moderate heat.

Their colour black, greyiſh black, dark green, yellowiſh, or greyiſh white; generally found in inconſiderable and detached maſſes, either frothy, or compact.

Its luſtre, 3; its tranſparency, 3.2.1; fracture conchoidal.

Hardneſs, from 9 to 10.

Sp. gr. variable, from 2 to 3; according to their more or leſs frothy, porous, or compact ſtate, and alſo to their compoſition.

Mr. Bergman has given us the analyſis of a glaſs of this ſort from the *Lipari Iſlands*, which contained 69 per ct. of ſilex, 22 argill, and 9 of iron. 3 Bergm. p. 204. In another, he found 49 per ct. ſilex, 35 argill, 4 calx, and 12 of iron. De Prod. Volcan. 1ſt edition.

But all theſe reſults are evidently fortuitous, as the compoſitions muſt ever vary, with thoſe of the original ſtones or earths that are vitrified.

3d, Of Enamels.

Analogous to vitreous lavas are the imperfect vitrifications called *enamels*.

Their colours are white, grey, or brown, often with round ſpots of a different colour from the ground. Luſtre, 2.3. Tranſparency, 0.

Fracture, rather more granular than that of glaſs, or between that and the porcelain grain.

Hardneſs from 9 to 10. Sp. gr. approaching to 3, often higher.

Sometimes contain cryſtals of ſhorl, or felſpar, not completely melted.

4th, Of Volcanic Scoriæ.

Theſe are compounds of iron and ſtony matter that owe their fuſion to ſulphurated iron, which is known to be much more fuſible than iron in any other ſtate; they are tumefied and expanded by the ſulphureous vapors, and commonly inveſt the ſurface of cellular lava, as ſulphur can burn only where in contact with the air.

Their colour is generally black, but ſometimes reddiſh, from the calcination of the iron.

Their ſurface rough, uneven, and tumefied.

Luſtre, 2.3, when decompoſed 0. Tranſparency, 0.

Their texture cavernous, the cavities larger and more irregular than thoſe of cellular lava, but never fibrous.

Their hardneſs, from 7 to 9, very brittle.

Their ſp. gravity, when they are very porous, is often ſuch as to admit them to float in water; but, when well ſoaked in it, their ſp. gravity, generally exceeds 2,7.

Mr. Dolomieu found at leaſt 8 per ct. of iron in all thoſe he examined, and generally more. Cryſtals of felſpar, white garnet, and baſaltine, have been found in them. They all reſemble each other. Ponces, p. 147.

Beſides the ſcoriæ that accompany beds of lava, there are others, thrown out in detached maſſes. Theſe mixed with volcanic aſhes form the crater of volcanos; they are generally more completely vitrified, and though more tumefied than other ſcoriæ, yet they ſink in water, as they are more eaſily penetrated by it. They are moſtly of of the ſize of a nut, and readily moulder by expoſure to the air. At Naples they are called, *Rapillonero.* Dolom. p. 203.

5th, Of Volcanic Slaggs.

Theſe intirely reſemble the droſs of forges, they are generally red, and heavy.

§ III.

Of Cellular Lava.

Its colour is brown, or reddiſh brown, or greyiſh black, ſeldom grey.

Its ſurface, unequal, rough, and full of cavities.

Its luſtre, 0. Its tranſpareney, 0. Its fracture earthy, and full of cavities.

Its hardneſs, from 7 to 9. Its ſp. gravity variable with its poroſity, but does not exceed 2.8.

Mr. Dolomieu pretends, that its internal pores diſtinguiſh it from porous ſtones of Neptumin origin. Notes on 3 Bergm. p. 184. Theſe pores are larger near the ſurface, than towards the center. Ponces, 295.

It is more ſubject to deſtruction than compact lava; yet no compact lava is ever found wholly deſtitute of the cellular. Ponces, 277.

It generally affects the magnetic needle.

§ IV.

Of Compact Lava.

By compact lava, volcanic writers denote an earthy ſubſtance, which, after having been fuſed but not vitrified, becomes, on cooling, compact, cloſe, and ſolid.

Whether this degree of ſolidity is ſuch as *totally* to exclude that evidently porous and cavernous ſtructure, which cellular lava preſents, is not perfectly agreed upon.

Thoſe who are guided by obſervation on modern and undiſputed volcanic torrents, allow that no lava abſolutely compact, and deſtitute of pores in an extent of more than a few ſquare inches is ever found. Thus Mr. Bergman defines compact lavas to be, "thoſe which, "though not abſolutely deſtitute of cavities, yet "contain ſo few, that they may be cut into ſlabs "with an almoſt intire ſurface, and poliſhed "like marble." 3 Bergm. p. 201. To this definition, Mr. Dolomieu, in his notes on Bergman's Diſſertation, makes no objection; from which we may conclude, that in a ſmall extent, ſuch as that of common marble ſlabs, they never exhibit an uninterrupted ſurface. This laſt mentioned Philoſopher, indeed, having unfortunately wiſhed to comprehend, in his definition of compact lava, ſtony maſſes, not found in modern and undiſputed beds of lava, but in *ſuppoſed* antient currents,

currents, found himſelf much embarraſſed; “there is, ſays he, ſuch uncertainty in the characters of compact lava, that, independently of local circumſtances; the moſt experienced eye may be deceived [*].” Yet theſe circumſtances, not properly attended to, are thoſe which have ſeduced him into the moſt palpable miſtakes.

Gioeni, though in many inſtances miſled by Dolomieu, yet acknowledges that lava, ſo compact as to be totally deſtitute of pores, is not found. Litholog. Veſuv. p. 85. Padre Torre who, independently of any ſyſtem, has candidly and impartially examined the products of Veſuvius, expreſly denies the exiſtence of lava deſtitute of pores, none other but the porous being found in currents of modern date [†]. Galeani, in his Catalogue of the Lavas of Veſuvius, drawn up in 1772, hardly mentions any compact lavas: Gioeni, in his Catalogue, intirely omits this diſtinction; and Mr. Dolomieu acknowledges, that not a ſingle ſpecimen of compact lava is to be found in the cabinet of Prince Biſcari.

Thoſe, on the other hand, who, guided by ſyſtem, beſtow the name of lava on ſtony maſſes, which they *ſuppoſe* to have anciently flowed, either from real ſtill ſubſiſting, or imaginary ancient extinct, volcanos, find *compact* lava intirely deſtitute of pores, very *ſcarce* indeed in the *ſuppoſed* currents from modern, but in *great plenty*, in thoſe which they aſcribe to their fictitious volcanos now extinct, as well as in the very bowels of thoſe volcanos.

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[*] Ponces. 171.

[†] Ponces. 174.

Gioeni, after telling us, from Dolomieu, that compact lava occupies the center of the beds of lava, and porous lava the upper part, acknowledges that this gradation ſeldom takes place; " *few*, however (ſays he), are the viſible currents of lava on Veſuvius, in which we meet " this gradation." It ſeems he ſhould rather have ſaid, *none*; for, ſome lines after, he tells us, " that modern volcanos have loſt the power " of producing any [*]." The detached maſſes that paſs for compact lava, he acknowledges to have been ejected in their ſolid form by the exploſive power of the volcano, and conſequently are not real lavas, but rather natural ſtones, torn from the ſides of the mountain [†]. Mr. Dolomieu, tells us that compact lavas are ſtones, which after having been melted reaſſume their natural ſtate and appearance without any change in their external or internal properties, or ſcarce any change [‡]; and that ſome are perfectly compact (that is, deſtitute of pores), namely, thoſe that are buried under, not other lavas, but under an entire and immenſe volcano [§]; he, therefore, gives up the idea of finding theſe not only in the *beds* of modern, but even in thoſe of extinct ancient volcanos. Hence he tells us, that they are much more common in extinct volcanos; and that in Ætna they do not conſtitute the $\frac{1}{1000}$ part of the whole; whereas in Vivarois and Auvergne they form whole mountains. Now moſt of theſe ancient volcanos of the Vivarois appear to me, and many others, to be mere creatures of imagi-

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[*] Lithol. Veſuv. L. LIII.

[†] Lithol. Veſuv. LI.

[‡] De prodotti. Volcan. p. 162. Ponces, 170, &c.

[§] Ibid. 179.

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nation, and conſequently, until the ſubſtances they contain are proved to have been in fuſion, no definition, grounded on the appearances of theſe ſubſtances, can paſs for that of real compact lava.

In beds, however, of real undiſputed lava ſome parts are found, that, having been preſſed by the ſuper-incumbent weight, are more compact than common porous lava; and theſe, comparatively to the former, may be called compact; but ſcarcely more than a few ſquare inches of their ſubſtance is deſtitute of viſible pores.

Their colour is brown, yellowiſh, reddiſh brown, bluiſh, or black, more rarely grey. Their luſtre, 0.1. Tranſparency, 0.1.

Their fracture, earthy, or fine ſplintery, more rarely foliated, and preſent ſmall internal pores, if of ſufficient ſize, in ſome part of their ſubſtance.

Hardneſs, from 7 to 9. Specific gravity, 2,75 to 288.

Much circumſpection is requiſite, in framing a deſcription of compact lava, from a view of the ſpecimens brought to us from volcanic countries, as they are all collected by perſons, who take indiſcriminately from real, and from ſuppoſed, volcanic currents, even from mountains in which no volcano ever exiſted.

To form a true idea of theſe lavas, we ſhould attend to the following circumſtances:

1ſt, That the heat of moſt volcanos (I exclude thoſe that for the moſt part produce only vitrified ſubſtances) ſeldom reaches 100°, of Wedgewood; the proof of which is, that almoſt all real lavas, whether cellular or compact, are vitrifiable at that degree. Since, therefore, they were

were not vitrified in the volcano, it is plain that in it they did not attain that degree; 90 or 95 degrees may then be aſſumed as the average heat of moſt volcanos.

2d, In this heat, many ſtones of the argillaceous genus, as traps, hornblends, and argillites, undergo a change; for they alter their colour, become porous, aſſume a porcelain grain, and conſequently begin to vitrify, as I have found on repeated trials; but they never flow in this heat, nor conſequently form a lava; but bitumen will flow in this heat, and even in one much inferior, and be decompoſed. If, therefore, the argillaceous ſtones be mixed with, and drenched in, bitumen, they will be ſoftened by it, and flow with it; and where the air erupting both from them, and the decompoſing bitumen has moſt liberty to eſcape, it will tumify, burſt through the liquid maſs, and form cellular lava, but, where it is more compreſſed, leſs of it will be diſengaged, and the lava will be compact, and reſemble, in ſome degree, the original ſtone of which it is formed.

3d, Stones of the ſiliceous genus undergo no change in this heat, not even ſhorls or felſpars; and hence, though immerſed in the fiery torrent, they cannot with propriety be called lavas, as they are not even ſoftened by the mixture of bitumen, as ſtones of the argillaceous genus are.

Between ſiliceous and argillaceous ſtones there are many gradations, and various mixtures, which muſt occaſion correſponding varieties in the effects which heat, and various other circumſtances may produce. It is ſufficient here to eſtabliſh the principles on which moſt of them may be explained. Compact lavas abound in heterogeneous ſubſtances which either have not been fuſed, or only partially fuſed, or ſcorched, or decompoſed by heat, as felſpar, ſhorls, garnets, zeolytes, &c. Every volcano has ſome that are peculiar to it. Thus the lavas of Veſuvius abound in that called white garnet, and which I call Veſuvian; thoſe of Ætna abound in felſpar, &c.

Hence we muſt exclude from the rank of lavas all ſtones which do not appear, either from their external characters, nor local circumſtances, ever to have been ſoftened by heat; and conſequently all thoſe detached pieces, which are ejected at the begining of an eruption without fuſion, and many others which volcanic collectors enumerate among compact lavas, merely from having found them in the vicinity of volcanos. Thus Mr. Dolomieu, Lipari 85, reckons among volcanic ſtones one, in the interior of which he diſtinctly perceived a leaf of ſea-weed. Few, indeed, are the ſtones contained in his catalogue which can be deemed really volcanic. p. 70, of the ſame treatiſe, he tells us, that the lava which burſt from the ſides of Ætna in 1669, had for its baſis a granite *no way altered*: but, when he expreſſly treats of the products of Ætna, he tells us, *L'Ætna paroit n'avoir jamais traité le granite.* The miſtakes of this great man, for ſuch I certainly hold him, have had ſo wide a ſpread, and have miſled ſo many who have not had an opportunity of viewing volcanic countries, that I feel myſelf neceſſitated to detect them; a liberty which, I am perſuaded, his candour and love of truth will readily induce him to excuſe.

All real lavas except thoſe of the vitreous kind affect the magnetic needle, unleſs the iron they contain

contain be much oxygenated, as it often is in thoſe of a red colour, but even theſe are frequently magnetic by reaſon of the ſhorls embodied in them.

The component ingredients of lavas are various, according to the nature of the original ſtones, and the accidents they meet with in their liquified ſtate. Mr. Dolomieu found them to contain from 40 to 60 per ct. of ſilex, from 16 to 3 of magneſia, from 5 to 1 of calx, and from 6 to 25 of iron. Ponces, 184.

§ V.

Of Volcanic Aſhes, Sand, Pouzzolana, Traſs, Tuſa, and Piperino.

1ſt, Of Volcanic Aſhes.

Their colour is browniſh or reddiſh grey.

Of a looſe and duſty conſiſtence, very light and ſubtle, and ſmooth to the touch.

Slowly diffuſible in water, and when wet ſomewhat ductile.

They efferveſce ſlightly with acids, and contain about ½ their weight of argill, a ſmall proportion of calx, magneſia, and iron; and the remainder is ſiliceous.

In different volcanos, nay in different eruptions of the ſame volcano, the properties differ. Magnetiſm

netiſm in them is merely caſual, few of them poſſeſs it. Dolom. on Bergm. p. 26.

Though Dolomieu, Ponces, 337, thinks theſe aſhes have no reſemblance to thoſe of common inflammable ſubſtances, yet, as well by their external appearance as by their analyſis, they appear to me exactly the ſame as thoſe that proceed from various ſorts of coal. From what elſe but the combuſtion of coal could the thick black ſmoke ariſe which always precedes the eruption of aſhes? ſurely not from the combuſtion of ſulphur or pyrites! All volcanos contain coal and bitumen, whoſe combuſtion muſt produce aſhes. Immenſe quantities muſt be conſumed before lava can be formed; and hence aſhes always precede lava.

Volcanic ſand conſiſts of minute hard grains, that readily ſink in water, generally fragments of lava and ſcoriæ, together with olivin, garnets, felſpar, and ſhorl. Dolomieu. Ibid.

2d, Of Pouzzolana *.

Reddiſh, or reddiſh brown, grey, or greyiſh black. That of Naples is generally grey, that of Civita Veichia more generally reddiſh, or reddiſh brown. Dolomieu's Notes, 32,

Its ſurface rough, uneven, and of a baked appearance. It comes to us in pieces of from the ſize of a nut, to that of an egg.

Its internal luſtre, 0. Its tranſparency, 0.

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* 34 Mem. Stock. 27, and 31. Gioeni LXVI. Dolom. Notes 32.

Its fracture uneven, or earthy, and porous, commonly filled with particles of pumice, quartz, ſcoriæ, &c.

Hardneſs, 3. Very brittle. Sp. gr. from 2,570, which is that of the black, to 2,785, rarely 2,8. Has an earthy ſmell.

It is not diffuſible in cold water, but in boiling water it gradually depoſites a fine earth. It does not efferveſce with acids.

Heated it aſſumes a darker colour, and eaſily melts into a black ſlagg, or with borax into a yellowiſh green glaſs.

It is magnetic before it is heated, but not after. This is the moſt remarkable of its properties.

By Mr. Bergman's analyſis, it contains from 55 to 60 per ct. of ſilex, 19 to 20 of argill, 5 or 6 of argill, and from 15 to 20 of iron. 3 Bergm. p. 194.

When mixed with a ſmall proportion of lime it quickly hardens, and this induration takes place even under water. This ſingular property appears to me to proceed from the magnetic ſtate of the iron it contains, for this iron being unoxygenated, ſubtilly divided, and diſperſed through the whole maſs, and thus offering a large ſurface, quickly decompoſes the water with which it is mixed, when made into mortar, and forms a hard ſubſtance analogous to the ſpecular iron ore as it does in the iron tubes, in which water is decompoſed, in Mr. Lavoiſier's and Dr. Prieſtley's Experiments. For in theſe the iron ſwells and increaſes in bulk, Mem. Par. 1781, p. 277. And ſo does pouzzolana when formed into mortar. Higgins on Cements, 125. One principal uſe of lime ſeems to be to heat the water, as while cold it it cannot readily pervade the caked argill that inveſts the ferruginous particles, yet in time even cold water may pervade it, and produce hardneſs; and hence lavas become harder when moiſtened, as Mr. Dolomieu has obſerved. Ponces, 417. If the mortar be long expoſed to the atmoſphere, fixed air, as well as pure air, will unite to the iron, ruſt will be produced, and the mortar will not then harden, as Dr. Higgins has alſo noticed. Clay, over which lava has flowed, is frequently converted into pouzzolana. Ponces, 332. But volcanic ſcoriæ never afford it; ibid.; either becauſe they are much calcined, or retain ſulphur, or its acid.

3d, Traſs, or Terras *.

I couple this with pouzzolana, on account of their ſimilarity to each other, and not becauſe I look upon it as conſtantly, and neceſſarily, a volcanic production. On the contrary, I believe it to be generally the product of pſeudo-volcanos, or external fires.

It is found in many places, but principally near Andernach, in the vicinity of the Rhine, alſo near Frankfort, Cologne, Pleith, &c. and there called tuffſtein.

Its colour is grey brown or yellowiſh.

Its ſurface rough and porous.

Its luſtre and tranſparency, 0.

Its fracture, commonly earthy, rarely lamellar; it contains fragments reſembling pumice (though not real pumice, Voight *Fuldæ*. 221); alſo fragments

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[*] 32 Mem. Stock. 51.

ments of argillite and baſaltine; often branches of trees half cleared, and impreſſions of leaves. 2 Noſe 182. Mica, iron ore, and other heterogeneities, are more frequent in it than in pouzzolana. 3 Bergm. 196.

Its hardneſs, from 5 to 7.

Feels dry and harſh. Scarcely effervesces with acids.

It is not diffuſible in cold water, but in hot it gives an earthy ſmell, and depoſites a finer earth.

It meltsinto a greyiſh brown ſlagg.

It is found in valleys ſome feet under the ſurface, to which no ſtreams of water have had acceſs. Sometimes in columnar maſſes of a grey, or Iſabella yellow colour, ſome round and ſome quadrangular, ſtanding cloſe to each other, and forming internally one common maſs. 3 Berl. Beob. 199.

According to Mr. Bergman it conſiſts of nearly the ſame principles as pouzzolana, only the calcareous ſeems more plentiful in this.

Artificial terras, or pouzzolana, is made by burning clays or ſlates that bound in iron, and then grinding them to a fine powder.

4th, Tufas *.

Theſe ſeem to be a pouzzolana formed by nature into a mortar.

Their colour, brown, or reddiſh brown, brick red, or ſpeckled with various colours, or green.

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* Gioeni LXXVII, and 174. Dolom. Notes, 34, and 233.

Luſtre and tranſparency, o.

Fracture, earthy, contain ſand, ſcoriæ, fragments of lava, limeſtone, and pumice, often baſaltines and Veſuvian. Hardneſs, 6.

Commonly magnetic, and not eaſily decompoſed by the action of the air.

5th, Piperino *.

This alſo ſeems a concretion of volcanic aſhes, and is ſaid to be the ſubſtance that covers Pompeia.

Its colour, grey, or reddiſh brown. Its luſtre and tranſparency, o.

Its fracture earthy, contains fragments of white marble, felſpar, mica, garnets, ſcoriæ, gypſum, ſhorl, granite, &c.

Its hardneſs, 6.

Sometimes magnetic, ſometimes not.

It ſeems to differ from tufas, in containing more heterogeneities, being in fact a kind of porphyry or breccia, and being more eaſily decompoſed by expoſure to mixture and the open air, but if preſerved from moiſture it hardens when expoſed to the air.

6th, Pumice.

1ſt Variety.

Its colour grey, or greyiſh white, rarely brown, or blackened by fuliginous fumes.

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* Dolom. Notes, 34, and 233.

Its ſurface rough and fibrous, with elongated pores.

Its luſtre glaſſy 2. Tranſparency 1.2.

Its fracture ſtriated and open. Fragments, oblong and obtuſe.

Its hardneſs, 3. Brittle in a high degree. Sp. gr. below 1.

2d Variety.

Its colour grey, or browniſh grey, rarely red.

Its ſurface rough and dull, with exceeding minute pores. Its fibres not diſcernible.

Its luſtre and tranſparency, 0.

Its fracture, uneven and ſplintery. Fragments irregular and obtuſe.

Its hardneſs, 3. Sp. gr. 0.

Both are fuſible at 130°, into a grey ſlagg. 2 Gerh. Geſch. 42.

Mr. Dolomieu mentions two other varieties heavier than water, and conſiderably harder than theſe. I ſhould rather call them pumiceous mixtures; he does not deſcribe them.

§ VI.

Of Stony Subſtances ejected, unaltered, or but ſlightly injured.

Not only ſhorls and garnets have been ejected from volcanos unfuſed, but even calcareous and

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fluor ſpars, with their tranſparency unimpaired [*]; which could not happen if they had been expoſed even to the loweſt red heat; we muſt ſuppoſe them. therefore, to have been expelled by the mere force of the exploding elaſtic fluids, whoſe power is fully equal to ſuch an effect, ſince when confined they ſhake, agitate, and convulſe whole mountains.

Earths of the argillaceous and muriatic genera expoſed to the ſlighter degrees of heat, as clays and ſteatites, are barely hardened; and ſtones of theſe genera loſe their luſtre and tranſparency. In a greater they become porous. Stones of the ſiliceous genus alſo loſe their luſtre and tranſparency, and become brittle.

Granites have been found in beds of lava in different ſtates; thoſe on the ſurface of the bed have had their felſpar ſomewhat altered, being there expoſed to actual flame. But thoſe in the center, having never been in fuſion, are only rendered more brittle [†].

In the ſame manner *porphyries* have been involved in beds of lava, even porphyries that have hornblende for their baſis, without having thereby ſuffered any alteration [‡]; an evident proof of the low degree of heat which generally prevails in volcanos.

In vain have ſome philoſophers of late attempted to account for theſe appearances, by aſcribing them to the fuſion of granites and porphyries under an immenſe preſſure.

Before an effect can with any degree of probability be aſcribed to a given cauſe, the exiſtence

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[*] Dolom. Notes, 227.

[†] Dolom. Notes, 76.

[‡] Ibid. 78.

of that cauſe muſt either be *certain*, or at leaſt *probable*; and the cauſe, if it does exiſt, muſt be known to be adequate to the effect aſcribed to it. Now the above aſſertion is incompatible with both theſe maxims; for, firſt, the exiſtence of a degree of heat, ſufficient to melt the immenſe exiſting maſſes of granite, has never yet been proved, nor has the ſlighteſt inducement, even to ſuſpect it, ever yet been offered; on the contrary, it is repelled, and glaringly contradicted by every phænomenon.

Secondly, If ſuch a heat could be proved to to exiſt, this would not be ſufficient; the exiſtence of a preſſure, ſufficient to ſtifle the eruption of all the elaſtic fluids it would tend to evolve, ſhould alſo be proved: how can it?

Thirdly, If all this were evident, ſtill ſuch a cauſe would be inadequate to the effect; in granite three or more diſtinct ſpecies of ſtone adhere, unmingled with each other. Is this the effect of any fuſion of ſtony matter ever yet obſerved? have ſtones, one of which is a flux for the other, ever yet remained ſeparate, though both in fuſion?

After all, why thus war with all known experiments and analogies? No other cauſe is aſſigned but the *ſuppoſed* origin of baſalt from fuſion, and the near approach of this ſtone to granites. "Notwithſtanding (ſays Dr. Beddoes) the recent "objections of Mr. Werner, I ſhall aſſume the "origin of baſaltes from ſubterraneous fuſion, "as thoroughly eſtabliſhed by various authors," and the near approach and connection of baſalt with granite that both have had the ſame origin, that is, have been produced by the ſame natural

cauſe,

cauſe, I ſhall not diſpute; but that baſalt was never actually fuſed will clearly be ſeen in a ſubſequent ſection.

CHAP. II.

Of Pſeudo-Volcanos, and Superficial Fires.

Pſeudo-volcanos are ſo called, becauſe, like volcanos, they emit ſmoke, and ſometimes flame, but never lava, in which reſpect they differ from true volcanos. Moſt of theſe are coal mines which have accidentally taken fire; ſome appear, however, to be natural, as ſeveral in Kamſchatſka and Peru. In Europe theſe pſeudo-volcanos are not uncommon. Thus a coal mine in the mountain of Fontaynes, in Rouergue, having taken fire in 1770, has continued to emit ſmoke and flame and ſulphureous fumes ever ſince. Mem. Par. 1781, p. 201. Sulphur has been ſublimed from it; for it is found on the trunks of trees growing on its ſurface, and alſo cryſtallized ſal ammoniac.

The mountain of Cranſac has continued burning ever ſince the year 1400. In the mountain of Scadalia another pſeudo-volcano near that of Cranſac; but ſprings have been formed, ſome of which have now loſt their heat, as the fuel which occaſioned it has been conſumed. Mem. Paris. Ibid.

Theſe mountains not only produce ſulphur, ſal ammoniac, and other ſalts found in true volcanos,

canos, but alſo tufas, ſcoriæ, and porous lava. Ibid. 224. And alſo tripoli and pouzzolana.

Superficial combuſtions are not uncommon, and produce ſingular effects, which have often been miſtaken for thoſe of true volcanos. Among others, columnar argillaceous iron ore, ſlates converted to ſlaggs, and others, with vegetable impreſſions.

CHAP. III.

Of the Diſtinctive Characters of Volcanic and Neptunian Mountains.

Theſe are taken from the form and arrangement, or from the nature of the materials of which theſe mountains are formed.

The peculiarities of volcanic mountains are, 1ſt, That they ſtand ſingle and unconnected, are of a conic form, and are furniſhed with an opening of the ſhape of a funnel, or inverted cone called the *crater*.

2d, A total abſence of ſtratification near the crater, for here the volcanic cinders, ſcoriæ, and aſhes mixed with ſulphur and indurated, lie in confuſed heaps.

3d, A ſtratification, where any is found, peculiar to volcanos, that is unequally diffuſed and confuſedly arranged; for this ſtratification, ſuch as it is, ariſes from the liquid matter ejected by the volcano at different periods. Now, at each period the matter gradually cools as it deſcends;

none but the hotteſt part extends to a great diſtance; and hence it is always denſeſt where nearer to the crater or opening from which it iſſues, than at a great diſtance from it; and the lavas of different periods, being unequally heated, muſt be diffuſed in a manner very different from each other, and conſtitute beds of very unequal denſities. Beſides, the cone itſelf being formed by a long ſucceſſion of eruptions, the firſt having met with little or no declivity, have remained near the mouth of the volcano. Moreover, eruptions from the ſides of the cone often happen, which burſting through the former beds of lava occaſion a ſtill greater irregularity in the general arrangement.

4th, The form of a bed of lava is always narrower near the crater, or mouth from which it burſt; for it expands as it proceeds to a greater diſtance.

5th, Metallic veins are never found in beds of lava, nor indeed veins of any kind, at leaſt of any extent, being incompatible with the confuſion that reigns in them. Now Ætna is ſaid to contain veins of various metals, the part that contains them is therefore not of volcanic origin.

Again, the ſubſtances peculiar to volcanos are thoſe of volcanic origin; many of them, however, may owe their production to pſeudo-volcanos, as we have ſeen; and therefore, if local circumſtances be not alſo attended to, may occaſion conſiderable miſtakes. Theſe ſubſtances are pumice, volcanic aſhes, pouzzolana, tufas, piperino, vitrifactions, porous and compact lavas, each of which ſhould carefully be examined to diſtinguiſh it from other ſubſtances produced in the

the moiſt way, which at firſt ſight may be found to reſemble it.

1ſt, *Pumice*; this of all ſubſtances is moſt peculiarly appropriated to volcanos, particularly that of the firſt variety; yet ſometimes a compacted congeries of felſpar, and ſhorl, cryſtals with ſome ſcales of mica, have been miſtaken for it; 2 Noſe. p. 183; nor is mere floating on water a ſufficient character whereby to diſtinguiſh pumice, for various porous lavas float on water; Fauj. Mineral. des Volcan. 265; ſo alſo do the ſcoriæ of ſome ſlates which alſo have a greeniſh grey colour. 1 Sauſſ. 78. It ſhould alſo be remembered, that pumice as it floats on water may be conveyed from a great diſtance.

2d, *Volcanic Aſhes*; theſe, when indurated, much reſemble wacken; and accordingly this laſt has often been taken for them. Mr. Dolomieu has fallen into this miſtake in his deſcription of Lipari, p. 57, as muſt be evident to any impartial perſon that conſiders it. Others have taken comminuted argillite for volcanic aſhes. 2 Noſe. 158.

3d, *Pouzzolana*; decayed traps, or trap porphyries, particularly when compacted with clay, much reſemble pouzzolana, and often anſwer the ſame purpoſes; therefore they have often, paſſed for it. See 1 Noſe. 64, 65; 2 Noſe. 74. 11; Nev. Entd. p. 69; and Leſke G. 209, 221.

4th, *Tufas*; wacken has been ſometimes taken for theſe.

5th, *Piperino*; amygdaloids, out of which their kernels had fallen by decay, ſometimes reſemble this ſtone; ſo alſo do decayed traps, or baſalts. 1 Bergbau. 398.

6th, *Vitrifactions*; hyalite, otherwiſe called muller's glaſs, has paſſed upon many as a product of heat, the infuſible at 150°; glittering fragments of felſpar bear often a deceitful reſemblance to glaſs.

7th, *Porous lavas*; Amygdaloids with a trap baſis, and argillites often reſemble theſe ſo ſtrongly that Mr. Sauſſure, who found ſome on the Alps, owns he would have taken them, if he met them elſewhere, for genuine lavas. 1 Sauſſ. p. 142, 143. Mr. Dolomieu cautiouſly marks this ſource of deluſion. " Eaſy as it may appear (ſays he) " to diſtinguiſh cellular lava, the obſerver ſhould " be very circumſpect, and examine with attention the local circumſtances, before he can " decide on the nature of a porous ſtone he may " meet. External appearances may deceive; " there are rocks which by their decompoſition " acquire pores though they have no relation to " volcanos. I have ſeen ſerpentines partly decayed by expoſure to the air, in which round " irregular cavities were formed perfectly reſembling the pores of lavas. Some are capable of " forming the moſt perfect illuſion. I found on " the Pyrenees hornblende ſo altered by the " viciſſitudes of the atmoſphere as to contain as " many cells and cavernoſities as certain blocks " launched from a volcano." Ponces, 276.

Mr. Dolomieu, it is plain, was well aware that ſubſtances found in countries not volcanic could not owe their origin to volcanos. But unhappily he did not conſider that *all* ſubſtances found in volcanic countries were not on that account neceſſarily volcanic. Here lies the ſource of the numerous deceptions with which his account of the Lipardi iſlands abounds. *Similitude and analogy*

logy to real and acknowledged lavas, or at leaſt *fuſibility*, enters as neceſſarily into the proof of the volcanic origin of any foſſil as the mere circumſtance of *locality*. It is the union of both that makes the proof complete.

Mr. Faujas, whoſe teſtimony on this occaſion is above exception, acknowledges that traps and porphyries may aſſume the appearance of lavas, ſo completely, as to lead the moſt experienced obſervers into error, if local circumſtances be not attended to. It is by attention to them that he has ſhewn that neither the toadſtone of Derbyſhire, nor the whinſtone of Scotland, are really volcanic *.

Dr. Prieſtley, among his numerous diſcoveries, ſeems to have found a deciſive character of lavas: he obſerved that real lavas yield but little air, an ounce not affording above 5,5 ounce meaſures of air, and ſometimes ſcarce any. Whereas fictitious lavas, as baſalts, &c. yield from 20 to 30 ounce meaſures. 6 Pri. 217.

I have often found real lava to yield hepatic air, baſalt never.

Some ſtones which confeſſedly have been formed by means of water, have nevertheleſs had a volcanic origin aſcribed to them. They have been deduced from muddy eruptions, of which ſeveral are ſaid to have iſſued from Veſuvius in the laſt century. Signior Gioeni, however, one of the lateſt and moſt judicious obſervers of that volcano, ſatisfactorily refutes this opinion. That water ſhould be collected in the focus of an active volcano, is indeed incredible. Some may indeed be formed during the inflammation, but in a

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* Sur les Traps, 23, 46, 62.

quantity too inconſiderable to form a mud. The greater part of that, which has been obſerved to attend eruptions, proceeds from the reſervoirs or caverns filled with water in the body of the mountain. This in the convulſions attending eruptions muſt often be thrown out, and pour down in torrents.

In the Hiſtory of the Globe we meet with only two accounts of the ſubmerſion of the earth under water, the firſt happened antecedently to the creation of animals, and the ſecond at the time of the general deluge. During the period of the firſt ſubmerſion, ſubmarine volcanos very probably exiſted and to them the excavation of the bed of the ocean may be attributed. But theſe lavas could not involve or cover marine animals, as theſe did not then exiſt. During the ſecond period alſo volcanos might have been in an active ſtate, and marine animals be buried under their ejections. Thus far we are under the guidance of hiſtory. But if we proceed farther, and aſſume alternate ſtratifications of marine and volcanic productions, we muſt have either particular hiſtorical evidence to reſt upon, or undoubted proofs that the ſubſtances aſſumed to be volcanic are really ſuch.

Mountains of Neptunian origin are diſtinguiſhed by their materials, and often by the arrangement of thoſe materials.

1ſt, Mountains conſiſting of granite, gneiſs, jaſper, argillites, ſerpentines, limeſtones, are confeſſedly of Neptunian origin; ſo alſo are thoſe that conſiſt of ſtrata of coal, clay, ſandſtone, marl, &c. So alſo are thoſe in which metallic ſtrata, or veins, are found.

2d,

2d, The affinity and order that ſubſiſts between the different ſtrata often evince a Neptunian origin: thus if we ſee a hard ſtone paſſing by imperceptible degrees into a ſofter which is not of volcanic origin (or vice verſa), and this into clay, and the clay into quartz, we may fairly conclude that the firſt in the ſeries is not volcanic. This mode of inquiry has been invented and ſucceſsfully purſued by Mr. Werner.

3d, As the Neptunian is by far the moſt general origin of ſtones, it may always be preſumed, until proofs of a volcanic origin be adduced.

CHAP. IV.

Of Stones to which a Volcanic Origin has been improperly aſcribed.

§ I.

Of Shorls, or Baſaltines, and White Garnets.

It is now generally agreed among volcanic obſervers, that the ſhorls found in lavas (more properly called baſaltines) pre-exiſted in the rocks which were the mother ſtones or baſis of lavas before the eruption, and were not formed by ſubſequent percolation through, and cryſtallization in the melted lava. This concluſion is grounded on the following reaſons:

1ſt, Becauſe theſe ſhorls or baſaltines are found in rocks confeſſedly not of volcanic origin, for inſtance in granite *.

2d, Becauſe the thin fuſion requiſite for cryſtallization would convert them into glaſs, a ſtate to which they do not even approach

3d, Becauſe the heat requiſite for their fuſion is ſuperior to that which flowing lava generally poſſeſſes, and yet the fuſibility of both is exactly the ſame; if, therefore, they were really fuſed, ſo alſo muſt the lava have been, which yet is not true, as we have already ſeen.

4th, Becauſe the percolation or infiltration of the particles of which they conſiſt through ſo viſcid a ſubſtance as flowing lava is not eaſily conceived, that is, is not conformable either to obſervation, experiment, or analogy.

5th, Becauſe their cryſtallization in the midſt of a denſe viſcid ſubſtance is equally inconceivable.

Theſe reaſons are ſtill more ſtrongly applicable to white garnets (Veſuvian) felſpars, and olivins which are ſtill leſs fuſible than baſaltines.

Mr. Faujas and Baron Diedrich imagined that ſhorls expoſed to volcanic fires might be diſtinguiſhed from thoſe found in ſubſtances that had never felt their action, by their influence on the magnetic needle. But Mr. Sauſſure obſerved the ſhorls found in the neighbourhood of Geneva, to exert the ſame influence as thoſe contained in ſubſtances confeſſedly volcanic.

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* Helvet. Magaz. p. 156. 1 Sauſſ. p. 67.

§ II.

§ II.

Zeolytes.

The zeolytes generally contain from $\frac{1}{8}$ to $\frac{1}{5}$ of their weight of water, an ample teſtimony one would think of their Neptunian origin. Yet the circumſtance of their being found in the vicinity of ſome volcanos has induced many to imagine ſuch a connection between them and volcanic operations, that from their exiſtence, at leaſt in certain circumſtances, they have thought themſelves intitled to conclude, that the rocks in which they are found were ſubjected in ſome antient period to ſuch operations. Some have aſcribed their origin to the decompoſition of lavas; ſome to the infiltration of ſea-water through lavas; and ſome imagined them inveloped in lavas in actual fuſion.

The following facts, however, ſubvert all theſe opinions:

1ſt, Zeolytes are found in countries where nothing is volcanic, unleſs the whole earth be deemed ſo. They are found in copper and gold mines in Sweden. 3 Bergm. 224. They are found between granites in maſſes of ſome hundreds weight in Poland. 2 Chym. Ann. 1791, 196. They are found amidſt the granites of St. Gothard in Swiſſerland. Haiding. 52.

2d, Zeolyte is not found in the lavas either of Ætna or Veſuvius, and, indeed, ſcarce at all on thoſe

thoſe mountains; and when found it is in ſubſtances that are not volcanic. Neither Dolomieu nor Gioeni could find any on Veſuvius, nor near it; *Ponces*, 433; and yet, aſſuredly, it is not deficient in lavas in a ſtate of decompoſition. Gioeni, indeed, tells us he diſcovered *one* ſpecimen of zeolyte on Ætna; not, however, in a lava, but in a marl that inveloped it. He alſo mentions *one* found in a brown lava, and *one* in another in a ſtate of decompoſition *; but as he improperly aſſumes many ſubſtances for lavas which are not really ſuch, we may ſtill doubt, whether, even in the few inſtances adduced by him, he has not been deceived.

3d, The ſubſtances in the neighbourhood of volcanos, in which zeolytes are found, are ſuch as we have reaſon to judge rather of Neptunian than of volcanic origin. Mr. Dolomieu, after informing us that he never found zeolytes in the modern lavas either of Veſuvius, Ætna, or the Sicilian iſlands, tells us he has found them in abundance in ſuch of the antient extinct volcanos of Italy, Sicily, and the adjacent iſlands, as have been antiently buried under the ſea, and are covered with calcareous rocks, and other marine remains. The reality of theſe volcanos, however, ſtill remains to be proved.

All the zeolytes he mentions in his Catalogue are contained in *what he calls lavas* rendered priſmatic, by flowing into the ſea; in theſe he thinks them formed by the gradual filtration of ſea-water. Yet the 7th number of his Catalogue, even in his own opinion, is ſcarcely compatible with this idea; for, the zeolyte contained in this *ſup-*

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* Gioeni, 38, 195, 196, 197.

poſed lava amounts to half of the whole maſs, and appears ſo neceſſary a part as clearly to evince that both were of ſimultaneous formation *. As the water in zeolytes is not ſalt, and as no ſalt is found in the ſtone through which this water is ſuppoſed to have penetrated, the idea of infiltration cannot be ſupported. Theſe pretended lavas are therefore moſt probably traps or baſalts, which often contain zeolytes, and are not of volcanic origin, as will preſently be ſeen. If this great geologiſt had recollected his own aſſertion, that thoſe ſtony maſſes, on which he beſtows the name of *Compact Lava*, are ſcarce at all different when ejected out of a volcano from what they were in their natural ſtate; and alſo that zeolytes muſt be perceptiby altered even by the moſt moderate heat; he would rather have concluded that theſe maſſes that reſemble lava, and yet contain unimpaired zeolytes, were not genuine lavas, but rather primitive ſtones out of which lavas are formed.

Hence the exiſtence of zeolytes in any mountain or foſſil, ſo far from affording any ſuſpicion of their volcanic origin, ſhould rather lead us to conclude that they were never ſubjected to the operations of the igneous element.

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* Ponces, 347.

§ III.

Of Traps and Baſalts.

As the various opinions concerning the origin of baſalts form an intereſting part of the Mineralogical Hiſtory of this century from the numerous reſearches they occaſioned, and the many diſcoveries both of unknown truths and unſuſpected errors that thence reſulted, it will not be amiſs to ſtate theſe opinions in the order in which they were offered to the public, before we enter into a particular examination of the merits of each.

The circumſtance that firſt led philoſophers into a particular enquiry concerning the origin of baſalts, was the diſcovery of antient volcanos, now extinct, made by Mr. Guethard, of the Royal Academy of Paris, in the year 1751, and publiſhed among the Memoirs of that learned body for the year 1752. Theſe he found in Auvergne; he inferred their antient volcanic ſtate from the ſtrong reſemblance between ſeveral foſſils they contained and thoſe of Veſuvius; among theſe foſſils, however, he does not reckon baſalts; on the contrary, in his Mémoires de Phyſique, publiſhed ſeveral years after, he aſcribes to them a Neptunian origin.

In 1763, Mr. Deſmaretz, a member of the ſame academy, travelling through Auvergne, obſerved a multitude of baſaltic pillars on the road between Clermont and the celebrated mountain Puyde Dome. Theſe pillars he ſuppoſed to be lavas, from the cloſeneſs of their texture, their containing a number of ſhining points, and their having a black or grey colour *; their priſmatic form proceeded, as he thought, from their having been in fuſion †. This account was publiſhed by himſelf in the Paris Memoirs for 1771; but it was mentioned long before, by Mr. Montet, in thoſe for 1766. About the ſame time he diſcovered articulated baſaltic columns near the village of Rochefort, and found, by comparing them with thoſe of the Giant's Cauſeway of the county of Antrim, that they were of the ſame nature; both he pronounced to be undoubtedly volcanic.

Moſt of the priſmatic maſſes which he afterwards diſcovered announce clearly, he tells us, by their ſituation (at the extremity and borders of currents of melted matter ‡), their origin and nature, viz. that of compact lava; yet ſome, in conſequence of ſubſequent alterations of the primitive diſpoſition of theſe currents, either by derangement from poſterior eruptions, or degradations cauſed by ſtreams of water, no longer preſerve their antient connection with theſe currents, and hence are found on inſulated ſummits, whoſe baſis or under ſtrata have never been attacked by fire §; often alſo does it happen that they have no connection with interrupted currents, or even with volcanos; in theſe caſes he ſuppoſes them to have been melted where they

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* Mem. Par. 1771, p. 725, 8vo.

† Ib. 722.

‡ P. 723.

§ P. 746.

ſtand, and their volcanity is, he thinks, eſtabliſhed by their colour, grain, and the ſcoriæ, baked earth, and ſpungy ſubſtances, that conſtantly accompany them.

Granite, he afterwards tells us, is the motherſtone, by whoſe fuſion baſalt is produced *; ſenſible, however, that he had as yet offered no ſatisfactory proof that theſe baſaltic pillars were real lavas, and wiſhing to obviate the ſtrong objections of the celebrated Wallerius, who inſiſted that lavas were eſſentially porous, he adds, that he had viewed actual volcanos, and in the torrents of lava iſſuing from them he had obſerved the upper part of the bed to be ſpongy, but that the lower part had always an uniform compact grain like baſalt †.

In 1771, Mr. Raſpe, in an ingenious treatiſe on ſome German mountains, which he ſuppoſes to be volcanic, for much the ſame reaſons as Mr. Guettard hazarded a conjecture, that the baſalts found in them were lavas that broke their way immediately into the ſea, or at leaſt were formed in caverns and holes under its level, at the time that the whole earth was deluged by it.

In 1774, Mr. Monnet, in anſwer to an objection of Mr. Guettard's, that it was abſurd to ſuppoſe, that during the agitation and tumult of a volcanic eruption any thing like a regular cryſtallization could be formed, threw out a ſuſpicion, that baſalts were cryſtallized in the boſom of the volcano in which they were originally fuſed ‡. The ſame conjecture occurred alſo to Mr. Gerhard, of Berlin, in 1781 §.

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* Mem. Par. 1771, p. 752, 8vo. † Ib. 824.

‡ 4 Roz. p. 75.

§ 1 Geſch. 177.

In 1777, the volcanic hypotheſis met with a formidable adverſary in the celebrated Bergman, who, after weighing with the greateſt impartiality the arguments produced on either ſide, decided in favour of its production in the moiſt way. His objections to the volcanic origin will preſently be ſtated.

In 1786, The Reverend Mr. Hamilton publiſhed his very entertaining Letters concerning the Northern Coaſt of the County of Antrim, in which, with great ability, yet with ſome heſitation, he ſupports the volcanic origin of the Giant's Cauſeway, and other baſaltic columns of that county, and endeavours to prove that they were cryſtallized by tranquil fuſion and ſlow refrigeration, in the very focus of a volcano. This opinion, though liable, as we ſhall ſoon ſee, to inſuperable difficulties, obviates many of thoſe that occurred in former theories, and was, therefore, readily embraced on the continent. Baron Veltheim in particular, who had long before entertained the ſame notion, publiſhed an able defence of it in 1787.

After ſo much had been publiſhed on this ſubject, the reaſons adduced by both parties appeared to balance each other ſo nearly, that many ſuſpected that baſalts and traps might originate in ſome caſes from fire, and in others from water: Ferber, and, finally alſo, Mr. Gerhard, declared in favour of this double origin. But it found its firmeſt ſupport in Mr. Dolomieu. His opinion is, that baſalts, exiſting in the neighbourhood of actual volcanos, and (what he ſuppoſes) extinct volcanos, were formed by the ſudden refrigeration of compact lava, flowing either into the ſea, or exiſting in ſome other circumſtances productive of ſudden cooling; hence he thinks that baſalt was not cryſtallized, but owes its priſmatic ſhape to ſudden burſting *. In countries, however, in which no volcanic veſtiges can be traced, he thinks it, like other ſtony maſſes, of Neptunian origin.

The period, however, at laſt arrived, at which all volcanic ſyſtems, however modified, received a deadly blow. Mr. Werner, of Friburgh, the moſt eminent and judicious mineralogiſt that has yet appeared, having caſually obſerved the tranſition of baſalt into wacken, of wacken into clay, and of this clay into mere quartzy ſand, ſubſtances that were never ſuſpected to have any other than an aqueous origin, by an eaſy application of the ſimpleſt fundamental laws of Mineralogy, inferred that baſalt muſt alſo have been formed in the ſame fluid. This important obſervation (or rather the conſequences deduced from it) was afterwards controverted by Mr. Voight, a mineralogiſt deſervedly in high repute, in my opinion, however, with little ſucceſs †. Obſervations were henceforward multiplied on moſt of the German mountains, that had heretofore paſſed for volcanic, and many were revendicated to Neptune's antique demeſne. Of theſe obſervations, thoſe of Mr. Reuſs on the Bohemian, and of Mr. Noſe on the hills contiguous to the Rhine, are worthy of particular attention.

During this controverſy, many impartial mineralogiſts, wiſhing to ſee the merits on each ſide compendiouſly ſtated, Mr. Hoepfner, of Viel,

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* Notes on Bergm. 57. 37 Roz. 197.

† 2 Bergm. Jour. 1788, and 1 Bergm. Jour. 1789.

in Swiſſerland, a mineralogiſt and chemiſt of diſtinguiſhed merit, generouſly offered a premium of 25 rix-dollars to him who ſhould give the moſt ſatisfactory anſwer to the following queſtions: *What is baſalt? Is it volcanic, or is it not?* The premium was adjudged to Mr. Weideman, a diſciple of Mr. Werner's, who combated the volcanic theory; not becauſe the controverſy was thought to be irrefragably decided, but on account of the maſterly manner in which he handled the ſubject.

It now remains that I ſhould ſtate the reaſons that impreſs conviction on my mind, that neither baſalt nor trap are of volcanic origin. In doing this, I ſhall at the ſame time meet the arguments adduced in ſupport of the different modifications of the volcanic theory already ſtated.

The firſt circumſtance that ſtrikes me very forcibly, and operates equally againſt all the volcanic theories, is the total abſence of every internal mark of fuſion. Baſalt, I mean the moſt perfect regularly figured priſmatic baſalt, is a heavy perfectly compact body, whoſe fracture diſcovers a fine ſplintery or earthy fracture, deſtitute of all luſtre, except that which proceeds from a few diſperſed glimmering particles of hornblende cryſtals. In maſſes of ſeveral feet in length I have not been able to diſcover the ſmalleſt internal cavity, either in that of the Giant's Cauſeway, nor in that of Stolpe; nor has Mr. Bergman in thoſe he examined *. Now, all fuſed earthy ſubſtances preſent either a porcelain grain, always glazed if the fuſion extended to even one

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* 3 Bergm. 211. Van troil, 388. & Guettard's Memoirs, 257.

half of the whole, or conchoidal and glazed if it extended farther, and ſome air blebs, even if converted into glaſs; therefore baſalt wants the peculiar marks of fuſion.

To this plain reaſon ſeveral anſwers have been given. According to Mr. Hamilton, all the baſalts, he has ſeen, exhibit, in one part or other of their ſubſtance, air-holes; and it is remarkable (ſays he), that even the pillars of our Giant's Cauſeway, which are ſingularly compact, have their upper joints more or leſs excavated *; and for this he appeals to a view of thoſe of Dublin College. The groſs pillars in the capes and mountains, he tells us, frequently abound in thoſe air-holes, through all their parts, which ſometimes contain clay, and other foreign bodies, and the irregular baſalts where the pillars ceaſe, or which lies over them, is, in general, extremely honey-combed, containing in its cells cryſtals of zeolyte, brown clay, or ſteatites, &c.

After reading this paſſage, I carefully examined the pillars in our college, and found, in truth, that in ſome part, namely, in the top of each pillar, there were two or three minute cavities of the ſize of the head of a pin, and one twentieth of an inch, perhaps, in depth, and no more, in the ſpace of twenty ſquare feet. It is plain, therefore, theſe aroſe from decompoſition, or external accidents; for, if they proceeded from internal air, they would have penetrated much deeper into the body of the ſtone. This Mr. Dolomieu acknowledges, and gives even as a criterion of ſtones really volcanic, "I pori "eſiſtono nell' interno equalmente inquelle pietre

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* P. 149.

"che realmente ſono di volcanica origine [*]." But in the interior of theſe baſalts not the ſmalleſt pore appears. Of the opacity, dulneſs, and texture, of theſe ſtones he takes no notice. As to the holes in the irregular baſalts, it appears, from his own account, that they proceed from the decompoſition of other ſtones, that were previouſly contained in them. That many of them contain clay, ſteatites, or zeolyte, is an evident proof that they are not volcanic; for, the fire that could melt them would evidently harden the ſteatites, harden or melt the brown clay, and certainly melt the zeolytes, which are not even deprived of their water of cryſtallization. Mr. Voight, a zealous ſtickler for the fuſion of baſalt, anſwering this objection, contents himſelf with ſaying that *many* baſalts are found *not entirely deſtitute of pores* [†]; admitting thereby, that *many*, if not *moſt*, are free from them; and that thoſe that have any have but few. Now, if any be deſtitute of them, we cannot hold them for real lavas, and thoſe that have any (ſince they are all of the ſame origin) muſt derive them from ſome other cauſe than the expulſion of air by fire.

2d, Mr. Dolomieu anſwers this objection by allowing it *to be true in every point of view*, and inſiſting that the igneous origin of baſalt can be proved ſolely by local circumſtances. In his Notes on Bergman, p. 59 he tells us, "It is "very true the lavas of priſmatic columns, and "all other compact lavas, preſerve no appear-"ance whatever of fuſion, when cold, becauſe "lavas are not vitrifactions; volcanic fire does

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[*] On 3 Bergm. De Prodotti Volcan. 185.

[†] Mineralogiſch and Bergm. Abhand. 171.

" not commonly change either the grain, texture, external appearances, nor the eſſential " qualities of ſtones to which it has nevertheleſs " communicated a conſiderable degree of liquidity to make them flow in a torrent." And, in the preface to his account of the Pontian iſlands, he aſſerts, " that volcanic fire does not " act like the fires of our furnaces; it produces a " liquidity that does not reſemble vitrifaction; " it has no intenſity, and cannot vitrify the moſt " fuſible ſubſtances, ſuch as ſhorl. It produces " liquidity by a ſort of diſſolution, by a ſimple " dilatation, which permits the integrant parts " to ſlide over each other; and, perhaps, by the " aſſiſtance of another matter which is the inſtrument of fluidity."

If the action of this fire were really different from that of all fires with which we are acquainted, it would be impoſſible for us to affirm or deny any thing concerning it; but, before we admit ſuch a myſtery, we ſhould be well aſſured of its exiſtence: in truth, the ſubſtance, called *compact lava*, was never really *fuſed*, but rather *diffuſed* through liquid bitumen, or bitumen and ſulphur, as I have already obſerved in treating of that ſubſtance. But regular baſaltic columns, ſuch as are here meant, were either fuſed or diffuſed through any ſubſtance liquified by fire, though in all probability they are one at leaſt of the mother-ſtones out of which lavas are formed, as Mr. Werner has moſt ingeniouſly and happily ſuggeſted.

As to the abſence of all ſigns of vitrification, Mr. Hamilton anſwers, " We are to conſider, " that ſubſtances in fuſion are very differently af- " fected, in proportion as they are more or leſs

" expoſed

"expoſed to the acceſs of freſh air; the preſence "of this element being abſolutely neceſſary, in "order to deprive a body of its phlogiſton: thus "metals, which may readily be vitrified by ex-"poſure to heat, and the free afflux of air, will "yet bear the moſt intenſe action of fire in cloſe "veſſels, without being deprived of that princi-"ple. Baſalts may have been therefore ſubjected "to a very great degree of heat, and yet ſhew "no marks of vitrification; and hence it may "be explained how it comes to paſs that the iron "principle of the baſalts ſtill retains its phlo-"giſton, acting ſo ſenſibly on the magnetic "needle."

In reply to this, little need be ſaid; baſalt is not a metal, but a ſtone, and air has nothing to do with the vitrification of ſtones; if it had, baſalts, whoſe iron he ſays is ſtill phlogiſticated, could not be vitrified in cloſe veſſels; the contrary of which is notorious. I have myſelf conſtantly vitrified it in cloſe veſſels; ſo have Meſſ. Pott, D'Arcet, Gerhard, and others. If the iron in baſalt were in its metallic ſtate, it would not unite with the earths at all, but ſeparate from them, as I know by experience; to unite with them it muſt be in that ſemi-calcined ſtate which leaves it at once magnetic, and a medium of vitrification; if it were more calcined it would not promote vitrification, as is well known.

Mr. Voight admits the poſſible abſence of all ſigns of vitrification, and in ſo doing admits the abſence of all fuſion, as the fuſion of ſtones is nothing elſe than a more or leſs perfect vitrification. But he objects that many recent lavas of Veſuvius preſent as few ſigns of fuſion; and yet it muſt be allowed they were once fluid. Mr. Voight's

Voight's miſtake in this inſtance is certainly very excuſable. He was led into it by the faulty deſcriptions of almoſt all the obſervers of actual volcanos; they almoſt all miſtake the *flowing* of lava, for the *fuſion* of lava, though its flowing proceeds almoſt ſolely from the liquid bitumen with which it is mixed, as the flowing of mud proceeds from the water, and not from the liquidity or diſſolution of the earth it contains. Hence Mr. Dolomieu, the moſt ſagacious, exact, and philoſophical, of all of them, allows, in the terms already quoted, that volcanic fire has not ſufficient intenſity to vitrify even the moſt fuſible ſubſtances: this, however, muſt be admitted with ſome reſtriction, as vitreous lavas are ſometimes found, though rarely, and ſcoriæ more abundantly; but where any *real* fuſion has taken place the veſtiges of it are ſufficiently diſcernible. It has occurred to ſome, that baſalts and compact lavas may have been in real fuſion, and yet by cooling ſlowly all marks of it may have been obliterated, as happens in the fuſion of glaſs, by Mr. Keir's account; but Mr. Keir does not ſay that all marks of fuſion diſappeared in his experiment, but barely, that the glaſs cryſtallized and became ſemi-opake. I have ſome now by me that cooled ſlowly in Mr. Dean's glaſs houſe, part of which is cryſtallized and ſemi-opake, but retains all the ſharpneſs, luſtre, and rigidity of glaſs; but the compariſon of ſtony ſubſtances and glaſs is eſſentially defective; for, the ſalts that enter into the compoſition of glaſs evaporate in great meaſure in a ſtrong heat long continued, and leave the other ingredients nearly in their primitive ſtate, and almoſt as infuſible; whereas, in the fuſion of moſt ſtones in our furnaces, nothing

nothing eſcapes but water and air, and the alteration they thereby receive muſt for ever remain. Baſalts in particular are as fuſible as they can be ſuppoſed to have ever been.

The ſecond reaſon that appears to me a demonſtration that baſalts nor traps are never ſubjected to the operations of heat is, that they contain ſubſtances in a ſtate abſolutely incompatible with ſuch operations; for inſtance, they contain mild calcareous earth, as an eſſential ingredient in their compoſition, which muſt neceſſarily have been calcined, at leaſt in the ſuperficial parts of thoſe baſalts, in a heat much inferior to that which could fuſe the baſalts. They often contained zeolytes, which muſt at leaſt have loſt their appropriated water; they contain horblende cryſtals, which yet are fuſible, and conſequently deſtructible in as low a heat as baſalt itſelf; they often contain calcareous ſpars, which muſt have been decompoſed in the ſame heat, nay more, neither calcareous ſpar nor zeolytes are ever found in any modern (that is to ſay, in any uhdoubted) lava, as Mr. Dolomieu acknowledges. Ponces, 424.

Neither Mr. Hamilton nor Mr. Voight take any notice of this objection. Mr. Dolomieu endeavours to evade it, by allowing the liquidity of lava not to proceed from fire. With reſpect to ſhorls, he expreſſes himſelf thus: "It is no "longer neceſſary to refute the opinion of thoſe "who have believed that the ſhorls of lavas "were products of fire, and that they were form"ed either during their fuſion or their cooling; "it is too evident that their exiſtence preceded "the fuſion of lava*;" and again, "It will be

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* Ponces, 246.

"ſtill more extraordinary to find, that ſhorl, ſo "fuſible a ſubſtance, has not received the ſmalleſt alteration, has preſerved its angles, its "hardneſs, its internal texture, and, in general, "all its properties. How has it happened that "this ſingle obſervation has not indicated that "the fuſion of lavas has no relation to the vitreous fuſions which we operate in our furnaces? I cannot, therefore, too often repeat, "that the fluidity of lavas is not a vitrification; "they flow, becauſe they are carried off by a "ſubſtance extremely fuſible, which burns at "the ſame time; and when they congeal, it is "leſs through the ceſſation of heat than on account of the entire combuſtion and diſſipation "of the matter that operated their ſoftneſs." It is ſurprizing he has not named bitumen, whoſe operation he ſo juſtly deſcribes. But why has not the ſubſtance, which ſoftened lavas and left them porous, alſo ſoftened ſhorls and zeolytes, and rendered them porous?

I ſhall now proceed to ſhew the inſufficiency of the principal volcanic theories of the formation of baſalt, beginning with Deſmaretz's as the firſt, and ſtill the moſt generally received. This ingenious academician ſuppoſes that baſalts were formed by the cooling of lava erupted from antient volcanos; if ſo, we ſhould naturally expect to find them in the currents of modern volcanos; yet none are found. Mr. Hamilton allows this, and thinks it a ſtrong proof of the truth of his own hypotheſis; Mr. Dolomieu aſſures us, that, of the modern torrents of lava from Ætna, many have been flawed by cooling in the open air, yet they preſent nothing but irregular maſſes; many alſo of the more antient beds of lava have been laid

laid open, but priſms were never found among them, nor were any found in the caverns of Monte Roſſo, nor in the ſubterraneous galleries of thoſe currents. Ponces, 446, 447. Gioeni, in his Catalogue of the Minerals of Veſuvius, intirely omits them; and tells us, " The baſalts are cer-" tainly of volcanic origin, yet volcanos in our " days ſeem to have loſt the power of producing " them." Introduction, LIII.

Perhaps I may be told that Sir William Hamilton obſerved ſome baſaltic pillars near Torre del Græco; but Sir William's own words are, " The " lava of Veſuvius that runs into the ſea near " Torre del Græco, has an evident tendency to " the baſaltic form; on Mount Veſuvius I never " ſaw any thing like baſalts except that at Torre " del Græco and ſome fragments thrown up by " the eruption of 1779 *." Of the latter we ſhall preſently ſpeak, but the former were not baſalts, as it ſeems; for, Gioeni tells us, " I wiſhed to " verify the baſalts which I was told were to be " found on the ſea-coaſt near the park of Portici, " but I diſcovered nothing but a courſe of com-" pact lava with very irregular perpendicular " fiſſures, whence reſulted quadrangular and tra-" pezoidal columns. Such fiſſures are often ob-" ſerved in tufas, and earths of different kinds, " and can impoſe on no one, habituated to diſ-" tinguiſh their true cauſe. The only baſalts I " found on Veſuvius were thoſe erupted in 1779, " which were collected by Sir William Hamil-" ton." It is even doubtful whether what he calls compact lava be really ſuch, as moſt of the volcanic obſervers have hitherto confounded the

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* Phil. Tranſ. 1786, p. 376.

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mother-ſtones of lavas with lavas themſelves; as to the fragments ejected we ſhall preſently have occaſion to mention them again.

This theory having appeared unſatisfactory to many of the volcaniſts themſelves, they next deviſed that which aſcribes the formation of baſaltic columns to cryſtallization in the inſide of the volcano, on the very ſpot on which it was originally fuſed. Common trap, or, as they call it, imperfect baſalt, they ſtill aſcribe to effuſions of melted matter; in the firſt caſe perfect reſt, and the moſt gradual diminution of temperature, have permitted the parts of the melted maſs, to exert their proper laws of arrangement, ſo as to aſſume the form of columnar lava..

This hypotheſis explains perfectly well why modern volcanos exhibit no baſalts; " we muſt " wait, ſay its patrons, until they are burnt out, " when the immenſe vaults which now lie within " their bowels ſhall fall in, then we may expect " to behold all the varieties of cryſtallization " that take place in theſe vaſt laboratories of " real nature."

But if this hypotheſis gets rid of ſome difficulties, it is preſſed by ſeveral others that attend it on every ſide, to ſay nothing of the general objections already mentioned,

1ſt, Almoſt all cryſtals have a lamellar, ſome few, perhaps, a ſtriated, or perfectly uniform and vitreous texture, and none whatſoever an earthy fracture. But baſalts preſent an irregular earthy grain, without the ſmalleſt tendency to the lamellar.

2d, All cryſtals have a ſmooth, and, at leaſt, one poliſhed ſurface, or, if not exactly ſo, one ſees at leaſt that the aſperity or inequality of their ſurface

ſurface proceeds from the fracture of ſome of the lamellæ, or the adherence of ſome uncryſtalled ſubſtance; but baſaltic priſms, though they ſhew an even, yet there is nothing like a ſmooth or poliſhed ſurface, or any veſtige of fractured lamellæ.

3d, All cryſtals preſent either one regular form, or forms, that, one way or other, may be deduced from one regular form, as Abbé Hauy, and Mr. Rome de Liſle, have abundantly proved; but baſalts are found of all forms, trigonal, quadrangular, pentagonal, hexagonal, octagonal, &c. as chance directs.

4th, Cryſtals are formed under ſome determinate angle, but baſalts have none that can be deemed common to them; nay, ſometimes they are deſtitute of all angles, being cylindrical, or oval *.

5th, Baſaltic pillars are frequently articulated, a configuration never obſerved in true cryſtals.

6th, Mr. Hamilton obſerves, that baſaltic pillars are of a looſer and ſofter texture at the top, but true cryſtals are homogeneous, and of the ſame texture throughout: this difference of conſiſtence is very common in uncryſtallized ſtones, as argillites †, and even quartz ‡, but never in the cryſtallized, except when beginning to be decompoſed; therefore baſalts differ from cryſtals in every point of view, except in poſſeſſing in common with them a regular polygon figure, a figure often obſerved in marls and porphyries, whoſe cryſtallization was never ſuſpected.

Hence the late excellent cryſtallographiſt, Mr. Romé de Liſle, whoſe willingneſs to find, and

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* Fauj. Mineralog. des Volcanos, Chap. IX.

† See Guethard, Mem. Par. 1757, and Laſius, *Hartz*, 102.

‡ Laſius, Ibid. 137.

ſagacity in tracing, cryſtalline forms are acknowledged, though he at firſt admitted baſalts among them, yet, in his Second Edition, on mature conſideration, he has excluded them: "theſe cryſtalliform maſſes (ſays he) are always the products, not of a true cryſtallization, but of a heterogeneous matter, not diſſolved, but precipitated under an irregular form, and afterwards, either by deſiccation or cooling, burſt or contracted into priſms of a greater or leſſer number of ſides, but always indeterminate. In vain ſhould one ſeek in theſe pretended cryſtals, either a conſtant paralleliſm of the planes, or a determinate meaſure in the angles, &c."
1 Cryſtallogr. p. 439.

Beſides, it is well known, that no ſubſtance can cryſtallize either in a menſtruum, or from a ſolution by heat, unleſs it be ſo perfectly diſſolved that its parts have liberty to arrange themſelves according to their peculiar attractions; ſo that, if they cryſtallize from a ſtate of fuſion, the fuſion muſt have been thin and perfect: now it is evident, from ſuch fuſion, glaſs or enamels muſt be formed, unleſs the moſt fuſible parts be diſſipated or ſeparated; which is not the caſe in baſalts, ſince in their actual ſtate they are eaſily and perfectly fuſible, ſo that we have herein a demonſtration, *a priori*, that they are not formed by cryſtallization in the dry way.

Again, baſalts are frequently found on the ſummits of mountains; how then can their formation be confined to internal cavities? Mr. Deſmaretz found them on the ſummits of Puy de Beſelle, Puy de Treuil, Puys d'Eragnes, Puy de Mazeires, &c. in Auvergne; Mr. Halck on that of Cottener, near Kænigſtein, in Miſnia; Mr.

Mr. Voight on that of Franenberg; and many others, in the dioceſe of Fulda; and Mr. de la Fonda une multitude de grands pies courronés par des chauſſées de baſaltes en priſmes. *Volcans Eteints*, 327.

To obviate this objection recourſe has been had to various ſuppoſitions grounded on the antient revolutions of the globe, by which it is imagined theſe hills were in part deſtroyed, and only thoſe parts left which ſupport the baſaltic pillars; but is not this explaining a *fact* by a poſſibility? What proof can be adduced, not of a reſolution, for that is admitted, but that this revolution has changed the ſtate of theſe hills? How can this general agent be with any probability applied to this particular caſe? This is what is required, otherwiſe a principle is aſſumed that is the ſubject of debate; it were ſtrange that ſuch convulſions as ſhould rend mountains ſhould leave the baſaltic pillars upright, and ſtanding in their reſpective ſockets, as thoſe do on the coaſt of Antrim,

Another inſuperable difficulty attendant on all the volcanic theories, but particularly this hypotheſis, is, that baſalts ſtand on or adjoin ſubſtances, which appear not to have ſuffered in the ſlighteſt degree, or to have been at all expoſed to heat. How is it poſſible that ſuch immenſe maſſes ſhould have been in a melting heat, for a conſiderable time, and yet that the adjacent ſtones, or earths, ſhould not have been at all altered? All this, however, muſt have happened if baſaltes were formed, as the theory which I now conſider demands; for, it is found on limeſtone undecompoſed, on gneiſs unaltered, on ſandſtone unmelted, on coal, and even intercepted between ſtrata of coal.

Deſmaretz felt this inconſiſtence, and endeavours to explain it away. " Moſt of the priſmatic " maſſes (ſays he) announce clearly, by their " ſituation, their origin, and nature of compact " lava; but ſome of theſe maſſes, in conſequence " of alterations that have viſibly taken place in " the primitive diſpoſition of the currents, either " in the tumult of poſterior eruptions, or more " eſpecially by the degradations ariſing from water, have no longer preſerved their connexion " with theſe currents, and in that caſe we find " theſe pillars ſingle, perched on inſulated ſummits, whoſe baſis is a ſubſtance no way injured " by fire." It is ſurpriſing, however, that water ſhould ſweep away the foundation on which they ſtood, and yet leave them ſtanding; but even this harſh ſuppoſition will not ſolve the difficulty. Mr. Faujas, near Villeneuve de Berg, found maſſes of limeſtone and baſalt adjoining to each other, and even incorporated, and mixed with each other; he examined the limeſtone thus mixed, and inſtead of finding it cauſtic, as ſhould naturally be expected, it efferveſced as uſual. In Leſke's Cabinet, G. 294, we meet with baſalt ſtuck in granite, and yet the felſpar of this granite retains its luſtre, and the quartz its tranſparency.

Dr. Hamilton does not ſeem willing to allow the fact; he tells us, he found the flints intermixed with baſalts, opake and ſhinery, and the coal as if it were glazed, and charred, refuſing to inflame. As to the flints, it is ſo common to find them dull, whitiſh, and opake, in countries moſt certainly not volcanic, that this indication cannot be

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much inſiſted on. As to the coal, it requires more conſideration; in the firſt place, it is plain, it cannot be charred by melted baſalt lying on it, for this would prevent the diſſipation of the elaſtic fluids neceſſary to its charred ſtate. The truth is, that the coal which is often found thus free, or nearly ſo from bitumen, is the natural carbonite, or carbonic ſubſtance, which occurs elſewhere, as well as in baſaltic countries; a certain ſign that the heat of baſalt had not deprived it of its bitumen is, that bituminous wood is frequently found under baſaltic maſſes.

The next hypotheſis that occurs to our conſideration is that of Mr. Dolomieu. This, it muſt be owned, eſcapes moſt of the objections made to the former theories; it evades thoſe made to the fuſion of baſalt by allowing it was never really fuſed; thoſe made to its cryſtallization, by attributing its priſmatic form to ſudden cooling, chiefly by flowing into the ſea; and thoſe ariſing from its ſituation on the ſummit of hills totally unconnected with any thing volcanic; by allowing that ſuch baſalts are not of volcanic origin. 37 Roz. 1790. Hence it is plain Mr. Dolomieu gives up almoſt every point in diſpute, yet he ſtill maintains that the baſalts found in the neighbourhood of ſome few living volcanos, and in thoſe which he ſuppoſes to be antient, and now extinguiſhed volcanos, to have been once rendered liquid by fire though not *fuſed* in the manner that earths and ſtones are in our furnaces. We muſt, therefore, ſhew the futility, or the inſufficiency of each of theſe grounds, for attributing to baſalts a volcanic origin.

And firſt, as to the ſort of fuſion he contends for, unleſs he means the liquefaction by means of bitumen, it is utterly incomprehenſible. This latter is intelligible, but will not anſwer his purpoſe; for even this ſort of fuſion will render ſubſtances that undergo it porous, at leaſt in ſome degree, as we ſee in genuine compact lava; it will deprive zeolytes of the water of cryſtallization, and dull the luſtre of ſhorls, for we ſee the felſpars, and white garnets of modern lavas, thus affected.

2d, The effuſion of melted lava into the ſea would not barely ſplit it into priſms, but fritter it to pieces; this I have experienced by pouring melted baſalts into water, and throwing a crucible filled with it into cold water.

3d, The circumſtance of the vicinity of baſaltic priſms in the ſea adjoining the actual volcanos of the Sicilian iſland, either proves nothing, as it does not follow that they are rather the effuſions of thoſe volcanos than the motherſtones out of which lavas are formed; or, if we couple it with the above experiment, it rather proves that they are not lavas.

4th, The diſcovery of baſaltic pillars in antient, but now extinct volcanos, is undoubtedly the corner ſtone of all the volcanic theories, particularly where they ſeem accompanied with pouzzolana, volcanic aſhes, pumice, tufas, &c. However, it never once occurred to the naturaliſts who made this diſcovery, that the baſalts might be the mother-ſtones of which lavas were formed, a ſuppoſition infinitely more conſiſtent with all their properties and relations than that of their being themſelves lavas.

Yet I am far from thinking that all the mountains in which baſalts are found, ſeemingly accompanied as above mentioned, are in reality volcanic; few of thoſe who have obſerved them have given any proof that the ſubſtances on which they beſtowed the name of porous lava, pouzzolana, volcanic aſhes, &c. were that in reality which their names import. Mr. Whitehurſt, and others, have beſtowed the name of lava on the toadſtone of Derbyſhire, the rowley ragg, and whinſtones; yet Mr. Ferber, and Faujas de St. Fonds, both ſufficiently expert in detecting lavas, deny theſe ſtones to be really volcanic; and Dr. Prieſtley found their aërial contents very different from thoſe of genuine lavas.

The ſtone called wacken has often been taken for indurated volcanic aſhes; decayed traps, and porphyries, for pouzzolana. Real pumice is indeed volcanic; but it is often found at great diſtances from the places that gave it birth; hollows formed on the tops of hills by water, or by ſhepherds for ſhelter, have been taken for the mouths of volcanos, from which ſtreams of lavas have iſſued ſufficient to cover countries ſome hundred miles in circumference, though theſe were often but a few feet in diameter; where no ſuch hollows were found (and this is the moſt common caſe), they are ſuppoſed to have been deſtroyed by ſome ſubſequent revolution; where the pretended lavas alternate with marine *exuviæ*, this is attributed to ſucceſſive alternating revolutions. The ſublimity and marvelloufneſs of theſe ſtupendous operations ſuperſede the neceſſity of proving them; yet, even in works profeſſedly deſigned to excite theſe emotions, it is a rule, *nec Deus interſit niſi dignus vindice nodus*, much leſs ſhould theſe revolutionary principles be admitted in natural philoſophy; regularity and uniformity being the great character of the operations of nature, unleſs their veſtiges be fully and inconteſtibly eſtabliſhed.

Let it not be thought preſumptuous, in thoſe who have not ſeen living volcanos, to conteſt the volcanic character of foſſils with thoſe who have long and often contemplated thoſe great phenomena; for, the moſt ingenuous of thoſe who have beheld theſe eruptions acknowledge that very little is to be learned from them. Collini, who twice aſcended Veſuvius and witneſſed its eruptions, complained that he was thereby no way forwarded in volcanic knowledge. Strange affirms that the view of extinct volcanos is much more inſtructive. "The phænomena of recent "volcanos (ſays he) are very little calculated to "give us much inſtruction. A few days tour in "ſuch countries as Auvergne, Velais, and the "Venetian ſtate, are worth a ſeven years appren"ticeſhip at the foot of Veſuvius or Ætna." In effect, lavas, pouzzolana, tufas, &c. may as well be examined at a diſtance as in the neighbourhood of volcanos, and are generally brought to diſtant countries as objects of curioſity; but amygdaloids, and decayed porphyries, and wackens, which bear a ſtrong reſemblance to volcanic products, are not much attended to, nor commonly known by volcanic obſervers, and hence when they quit real volcanic countries, and meet theſe, they miſtake them for thoſe products to which their eyes were accuſtomed, and from theories poſſibly very ſublime, but perfectly romantic.

Sir William Hamilton diſcovered a few fragments of baſaltic columns, ejected by Mount Veſuvius during the eruption of 1779. This Baron Veltheim deems a ſtrong proof of his theory; namely, that baſalts are formed by cryſtallization in the bottom of volcanos; to me, however, it it ſeems a deciſive proof of Mr. Werner's opinion, that baſalts and traps are the mother-ſtones (though not ſolely) of lavas; for, in the firſt place, it is plain theſe columns were not formed by ſudden refrigeration, as Mr. Dolomieu pretends; and, in the next place, it is evident that this volcano being as yet in its vigour (for it had not cooled ſince 1777), the ejected baſalt could not have been formed by cryſtallization on cooling; nor can it be ſuppoſed to have been formed in any antient period, as the lavas antiently formed muſt have been long before diſgorged in the many eruptions that took place ſince 1631. The moſt probable account, therefore, that can be given of it is, that, as the volcanic fire yearly ſcoops out the mountain to greater depths, it at laſt deſcended to Neptunian ſtones, which until then remained untouched; what adds great probability to this conjecture is, that Gioeni expreſly remarks that part of it was untouched by fire. Lithol. Veſuvian. LIX.

It has been obſerved, that bricks and earthenware emit a clear ſound when ſtruck, and, as baſalt has alſo this property, ſome have thought this a proof of its having had a volcanic origin, not recollecting that common roof-ſlates poſſeſs this property, and many lime-ſtones, as Mr. Sauſſure obſerved, and particularly thoſe of the mountain of St. Barbe in Provence; 35 Roz. Jour. p. 31; and even ſtalactites, Laſius, *Hartz*, 198.

The magnetiſm of ſome baſalts appears to ſome a proof of volcanity; but all baſalts are not magnetic. Baron Veltheim tells us he ſcarcely met one in a thouſand that was ſo; but, if they all were, this property would not decide their origin,

origin, for many ſtones are magnetic which no one pretends to be volcanic. For inſtance, garnets, hornblendes, the ſhorls found near Geneva, and the metalliferous ſtone of Born. 1 Bergm. Jour. 1789, p. 607.

There is another ſyſtem which attributes not only to baſalts, but to all ſtony ſubſtances, an igneous origin; it is that of Lazaro Moro, revived, and wonderfully improved, by Dr. Hutton, of Edinburgh, well known, by his excellent Eſſay on the Origin of Rain. This may be called the *Plutonic* ſyſtem. I have endeavoured to ſhew its fallacy in a paper lately read to the Royal Iriſh Academy, which will appear in the next volume of its Tranſactions.

All that has been hitherto ſaid tends to diſprove the igneous origin of baſalts, and conſequently to evince its production in the moiſt way, as there is no medium between the one and the other; I ſhall now, however, ſtate a few reaſons that point directly to a Neptunian origin.

1ſt, It is well known, to thoſe who occupy themſelves with mineralogical reſearches, that in ſtones compoſed of three or four ingredients, tranſitions or gradations are frequently obſerved, from the more ſimple to the more compound, or *vice verſa*, or from one ſpecies of ſtone to another that bears it a kindred relation; ſo that, if any of the terms of the tranſition be of volcanic origin, the whole graduating ſeries muſt be of the ſame origin; and, if any of the terms be decidedly Neptunian, the whole ſeries muſt be Neptunian. This ingenious and convincing mode of inveſtigation was diſcovered, and, in this caſe, happily applied, by Mr. Werner, on the moun-

mountains of Scheibenberg. Here gneiſs forms the loweſt ſtratum or baſis of the hill. On this a quartzy ſand immediately repoſes, which is indiſputably of Neptunian origin, if any ſtone be ſo; immediately over this ſand there lies a ſtratum of clay, much blended with ſand; above that the clay is leſs ſandy; above that it becomes harder; ſtill higher it is found mixed with wacken; ſtill higher the wacken becomes harder; and ſtill higher it paſſes into baſalt. Who does not ſee that this whole graduating ſeries of foſſils muſt have had a common origin, and all to have been formed in the ſame fluid? and let it be conſidered, that wacken muſt have been formed in the moiſt way; for, in fire it becomes remarkably cellular. Beſides, branches, leaves, and roots of trees, have frequently been found in it. In various other inſtances, baſalt or trap has been found to paſs into argillites and ſandſtones, both, confeſſedly, of Neptunian origin.

2d, Dr. Beddoes, in the Philoſophical Tranſactions for 1791, has ſhewn (though with a very different intention) an evident connection between baſalt, trap, and granite. They lie, as he obſerves, "ſo contiguous, and often ſo in-"volved in each other, that one cannot but ſup-"poſe both to have undergone the ſame opera-"tions of nature at the ſame time;" a concretion of this ſort extorted from Ferber an avowal that baſalt might be produced in the moiſt way. *Italy*, 16 Letter.

3d, Some irregular baſaltic pillars were lately diſcovered in Bohemia, containing indurated marl, with the impreſſion of a vegetable reſembling ceraſtium, or alpine. 1 Chy. Ann. 1792, p. 70. The conſequence is obvious. The great ſtumbling-

ſtumbling-block in the way of this theory, and, indeed, of every other, is the difficulty of accounting for the regular formation of the priſms. It, however, is much eaſier accounted for in this ſyſtem than in the volcanic, as we can produce many inſtances of ſimilar priſms in foſſils *undoubtedly* formed in the moiſt way, and none at all of any *undoubtedly* formed in the dry. This form ſeems to me to proceed from the ſudden burſting of baſaltic maſſes, whether from drying, or the abſorption of air, I ſhall not decide. This opinion is founded on the following reaſons:

1ſt, In a heap of ſtones of the ſpecies called, in Dublin, *Black Quarry-ſtone*, extracted from a quarry near Palmerſtown, and deſcribed in my Elements of Mineralogy under the name of *Calp*, Mr. Gandon, the celebrated architect of moſt of our public edifices, diſcovered one lying under ſeveral others in the area of the Cuſtom-houſe, which had burſt ſince it was brought there into regular pillars, ſome of an hexagonal, and ſome of an octagonal form, and ſome articulated exactly like the pillars of the Giant's Cauſeway. Theſe pillars were at firſt about ſix inches long, and one fourth of an inch in diameter, but afterwards accidentally broken when removed to his apartment; in this ſtate I have ſeen them. One of our commiſſioners of the revenue ſaw them before their removal. This ſtone reſembles baſalt ſomewhat in its compoſition, but contains a much larger proportion of calcareous earth, and a much ſmaller of iron.

2d, Mr. Dolomieu, in the province of Volaterra, found micaceous marls to aſſume a priſmatic form on drying. Near Cape del Bove he found

found tufas ſplit into regular hexagonal pillars, ſix or ſeven feet long. Mr. Strange diſcovered granitic pillars in the Euganeon mountains, undoubtedly formed in the ſame manner. Columnar porphyries have ſeveral times been obſerved. We ſhould therefore no longer wonder at ſeeing baſaltic pillars formed by the ſame accidents.

THIRD APPENDIX.

Of the Chemical Analyſis of Earths and Stones.

THIS ſubject, treated in its full extent, would require a particular account of the manner of analyzing not only each particular genus, but alſo moſt of the various ſpecies contained under thoſe genera; it is eaſy to ſee this would require an immenſe detail; my intention, therefore, is to conſider theſe foſſils abſtractedly from all external characters, and ſolely in their relation to chemical agents, particularly to ſpirit of nitre, and the vitriolic acid.

In this point of view they may be divided into ſeven claſſes:

1ſt, Thoſe that are wholly or partially ſoluble, and with efferveſcence, in nitrous acid, whoſe ſpecific gravity is 1,4, or higher.

2d, Thoſe that are inſoluble in nitrous acid 1,4, but wholly or partially ſoluble, and with efferveſcence, in nitrous acid 1,25, in the temperature of 60°.

3d, Thoſe that are inſoluble in ſpirit of nitre or nitrous acid 1,25, but totally or partially ſoluble,

luble, and with efferveſcence, in ſpirit of nitre 1,10.

4th, Thoſe that are ſoluble in ſpirit of nitre, in the temperature of the atmoſphere, but without efferveſcence.

5th, Thoſe that are ſoluble in the nitrous acid, without efferveſcence, but only in the temperature of from 150° to 180°, or higher.

6th, Thoſe that do not efferveſce with the nitrous, but efferveſce ſlightly with the concentrated vitriolic acid.

7th, Thoſe that are inſoluble both in the nitrous and vitriolic acid, or only very ſlightly ſoluble, and with little or no efferveſcence, without particular management.

Before earths or ſtones are ſubjected to this teſt they ſhould be reduced to powder. Earths in particular ſhould be boiled in ſixteen times their weight of water, to diſcover their ſaline contents; diſtilled to diſcover their volatile ingredients, and gradually heated to redneſs in a covered, and afterwards to whiteneſs in an open crucible for half an hour, to obſerve their change of colour and loſs of weight; both, as circumſtances indicate, may be projected on melted nitre heated to redneſs, to diſcover whether they contain the carbonaceous principle.

In the preſent ſtate of mineralogical knowledge, analyſis is become an object of complicated attention, as notice muſt be taken of the nine earths already enumerated;—five acids, namely, the vitriolic, marine, ſparry, phoſphoric, and boracic;—five metallic ſubſtances, iron, manganeſe, nickel, cobalt, and copper.—Not that all theſe are ever found in any compound, but, it being uncertain which of them may occur, none of of them can be overlooked in general analytic formulas.

The combinations of the tungſtenic acid I refer to the fourth part of this treatiſe.

Before any analyſis is attempted, the following ſubſtances ſhould be procured in ſufficient quantity, and in the greateſt purity: concentrated vitriolic acid of the ſpecific gravity of 1,8, ſpirit of nitre 1,400. 1,250. 1,110. ſpirit of ſalt 1,12, diſtilled vinegar, pure vegetable alkali, cryſtallized ſoda, Pruſſian alkali, cauſtic and mild volatile alkalis, common lime-water, ſtronthian lime-water, barytic lime-water, acetated and nitrated barytes, ſolutions of nitrated calx, nitrated mercury and nitrated ſilver, ſugar of lead, purified chalk, and ſpirit of wine, with plenty of diſtilled water.

Of Stones and Earths eaſily ſoluble, not leſs than 400 Grains, ſhould be employed; but, of the difficultly ſoluble, 200 may be ſufficient.

Filtres formed of unſized paper, and of different dimenſions, ſhould be had, dried in the temperature of 80°, greaſed at the edges with melted tallow, and weighed; their weight after burning ſhould alſo be known and noted.

The mouths of the larger veſſels ſhould be ſurrounded with wax, and a waxen ſpout contrived in the part out of which the liquors are to be poured.

Silver crucibles ſhould be employed whenever the heat required will permit their uſe.

Other circumſtances, commonly known, I omit.

Every ſtep of the proceſs ſhould be regiſtered as ſoon as taken.

§ I.

Of Stones or Earths wholly or partially ſoluble, and with Efferveſcence in Spirit of Nitre, whoſe Specific Gravity is 1,4 or higher.

1. Stones which when pulverized are ſoon and entirely ſoluble in a heat below 80°, and with efferveſcence in ſpirit of nitre, whoſe ſpecific gravity is 1,4, at the temperature of 60°, and whoſe ſolution is colourleſs, are either entirely calcáreous, or conſiſt partly of calcareous, and partly of muriatic earths combined with fixed air.

2. However, there are ſcarce any ſtones but the pureſt calcareous ſpars that are ſo circumſtanced; moſt other ſtones of the calcareous genus have ſome ſediment undiſſolved, or afford a ſomewhat turbid ſolution, or are ſlightly diſcoloured.

3. The inſoluble reſiduum may conſiſt of mild barytes or ſtronthian, or of either or both of theſe combined with the vitriolic, or, perhaps, other acids, or of calcareous earth combined with the vitriolic

vitriolic acid; but moſt commonly it conſiſts of argill, or argill and ſome ſand of the ſiliceous kind, commonly blended alſo with calx of iron.

Examination of the Solution.

4. The ſtone or earth charred from all foreign viſible ingredients, and dried as already mentioned, if an earth, and hardened by that heat, it ſhould again be pulverized, weighed, and put into a portion of the acid, alſo weighed in a balanced flaſk, that the weight of air loſt may be found in the uſual manner.

5. After a few hours the ſolution ſhould be diluted with diſtilled water, ſhaken, thrown on a filtre, and the reſiduum waſhed until the water comes off taſteleſs, or gives no precipitate with a mild alkali; this reſiduum, when dried, ſhould be added to No. 3.

6. The ſolution ſhould then be gently evaporated to a moderate quantity, and heated with cauſtic volatile alkali as long as any precipitation appears; this will precipitate the argill and calx of iron, and part of the magneſia, and alſo phoſphoric ſelenite, if theſe ſubſtances exiſt in it. The precipitate ſhould be well waſhed on the filtre, and the waſhings added to the ſolution.

7. The ſolution thus cleared can conſiſt only of lime and ſome magneſia; to ſeparate theſe, add the vitriolic acid as long as any precipitation appears, evaporate the liquor to nearly its original bulk No. 4, or farther, and throw the whole on a filtre; waſh the precipitate with dilute ſpirit of wine, and add the waſhings to the ſolution.

8. The ſolution can now contain nothing but magneſia, and ſome portion of ſelenite; evaporate it conſiderably, the ſelenite will fall; throw this alſo on the filtre, and edulcorate as before.

9. Evaporate the remainder of the ſolution to dryneſs, and re-diſſolve it in pure water, adding more acid; if neceſſary, precipitate the whole by a mild fixed alkali; dry the precipitate firſt gently, and then in a heat nearly red; its weight is that of the mild magneſia in the ſolution.

10. Next proceed to the ſelenite; this ſhould firſt be gently dried, then heated to redneſs, and weighed; 100 grains in that dry ſtate contain about 37 grains of lime; but the beſt method of finding its true contents is to decompoſe by boiling it with 1,5 its weight of cryſtallized ſoda, the boiled liquor will leave on the filtre the mild calx, which, waſhed, dried, and heated to redneſs for half an hour, ſhould be weighed; its proportion of lime is generally as 9 to 5.

Examination of the Precipitate, No. *6.*

11. This may conſiſt, as we have ſaid, of argill, calx of iron, ſome portion of magneſia, phoſphorated calx, and, perhaps, ſome ſiliceous ſubſtance which often paſſes the filtres.

12. Let the precipitate be well dried, heated nearly to redneſs, pulverized, weighed, and heated with four times its weight of pure nitrous acid.

13. If it contains phoſphorated calx, this will be ſlowly diſſolved in the common temperature of the atmoſphere, and ſcarce any thing elſe will be taken up.

14. To

14. To determine this, drop a little vitriolic acid into the ſolution; if it contains phoſphorated calx, a precipitate will appear.

15. As a ſmall proportion of gypſum may alſo exiſt in the ſolution, to determine this doubt, let a few drops of nitrated barytes fall into the ſolution; if a precipitation ariſes in this caſe, and none in the former trial, it muſt be from ſome vitriolic ſalt in the ſolution.

16. If a precipitation takes place in both trials, it may be doubted whether it proceeds in this laſt trial from the phoſphoric acid ſingly, or from the preſence of the vitriolic ſalt; the doubt may be decided by examining the precipitate.

17. But if in neither caſe a precipitate appears, we may be aſſured that in the precipitate No. 6 neither gypſum nor phoſphorated calx exiſt.

18. In caſe either or both theſe acids be found, we ſhall ſee in No. 37 and 67, how they and their baſes are ſeparated and determined.

19. Suppoſing then the four parts nitrous acid to be inactive, or nearly ſo, without the aſſiſtance of heat, let the whole be ſtrongly and repeatedly digeſted until the greater part is diſſolved; let the acid then be diſtilled off to dryneſs twice, pulverizing the dried maſs each time, before any new affuſion of acid; and at laſt heated to redneſs in the retort for half an hour, after which the dried maſs is to be gently digeſted in dilute nitrous acid, which will take up the argill and magneſia, leaving the calx of iron highly oxygenated: let the whole be thrown on a filtre and waſhed.

20. The filtred liquor ſhould then be precipitated by mild fixed alkali, and the whole boiled

to expel the looſe fixed air, that may keep the earth in ſolution.

21. This precipitate ſhould then be thrown on a filtre waſhed, dried, heated to redneſs, and weighed,

22. Then pulverized again, treated for a few hours with eight or ten times its weight of diſtilled vinegar without heat, to take up the magneſia, if any, and filtred.

23. The acetous ſolution ſhould then be treated with a mild fixed alkali, it will precipitate the magneſia, which is then to be filtred, waſhed, dried, heated nearly to redneſs, and weighed.

24. If any argill be ſuſpected to be contained in it, the vitriolic acid by its ſlow ſolution of it will detect it.

25. Argill and magneſia may alſo be ſeparated by boiling the whole in dilute vitriolic acid, and ſaturating the acid exactly by mild calx, which will precipitate the argill, but not the magneſia; and as the ſelenite alſo falls to the bottom on cooling, the magneſia will remain in ſolution, and be diſcovered by the taſte.

26. If the quantity of argill be but ſmall, relatively to that of magneſia; it may moſt conveniently be ſeparated by boiling the whole in pure cauſtic fixed alkali, which will take up the argill, and leave the magneſia.

27. The diſſolved Epſom ſalt, No. 25, will be made to depoſite the ſelenite it may ſtill contain by gradual evaporation.

28. The reſiduum on the filtre, No. 22, may be ſuppoſed to be pure argill, if it be perfectly white; if not, it ſhould again be diſſolved in nitrous acid, which will leave the iron, if any, undiſſolved.

29. To remove all doubt of the nature of the argill, it may be eſſayed with boiling cauſtic fixed alkali, which diſſolves argill, but not jargonia.

30. The calx of iron, No. 19, ſhould then be roaſted with a little wax for a quarter of an hour in a red heat, it will thereby be ſo far reduced as to be magnetic, and contain about 70 per ct. of metallic iron.

In many caſes where metallic ſubſtances are fully diſengaged, and the ſolution coloured by them, they may be precipitated by the Pruſſian alkali, as will be ſeen No. 95.

Examination of the Undiſſolved Reſiduum, No. 3.

31. This reſiduum waſhed, dried, heated to redneſs, and weighed, is firſt to be eſſayed for ſtronthian, by treating it with ſpirit of nitre 1,4, diluted with its own weight of water; whatever diſſolves in this acid with efferveſcence, without the aſſiſtance of heat, is mild ſtronthian; the ſolution ſhould then be diluted and filtred, and the depoſite on filtre waſhed, dried, and added to the remainder of the undiſſolved reſiduum.

32. The filtred liquor ſhould then be gently evaporated, and ſet to cryſtallize, and the cryſtals rediſſolved in about their own weight of water, in the temperature of 66°, as cryſtallization, and ſolution in this quantity of water, of that temperature, are additional proofs of ſtronthian; the ſolution of the cryſtals ſhould then be precipitated by mild ſoda, the precipitate waſhed, dried, ignited for half an hour, and weighed.

33. After eſſaying the reſiduum, No. 3, for ſtronthian; whether it be found or not, let it be eſſayed for barytes, by ſpirit of nitre 1,4 diluted with four or five times its weight of water; if an efferveſcence then ariſes, and not before, we may be aſſured the reſiduum contains mild barytes, which is to be extracted, as ſhewn No. 32; the barytic ſolution ſhould cryſtallize, but the cryſtals require many times their weight of water, to diſſolve them; a circumſtance which diſtinguiſhes them from thoſe of ſtronthian.

34. The reſiduum ſhould next be eſſayed for argill by repeated digeſtion in ſtrong nitrous acid, abſtracting that acid by diſtillation to dryneſs, as in No. 19, and diſſolving the reſiduum in dilute nitrous acid; thus the adhering calx of iron may be ſeparated as there ſhewn.

35. The ſubſtances undiſſolved, after theſe eſſays, may be either gypſum, baroſelenite, ſiliceous ſand, or calx of iron; to ſeparate theſe let this reſiduum be waſhed, dried, and mixed with two and a half times its weight of aërated ſoda deprived of its water of cryſtallization; and the mixture roaſted for an hour or more, in the loweſt red heat, in a crucible covered by another, then ſufficiently waſhed on a filtre, and dried.

36. The filtred liquor ſhould with the waſhings be ſomewhat evaporated, ſaturated with marine acid, while any efferveſcence ariſes, then farther evaporated, and filtred, a ſiliceous ſubſtance is often thus detected, which ſhould be dried, heated to redneſs, and weighed; argill is alſo often thus had.

37. The remainder of the filtred alkaline liquor ſhould then be diluted, and eſſayed for

vitriolic acid by nitrated or muriated barytes, the baroſelenite precipitated, waſhed, dried, ignited, and weighed, will determine the quantity of vitriolic acid in the ſolution, as baroſelenite thus made contains one third of its weight of vitriolic acid, of the ſame ſtrength as that in tartar vitriolate.

38. We now recur to the dried depoſite, No. 35; this ſhould be treated with nitrous acid, which will take up the barytic and calcareous earths, if any, and poſſibly ſome portions of argill and iron, from which the ſolution ſhould be freed by cauſtic volatile alkali, and filtration; theſe are to be ſeparated from each other, as in No. 34.

39. The filtred liquor now contains nothing but calx and barytes.

40. Theſe may be ſeparated by precipitation, by the vitriolic acid which will form a maſs of baroſelenite and gypſum; hot water will gradually take up the gypſum, but leave the baroſelenite; the water gives up the gypſum, by evaporation to dryneſs; the dry maſs ſhould be heated to redneſs, weighed, and treated as in No. 10, and the baroſelenite as in No. 37.

41. After theſe ſeparations nothing but the calx of iron and ſilex can remain; the calx of iron ſhould be taken up by marine acid, or by aqua regia, and, being filtred, the ſilex will remain on the filtre, which, when dried, ſhould be heated to redneſs, and weighed. The martial ſolution ſhould be precipitated by cauſtic volatile alkali, which ſhould be treated as in No. 19 and 30.

42. If the fluor or boracic acids be ſuſpected in theſe ſtones, how the former may be detected will be ſhewn in No. 72, and the latter in No. 81.

43. If the marine acid exiſts in them, it will be found in the ſolution No. 4, and may be pre-

cipitated by the ſolution of nitrated ſilver, of which 235 grains contain, when heated below redneſs, as much marine acid as 100 grains of common ſalt 44.

100 parts luna cornua, dried in the temperature of 212°, contains 16 grains of marine acid, and 9 of water.

§ II.

45. Of Stones inſoluble in Spirit of Nitre 1,4; but wholly or partially ſoluble, and with Efferveſcence, in Spirit of Nitre 1,25, in the Temperature of 60°.

46. Theſe ſtones are of the ſtronthian genus, but may contain a mixture of barytes, baroſelenite, gypſum, argill, calx of iron, and ſilex.

47. How ſtronthian barytes and argill ſhould be ſeparated, may be ſeen from No. 31 to No. 35.

48. How gypſum, baroſelenite, calces of iron, and ſilex, may be diſtinguiſhed and ſeparated, has been ſhewn from No. 35 to 41 incluſively.

49. The nitrous acid 1,25 may, along with the ſtronthian, diſſolve a portion of gypſum; this however, cannot ſtand in the ſolution along with the ſtronthian, as it would immediately be decompoſed and a vitriolated ſtronthian formed; this would precipitate, and ſhould be decompoſed by calcination with mild ſoda, as in No. 35, the alkaline part waſhed off, and treated for vitriolic acid, ſilex, and argill, as in No. 36 and 37.

50. The depoſite on the filtre from the alkaline ſolution may then conſiſt of mild ſtronthian, barytes, and calx, as alſo of argill, ſilex, and calx of iron.

51. To ſeparate them, the whole, or all that is eaſily ſoluble, ſhould be diſſolved by digeſtion in nitrous acid; the digeſtion need not be obſtinate, as only the argill, ſilex, and calx of iron, can make any conſiderable reſiſtance, and they may afterwards be treated apart, as in No 34 and 41.

52. The barytic ſtronthian and calcareous earths being held in ſolution together, perhaps with ſome portions of argill and calx of iron, the two laſt ſhould be got rid of by precipitation with cauſtic volatile alkali, and afterwards ſeparated from each other by the means already often mentioned.

53. The ſolution is now ſuppoſed to contain only the three firſt earths; to aſcertain this point it ſhould firſt be well boiled, to expel the fixed air that might have been abſorbed, and then a ſmall portion of it eſſayed with ſtronthian lime water; if this produces a precipitate we may be aſſured that calx exiſts in the ſolution, otherwiſe not.

54. If ſtronthian lime-water produces no precipitation, we ſhould eſſay another portion of the ſolution with barytic lime-water; if this produces a precipitate (ſtronthian lime-water producing none), we may infer that ſtronthian exiſts in the ſolution, and not calx; but, if barytic lime water produces none, we may conclude that barytes only exiſts in the ſolution; if both ſtronthian lime-water and barytic lime-water occaſion precipitates, it remains dubious whether the three earths

earths are contained in the ſolution, as this appearance would take place if calcareous earth alone exiſted in it.

55. This doubt, however, may be reſolved by evaporating the ſolution in a moderate degree, and ſuffering it to cool; for, firſt, the nitrated barytes, and then the nitrated ſtronthian, would cryſtalize; the nitrated calx, not. The nitrated ſtronthian is ſoluble in once or twice its weight of water; the nitrated barytes requires much more.

56. Or ſtill better, by precipitating the whole with vitriolic acid, filtering and evaporating the remainder nearly to dryneſs, to obtain the whole of the ſelenite, if there be any, the depoſite on the filtre will then be freed from ſelenite by repeated affuſions of hot water, and the ſolution, by evaporation, will depoſite it, adding ſpirit of wine towards the end.

57. This being done, the precipitate on the filtre can now conſiſt only of vitriolated ſtronthian and barytes; to ſeparate theſe, the dried maſs muſt be heated with two and a half times its weight of dephlegmated aërated ſoda to redneſs, for an hour or more, in a ſilver crucible, and then the alkaline matter waſhed off on a filtre.

58. The depoſite on the filtre, ignited and weighed, ſhould then be treated with nitrous acid, which will hold both the ſtronthian and barytic earths diſſolved; the ſolution, having been boiled for ſome time, may be heated with barytic lime-water, which will precipitate the ſtronthian, if any exiſts in it, if not, it is wholly barytic.

59. If ſtronthian exiſts in it, it will be left on the filtre in the ſtate of lime, which ſhould again be rediſſolved in nitrous acid, and precipitated by

mild volatile alkali; this, waſhed, dried, heated, and weighed, gives the quantity of mild ſtronthian, which, ſubtracted from that of the mixed depoſite, No. 58, gives that of the mild barytes. It is probable alſo, that nitrated barytes and ſtronthian may be ſeparated by cryſtallization, as the barytic part may be preſumed to cryſtallize long before the nitrated ſtronthian.

§ III.

60. Of Stones inſoluble in nitrous acid 1,2, but totally or partially ſoluble in Spirit of Nitre, whoſe ſpecific gravity is 1,10, and with effervescence,

61. Theſe ſtones conſiſt of mild barytes, with, perhaps, a mixture of gypſum, baroſelenite, argill, ſilex, and calx of iron; the barytic part being diſſolved, how the others ſhould be ſeparated has been ſhewn from No. 35 to 41 incluſively.

§ IV.

§ IV.

62. Of Stone ſoluble in nitrous Acid, with none, or ſcarce any, Efferveſcence, in the Temperature of the Atmoſphere.

63. Of this ſort I know none but phoſphorated calx*; and, as it may contain ſome portions of aërated calx, to detect this, the portion of the ſtone to be analyzed ſhould be weighed and diſſolved in five times its weight of nitrous acid, and the loſs of weight, if any, indicating the aërated ſtate of the ſtone ſhould be noted, the ſolution filtred, the reſiduum on the filtre waſhed, and the waſhings added to the ſolution.

64. The filtred ſolution ſhould then be treated with cauſtic volatile alkali, which will precipitate the phoſphorated calx, and leave that portion of calx which was ſimply aërated in the ſolution; the phoſphorated calx ſhould then be ſeparated by filtration, waſhed, dried, and heated.

65. The ſolution, now containing the aërated calx ſingly, ſhould be heated with mild volatile alkali, which will precipitate the calx in an aërated ſtate, to be afterwards waſhed, dried, and heated to redneſs for half an hour, and then weighed; the quantity of calx will be to the whole of the aërated calx as 5 to 9. If magneſia

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* Dolomias efferveſce more conſiderably and durably.

be

be ſuſpected, the ſolution may be treated with vitriolic acid, as ſhewn from No. 7 to 10 incluſively.

66. We now return to the phoſphorated calx, No. 64; this ſhould be diſſolved in four times its weight of nitrous acid; after ſolution, the vitriolic acid ſhould be added as long as any precipitate appears, the whole ſhould then be filtred, and the ſelenite on the filtre waſhed with dilute ſpirit of wine; the filtred liquor ſhould then be conſiderably evaporated, to make it depoſit the whole of the ſelenite; the ſpirit of wine may alſo be added to promote its ſeparation, and the whole afterwards caught on a filtre.

67. The ſelenite being thus expelled, the liquor ſhould again be ſlightly diluted, and kept in a boiling heat, to expel the nitrous acid; the phoſphoric will ſoon after thicken, and often grow purpliſh from mangeneſe contained in it; the glaſs containing it ſhould then be taken up and weighed; that this acid is the phoſphoric may be evinced by its copious precipitation of lime-water, by its giving white precipitates with the ſolutions of vitriol of iron, and nitrated mercury, and its inability to precipitate the ſolutions of nitrated or muriated barytes.

68. The ſelenite is next to be decompoſed by boiling it with mild ſoda, as in No. 10.

69. The depoſite on the filtre, No. 63, if any be, ſhould next be examined; it may contain gypſum, baroſelenite, argill, ſilex, and calces of iron, the ſeparation has been already ſhewn, from No. 35 to 41.

Phoſpholite ſhould alſo be diſtilled with its own weight of ſtrong vitriolic acid, to diſcover whether it contains the fluor acid, as it often does; the ſparry

ſparry acid air may be known by its abſorption by moiſt charcoal, on which it depoſites a ſiliceous cruſt. It may alſo be eſſayed for marine acid by boiling it in water, and examining the water by the ſolution of ſilver.

§ V.

70. Of Stones that efferveſce ſlightly with the Concentrated Vitriolic, but not with the Nitrous Acid.

71. The only ſtones I am acquainted with are the fluors which conſiſt of calx and fluor acid, with ſome mixture of ſilex and iron.

72. To analyze theſe or any other ſtone ſuſpected to contain the fluor acid, let one part of the pulverized ſtone be well mixed with two parts of dried mild ſoda, and the mixture melted in a ſilver crucible; let the melted maſs pulverized be thrown into warm water, and digeſted in a boiling heat in a pewter veſſel, and then filtered; the earthy part will remain on the filtre, and ſhould be waſhed, dried, and heated to redneſs.

73. The ſolution then containing the alkali united to the ſparry acid ſhould be ſlightly evaporated, and the unſaturated part of the alkali neutralized by diſtilled vinegar (as this will not expel the ſparry acid), and then boiled to expel the fixed air abſorbed during the ſaturation with the acetous acid.

74. The ſolution of fluorated ſoda, being thus prepared, diſſolve a known portion of acetated lead in a known weight of pure water (to which a little diſtilled vinegar ſhould be added to prevent precipitation), and gradually drop the ſolution into that of fluorated ſoda; the fluor acid will unite to the lead, and immediately precipitate; ſeparate this precipitate by filtration, waſh, dry, and heat it to 400°, and then weigh it; its weight, minus that of the lead and of the ſilex that may be mixed with it, gives that of the ſparry acid contained in the ſtone.

75. To find the weight of the lead and ſilex, two proceſſes are neceſſary:

Firſt, Mix the fluorated lead well pulverized with about its own weight of charcoal, place the mixture in a covered crucible, and heat it to whiteneſs for a quarter of an hour; weigh the reduced lead.

Second, Take a quantity of acetated lead (or double, or treble, &c.) to that employed in precipitating the ſparry acid, reduce it by fuſion with charcoal as before, and find its weight.

76. If the weight of the lead found by the ſecond proceſs be juſt equal (or double or treble, if ſuch quantities were uſed) to that found in the firſt proceſs, then the fluorated lead, No. 74, contained nothing but lead and ſparry acid; but if the lead in the ſecond proceſs exceeds the proportions juſt mentioned, the exceſs denotes the weight of the ſilex mixed with the fluorated lead; if it fell ſhort, the operations were ill conducted, and ſhould be repeated.

77. Another method of finding the quantity of lead in the fluorated lead may alſo be employed: let a quantity of acetated lead, equal to that

that uſed in precipitating the ſparry acid, be diſſolved in water, and to this ſolution add as much vitriolic acid as is neceſſary to precipitate the lead, then evaporate the whole to dryneſs, and heat the dry maſs to redneſs for near a quarter of an hour, its quantity of lead will be ſeven-tenths of the whole weight.

78. The depoſite on the filtre, No. 72, ſhould next be examined, and aſſayed for phoſphoric acid, as ſhewn in No. 66; and alſo by volatile alkali, and the ſilex and calces of iron ſeparated, as in No. 41.

§ VI.

79. Of Stones ſoluble without Effervefcence in the nitrous Acid, but whoſe Solution requires a Heat of from 180° to 212°.

80. Stones compounded of argill and unaërated calx, or magneſia, or either or both of theſe earths, combined with the boracic acid, are comprehended under this head.

81. To diſcover and ſeparate this acid, theſe ſtones, heated, pulverized, and weighed, ſhould be digeſted in the nitrous acid, to which concentrated vitriolic acid, one quarter of the weight of the ſtone, ſhould afterwards be added, and the whole gently evaporated, nearly to dryneſs, in a glaſs retort; during the exſiccation, part of the boracic acid will ſublime; ſpirit of wine added

added to the dry maſs, while ſtill hot, repeatedly, will diſſolve the remainder; when the ſpirit of wine takes up no more (which will be known by evaporating it to dryneſs), water ſhould be added to detach the maſs from the retort, and the whole thrown on a filtre, waſhed, dried, and mixed with 2,5 its weight of dried mild ſoda, and heated to redneſs for one or two hours, then thrown on a filtre and waſhed.

82. The filtred liquor, ſaturated with an acid, and boiled to expel the fixed air, and gradually evaporated, will depoſit the ſiliceous and poſſibly the argillaceous matter it may contain.

83. The waſhed maſs, No. 81, ſhould then be dried, diſſolved in nitrous acid, and heated with cauſtic volatile alkali, to precipitate the argill and part of the magneſia it may contain; and then proceed, as ſhewn from No. 6 to 30.

§ VII.

84. Of Stones inſoluble in Acids, without particular Management, or, at leaſt, ſcarcely ſoluble, and with little or no Effervеſcence. Of this Sort are moſt of the Stones of the Muriatic, Argillaceous, and Siliceous Genera, and alſo Gypſum and Baroſelenite.

85. All theſe, even the ſofter, are much more eaſily decompoſed when their parts are diſintegrated by torrefaction, in a low red heat, with twice, or twice and a half, their weight of dried mild

mild ſoda, avoiding fuſion, but the hardeſt, as the precious ſtones may be even melted with ſix or eight times their weight of cauſtic fixed alkali, and one or other of theſe operations ſhould be repeated until the ſiliceous part of the ſtone, after digeſtion in aqua regia, and ſubſequent torrefaction, becomes white, and perfectly vitrifies with its own weight of fixed alkali, with efferveſcence, or abſolutely refuſes to do ſo, and thus appears to be adamantine.

86. The torrefied, or melted maſs, if whitiſh, contains but little of any metal; if bluiſh, probably manganeſe; if greeniſh, manganeſe and iron; it ſhould then be well pulverized, thrown on a filtre, and treated with pure water, until the water comes off taſteleſs. Many ſaturate the alkalized maſs immediately with nitrous or marine acid, inſtead of water; and often this is advantageous and proper, as all the ſoluble earths are then in a greater ſtate of diviſion, and conſequently more eaſily ſoluble; but it may alſo happen, that the ſtone contains the vitriolic acid, which, during torrefaction, with the alkali, unites with this alkali, and alſo calx, or barytes, or magneſia; when the whole is afterwards diſſolved in the nitrous or marine acids, a double decompoſition in this caſe takes place, and the ſelenite or baroſelenite are re-produced. Hence the former method is *in general* the ſafeſt.

87. The alkaline ſolution ſhould be duly evaporated if too aqueous, and ſaturated with nitrous acid, even to a ſlight exceſs; the ſiliceous part of the ſtone will thus be precipitated frequently in a gelatinous form; and, to haſten its precipitation, it ſhould be heated to 180°, and gradually evaporated to a conſiderable degree; ſome argill,

argill, alſo taken up by the alkali, often thus is depoſited. The neutralized liquor ſhould then be filtred, the depoſit waſhed, and dried, and the filtred liquor eſſayed for vitriolic acid, as in No. 37.

88. The depoſites, No. 87, may conſiſt of ſilex and argill, which are beſt ſeparated by boiling in the vitriolic acid, and precipitating the ſolution by mild volatile alkali; the argill thus found, to be dried, heated to redneſs for half an hour, and weighed, or eſſayed, for jargonia, as already mentioned; the ſilex alſo to be heated, and weighed, as before ſhewn.

89. We now proceed to the filtred maſs, No. 86; this may conſiſt of mild calx, ſtronthian, barytes, magneſia, argill, jargonia, adamantine, beſides ſome remains of ſilex, with calces of iron, manganeſe, or nickel, or ſome undecompoſed part of the original ſtone.

90. To ſeparate theſe, or as many of them as exiſt in the ſtone, treat the whole with aqua regia, formed of two parts marine, and one part nitrous acid, in a retort, and boiling heat, repeatedly cohobating, or adding freſh acid, until the whole, or nearly the whole, if poſſible, is diſſolved; what eſcapes ſolution may be either ſilex or adamantine, which may be decided by its fuſibility or infuſibility with fixed alkalis. If Sydneia be ſuſpected, it may be diſcovered by its ſolution in pure marine acid, precipitation by water, and other teſts of that earth. If any conſiderable part of the ſtone has eſcaped decompoſition, it ſhould again be torrefied with fixed alkalis.

91. The ſoluble earths being thus held in ſolution, the colour of the ſolution is to be conſi-

dered; if yellowiſh, it probably contains iron, and no other, or but little of any other metallic ſubſtance; if browniſh, probably manganeſe; if greeniſh, poſſibly nickel, or copper; if bluiſh, copper.

92. To diſtinguiſh whether the greeniſh colour proceeds from nickel, or copper, ſuperſaturate a portion of the ſolution with cauſtic volatile alkali; if a blue colour does not ariſe, the colour muſt be from iron; but if the colour changes blue, it muſt be from copper, or nickel; if from copper, a clean poliſhed iron will precipitate the copper, but, if from nickel, it will be of no effect; beſides, the calx of nickel will recover its greeniſh colour as ſoon as the volatile alkali is exhaled, whereas that of copper will not.

93. If the ſolution contains no other metallic ſubſtance, but iron, or iron and manganeſe, we may precipitate theſe by cauſtic volatile alkali; the precipitate filtred, waſhed, and heated to redneſs, ſhould be repeatedly treated with nitrous acid, evaporated to dryneſs until the calces become thoroughly oxygenated, and, finally, the argill and magneſia that may exiſt in the precipitate are to be re-diſſolved, and ſeparated from the metallic calces by dilute nitrous acid, and from each other, as ſhewn from No. 19 to 29 incluſively.

94. The calces of iron and manganeſe are next to be ſeparated; to effect this, let them be boiled in a concentrated lye of cauſtic vegetable alkali, which will take up the manganeſe, and not the iron; or let them be well mixed with eight or ten times their weight of pulverized nitre thrown into a crucible, and kept in fuſion for one hour; pour the melted maſs on a ſtone ſlab, leaving the iron

iron at bottom; let the melted maſs be pulverized, and thrown into a glaſs veſſel filled with water; it will exhibit various colours, and, in a few days, ſubſide in a brown maſs; pour off the filtred water, and treat this brown maſs with dilute nitrous acid, adding ſugar, from time to time, or, what is ſtill better, ſulphureous acid, the calx of manganeſe will ſoon diſſolve, precipitate the ſolution with mild ſoda, and weigh the white precipitate, gently dried, of which 180 grains denote 100 of the regulus of manganeſe; the weight of iron is to be determined as in No. 30.

95. If the ſolution contains other metallic ſubſtances, it ſeems beſt, after expulſion of exceſs of acid, and ſufficient dilution, to precipitate them by cryſtallized Pruſſian alkali, made as directed in the ſequel, the quantity employed ſhould be known, and noted; if the precipitation be ſlow, the ſolution ſhould be warmed, or even heated nearly to boiling, ſpirit of wine being added, and often filtred. I ſhall ſuppoſe the precipitate, now obtained, to contain the different metallic ſubſtances, it ſhould be waſhed, and the firſt waſhings added to the ſolution, as theſe waſhings contain part of the ſolution of the earths entangled in the precipitate, but when the waſhings ceaſe to be acid, or when it is perceived that, when mixed with the ſolution of iron they produce a blue, they ſhould ceaſe, otherwiſe much of the precipitate would be carried off. When waſhed, it ſhould be thoroughly dried, heated to redneſs, and weighed.

96. In this ſtate the calces ſuppoſed to contain nickel, cobalt, and copper, are to be treated with cauſtic volatile alkali, which will turn blue,

with the calces of copper, or nickel, and gradually extract them; to be certain that the whole of the nickel is ſeparated, the precipitate ſhould be again diſſolved in the nitrous acid, the ſolution evaporated to dryneſs, weighed, and repeatedly treated with cauſtic volatile alkali, as long as it aſſumes a blue colour.

97. To ſeparate the calces of copper and nickel, the volatile alkaline ſolution ſhould be duly ſeparated with any acid.

98. If there be any cobalt in the ſolution, it would be precipitated during the ſaturation.

99. The neutralized ſolution ſhould be then divided into two equal portions; into one of which clean poliſhed iron plates ſhould be immerſed; on theſe the copper contained in that portion of the ſolution will be depoſited; this ſhould be ſcraped off, and the operation continued as long as any copper remains; as theſe depoſits, however, are contaminated with iron, they ſhould be re-diſſolved in nitrous acid, the ſolution evaporated to dryneſs, and again treated with cauſtic volatile alkali, which will take up the calces of copper ſingly; the alkaline ſolution evaporated to dryneſs, and the reſiduum heated to redneſs for half an hour, is the true weight of the calx of copper.

100. The ſecond portion of the neutralized ſolution ſhould then be evaporated to dryneſs, heated in the ſame manner, and weighed: from this weight ſubtract that of the calx of copper found in the laſt proceſs, the remainder gives the weight of the calx of nickel contained in the ſecond portion, which doubled gives that of the nickel in both portions, as the weight of the copper

copper doubled gives the whole of that of copper.

101. The reſidue of the calces left by the cauſtic volatile alkali, No. 96, containing either iron, or iron and manganeſe, is to be treated as in No. 94; but, from the weight of the iron, we muſt ſubtract that of the calces contained in the Pruſſian alkali employed, of which we ſhall preſently treat.

102. We now return to the ſolution, No. 95, which we ſuppoſe cleared from all metallic ſubſtances, but *poſſibly* containing all the earths (though, if the metallic ſubſtances were precipitated by cauſtic volatile alkali, the argill and jargonia would alſo be ſeparated). Not that *all* theſe earths have ever been found together in any ſtone, but as three or four of them indiſcriminately taken often have, it is neceſſary to give a general method of diſcriminating and ſevering them; it were beſt, however, to inſtitute ſmall eſſays of each, to find which of them ſhould be excluded from attention. Thus, if vitriolic acid, inſtilled into a portion of the ſolution, does not, after 10 or 15 minutes, cauſe a precipitate, we may be aſſured that neither barytes nor ſtronthian exiſt in it; and if, even after evaporation of the eſſayed portion, no precipitate appears, calx alſo may be excluded. So, if cauſtic volatile alkali cauſes no precipitate, argill and magneſia may be excluded from the ſolution; if it does cauſe a precipitate, let this precipitate be re-diſſolved, and again precipitated by mild volatile alkali, and dry it well; if then it eaſily diſſolves in marine acid, it is magneſia, and argill may be excluded; but if not it is argill, and magneſia

may be excluded *. But if all theſe be found, as they often are, operate as follows:

103. Dilute the ſolution pretty largely, and precipitate the barytes, ſtronthian, and calx, by adding vitriolic acid as long as any precipitation appears; filtre this off, waſh it; it will probably contain only vitriolated barytes and ſtronthian.

104. Evaporate the ſolution ſtill farther, and add a few drops of vitriolic acid; if a precipitate then appears, it is vitriolated calx; add the vitriolic acid until this alſo ceaſes; filtre, and waſh the matter on the filtre with dilute ſpirit of wine; evaporate ſtill farther, more ſelenite will appear, which is to be filtred off, waſhed, and dried, as the former product, and at laſt heated and treated as in No. 10.

105. The waſhed maſs, 103, ſhould then be eſſayed for ſelenite, by pouring on it 500 times its weight of water, heated to 180; if this affords no precipitate with ſtronthian lime-water, we may be aſſured it contains no ſelenite; if it does, the ſelenite ſhould be waſhed off.

106. The vitriolated maſs, 103, containing nothing but vitriolated barytes or ſtronthian, or both, ſhould then be treated as ſhewn from No. 57 to 59 incluſively.

107. The ſolution, No. 103, can now contain nothing elſe but magneſia and argill; theſe are, therefore, to be precipitated by mild volatile alkali, and ſeparated, as ſhewn from No. 21 to 30.

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* Set aſide ſome proportionate part of the ſolution, as one eighth, or one tenth, for ſuch eſſays to be afterwards brought into the general account.

§ VIII.

Of the Pruſſian Alkali.

The Pruſſian alkali is an agent of great importance, as it is an infallible teſt, not only of metallic ſubſtances in general, held in ſolution by any unmetallic acid (platina excepted), but even of the ſpecies and weight of that metal, if ſingle, and the alkali properly conditioned.

To anſwer theſe purpoſes, it muſt be carefully prepared and properly applied; otherwiſe it will not only precipitate metals without their characteriſtic colours, or any deſignation of their weight, but alſo earthy ſubſtances, and particularly the barytic and the argillaceous.

To apprehend the reaſons which determine the preference of one among the many preparations that have been hitherto deviſed, it is neceſſary to ſtate a few circumſtances relative to its general nature and mode of action, which have not yet been ſufficiently developed.

Pruſſian, or Pruſſiated alkali, formerly called the phlogiſticated alkali, is an alkali united to a particular tinging ſubſtance by the intermediation of iron, calcined indeed, but only to that degree that does not prevent it from ſtill being magnetic.

This tinging matter is itſelf an acid of the volatile kind, and of a very peculiar nature; for, though it ſeems to have a greater affinity to alkalis and earths than to any metal, yet it unites to them much more difficultly when in its free ſtate, and adheres to them more feebly than the metallic ſubſtances, which I ſuſpect ariſes from its being more condenſed in the latter than the former. When united to alkalis it is ſeparable from them by the mere action of ſolar light, and alſo by a heat not exceeding 110°, or even a lower, in a longer time.

Metallic ſubſtances united to this acid are called Pruſſiated Metals.

Alkalis and earths extract this acid imperfectly from Pruſſiated metals; but, when once united to this acid, they have a ſtrong affinity to the metals whence they received it, and thus form triple ſalts, or rather ſaline compounds, called Pruſſiated alkalis, or Pruſſiated calx, &c. Pruſſiated alkalis, to whoſe conſideration I now confine myſelf, are capable of cryſtallization (except the volatile), and ſoluble in three or four times their weight of water, in the temperature of the atmoſphere; moreover, if not overloaded with iron, the metal to which they are commonly united, they are not readily decompoſed by acids without the aſſiſtance of heat, or digeſtion in large quantities of the ſtronger acids.

On the other hand, iron (or rather its calces) forms, with the Pruſſian acid, compounds of two different kinds; the one fully ſaturated, the other unſaturated.

Calces of iron, thus circumſtanced, preſent different colours; the fully ſaturated, a deep blue, and intermediate gradations of ſaturation, with correſponding ſhades of blue; the unſaturated are yellow; when both are mixed they afford a green.

The unſaturated calces have a ſtrong affinity to the quantity of Pruſſian acid requiſite to ſaturate them; they are alſo ſoluble in common acids; but, if the common acids are not in ſufficient quantity to diſſolve the whole of them, the Pruſſian acid expelled from the diſſolved part unites to the undiſſolved part, and converts this by ſaturating it into a blue calx; the blue calx is very difficultly decompoſed by any acid, even the ſtrongeſt, in the temperature of the atmoſphere.

Alkalis and earths unite with both ſorts of calces, but moſt ſtrongly with the blue, yet they can unite with either; they muſt themſelves be impregnated with a portion of the Pruſſian acid, of which they ſtrip them, as already ſaid.

Hence when an alkali or earth is digeſted with a blue calx, it firſt ſtrips a part of its ſaturating proportion of the tinging acid, and thus converts that part into the yellow calx, it then takes up not only a portion of blue calx, but a ſtill larger of the yellow calx. Now, to expel from the alkali this yellow part, which adheres more weakly to it than the blue, is, or ought to be, the object of all purifications of this teſt. If to an alkali, which contains a large proportion of this yellow calx, an acid be added, the precipitate will nevertheleſs be blue, becauſe that part of the tinging matter that was more immediately united to the alkali quits it, and, joining the yellow calx, renders it blue.

I now proceed to examine the preparations of this teſt, that have been moſt frequently uſed in mineral analyſes.

The

The firſt, and original compound of this ſort, is that which is called the blood lye, being formed by the calcination of dried blood, with fixed alkalis. In this compound the tinging matter, accompanied with a ſmall proportion of the calx of iron, is combined with the fixed alkali; but the high degree of heat in which the union takes place, and the ſmall proportion of iron prevents the alkali from being perfectly ſaturated, or, at leaſt from being ſo, firmly and durably; beſides, in the alkali uſually employed, there is a contamination of vitriolated tartar, or vitriolated ſoda, ſome coal from the blood, with volatile alkali, and ſulphur reſulting from the mixture of the coal and the vitriolated ſalts, during ignition.

This, therefore, is an improper teſt; its unſaturated or feebly ſaturated part decompoſes ſolutions of earths, particularly when they contain an exceſs of acid, as thoſe of alum and barytes always do; the vitriolated ſalts alſo precipitate barytic, ſtronthian, and calcareous earths; theſe latter inviſibly, if the ſolution be dilute. This lye, poured on a ſolution of iron, produces a greeniſh precipitate; but an acid, poured on the precipitate, turns it blue, by diſſolving the yellow calx, produced either by the action of the unſaturated part of the alkali, or owing its colour to imperfect ſaturation with the tinging matter.

Hence the common Berlin blue of the ſhops is produced by the mixed ſolutions of vitriol of iron and of the alum by the blood lye; for the acid of the alum neutralizes the unſaturated part of the blood lye, and alſo that which might be feebly impregnated with the tinging matter, and hence the precipitate is blue.

It is plain, therefore, that the Berlin blue, ſo I call the Pruſſian blue of the ſhops, is not pure Pruſſiated iron, but a mixture of this with embryon alum; that is, with alum which is barely ſtripped of its exceſs of acid, together with coal, ſulphur, and other impurities of the blood lye.

Macquer firſt diſcovered that Pruſſiated iron, or Berlin blue, might be ſtripped of the tinging matter by digeſtion with alkalis; and that theſe, when ſaturated, do not decompoſe ſaturate ſolutions of any earth, though, by means of a double affinity, they decompoſe and precipitate metallic ſolution; an alkaline lye, thus ſaturated with the Pruſſian acid, or Pruſſiated iron, is called Macquer's Lye or Teſt.

It is to be remarked, however, that though an alkali may thus be neutralized, it will not long continue neutral, becauſe it takes up much of the yellow calx (which originates from the heat neceſſarily employed to impregnate the whole of the alkali); and this calx, adhering lightly, ſoon falls in the form of a blue calx, particularly if expoſed to the air, from which the alkali may derive the aërial acid; ſo alſo mineral acids, or even weaker acids, decompoſe it, if not immediately, at leaſt after a few hours, an effect which has often been falſely aſcribed to the iron contained in thoſe acids; hence earthy ſolutions that contain an exceſs of acid, as thoſe of alum and barytes, are ſoon precipitated by it; yet if theſe ſolutions contain a large exceſs of acid they may eſcape precipitation, as, after ſaturating the weakly combined part of the alkali, enough of the exceſs may ſtill remain to keep the earths in ſolution,

ſolution, but they will aſſume a blue colour, from the precipitation of the yellow calx, as already explained. This lye alſo takes up the ſulphur, coal, and, by the waſhings, part of the tartar vitriolate and earth of alum contained in the Berlin blue, for which reaſon it will always precipitate barytic or ſtronthian ſolutions viſibly, and thoſe of calx, though perhaps inviſibly, by reaſon of the greater ſolubility of ſelenite, and hence it is a bad teſt for metals.

Baumé endeavoured to remedy theſe defects, by adding diſtilled vinegar until the lye ceaſed to depoſit a blue calx; but, as the action of this weak acid muſt be exerted ſome hours, and even days, before it can precipitate various gradations even of the yellow calx, it is impoſſible to determine its quantity with preciſion; if too little be added, the lye ſtill continues defective; and if too much, this, after many days, or perhaps weeks, will looſen the union of the blue calx, by expelling from the alkali that portion of the tinging matter neceſſary to keep it in the ſtate of a blue, and leaving it for a while only that which retains a yellow calx united to the alkali, and thus leaves it in a ſhort time as imperfect as at firſt; beſides, the vitriolic contaminations ſtill remain.

Mr. Bergman's lye is the ſame as that of Macquer; the proportions only being more accurately defined, for the purpoſe of ſubſequent correction. His alkali is formed by the detonation of equal parts nitre and cream of tartar, and, conſequently, nearly cauſtic. This he diſſolves in about a pint of water, and digeſts with four times its weight of Berlin blue, gradually added until it ceaſes to be diſcoloured, ſupplying it with

with water, in proportion to the quantity evaporated; and, laſtly, boiling the whole for half an hour. This lye it is evident takes up the ſame impurities as the former, and is equally defective.

Others have prepared this teſt by ſaturating lime with the Pruſſian acid; but, as it is decompoſed by the mere action of the vitriolic acid, it is frequently fallacious, not to inſiſt on other defects.

Others prepare it by ſaturating volatile alkali with the tinging matter; this, if it could keep always homogeneous, would anſwer remarkably well. I omit various other methods of purification that have been deviſed, as they have not been employed in mineral analyſis. I ſhall only remark, that almoſt all of them leave ſo much Pruſſiated iron combined with the Pruſſiated alkali as totally to diſguiſe the colours of the metals precipitated by them. In general, any preparation of this teſt that contains, when in a dry form, more than 30 per ct. of Pruſſiated iron, will diſguiſe the colour of moſt other metals precipitated by it, even a ſmaller quantity will produce this effect if it contains the yellow calx. Now, by Weſtrumb's experiments, Macquer's Pruſſiated alkali cryſtallized affords 40 per ct. of Pruſſiated iron, and after Baumé's purification 33; Bergman's purified by ſpirit of ſalt 28; Fourcroy's 31; Scopoli's 27; Giovanetti's 24; Brugnatelli's 24; Struvius's 22; Klaproth's 22. I ſay affords, for, in fact, the iron they contain is not fully Pruſſiated until it and the tinging matter are expelled from the alkalis by the ſupervening acid.

The ſame able and induſtrious chemiſt has ſhewn that Pruſſiated iron, well waſhed and dried, contains very nearly half its weight of the tinging matter; and it will preſently be ſeen that 100 parts vegetable alkali take up 46 of the tinging matter.

Of Klaproth's Teſt and its Application.

1. Prepare a pure vegetable alkali, by gradually projecting a mixture of equal parts purified, nitre and cryſtals of tartar into a large crucible heated to whiteneſs; when the whole is injected, let it be heated to whiteneſs for half an hour, to burn off the coal.

2. Detach the alkali thus obtained from the crucible, reduce it to powder, ſpread it on a muffle, and expoſe it to a white heat for half an hour.

3. Diſſolve the calcined ſalt in ſix times its weight of water, and filtre the ſolution while warm.

4. Pour this ſolution into a glaſs cucurbit or receiver, heated to 170 or 180°, in a ſand furnace, and then gradually add the beſt Pruſſian blue in powder, injecting new portions according as the former becomes grey, and ſupplying water as faſt as it evaporates; continue until the added portions are no longer diſcoloured, then increaſe the heat to 212°, for half an hour.

5. Filtre the lye, thus obtained, and ſaturate it with vitriolic acid, moderately diluted; a precipitate will appear when this ceaſes; filtre off the whole, and waſh the precipitate.

6. Evaporate the filtred liquor to about one quarter, and ſet it to cryſtallize; after a few days, yellowiſh, cubic, or quadrangular cryſtals will be found mixed with ſome tartar vitriolate, and calx of iron; pick out the yellowiſh cryſtals, lay them on blotting paper, and rediſſolve them in four times their weight of cold water, to exclude the tartar vitriolate.

7. Eſſay a few drops of this ſolution with barytic lime-water, and add ſome to the remainder; if neceſſary, filtre off the ſolution, and ſet it to cryſtallize for a few days; thus the barytic lime, if any ſhould remain, will be precipitated; if the cryſtals, now obtained, are of a pale yellow colour, and diſcover no bluiſh ſtripes when ſprinkled over with marine acid, they are fit for uſe; but, if they ſtill diſcover bluiſh or green ſtreaks, the ſolutions and cryſtallizations muſt be repeated.

8. Theſe cryſtals muſt be kept in a well-ſtopped bottle; and I think it right to fill it with ſpirit of wine, to preſerve them from the air, as they are inſoluble in ſpirits.

9, Before they are uſed, the quantity of iron they retain (and which I therefore call their *retent*) ſhould be aſcertained, by heating 100 grains to redneſs for half an hour in an *open* crucible, the Pruſſian acid will be conſumed, and the iron will remain in the ſtate of a reddiſh brown magnetic calx, which ſhould be weighed, and noted; if the calx be black, it will weigh conſiderably more than it ſhould, and muſt be calcined anew; the red calx is half the weight of the Pruſſian blue, afforded by the Pruſſian alkali; its weight muſt be ſubtracted from that of metallic precipitates formed by this teſt. Hence the weight of the

the cryſtals, in a given quantity of the ſolution ſhould be noted, that the quantity employed in precipitation may be known.

Remarks on the Analyſis already made.

It has been to many matter of much ſurprize that the ſame ſtone, analyzed by different eminent artiſts, has been found to contain either different ingredients, or, at leaſt, different proportions of the ſame ingredients; of ſuch differing reſults, various examples have been ſeen in the foregoing chapters; ſeveral have been led to ſuſpect, that chemical analyſes have hitherto been either very imperfect, or totally uſeleſs.

The opinion, however, of the inutility of developing the principles of which any compound conſiſts, is too abſurd to deſerve attention; who can deny the properties of a compound are either the reſults of thoſe of the ingredients of which it conſiſts, modified by the proportion of thoſe ingredients, or new ones reſulting from, and grounded on, particular proportions of thoſe ingredients, neither of which circumſtances can be determined otherwiſe than by analytic inveſtigation?

The imperfection of many of the analyſes hitherto made muſt indeed be allowed, though the inſtances are not ſo frequent as have been imagined; ſeveral ſtones that have been denoted by the ſame name are in reality different, and have been found to be ſo, ,even by an attentive conſideration of their external characters; for inſtance, the different ſorts of felſpar, ſhorl, actynolites, &c. no wonder, therefore, that their analyſes ſhould preſent different reſults.

The real imperfections of many analyſes have ariſen from various cauſes; as, firſt, our ignorance of ſome of the ſimple earths, thus ſtronthian has hitherto been confounded with barytes, or perhaps with calx, jargonia with argill, and adamantine with ſilex; ſydneia has as yet been ſcarcely noticed; this ſource of error, inevitable in an art ſprung up within theſe twenty years, will neceſſarily daily diminiſh; analyſts will become more circumſpect in determining the nature of any ſubſtance, before two or three of its moſt eſſential properties will have been aſcertained.

Secondly, Many deceptions have ariſen from the eroſion of mortars, during trituration, many from the mixture of the earths of crucibles during calcination.

Thirdly, The difference of the proportion of ingredients in many ſubſtances is often more apparent than real, ariſing intirely from the various degrees of deſiccation that have been employed by different analyſts, and ſometimes by the ſame; this point is ſo important, that I ſhall examine it more particularly, hoping that ſome of our moſt eminent artiſts may determine ſome preciſe degree, and the term of its duration that ſhould in future be always obſerved.

Mr. Bergman, in his eſſay on the analyſis of mineral waters treating of the weights of earths, mentions no preciſe limit or degree of heat to which they ſhould be expoſed; in his treatiſe on metallic precipitates, he requires indeed theſe to be dried, firſt in a gentle, and at laſt in the heat of boiling water for five minutes; but eſtimating the weight of different ſalts, in his eſſay on mineral waters, he takes them in their cryſtallized form, and conſequently dried in a low heat.

Siliceous earth he deſires ſhould be barely dried [*], I ſuppoſe in the temperature of the atmoſphere

With reſpect to *calx*, *argill*, and *magneſia*, in his treatiſe on mineral waters, he ſubmits to the operator whether the maſs that contains them ſhould be calcined or not [†], and then weighed; he ſeparates the magneſia and calx from the containing maſs by diſtilled vinegar; to obtain their joint weight, he requires the maſs from which they were extracted to be waſhed, *dried*, and weighed, and their weight diſcovered by the loſs of weight of the dried reſiduum. Here it is plain the reſiduum muſt again be calcined to diſcover the weight it had loſt, as in a lower heat this muſt vary conſiderably; but how the weights of the calx and magneſia, ſeparately, are to be determined, he does not clearly indicate. Nor in his eſſay on gems is he more explicit, defining the weight of the calx and magneſia only by the quantities of gypſum or Epſom they may yield, that of Epſom muſt vary conſiderably in a high heat. In his analyſis of lythomarga he directs the argill to be barely *dried* [‡].

Hence we ſee he follows no certain rule in eſtimating the quantities of argill, magneſia, and calx; theſe laſt he wiſhes rather to determine by the quantity of ſaline matter they yield when converted into ſalts and cryſtallized [§], the quantity of earth in theſe cryſtals being already

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[*] 2d Bergman, 92. 4th Bergman, 148.
[†] 1ſt Bergman, 123.
[‡] 4th Bergman, 151.
[§] 1ſt Bergman, 124.

determined; but it is well known that cryſtallization ſcarcely ever affords the whole of the ſubſtances contained in the ſolution; with regard to Epſom, in particular, its weight varies with the temperature of the water in which it was cryſtallized, and the heat and moiſture of the air in which theſe cryſtals are dried; this method is therefore very inſecure.

Moreover, Mr. Weſtrumb found that 69,75 grains of ſiliceous earth, precipitated from *liquor ſilicum* (ſilicited alkali) well waſhed and dried, weighed no more after expoſure to a red heat than 61,5, and conſequently loſt 11,8 per ct.*: whether this loſs of weight proceeds from ſome inflammable matter, or from water retained, it is equally certain that deſiccation in the heat of the atmoſphere does not determine the real quantity of this earth; on another occaſion he found ſilex weighing at 112°, 25,5 grains to weigh after a red heat only 22†, the difference is about 13,7 per ct.

By this remark I am far from meaning to detract from the merit of this truly reſpectable philoſopher, ſo far indeed that I freely own, that, in the few analyſes I made myſelf, I fell into the ſame miſtakes; ſuch errors are incident to the firſt attempts in every art.

With reſpect to argill, the difference of weight ariſing from different degrees of deſiccation is enormous. Mr. Wenzel found that argill precipitated by mild ſoda, and weighing when dried in the air 140 grains, might by ignition continued for two hours be reduced to 56, that is, to

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* 2d Chy. Ann. 1790, p. 218.

† 2d Bergb. 29.

leſs than one half its weight. Knock found that argill dried at 66° of Fahrenheit and 51 of Sauſſure, and then weighing 32 grains, loſt by ignition continued for one hour 12 grains, that is, 37,5 per ct.[*] Weſtrumb obſerved, dry argill, weighing 16,625 grains, to weigh after a long continued calcination only 10, it loſt therefore above 40 per ct.[†]; but this had been precipitated by cauſtic volatile alkali; in another experiment, argill that had been precipitated by mild ſoda, and conſequently taken up fixed air, weighed when dry 30 grains; but, after long continued ignition, he found it reduced to 10, and conſequently had loſt two thirds of its weight[‡]. Here then a diſtinction appears, which ſhould not be neglected; in my own experiments I generally found argill precipitated by mild volatile alkali, and dried in a heat of 70°, to loſe, in a red heat continued for half an hour, about 36 per ct. and unaërated argill, about 30 per ct. much, however, depends on the previous drying in air of different degrees of moiſture; for, Mr. Klaproth found aërated argill, well dried in a heat exceeding that of the atmoſphere, to loſe by two hours calcination only 30,5 per ct.[§].

Wiegleb for ſome time followed the method of Bergman; previous to the year 1786, he contented himſelf with barely drying his earths[‖]; but, ſince that period, he ſeems to have generally

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[*] 2d Chym. Ann. 1789, p. 24.

[†] 2d Bergb. 30.

[‡] 2d Bergb. 32. Knock denies the diſtinction; but it is evident he was ſomehow deceived.

[§] 5 Berl. Beob. 67.

[‖] 11 Nev. Entdeck. And 2d Chym. Ann. 1784, p. 146. 1ſt Chym. Ann. 1785, p. 25, 249, 394.

rally ignited them, though probably not long enough[*].

Weſtrumb has alſo conſtantly determined the weights of his earths by ignition, and in many inſtances has ſhewn the differences of their weights when heated in the uſual manner, and after ignition; he has proved that even ponderous ſpar requires ignition to dry it perfectly; but he does not ſeem to have regulated the time they ſhould be expoſed to a red heat.

Dr. Withering dried his argill in a low red heat for 10 minutes; the other earths he ſeems to have barely dried in the heat of the atmoſphere. Klaproth conſtantly aſcertains the weight of *all his earths*, after low ignition for half an hour. As in moſt ſtones the component earths are in an exceeding dry ſtate, and, if not, the weight of water and air they contain ſhould be aſcertained previous to their analyſis; it ſhould ſeem that the deſiccation occaſioned by ignition is that which approaches moſt to their natural ſtate, and conſequently ſhould always be obtained.

4. The difficulties accompanying the application of the Pruſſian teſt have occaſioned many errors.

Weigleb conſtantly employed the blood lye[†]: this is ſcarce ever perfectly ſaturated, and, at leaſt after a ſhort time, precipitates earths as well as metals; alſo, by reaſon of the vitriolic acid it contains, calx cannot eſcape it; hence perhaps he has detected none where others have found it; beſides, he makes no deduction for the iron contained in this alkali.

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[*] 1ſt Chym Ann. 1786, 117. 1ſt do. 1787, 19. And 1788, 49.

[†] 1ſt Crell, Beytrage, 55.

Mr. Bergman informs us, the Berlin blue he employed in making his Pruſſian alkali contained 23 per ct. of Pruſſiated iron; the remainder being argill, or embryon alum.

Of this Berlin blue, he employed in making a quart of his lye 960 grains; and, ſince 100 of the blue contain 23, 960 muſt have contained 220,8 of Pruſſiated iron.

But Pruſſiated iron only contains half its weight of the tinging matter, then his Pruſſiated iron contained 110,4 of Pruſſiated acid, and 110,4 of calx of iron.

A quart of his lye he computed to contain 240 grains of alkali, and 110,4 of Pruſſian acid, and 16 docimaſtic pounds (that is, 0,6 grains multiplied by 16) = 9,6 of Pruſſiated iron. Or four docimaſtic pounds of this iron (that is, 0,6 multiplied by 4 = 2,4 grains) for every 60 grains alkali, as 240 grains alkali make up 400 docimaſtic pounds.

He then tells us, that a precipitate made by this lye, dried, I ſhould ſuppoſe, in a heat of 212° for 5 minutes, contains one-ſixth of its weight of metallic iron, deducting 2,4 grains for every 60 grains of alkali employed in making the precipitate. He does not tell us whether this quantity ſhould be deducted from the ſixth part thus found, or from the whole precipitate by the diviſion by 6; or, in other words, whether it ſhould be deducted from the quotient or the dividend; in his ſecond volume, p. 435, he ſeems to require it ſhould be deducted from the quotient, though, in reaſon, it ſhould rather be deducted from the dividend, as he tells us it is undecompoſed Berlin blue; however this may be, in his Analyſis of Lythomarga, vol. IV. p.

149, and in that of Pouzzolana, vol. III. p. 193, and his Treatiſe on Gems, he totally omits this deduction.

Let us now ſee how, on Mr. Bergman's ſtatement, a weight exceeding five times that of the metallic iron precipitated could accrue. 100 grains of metallic iron, being reduced to a calcined ſtate, weigh 140 nearly; theſe, when Pruſſiated, ſhould weigh 280 grains, as has been ſhewn. Again, 240 grains alkali take up by Bergman's account 110,5 of the tinging matter, then 304 of alkali would be requiſite to take up 140 of the tinging matter, the quantity required to Pruſſiate the 140 grains of iron. But every 60 grains of alkali depoſit 2,4, therefore 304 ſhould depoſit 12,16, then the weight of the precipitate ſhould be 280 + 12,16 = 292,16: 307 remain to be accounted for, and muſt by him be deemed to proceed from the argill and coal taken up by the alkali, and ſome alkali retained, beſides water *. Mr. Bergman does not ſtrictly adhere to the poſition, that 100 grains iron, ſeparated by the Pruſſian alkali, forms a precipitate weighing 600 grains; for, vol. II. p. 392, he reduces it to 590. Mr. Gadolin, in a maſterly defence of Bergman, publiſhed in the Swediſh Memoirs for 1788, informs us, that Bergman dried his precipitate in the temperature of the atmoſphere; and, according as that was warm or cold, moiſt or dry, the weight of the precipitate varied from 602 to 595, but, when dried in the temperature of 160 or 180° Fahrenheit, he conſtantly found it to

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* But principally from the *retent*, which far exceeds 12,16 grains, as Weſtrumb demonſtrates.

weigh 540 grains. The true account ſeems to be this: 304 grains alkali are requiſite to take up the tinging matter of 280 grains of Pruſſiated iron, the alkali ſhould then weigh 304 + 140 = 444 grains, but 80 grains of the alkali ſaturated in this manner take up 20 of calx of iron, as Mr. Weſtrumb has demonſtrated, conſequently 444 ſhould take up 111, then the precipitate ſhould weigh 292 + 111 = 403, the remainder may be argill, coal, and moiſture.

I make no doubt but Bergman and Gadolin found the reſults as they have ſtated them; but it is plain they make uſe of the ſame ſort of Berlin blue in Pruſſiating their alkali; another ſpecies of Berlin blue, containing more or leſs argill, charcoal, or Pruſſiated iron, would certainly produce a variance in the *retent*; and hence it is that every other chemiſt, who has examined a Pruſſiated alkali, formed like that of Bergman, found the quantity of calx of iron it retained very different, and if the *retent* be variable, the weight of the precipitate, dried how it may be, muſt alſo be variable, and conſequently this mode of determining the weight of iron in any foſſil is not to be depended upon.

1ſt, Dr. Withering employed an alkali formed by the detonation of nitre and cryſtals of tartar juſt as Bergman did, and boiled it over Berlin blue until it was ſaturated. He does not, indeed, tell us the proportion of Berlin blue to the alkali; neither is it material, as Gadolin owns, for he found no difference when the alkali was one-fourth, one-eighth, or even half*; and, having added this Pruſſiated alkali to a ſolution

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* Schwed. Abhandl. 1788, p. 115.

containing iron, he found the precipitate dried in the temperature of the atmoſphere to weigh 66 grains; this then, according to Bergman, ought to contain 11 grains of metallic iron, and, if we are to make a deduction of the Pruſſian blue contained in the alkali, ſtill leſs; yet Dr. Withering having calcined the precipitate in a low red heat found the whole to amount to 31 grains and a half, and after deducting 11 and a half, which were the retent of the Pruſſiated alkali, the quantity in the foſſil amounted to 20 grains, but this being in a calcined ſtate muſt be farther reduced in the proportion of 140 to 100, and then we have 14,29 of metallic iron inſtead of 11.

Again, it being eſtabliſhed that Pruſſiated iron is in a calcined ſtate, and contains its own weight of the tinging acid, and that 240 grains of the alkali take up the tinging acid of 221 grains of Pruſſiated iron, and conſequently 110,5 of the tinging acid, it follows that 100 grains of the alkali take up 46 of the tinging acid, and, *vice verſa*, 46 parts of the tinging acid require for their ſaturation 100 of vegetable alkali; if ſo, the 20 grains of calx of iron found by Dr. Withering took up 20 of tinging matter, and this quantity of tinging matter required 43,48 of alkali, conſequently its *retent* ought not, according to Bergman, to amount even to 2,4 grains of Pruſſiated iron, yet the Doctor found it to amount to 11,5 grains of calx, which when Pruſſiated amount to 23 of Pruſſiated iron; here we have the weight of the precipitate clearly accounted for, 40 grains being the part of the Pruſſiated iron contained in the foſſil, and 23 in the *retent* equal

equal to 63, the three remaining grains being argill or moiſture.

2d, Mr. Weſtrumb formed a lye of the ſame ſort as Bergman, by ſaturating eight ounces, of vegetable alkali with the tinging matter of the Berlin blue. This lye he evaporated and found to yield 10,81 ounces of Pruſſiated alkali*; it ſhould certainly yield much more (for ſince 100 grains of alkali take up 46 grains of the tinging acid, 8 ounces = 3840 grains, ſhould take up 1766 of the tinging acid, and conſequently weigh 11,66 ounces), had it not been that much of the natural ſalt thus formed is decompoſed during the evaporation, as Mr. Weſtrumb himſelf has ſhewn; for, two ounces of this ſalt being rediſſolved afforded one ounce and a half, and 12 grains of iron were depoſited; now 100 parts of this ſalt, being decompoſed by vitriolic acid, afforded him 40 parts of Pruſſiated iron, and when decompoſed by calcination 19,3 of calx of iron. He alſo found, that after a few minutes the lye decompoſes ſolutions of alum, and other ſolutions that contain an exceſs of acid.

Hence it ſufficiently appears, without adducing other teſtimonies, that this teſt, thus prepared, is productive of many errors; and that Mr. Bergman's computation of the quantities of iron is ſubject to two errors, which in ſome caſes correct each other, one which makes the quantity of iron too ſmall, by reckoning it only one-ſixth part of the precipitate, and another that makes it too great, by making too ſmall an allowance for the *retent* of the Pruſſian alkali; however, ſometimes one, and ſometimes the

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[*] 2d Weſtrumb, 155, 156, &c.

other, predominates; it ſhould alſo be remembered, that the quantities he indicates denote iron in a metallic ſtate, unleſs the contrary be expreſly mentioned.

The analyſis of Klaproth and Weſtrumb are free from theſe errors; laſtly, in thoſe caſes where ſtones are torrefied with aërated alkalis, it is difficult to know whether the calx and magneſia found in them were originally aërated or not, particularly when they abound. Bergman is guided by the exceſs or defect of weight.

ADDITION.

P. 172.—Species 20.

Baikalite.

Its colour, olive green.

Cryſtallized in quadrangular, hexangular, or octohædral priſms, terminated with an oblique pyramid; the octangular have four broad, and four narrow ſides. From two to ten inches long, and from half an inch to four inches thick. Surface ſmooth, ſeldom longitudinally ſtreaked.

Luſtre 1.2. Rather greaſy; often in ſome poſitions mutably reſplendent. Tranſparency, 0.1.

Fracture, ſplintery, paſſing into the conhcoidal. Fragments, 2.3. Hardneſs, 8.9. Specific gravity, 2,200. Gives a white ſtreak.

Does not efferveſce with acids, except ſome calcareous particles be contained in the rifts.

When heated, it ſometimes reddens, and at laſt melts into a dark green glaſs.

By the analyſis of Mr. Lowitz, it contains 0,44 ſilex, 0,30 magneſia, 0,20 calx, 0,06 calx of iron, and, caſually, fluor acid.

This ſtone has as yet been found only on the borders of the lake Baikal, in Siberia, from which it derives its name *. Some have called it

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* 7 Chy. Annal. 1793, 22. 5 Crell Beytr. 4 Stuk 407.

ſhorl, others *cryſtallized hornblende*; but the abſence of argill, and the quantity of magneſia it contains, to ſay nothing of its external characters, prove it to be a diſtinct ſpecies of the Muriatic Genus.

END OF VOL. I.