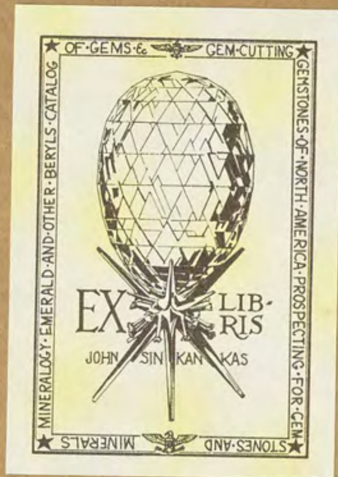
OF·GEMS·& GEM·CUTTING
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STONES·AND MINERALS
MINERALOGY·EMERALD·AND·OTHER·BERYLS·CATALOG
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10

ANALYTICAL ESSAYS

TOWARDS PROMOTING

THE

CHEMICAL KNOWLEDGE

OF

MINERAL SUBSTANCES.

BY MARTIN HENRY KLAPROTH, of Berlin

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ADVERTISEMENT.

THE merits of KLAPROTH, in Chemical Analyſis, are ſo eminently eſtabliſhed with men of ſcience throughout Europe, that it would ſeem improper to enlarge on the moſt conſummate ſkill and accuracy with which he performed his experiments, as well as on his laudable candour in ſtating their reſults.

On this conſideration, it is hoped that the tranſlation of his Analytico-chemical Eſſays, *&c. which is here offered to the patronage of the Engliſh Chemiſts, will meet with their kind approbation.— It may be neceſſary to add, that all the* Eſſays *of the Author relating to this ſubject, and which, in the German original, were publiſhed in two volumes, are, for the accommodation of the public, compriz-ed in this ſingle Volume.*

Whenever Mr. Klaproth, *as he has given hopes to the Tranſlator, ſhall give another collection of his laſt and neweſt Eſſays, they will be immediately rendered into Engliſh.*

☞ *If ſome typographical errors, and a few other miſtakes which unfortunately have eſcaped the moſt careful attention, ſhould create ſome difficulty in the ſenſe, the reader is requeſted to refer to the errata in the laſt page.*

PREFACE

OF

THE AUTHOR.

IT has long been my defign to collect my *Mineralogico-chemical Effays*, difperfed in various books and journals, and to publifh them, together with fome new Refearches; but want of time, and other impediments, have hitherto prevented me from accomplifhing it.

Much as I wifhed to give to my Analytical Inquiries the greateft poffible degree of truth and perfection, and thereby to fulfil the duties which the Chemift owes to the Science which he intends to promote by his writings, as well as to the Public, to whom he offers the fruits of his labour; I was, neverthelefs, too often under the neceffity of experiencing, how difficult it is to accomplifh this purpofe.

Of the 26 Treatifes contained in this *firft Vol. of Effays towards a Chemical Knowledge of Mineral Subftances**, the greater number is here publifhed

* Mr. *Klaproth* here alludes to the publication of the firft part of his Effays, at Berlin, 1795. The prefent volume comprehends alfo the fecond part of them; and what is faid by the author, with refpect to this laft, has been added at the end of this Preface.—Tranfl.

for the firſt time. Each of them being unconnected with the others, I followed no particular order with them; and I alſo diſregarded the order of publication, with reſpect to thoſe that were before publiſhed ſeparately. In my operations with the genus of *ſilver-ores*, I intended, for the farther advancement of the ſyſtematical part of *Oryctognoſy*, to ſubject to analytical examination, not only particular ſpecies and varieties, but entire genuſes, with their chief ſpecies. But I was ſoon convinced, that the execution of this deſign was impracticable, both on account of the few leiſure hours which I could command, and as, in general, it ſurpaſſes the powers of an individual.

Having merely in view the progreſs of Natural Science, founded on *pure experience*, that is to ſay, on plain facts, free from all hypotheſis, I entertain, on preſenting theſe labours to the Public, the moſt ardent deſire of ſeeing the words of *Bergmann**, "*Aliorum tentamina, preſertim cardinalia, candide ſunt revidenda,*" put into practice; for, as this philoſophical Chemiſt very properly adds: "*Plus vident oculi, quam oculus; ideoque, quæ nova exhibentur, pluribus teſtibus in diverſis locis utiliter confirmari puto.*"—Being thoroughly convinced of my own fallibility, I recommend this examination with the greater

* De Indagando Vero.

eagerneſs, ſince the reſults of ſeveral of my experiments, reſpecting the conſtituent parts of foſſils, are, frequently, in ſtriking contradiction to thoſe given by others. Thus the mineralogical world may be informed, on which ſide truth ſtands, or the leaſt error occurs; and the *Oryctologiſt* may, with greater certainty than before could be done, apply the data given him to the perfection of his art. On my part, I ſhall always receive with pleaſure any well grounded correction of my labours, and better information.

With reſpect to thoſe, who may poſſeſs patience and inclination ſufficient to undertake a repetition of my experiments, I have deſcribed every particular management, as circumſtantially as could be done, conſiſtently with keeping within due bounds that prolixity which is hardly ever ſeparable from the narrative of chemical proceſſes. Thoſe who are familiar with this ſubject, will perceive my endeavours to reduce the analyſis of mineral bodies to methods which are ſimple in themſelves, and lead to reſults that may be depended on. Among others, I flatter myſelf with having traced out a way of analyſing *gems*, which ſeems to deſerve being followed by ſkilful Chemiſts.

A circumſtance, ſeemingly indifferent, often produces in chemical experiments, as in other inveſtigations, unexpected conſequences; which may be proved by comparing my former with my later analytical experiments, made with the *Adamantine Spar*, and *Circon* (Jargon of Ceylon), which, on this account, I have placed next to each other in the refpective Treatifes. Who, for example, would have imagined, that the application of cauftic alkali in the *liquid* ftate fhould fo exceedingly facilitate the opening of hard ftony matter, and remove the greateft part of the difficulties with which I had to ftruggle, when employing the fame feparating medium in the *dry* ftate?

As many perfons think that the preparation of a perfectly pure cauftic lye is fubject to more difficulties than it really is, I will here briefly ftate my method of preparing it.—I boil equal parts of purified falt of tartar, (carbonat of potafh, or vegetable alkali prepared from tartar) and Carrara marble, burnt to lime, with a fufficient quantity of water, in a polifhed iron kettle; I ftrain the lye through clean linen, and, though yet turbid, reduce it by boiling, till it contain about one half of its weight of cauftic alkali; after which I pafs it once more through a linen-cloth, and fet it by in a glafs bottle. After fome days, when the lye has become clear of itfelf, by ftanding, I carefully pour it off from the fediment into another bottle. To convince myfelf of its purity, I faturate part of it with muriatic or nitric acid, evaporate it to drynefs, and re-diffolve it in water. If

If it be pure, no turbidnefs will take place in the folution. The quantity of cauftic alkali, which this lye contains, I afcertain by evaporating a certain weighed portion of the lye to drynefs, in an evaporating difh of a known weight. I alfo take care, in the preparation of this cauftic lye, that the alkali be not entirely deprived of carbonic acid; becaufe, in that cafe, I can, with greater certainty, depend on the total abfence of diffolved calcareous earth. By employing burnt marble, or, in its ftead, burnt oyfter-fhells, I avoid the ufual contamination of the cauftic lye by aluminous earth; becaufe lime, prepared from the common fpecies of lime-ftone, is feldom entirely free from argil.

Befides, the choice of the veffels requires great care. Since even the beft porcelain is attacked and diffolved by cauftic alkali, I employ filver, reduced from muriat of filver, (Horn-filver), for veffels appropriated to fufion. This material, however, notwithftanding its other advantages, is not abfolutely free from all inconvenience. For, if the crucible made of its has not been prepared with every poffible care, fmall fcales will detach from it, which mingle with the body to be examined, and frequently occafion illufive appearances. Having already found, unexpectedly, that even a crucible made of platina would not, as had been wifhed, refift the action of ignited cauftic alkali; I imagine that a crucible made of pure maffive gold would be the moſt eligible. On this account, Profeſſor *Storr* ſeems to be in the right, when he concludes his *Propoſals, reſpecting the examination of the mixture of gems**, with the following words: "The difficulties occurring in this operation will the ſooner diſappear, if a great amateur of gems ſhould choose to ſpend the value of ſome thouſand ducats for their examination." Meanwhile, I flatter myſelf with having in ſome manner counteracted thoſe difficulties; though I was not encouraged by ſuch a high premium.

Though for the moſt part I have followed the *new nomenclature*, I have not ſcrupulouſly confined myſelf to its terms; but have, for the ſake of brevity, now and then uſed the denominations, *Glauber's-ſalt*, *Common-ſalt*, *Horn-ſilver*, *Blood-lye*, &c. as alſo the term *mild*, in ſtead of carbonated, in oppoſition to *cauſtic*†. Speaking of water, to avoid too frequent repetitions, I have moſtly omitted to particularize it as *diſtilled*. Thus, alſo, I have not in every ſingle inſtance mentioned the *edulcoration* of the precipitates, or reſidues; this and ſimilar operations being always underſtood to have been performed.

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* *Crell's* Chemisches Journal, vol. VI. 1781. page 227.

† The Tranſlator, however, has, for the moſt part, preferred the *new nomenclature*, and frequently added the former denominations, for reaſons not neceſſary to be particularly mentioned.—Tranſl.

Concerning

*Concerning the Second Part.**

I HERE offer to the chemical and mineralogical public the *ſecond* volume of my *Eſſays*, &c. animated by the hope, that it will meet the ſame encouraging approbation with which the *firſt* has been honoured by ſcientific men, whoſe deciſion in this branch of the Knowledge of Nature commands reſpect.

The numbers of the Eſſays, contained in this volume, proceed in a continued ſeries with thoſe of the preceding. Of thoſe now given (1797), only a few have been before printed in various publications, and are here merely collected.—All the others are entirely new, and, at preſent, publiſhed for the firſt time.

As theſe eſſays were the fruit of my leiſure hours only, ſeveral of them have not arrived at that degree of perfection, to which, perhaps, they might

* This is the Preface to Mr. *Klaproth's* ſecond volume of the German Edition; and the words, PART I. and PART II. have been deſignedly inſerted in the following Table of CONTENTS; the better to diſtinguiſh the firſt 26 Eſſays belonging to the firſt volume from the remaining eſſays, publiſhed in the ſecond volume of the original.

have

have approached, if the ufual avocations of my duties had permitted me to perform them with greater convenience and opportunity.

In this refpect I earneftly wifh, that, for the advancement of the fcience, the *chemico-analytical refearches* publifhed in this fecond volume may fhare the fame good fortune with thofe of the firft: —I mean to fay, that they may be examined, corrected, and farther purfued by expert Chemifts.

M. H. KLAPROTH.

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I.

EXPERIMENTS

ON THE

HABITUDES OF VARIOUS SPECIES

OF

STONES AND EARTHS

IN THE

FIRE OF A PORCELAIN-FURNACE.

A Scientific enquiry into that clafs of natural bodies, which belong to the *mineral kingdom*, includes a number of particulars, which it is neceffary to unite, in order to obtain a complete knowledge of the fubject.

Thefe are:

1. Their *geognoftic* fituation*: and
2. Their *external characteriftic marks:* which both together conftitute their *natural hiftory*.
3. The experiments relating to the *phyfical properties* and powers of bodies in an undecompofed ftate. Such are: their fpecific gravity, elafticity, magnetic attraction, the phenomena exhibited by them with regard to light, and the like.
4. Their habitudes or changes in the *fire*; and
5. Their *chemical conftituent parts*.

* *Werner*, who introduced the expreffion *Geognofy*, underftands by it a general acquaintance with the folid parts of our globe, the various fituations or beds of foffils, and their reciprocal relations to each other. Thus he diftinguifhes geognofy from *mineralogical geography*, which only treats of the native places of foffils.—Tranfl.

As to the *habitudes of minerals in fire*, they indeed belong to the *chemical* part of natural ſcience; but ſo far only, as their conſtituent parts, or their proportions to each other, are made to ſuffer an alteration by this agent. Therefore, the phenomena, which take place on warming or heating, without producing a laſting change in the chemical mixture of the conſtituent parts, do not belong to this, but to its *phyſical* part. Thus, for inſtance, the power of attracting and repelling light bodies, excited in *Tourmaline* by warming it, ſhould only be reckoned among its phyſical properties; but, on the contrary, the phoſphoreſcence of the *Fluor-ſpar* and the *Apatite*, though but moderately heated, already effect ſome alteration in the natural chemical proportion of their conſtituent parts.

Though ſeveral induſtrious naturaliſts have examined various ſpecies of earths and ſtones merely by fire, few of them, however, have furniſhed *ſimple facts* or *experiments*. Some, as *Pott* and *Gellert*, according to their particular purpoſes, have directed their attention more to the products of fuſion, in compoſitions of their own making, than to the mere habitudes of the ſimple foſſils. Others, *D'Arcet* for inſtance, have indeed had regard to this laſt circumſtance; but they have miſſed their end, at leaſt for the greateſt part, by expoſing the body under trial to fire in immediate contact with argillaceous crucibles. For, the reſults could not fail to be falſe in moſt caſes, on account of the aluminous earth from the corroded maſs of the crucible mingling with the ſubſtance of the experiment.

So far as I know, Mr. *Gerhard** is the only chemiſt, who, in his valuable experiments concerning the habitudes

* *Gerhard's Verſuch einer Geſchichte des Mineralreichs*, 2 Vol. Berlin, 1781-82.—Vol. II. § 2. page 1—44.

tudes of foffils in the fire, has paid due attention to the nature of the veffels; and has communicated true refults, becaufe in his operations he employed crucibles of charcoal, befides thofe manufactured of clay and chalk.

The refults of my experiments on the effects produced by fire on various fpecies of ftones and earths, which I am now about to give, may ferve to confirm feveral, and in fome refpects be confidered as a continuation of thofe of *Gerhard*.

When fpeaking of the experiments on fufion made by the above mentioned naturalifts, as well as of my own, the mere action of *common* fire in wind and porcelain-furnaces is underftood. Hence, neither dioptrical and catoptrical experiments belong to this inveftigation; nor thofe, which feveral philofophers have made by ftrengthening the fire by means of oxygen gas. For, howfoever valuable the latter are in other refpects, I am inclined to think, that in a mineralogical view, the action of violent ignition fuftained by oxygen gas is not a convenient method for afcertaining the relative habitudes of minerals in the fire.

To be enabled to draw juft conclufions from experiments of this kind, it is neceffary that they be all performed with the moft equal degree of heat. This advantage was afforded to me by the furnaces of the Royal Porcelain-manufactory (at Berlin); into which the foffils, ready prepared for this trial, were put; together with the porcelain, fubjected to final baking.

For experiments to be performed in charcoal crucibles, a cavity was made in a thick fragment of well-burned charcoal, of a volume anfwering the fize of the foffil. This being put in, the cavity was clofed with a charcoal ftopper;

after which the charcoal-crucible was fitted into another crucible made of baked clay, and this laſt well joined with its cover by luting.

In order to make comparative experiments, I placed another quantity of each foſſil immediately in a crucible made of clay unmixed with iron. After the cover had been luted on, it was expoſed to the ſame intenſity of heat.

In every caſe where the loſs of weight could be aſcertained with ſome degree of certainty, I have always mentioned it.

No. I. ADULARIA; from Mount St. *Gotthard.*

a) In the *charcoal-crucible* *, a colourleſs glaſs, clear in its ſubſtance, but quite full of very ſmall froth-bubbles. On this account it appears of a greyiſh-white, and exhibits no vitreous ſplintery fracture, but a minute conchoidal, with very fine pores.

b) In the *clay-crucible.* The ſame.

No. 2. White ALABASTER.

a) CH. Cr. was rendered moderately hard, white paſſing into ſtraw-yellow, in ſome places finely ſtreaked, of a fine-grained earthy fracture, adhering to the tongue, and emitting an odour like that of alkaline ſulphuret.—Loſs of weight, 0,56.

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* For the ſake of brevity, the *Charcoal-crucible* is marked CH. Cr. and the *Clay-crucible,* CL. Cr.

In the ſame manner L. of W. means *loſs of weight.*

b) CL. Cr. A black-brown glafs, very fhining, little tranfparent on the edges, with feparate bubbles.

No. 3. AMIANTHUS; from *Greenland.*

a) CH. Cr. A roundifh fufed fcoria, of a dirty pearl grey, externally covered with fome fmall grains of iron. Fracture, dull, finely porous, with difperfed inlaid gloffy particles.

b) CL. Cr. Has run into a greenifh, opake fcoria, of a fracture almoft dull. The whole furface covered with cryftals of a greenifh and light brown colour, in the form of delicate needles, of a reticular form.

No. 4. ASBESTUS, mountain green: (Berg-holz) from *Siberia.*

a) CH. Cr. Unaltered as to form, fimply hardened by ignition. Its furface invefted with a thin reddifh cruft; the edges blackifh, and overlaid with fine exfuded grains of iron.—L. of W. 0,16.

b) CL. Cr. The form likewife unchanged; of a light-brown colour, rendered very hard, and covered with fome ferruginous fpots.

No. 5. ASBESTUS; from *Taberg.*

a) CH. Cr. A light-grey flag, fufed into a fphere, and covered with grains of iron, of a glittering furface, and having detached, fhining, large bubble-holes.—L. of W. 0,25.

N. 6. BASALT; afh-grey, coarfe-grained. (Swed. *Trap*; and, according to *Werner*, Grünftein;) from *Hünneberg*, in Weftgothland.

a) CH. Cr. Fufed into a compact glafs, of a clove-brown colour, tranfparent in fplinters, of a large conchoidal fracture. Externally, partly glazed brown, partly invefted with a ferruginous cruft, and large grains of iron. —L. of W. 0,06.

b) A folid black glafs, covered with a brown, fteel-grey, veined iron-cruft.

No. 7. BASALT, denfe, columnar; from the *Hafenberge*, in the middle mountains of Bohemia.

a) CH. Cr. Externally, a compact grey mafs, richly over-laid with pretty large grains of iron, and in part alfo covered with a tombac-brown ferruginous cruft. Its fracture of a bright afh-grey, and to appearance dull and earthy; but if examined with a lens, poffeffed of a texture very finely porous, and fpongy throughout; and very rough to the feel.—L. of W. 0,09.

b) CL. Cr. A black denfe glafs, tranfparent, and of a clove-brown, in thin fplinters, of an even or grofs-conchoidal fracture. At the top, it exhibits a light-brown, gloffy, and delicately-flowered cruft.

No. 8. BASALT, denfe, columnar; from *Stolpe*, in Saxony.

a) CH. Cr. A compact mafs, invefted at the top with a blackifh grey glazing, but, on the fides and underneath, with numerous grains of iron, and in part covered with a tombac-brown iron-cruft. In fracture, afh-grey, dull, denfe, fomewhat fplintery, in fome places of a fpongy texture hardly diftinguifhable, and in others exhibiting clove-brown gloffy veins.—L. of W. 0,08.

Note 1. Another, but fmaller quantity of the fame bafalt, treated in the fame manner, I found, had the fame external appearances: but its internal colour was white-grey; its texture was more denfe, and traverfed by minute, blackifh vitreous veins.

Note

Note 2. I put the fpecimen of No. 8. *a*) a fecond time into the charcoal crucible, after having feparated the iron-grains. It appeared afterwards of an amorphous, and on the upper part confufedly fibrous form; but its fracture prefented a darkifh grey, compact, fine-grained, untranfparent, highly glittering, and, towards the fides, greafy gloffy fcoria.

b) CL. Cr. As No. 7. *b*).

No. 9. BASALT, largely perforated, with interfperfed, fingle, fmall grains of olivin; from the ifland of *Skye*.

a) CH. Cr. On the furface overlaid with many grains of iron, of a confiderable fize. Fracture dark afh-grey, very rugged, dull, and earthy; but, viewed by a lens, fpongy, with fine pores.—L. of W. 0,08.

Note. The grains of iron being feparated, this mafs was again placed in a frefh CH. Cr. Its furface then affumed the figure of vermicularly twifted branches, lying flat; fome of which had a copper-red metallic luftre. Its fracture like No. 8, note 2.

b) CL. Cr. The fame as No. 7. *b)*

No. 10. BASALT, porphyraceous; from the new *Cammeni*, near *Santorini*.

Note. The principal black mafs was a medium between filiceous fhiftus, *(Kiefelfchiefer)* jafper, and bafalt; with diffeminated tender, white, vitreous fquares and grains.

a) CH. Cr. Melted into a folid, blackifh glafs; whofe fragments were of a yellowifh-green, and tranfparent. It was covered with a fteel-grey ferruginous cruft, and of a gloffy, large conchoidal fracture.—L. of W. 0,02.

b) CL. Cr. A compact, black glafs; but its fplinters clove-brown and tranfparent. Fracture of the large, and, in fome degree, fmooth conchoidal form. Surface invefted with a bright brown, fhining pellicle.

No. 11. LIGNIFORM ASBESTUS (Bergholz), brown; from *Tyrol.*

a) CH. Cr. Suffered no alteration of form; burned hard, and aſſumed a greeniſh-brown ſurface, with a red and white inveſtment. Its edges foliated in lamellæ, blackiſh, and garniſhed with extremely delicate exſuded grains of iron. Fracture bright, ſteel-grey, and glittering.—L. of W. 0,39.

b) CL. Cr. Coaleſcing by fuſion with the parts of the crucibles that were in contact with the fragments. Their external ſurfaces exhibited a texture, conſiſting of brown, reſplendent, implicated, ſhort ſtriæ. The fracture dark-grey, little ſhining, and of bright-grey rays and points, as it were interwoven, with ſome air-bubbles.

No. 12. BERYL, yellow; from *Siberia.*

a) CH. Cr. No change in the figure. Colour dirty pale-bluiſh-grey, with a greaſy luſtre, and a little tranſparent. Fracture uneven, groſs-ſplintery.—L. of W. 0,01.

b) CL. Cr. The ſame.

No. 13. BERYL, ſea-green; alſo from *Siberia.*

a) CH. Cr. In general of leſs ſplendour; but the lateral ſurfaces of the column covered all over with fine, ſhining, needle-formed radii. In other reſpects, as No. 12. *a*)

b) CL. Cr. Like No. 12. *b*)

No. 14. SHORLITE (*Schörlartiger Beryl*); from *Altenberg.*

a) CH. Cr. Unaltered as to form; indurated by the ignition; became grey, dull, and rough; with minute glittering points of a nearly metallic luſtre.—L. of W. 0,25.

b) CL. Cr. The ſame phenomena; but without ſhining points.

No.

No. 15. PUMICE-STONE, common; from *Lipari.*

a) CH. Cr. A bluifh-black-grey, denfe glafs, with fome air-bubbles; femi-tranflucid when reduced to thin fragments; and externally overlaid with a few grains of iron. L. of W. 0,10.

b) CL. Cr. Afforded a clearly fufed, light-blackifh-green, glaffy fubftance, of almoft colourlefs and clear fplinters, with fome air-bubbles.

No. 16. COMPOUND SPAR (*Bitterfpath*); from *Zillerthal*, in *Tyrol.*

a) CH. Cr. Fell into fmall yellowifh-grey, and yellowifh-brown, friable, and in part diftinctly rhomboidal pieces, of an earthy appearance.—L. of W. 0,45.

b) CL. Cr. On the upper part it run into a clear, bright grafs-green glafs, of a fmooth furface; but on the lower part into a light-grey frothy fcoria.

No. 17. BOLE, red armenian; *genuine.*

Note. Confifts of a red, friable lithomarga (*Steinmark*), with white fpeckles.

a) CH. Cr. Burned hard, was glittering, and of an iron-black colour.—L. of W. 0,20.

b) CL. Cr. Hardened by burning; partly fteel-grey, partly dirty-brown; having the furface covered with tranfuded and re-calcined or oxyded ferruginous particles; rough and porous.

No. 18. BOLE, red armenian; *common.*

a) Melted into an ill-fhaped hollow globe, whofe outward and inward furfaces were of a dim fteel-grey colour, and

and inlaid with refplendent grains of iron. Its fracture prefented a black-grey flag, fhining, and in part porous.—L. of W. 0,16.

b) CL. Cr. Gave a brown fcoria; gloffy like pitch; full of large bubbles; of an uneven furface, refembling the fpecular or grey iron-ore (*eifen-glänziz*).

No. 19. BORACITE; from *Lüneburg*.

a) CH. Cr. Each cryftal fell feparately into a globular form; acquired a cavity in the middle, and prefented here and there incumbent, very tender ferruginous grains. Fracture whitifh-grey, fhining, uneven, and foliated; in part alfo ftriated.

b) CL. Cr. Produced a yellowifh, clear glafs, containing fome air-bubbles; and having feparate, fmall, dim-white fpots.

No. 20. SIDERO-CALCITE (*Braunfpath*), in lumps*, grey-white; from *Freyberg*.

a) CH. Cr. Fell into black-brown, cracked and friable lumps, entirely refembling perfectly decayed fiderocalcite, and fhewed exceedingly minute, tranfuded metallic grains.

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* In German *derbe*, the precife meaning of which expreffion *Kirwan* afferts, (Elem. of Mineral. I. p 26) he could never learn. According to *Emmerling*, any folid foffil is called *derbe* which is concreted or imbedded in another, and is of the fize of a *hazel-nut*, and above, to any magnitude; whereas that which is called in German *eingefprengt* (diffeminated, interfperfed) is under the fize of a hazel-nut, to any minutenefs obfervable. As the fize of the foffils treated of in this work is feldom determined, the word *derbe* will be given in this tranflation by the expreffions *in lumps*, *in maffes*, and fometimes *maffive*.—Tranfl.

b) CL.

b) CL. Cr. Changed into a glaſs of a dark black-brown colour, tranſparent on the edges, and pellucid in ſmall fragments.

No. 21. CORNELIAN, oriental.

a) CH. Cr. No change in its form, very fragile, of a ſnowy-white from the outer edge, almoſt to the thickneſs of $\frac{1}{12}$ inch; but internally very pale reddiſh white. The fracture of the white border was conchoidal and reſplendent; that of the inner parts earthy and dull.—It ſuffered no loſs of weight.

b) CL. Cr. Throughout of a ſnow-white, partly ſpotted, ſomewhat greyiſh, and preſerving its external ſplendour.

No. 22. CHALCEDONY; from *Ferröe.*

a) CH. Cr. Of unaltered ſhape; white as ſnow; eaſy to be broken; externally, and in the fracture, glittering.—L. of W. 0,01.

b) CL. Cr. The ſame.

No. 23. CHLORITE, looſe, from the cavity of a rock-cryſtal; from *St. Gotthard.*

a) CH. Cr. A contracted, black, ſhining, ſomewhat radiated maſs, ſimilar to a brittle pit-coal.

b) CL. Cr. Fuſed into a ſolid, black-brown, vitreous ſubſtance.

No. 24. CHRYSOBERYL, from *Braſil.*

a) CH. Cr. Remained totally unchanged, except that its ſurface became a little rougher.

b) CL. Cr. Likewiſe unaltered; only its colour turned ſomewhat paler, and the external ſurface acquired ſpots of a dull white.

No.

No. 25. CHRYSOLITE, oriental.

a) CH. Cr. Its ſurface covered with a thick ferruginous cruſt, of a reddiſh-brown, paſſing into ſteel-grey, and glittering. Its original green colour was no longer perceivable in the fracture. Its form, ſplendour, and tranſparency, quite unaltered.

b) CL. Cr. No change as to form, tranſparency, and luſtre; but the colour inclined now to olive-green.

No. 26. CHRYSOPRASE; from *Koſemütz.*

a) CH. Cr. Had its figure unaltered, turned very light blackiſh-grey, of a ſtrong gloſs, and perfectly opake. In the ſtreak it exhibited a kind of metallic luſtre.—L. of W. 0,01.

b) CL. Cr. The ſame effect.

No. 27. CIMOLITE; from the iſland of *Cimolo* (Cimolia Plinii).

a) CH. Cr. A black-grey, moderately ſhining, ſcummy ſlag, of little weight.—L. of W. 0,25.

b) CL. Cr. A yellowiſh-white, half fuſed, hard, ſmall frothy ſcoria, reſembling corroded quarz.

No. 28. CYANITE, cryſtallized; from *St. Gotthard.*

a) CH. Cr. Burned white, was ſplit, became very friable, and internally ſhining.—No loſs of weight.

b) CL. Cr. The ſame.

No. 29. CYANITE, common; from the ſame place.

a) CH. Cr. Was rendered aſh-grey by ignition, and ſplit, in the manner of wood.—No loſs of weight.

b) CL. Cr. Snowy-white, and ſplit.

No.

No. 30. FEL-SPAR ? compact, blue; from *Krieglach.*

a) CH. Cr. Furnifhed a grey-white glafs, fcummy in the fracture, and thereby divided into fhapelefs cellules, like fine tabular quarz. It prefented detached ferruginous grains, and fhewed alfo on the furface a number of fine fplendid fpeckles.—L. of W. 0,40.

b) CL. Cr. Shrunk into milky-white, irregular, rough lumps, with a diftinctly beginning vitrification.

No. 31. FEL-SPAR, common, red; from *Lomnitz.*

a) CH. Cr. As No. 1. *a*)
b) CL. Cr. As No. 1. *a*)

No. 32. FEL-SPAR, vitreous, in hexagonal plates; from the *Porphyry* of *Drachenfels.*

a) CH. Cr. A greyifh-white glafs, almoft pellucid; of a ftrong glofs on the fracture, and having air-bubbles.—L. of W. 0,02.

b) CL. Cr. A femi-pellucid, bright-grey, fomewhat frothed glafs; in fome places fpeckled blackifh or brownifh.

No. 33. FEL-SPAR, green; from *Siberia.*

a) CH. Cr. Like No. 32. *a*)

b) CL. Cr. Produced a milk-white glafs, of a fine froth, but clear in fmall pieces.

No. 34. FLUOR-SPAR, yellow, cubic; from *Gerfdorf.*

a) CH. Cr. A milky-white fcoria; fufed on the outfide; in the fracture lamellar, of refplendent planes.—L. of W. 0,04.

b) CL. Cr. Fufed into a clear, bright grafs-green glafs.

No.

No. 35. SPECULAR GYPSUM (*Fraueneis, glacies Mariæ.*)

a) CH. Cr. Rendered white, very friable; and its lamellæ ſpecular or reflecting light.—L. of W. 0,60.

b) CL. Cr. Clove-brown glaſs, with large ſpherical air-bubbles.

No. 36. HYALITE, or Glaſs-ſtone, (VIOLET SHOERL); cryſtallized; from *Dauphiny*.

a) CH. Cr. A ſemi-pellucid greyiſh-white glaſs, brilliant, flat conchoidal fracture; outwardly ſpread over with ferruginous grains.—L. of W. 0,12.

b) CL. Cr. A denſe, ſemi-pellucid, deep clove-brown.

No. 37. HYALITE (*Violet Shörl*), in maſſes; from *Thum* (*Thumerſtone*).

a) CH. Cr. As No. 36. *a*).—L. of W. 0,10.
b) CL. Cr. As No. 36. *b*).

No. 38. MICA, grey, groſs-foliated; from *Cornwall*.

a) CH. Cr. A greeniſh-grey, ſemi-pellucid glaſs, overlaid with minute grains of iron.—L. of W. 0,10.

b) CL. Cr. Run into a compact, blackiſh, opake glaſs; of a ſmooth, ſtrongly-ſhining ſurface, and conchoidal fracture.

No. 39. GARNET, red, bohemian.

a) CH. Cr. Afforded a grey, turbid glaſs; full of grains of iron.

b) CL. Cr. Fuſed into an opake, almoſt compact ſcoria, whoſe colour internally changed by ſtripes from brown into green; very finely corroded.

No.

No. 40. GARNET, oriental.

a) CH. Cr. The ſame change as No. 39. *a*).

b) CL. Cr. Yielded a compact black glaſs; of a bright luſtre; covered with a ſteel-grey cruſt.

No. 41. GRANATITE, (till now ſo called); from St. *Gotthard.*

a) CH. Cr. Became hard; ſteel-grey; overlaid with ſmall ferruginous grains.

b) CL. Cr. Rendered hard; of an iron black colour; with ſhining points of a metallic luſtre.

No. 42, GREEN EARTH; from *Cyprus.*

a) CH. Cr. Fuſed into an irregular ſphere; which had externally a dirty green colour, and preſented in the fracture a ſomewhat porous maſs, compoſed of an emerald-green glaſs and a pale-green ſcoria. Here and there it was croſſed partly by white metallic lamellæ, partly by reguline copper. There was alſo found, in one of its cavities, a variegated copper-ore in ſmall grains.—L. of W. 0,17.

b) CL. Cr. Exhibited a fuſed compact ſcoria; in the fracture of which the upper part was brown and reſplendent; the lower one greeniſh grey, and glittering. At top it ſhewed grey-white, delicate plumoſe traces, of a luſtre nearly metallic, upon a brown ground.

No. 43. HELIOTROPIUM, oriental.

a) The figure unaltered; but rendered a little ſofter by the ignition. The colour changed from dull-greeniſh to a grey-white. Its fracture uneven, ſplintery, rough and glittering. The red points, which had diſappeared, left ſmall holes behind them.—L. of W. 0,01.

b) CL. Cr. The colour turned throughout whitiſh grey. In other reſpects as at *a*).

No. 44. HORN-BLENDE, baſaltic; from the crater of *Veſuvius*.

a) CH. Cr. A hardened, ill-ſhaped maſs, with grains of iron. Fracture light-grey, uneven, faintly glittering; without any trace of vitrification.—L. of W. 0,10.

b) CL. Cr. Melted into a denſe, black-brown glaſs; tranſparent in thin fragments; of a ſmooth ſurface, and a flat conchoidal, gloſſy fracture.

No. 45. HORN BLENDE, common; from *Neurode*, in the county of *Glatz*, in Bohemia.

a) CH. Cr. An indurated maſs; on the outſide wrinkled, of a colour verging into copper-red, inlaid with many granular particles of iron. Internally light pearly-grey, uneven, ſlightly glittering; here and there with a beginning vitrification.—L. of W. 0,06.

b) CL. Cr. As No. 44. *b*).

No. 46. HORNBLENDE? common; from *Nora*, in Weſtmanland.

a) CH. Cr. Run into an imperfect, greeniſh-black vitreous ſubſtance, tranſparent on the edges, overlaid with an iron black, rugoſe or ſhrivelled cruſt. Fracture, with air-bubbles, of a copper-colour.—L. of W. 0,14.

b) CL. Cr. A compact ſcoria, whoſe colour, from below upwards, changed from leek-green to greeniſh black. Covered with a ſteel-grey metallic cruſt. Fracture, moderately ſhining, of a greaſy luſtre.

No.

No. 47. HYACINTH; from *Ceylon.*

a) CH. Cr. Its colour became greyiſh-white. The cryſtals in ſome degree coaleſced; but remained in other reſpects unchanged, except their tranſparency being diminiſhed..—No. L. of W.

b) CL. Cr. Such of the cryſtals as were in contact with the crucible, united with it by fuſion, throwing up a ferruginous cruſt. The others were looſely conglutinated together. The colour, in part, paſſed into a wine-yellow.

No. 48. CAT'S-EYES, grey-white; from *Ceylon.*

a) CH. Cr. Became ſoft, grey, dimmed, and opake by the action of the fire.—No. L. of W.

b) CL. Cr. The ſame change.

No. 49. CAT'S-EYE, red; from *Malabar.*

a) CH. Cr. Like No. 48. *a*)

b) CL. Cr. The ſame.

No. 50. LABRADOR-HORNBLENDE *(Labrador-) ſtein).*

a) CH. Cr. Fuſed into a compact glaſs, of great luſtre, pellucid in ſmall ſplinters, of a pale-grey colour, with very minute, detached grains of iron.—L. of W. 0,04.

b) CL. Cr. A compact, duſky-white ſcoria, tranſparent on the edges.

No. 51. LAPIS LAZULI, deep-blue.

a) CH. Cr. A denſe, grey, ſemi-pellucid glaſs; overlaid with grains of iron.—L. of W. 0,12.

b) CL. Cr. A denſe, browniſh, black glaſs, with ſeparate grains of iron upon its ſurface.

No. 52. LAVA, looſe, frothy; from *Veſuvius*.

a) CH. Cr. Changed to a compact glaſs, of a greeniſh-grey tinge, containing granular particles of iron; and tranſparent on the edges.—L. of W. 0,08.

b) CL. Cr. A compact, browniſh-black glaſs, having ruſty ſpots on the upper part.

No. 53. LEMNIAN EARTH, common. (Bole).

a) CH. Cr. A denſe, deep-greeniſh-grey glaſs, covered with a cruſt coloured like ruſt of iron, and ſome ferruginous grains.—L. of W. 0,25.

b) CL. Cr. A compact greeniſh-black glaſs; ſhewing at the top light-brown points, lying flat.

No. 54. LEPIDOLITE (Lilalite); from *Roſna* in Moravia.

a) CH. Cr. Produced a pale-grey, denſe, ſemi-pellucid, very hard glaſs; partially covered with a grey ferruginous cruſt.—L. of W. 0,17.

b) CL. Cr. Afforded a greyiſh-white, tranſparent glaſs, with very ſmall bubbles; and on the upper parts covered with a light-brown cruſt, of a luſtre nearly metallic.

No.

No. 55. LEUCITE (not yet affected by volcanic fire); from *Vesuvius.*

a) CH. Cr. Outwardly a commencement of fusion; the inside little altered, and still very glossy. The hornblende which it contained within, was melted into separate, black, minute drops.

b) CL. Cr. Exactly the same.

No. 56. MARBLE, white; from *Carrara.*

a) CH. Cr. Was converted into quicklime.

b) CL. Cr. Changed into a dense, clear, hard, pale grass-green glass.

No. 57. PLASTIC SILICI-MURITE (*Meerschaum*, *Keffekil* of Cronstedt); from the *Levant.*

a) CH. Cr. Not altered; only rendered more meagre and indurated by ignition; very strongly adhering to the tongue.—L. of W. 0,30.

b) CL. Cr. The same.

No. 58. OBSIDIAN, black; from Mount *Hecla* in Iceland.

a) CH. Cr. A greenish-black glass, of great splendour; pellucid in small pieces, outwardly with a grey incrustation.

b) CL. Cr. Melted into a dense, black-brown glass; transparent only in its smallest splinters, and of a conchoidal fracture.

No. 59. OBSIDIAN, blackifh-grey, tranfparent; from *Lipari.*

a) CH. Cr. Gave a glafs, pellucid in larger lumps; of a fomewhat dufky, pale, grafs-green hue, containing air-bubbles, and externally covered with a grey turbid cruft.

b) CL. Cr. Fufed into a clear, pale-black-greenifh glafs, with feparate bubble-holes.

No. 60. OBSIDIAN; from *Tokay.*

a) CH. Cr. Like No. 59. *a*)

b) CL. Cr. Like No. 59. *b*)

No. 61. OLIVIN; from *Greenland.*

a) CH. Cr. The grains black, opake, finely glazed, and conglutinated.

b) CL. Cr. Almoft the fame change, and coalefced with the fides of the crucible, which it powerfully attacked.

No. 62. OLIVIN; from *Habichtfwalde.*

(*a* CH. Cr. As No. 61. *a*); only a little more firmly coalefced.

b) CL. Cr. As No. 61. *b*)

No. 63. OLIVIN; from *Ritterfdorff*, in the middle mountains of Bohemia.

a) CH. Cr. The concretion of the grains ftronger; alfo ftrongly glazed, and of a dirty leek-green.

b) CL.

b) CL. Cr. Like No. 61. *b*)

No. 64. OLIVIN ; from *Unkel.*

a) CH. Cr. Its grains were covered with a greenifh-black glaze, cemented together, and croffed by a white mafs, in fome places cryftallized in a delicate capillary form. Their outer fides were invefted with grains of iron.—L. of W. 0,02.

b) CL. Cr. Were fufed into one gloffy, fomewhat porous mafs, which, in the upper part, was cryftallized in a radiated form, with a brownifh-grey tinge ; but in the fracture it was partly greenifh-white, partly grafs-green.

No. 65. OPAL (femi-opal), brown-red ; from the *Telkebanya* mountains.

a) CH. Cr. Without alteration as to form. Externally black-grey, dull, and in every part covered with differminated fmall grains of iron. In the fracture, brownifh-grey, dull, and uneven.—L. of W. 0,18.

b) CL. Cr. Little changed in the form. Externally refembling the fpecular or grey iron-ore (*Eifenglanz*). Its fracture black, glittering, and in a fmall degree porous.

No. 66. OPAL (femi-opal), yellow ; from the fame place.

a) CH. Cr. Figure unaltered ; its colour turned greyifh-white, and it was much difpofed to fly in pieces. Some luftre on the outfide ; in the fracture, dull and earthy, of a fine grain.—L. of W. 0,06.

b) CL. Cr. The ſame changes; together with a ſomewhat brighter luſtre.

No. 67. OPAL, *ſemi-opal of a verdigris-colour (Heliotropium?)*; from Greenland.

a) CH. Cr. Was rendered ſoft, its fracture of a light-reddiſh-brown, ſpeckled with a copper-red; glittering, and exhibiting dim-white points and veins.

b) CL. Cr. Rendered not quite ſo ſoft by the ignition; and it acquired a liver-colour, with white ſpots.—L. of W. 0,06.

No. 68. PITCH-STONE, yellow; from *Meiſſen.*

a) CH. Cr. A greyiſh-white glaſs; though clear in itſelf, yet full of froth-bubbles. The outer ſurface preſented a deep-grey, ſhining cruſt.

b) CL. Cr. The ſame; but without the external incruſtation.

No. 69. PITCH-STONE, blue (ſo ſtyled); from *Menil-Montant*, near Paris.

a) CH. Cr. Became ſoft, yellowiſh-white, and ſplit or cleft in the manner of ſlate.

b) CL. Cr. The ſame changes; except its colour turning light-brown.—L. of W. 0,08.

No. 70. SHISTOSE PORPHYRY; from *Schlosſberg* near *Toplitz.* (Its chief maſs the *Klingſtein*, as it is called).

a) CH.

a) CH. Cr. Run into a denſe, very ſhining glaſs, of a grey tinge inclining to deep-green ; tranſparent in ſmall fragments, and inlaid with detached, nearly tin-white grains of iron.—L. of W 0,05.

b) CL. Cr. A compact browniſh-black glaſs, with tranſparent edges, and a conchoidal fracture.

No. 71. PORCELAIN JASPER, yellow; from Bohemia.

a) CH. Cr. Suffered no alteration in its form ; but was rendered ſomewhat contracted, of a deep ſteel-grey, and dull.

b) CL. Cr. Figure unchanged; externally yellowiſh-brown ; in the fracture, black and glittering.

No. 72. PRASE ; from *Breitenbrunn.*

a) CH. Cr. Its form unaltered; externally of a grey-white, ſhining, inlaid with tranſuded grains of iron. Its fracture, greeniſh-white, of a faint luſtre, and uneven. Totally opake.—L. of W. 0,03.

b) CL. Cr. The form likewiſe unaltered; externally of a ſmutty-greeniſh white, gloſſy, and ſpotted with minute drops reſembling pitch. Fracture grey and dim.

No. 73. QUARZ, red; from *Rabenſtein.*

a) CH. Cr. No change in the figure; colour entirely pale reddiſh-white; ſlightly tranſparent; and inveſted with a delicate glazing.—L. of W. 0,03.

b) CL. Cr. The ſame.

No. 74. RUBY, roſe-red, *oriental.*

a) CH. Cr. No alteration; except its ſurface having become a little dimmed.—Alſo without L. of W.

b) CL. Cr. Entirely unchanged. Its colour even ſeemed to be rendered ſtill purer and more lively than before ignition.

No. 75. MUSCOVY GLASS (*Gliſt, Mica*); from *Siberia.*

a) CH. Cr. In order to incloſe it in the crucible, ſeveral lamellas were rolled up. The outer ones became grey, glazed and brittle; the inner ones black, like tinder, and continued flexible.—No. L. of W.

b) CL. Cr. Every one of the lamellas thoroughly hardened by the ignition, glazed, brittle, rendered nearly ſonorous. Colour changed to a greyiſh-white; the ſurface in part alſo light-brown.—No. L. of W.

No. 76. SAPPHIRE, azure-blue; from *Ceylon.*

a) CH. Cr. Without alteration; except the ſurface, which became a little duſky, and dim and muddy.—No loſs of weight.

b) CL. Cr. Likewiſe unaltered. However, the colour was rendered in ſome pieces paler, and at the ſame time ſlightly opaleſcent.

No. 77. PRISMATIC SHOERL, black, longitudinally ſtreaked; from *Cornwall.*

a) CH. Cr. Little change in the figure. Outwardly, ſtill preſerving, in part, the priſmatic form, with grains of iron exuded

exuded. Fracture grey, of but little glofs, refembling that of fat.—L. of W. 0,09.

b) CL. Cr. Imperfectly fufed; on the upper part brown, with glittering points. Fracture of a blackifh-grey, flightly refplendent, with a greafy luftre, and exhibiting fine pores.

No. 78. SHOERL, black cryftallized, in columns of nine fides; from St. *Gotthard.*

a) CH. Cr. Externally afh-grey, and very much fhrivelled. In the fracture prefenting a compact, fmoke-grey, moderately fhining fcoria; with feveral large bubbles, containing on the infide diffeminated granular particles of iron.—L. of W. 0,08.

b) CL. Cr. Fufed into a tough, pale, olive-green flag, of a moderate glofs like fat; with feveral large air-bubbles.

No. 79. SHOERL, black, in large hexagonal columns; from *Greenland.*

a) CH. C. Converted into a fcoria of a greenifh-grey tinge, and tranfparent fragments. Its furface was coated with a dufky cruft, and fcattered grains of iron.—L. of W. 0,07.

b) CL. Cr. An olive-green flag, tranfparent in thin fplinters, of confiderable compactnefs, and a wrinkled furface.

No. 80. SERPENTINE, blackifh; from *Zöblitz.*

a) CH.

a) CH. Cr. Indurated; externally covered with a ferruginous cruſt, together with ſmall grains of iron. In the fracture, ſplintery, dull and of a grey colour.—L. of W. 6,12.

b) CL. Cr. Rendered hard. The ſurface glittering, glazed in part, and paſſing from iron-black to a copper-red. Towards the edges of the fracture likewiſe iron-black, but in the middle of a pale greeniſh-grey; ſmooth and dull.

No. 81. EMERALD; from *Peru.*

a) CH. Cr. Entered into an imperfect fuſion, and preſerved its green colour, though ſomewhat fouled. It alſo was rendered opake, and preſented detached minute grains of iron.

b) CL. Cr. A clear, greeniſh-white glaſs, with a few radiating points.

No. 82. EMERALD? oriental; (perhaps green ſapphire?)

a) CH. Cr. Quite unaltered in ſhape. The colour was rendered ſomewhat duller, and verging towards grey. The ſurface partially covered with a rough cruſt; ſome pieces reflected changeable variegated colours.

b) CL. Cr. Figure and luſtre as before. Turned opake. The green colour in part paſſed to a white, and in ſome pieces the variegated reflection of colours was ſtill more diſtinct.

No. 83. SPINELL (Ruby).

a) CH.

a) CH. Cr. Suffered no change, excepting that its furface became fomewhat muddy and foul.—No lofs of weight

b) CL. Cr. Part of it was imperfectly melted to a blackifh-brown fcoria, into which were cemented the other pieces, whofe colour and tranfparency were unimpaired.

No. 84. ACTYNOLITE (Strahlftein) common, green; from St. *Gotthard.*

a) CH. Cr. Externally covered with a ferruginous cruft, and numerous grains of iron. The infide fhewed a grey and dull fcoria, full of bubbles.—L. of W. 0,04.

b) CL. Cr. Converted into a fibrous flag, of a greenifh-grey fracture, and a brown furface, cryftallized in a radiated form.

No. 85. ACTYNOLITE, common, leek-green; from *Peterfburg.* (Swed. *Hornblenda*).

a) CH. Cr. Like No. 84. *a*); only with but few grains of iron in the furface, and with acicular cryftals in the froth bubbles.—L. of W. 0,04.

b) CL. Cr. A leek-green, and at the top red-brown, compact fcoria; of a fine ftriated fracture, and efflorefcent cryftallization.

No. 86. ACTYNOLITE, common, in feparate parallel prifms; from *Carinthia.*

a) CH. Cr. A dull, bluifh-grey fcoria, full of bubbles and its furface inlaid with grains of iron.—L. of W. 0,04.

b) CL.

b) CL. Cr. A denfe, greenifh-white, and in the fracture indiftinctly radiated flag. On the upper furface cryftallized in interwoven, reticular, fine, brown needles.

No. 87. GLASSY ACTYNOLITE; needle-fhaped, of an intermediate colour between deep mountain-green, and black-green; from *Taberg*.

a) CH. Cr. As No. 86, *a*). Its cruft had in fome places a cupreous luftre.—L. of W. 0.12.

b) CL. Cr. Fufed into a denfe, greyifh-white, opake fcoria, marbled of a brown-yellow at its top.

No. 88. GLASSY ACTYNOLITE, acicular, white; from *Taberg*.

a) CH. Cr. A greyifh-white mafs, fufed in a fpherical form; on the upper part with feparate, recumbent, fhining radiations; on the under part mixed with grains of iron. Fracture uneven, dull and rough; in parts ftriated.—L. of W. 0,20.

b) CL. Cr. A greenifh-white, denfe fcoria, with a glittering greenifh-yellow very fine efflorefcent furface of fmall ftellular points. Fracture finely fibrous and refplendent.

No. 89. ACTYNOLITE, olive-green, in prifmatic cryftals; from *Dauphiné*.

a) CH. Cr. The pieces did not fufe together, but were merely conglutinated firmly. External furface, iron-black, with fmall ferruginous grains, oozed through. Infide fteel-grey, fine earthy, and dull.—L. of W, 0,15.

b) CL.

b) CL. Cr. Melted into a highly refplendent glafs; of a black-brown colour; flat conchoidal fracture, and tranfparent fplinters.

No. 90. ACTYNOLITE, cryftallized in prifms, deep blackifh-green; from *Zillerthal* in Tyrol.

a) CH. Cr. Fufed into a fpherical, moderately fplendid, opake fcoria, of a bright greenifh-grey colour, and perfectly radiated fracture, furrounded with grains of iron.—L. of W. 0,06.

b) CL. Cr. A ftrongly refplendent, compact, opake flag, internally almoft apple-green; of a conchoidal fracture, and yellow furface, mixed with brown.

No. 91. STRONTIANITE.

a) CH. Cr. Form unaltered. Hardened by ignition; rendered dull, and very cauftic.—L. of W. 0,31.

b) CL. Cr. A clear, bright grafs-green glafs.

No. 92. TALC (of the *magnefian* or *muriatic* genus); greenifh-white; from St.-*Gotthard*.

a) CH. Cr. Became hard; fplit like flate; grey white; in two places flightly united with the crucible by fufion.

b) CL. Cr. Rendered yellowifh-white; hardened by the ignition, and acquiring flaty rifts.—L. of W. 0,05.

No. 93. TALC, Venetian.

a) CH. Cr. Indurated, flaty, bluifh-grey; in part with a thin red covering.—L. of W. 0,08.

b) CL.

b) CL. Cr. The ſame change. Its colour brown, reſembling decayed mica.

No. 94. TOPAZ; from *Braſil.*

a) CH. Cr. Rendered white, dull, untranſparent; of a fine earthy and longitudinally ſtriated fracture.—L. of W. 0,20.

b) CL. Cr. The ſame; with thin flakes, burſt off.

No. 95. TOPAZ; from *Schneckenſtein.*

a) CH. Cr. As No. 94, *a*).—L. of W. 0,20.

b) CL. Cr. As No. 94. *b*).—L. of W. 0,20.

No. 96. TREMOLITE, radiated; from St. *Gotthard.*

a) CH. Cr. Ran into an opake, grey-white, round ſcoria; of a foliated texture, and a radiated cryſtalline ſurface.—L. of W. 0,05.

b) CL. Cr. A compact, greeniſh-white flag, with little luſtre, and of a radiated fracture.

No. 97. TRIPOLI; from *Menil-Montant*, (the matrix of what is called *blue pitch-ſtone.*)

a) CH. Cr. An indurated, very contracted, black-grey, finely porous ſcoria.

b) CL. Cr. Its outer ſurface browniſh and glittering; its internal ſurface, or fracture, yellowiſh-grey, dull, and porous like ſponge.—L. of W. 0,20.

No.

No. 98. TOURMALINE, green, tranfparent; from *Brafil.*

a) CH. Cr. Hardened by the ignition. The fides compreffed inwards. Externally black-brown; internally greenifh-grey, opake and dull.—L. of W. 0,10.

b) CL. Cr. The fame change; but of a blacker tinge. The part of the crucible, in contact with it, covered with a brown glaze.

No. 99. TOURMALINE, black; from *Spain.*

a) CH. Cr. Hardened, and the cryftals conglutinated. Outfide black, with crofs rifts and dull; infide dim grey-white. Fracture, conchoidal. Slight glofs of the greafy kind.—L. of W. 0,15.

b) CL. Cr. Externally the fame. The fracture, of a fteel-grey, but with rather lefs luftre, and with fine pores.

No. 100. TOURMALINE, black; from *Zillerthal.*

a) CH. Cr. Affumed a very irregular fhape. Externally like No. 99, *a*); inwardly, of a conchoidal fracture, a fmoky grey colour, and greafy luftre.

b) CL. Cr. Tough; diffufed by melting; light-brown, opake, and of a middling greafy luftre.

No. 101. UMBER, (brown iron-ochre); from the neighbourhood of *Cologne.*

a) CH. Cr. Gave a denfe, opaline glafs; of a bluifh-grey in the fracture, tranfparent when in fmall fplinters, and of a ftrong greafy luftre. It was coated with a grey-white cruſt, finely dotted by very minute froth-bubbles. At the bottom was one conſiderable grain of iron, which ſeparated of itſelf.—L. of W. 0,33.

b) CL. Cr. Fuſed into a ſolid, black glaſs; whoſe upper part was covered with a cruſt of the ſpecular iron-ore, *(Eiſenglanz)* very delicately efflorefcent, and radiated in a ſtellular form.

No. 102. UMBER; from *Cyprus.*

a) CH. Cr. Like No. 101, *a*) except that its cruſt was ſtill more minutely dotted, and the inward colour of a clear ſmoke-grey.—L. of W. 0,33.

b) CL. Cr. Like No. 101. *b*)

No. 103. VESUVIAN, light-brown.

a) CH. Cr. A denſe, clear, ſtrongly reſplendent, nearly colourleſs glaſs. The outer ſurface was rather muddy, and was formed into groups of regular cryſtals *(druſigt)* exhibiting very minute ſhort protuberances, each of which ended in a point, by means of four triangular, exceedingly fine ſtriated facets. Numerous grains of iron were imbedded in its under ſurface.—L. of W. 0,25.

b. CL. Cr. A compact, very dark olive-green glaſs; of a bright luſtre, and flat conchoidal fracture.

No. 104. VOLCANIC aſhes; (from the eruption of Mount Veſuvius, collected at *Naples* in the ſummer of 1794.)

a) CH. Cr. Melted into a compact glaſs, of a dirty olive-green; ſmall fragments of which tranſmitted light. It contained ſome pieces of iron.—L. of W. 0,10.

b) CL. Cr. A denſe, browniſh-black glaſs.

No. 105. WACKE (a variety of baſalt, commonly ranked among the ſpecies of argillaceous earths); from *Joachimsthal.*

a) CH. Cr As No. 7. *b*).

Note. The ſame ſpecimen was again put into the charcoal-crucible, after it had been ſeparated from the grains of iron. When taken out, it was tuberous or knobby. The ſurface preſented a glittering black-brown incruſtation, whoſe fracture had a ſlight luſtre. But the interiour maſs had become pale-grey, and denſer than before.

b) CL. Cr. The ſame change as No. 7. *b*)

No. 106. FULLER'S EARTH (*Smectis*) genuine; from *Hampſhire.*

a) CH. Cr. A compact opake ſcoria of a dull grey, with many grains of iron.—L. of W. 0,25.

b) CL. Cr. A denſe, blackiſh-green ſcoria. Its ſmooth ſurface exhibiting red dots.

No. 107. WITHERITE; from *Anglezark.*

a) CH. Cr. In experiments repeatedly made with this ſubſtance, the inner charcoal-crucible was found conſumed for the greateſt part. Hence the witherite always entered into an imperfect fuſion with the contiguous part of the clay-crucible, which ſerved as a caſe to the charcoal-crucible.

b) CL. Cr. A green, ſomewhat turbid, and frothy glaſs.

No. 108. ZEOLITE, compact, ſiliceous, (*Prehnite*); from *Scotland.*

a) CH. Cr. Fuſed into a compact, deep-grey, opake ſcoria. Fracture, imperfectly conchoidal, and highly glittering. Coated with a ferruginous cruſt; and containing a few minute grains of iron.—L. of W. 0,05.

b) CL. Cr. An opake denſe ſlag. Its ſurface olive-green; the inner maſs, celadon-green, and the fracture glittering.

No. 109. ZEOLITE, radiated; from *Ferröe.*

a) CH. Cr. Swelled up into an ill-ſhaped, greyiſh-white, tranſparent ſcoria; full of froth bubbles.—L. of W. 0,16.

b) CL. Cr. The ſame; but as white as ſnow.

No. 110. ZEOLITE, volcanic grey; (according to *Fichtel*—according to others, zeolitic pitch-ſtone) from the Mount *Pap-Laſſo*, near *Telkebanya.*

a) CH. Cr. A glaſs of a dim, black-grey colour; of a clear tranſparence on the edges; of a greaſy gloſs in the fracture; and ſhewing ſeparate bubbles. It alſo had very ſmall grains of iron in ſeveral parts of its external ſurface.—L. of W. 0,05.

b) CL. Cr. Yielded a denſe, bright greyiſh-white, tranſparent, but not thoroughly clear glaſs; rendered turbid by very minute froth-bubbles. Its ſmooth ſurface poſ-

ſeſſed

feffed a great fplendour, and was marked with difperfed brown-red fpots, refembling agates.

No. 111. ZEOLITE, volcanic red; from the *fame place.*

a) CH. Cr. Like No. 110. *a*)

b) CL. Cr. Like No. 110. *b*); only fomewhat more turbid.

No. 112. CIRCON (Jargon); from *Ceylon.*

a) CH. Cr. No change, excepting that its colour turned white-grey, and its furface became a little more turbid.—Alfo no L. of W.

b) CL. Cr. Likewife unaltered. The greenifh colour had almoft difappeared, and in its ftead fucceeded a reddifh, bluifh, and in part perfectly white one. Several pieces emitted a whitifh luftre.—No lofs of weight.

Concerning the utility which thefe experiments on fufion may afford in various refpects, I fhall make only one or two remarks.

On reviewing the divifion of ftones and earths into *fufible* and *infufible*, which has been hitherto adopted, we obferve that feveral of them are claffed among the firft; which, however, are not fufible of their own accord, but acquire that property only by the co-operation of extraneous caufes. Thus, if we obferve the *Strontionite* (No. 91), the *Compound-fpar* (No. 16), *Sidero-calcite* (No. 20), *Marble*, (No. 56), and in general all the fpecies of calcareous earth, to vitrify in the melting-veffels, it is owing to the *argillaceous earth* of the clay-crucible, which by its contact effects the fufion of thofe ftony matters, which, when alone, are infufible.

 With

With refpect to many other fubftances, the caufe of their vitrification is their ferruginous contents; for *oxyd of iron* likewife promotes the fufion of many compofitions, otherwife not vitrifiable. This vitrification, therefore, cannot take place in *charcoal-crucibles*; becaufe in thefe, the calx of iron lofes its vitrefcent property, by being reduced to reguline iron, and hence is rendered incapable of continuing in chemical folution or combination with unmetallic-earths. It then feparates from them by a kind of eliquation.

An inftance of this is afforded by the *Bafalt*, (No. 6—10), ufually reprefented as a body, which very eafily melts into a black glafs. But this fufibility of bafalt obtains only when its ferruginous part finds no opportunity to be reduced and to feparate: for after this is withdrawn, the remaining portion of bafalt is no longer vitrifiable. It now appears, if examined by a lens, as a body almoft wholly corroded; and it is not converted into a fcoria, unlefs after continued expofure to the moft violent fire.

It is worth remarking, that, in the charcoal-crucible, not only is the iron of fuch foffils, as contain it in a very flight quantity, as *Pumice-ftone* (No. 15), *Boracite* (No. 19), *Mica* (No. 38), completely reduced; but alfo, that even fome fpecies of ftones, which in no manner undergo real fufion, nay, which hardly feem to become fofter, as the *Ligniform Afbeftus* (No. 11), *Chryfolite* (No. 25), *Brown-red Semi-opal* (No. 65), *Prafe* (No. 72), and *Serpentine* (No. 80), do neverthelefs depofite, as it were by exfudation, moft part of their iron.

The proportion of the ferruginous contents thus difcovered, may ferve at the fame time to determine in dubious cafes the claffification in the mineralogical fyftem. That is to fay, it may affift to decide, whether a foffil, whofe pro-

proportion of metallic parts is as yet unknown, ſhould obtain a place in the claſs of earths and ſtones; or, whether it ought to be ranged in the genus of iron-ores.—Such is the caſe with *Umber.* Of one hundred parts of umber from *Cyprus* (No. 102), there remained 67; and the iron, reduced from this reſiduum, amounted to 37; but the vitreous ſcoria, only to 30.—Of one hundred parts of *umber* from *Cologne*, there likewiſe remained 67, of which 35 were iron, and 33 were ſcoria. This mineral, therefore, as much deſerves a place under the genus of iron-ores, as ſeveral other iron-ores, leſs rich in ferruginous contents. It may be conſidered, either as a particular ſpecies of the brown iron-ſtone; or as a variety of brown iron-ochre.

Beſides, the trials made with fire may be of ſome utility with regard to thoſe foſſils, concerning which the opinions of the learned are yet divided, with regard to the means employed by nature for their formation. I even think, that in this branch of *geological* reſearches, the experiments made by *means of fire*, are rather more deciſive than the analyſis in the *moiſt-way.* Although it is quite contrary to my intention to enter into this diſpute, yet I think myſelf obliged to ſtate my own private opinion reſpecting this ſubject, independent of the authority of others; which is, that I cannot rank among the products of fire, either the genuine *baſalt*, or its kindred *wacke*, or the *porphyric-ſlate.* In this perſuaſion I am confirmed by perſonal inſpection of baſaltic diſtricts, eſpecially of the *Bohemian middle mountains*; as well as by the habitudes of the above minerals in fire. No. 6—10; 105; 70.

On the contrary, as to what relates to the generation of the *Obſidian* (No. 58, 60), *Pumice-ſtone* (No. 15), and pretended *Volcanic Zeolite* (No. 111, which laſt is reckoned by ſome among the *Pitch-ſtones*), &c, I willingly renounce my own opinion; adding only, that, on confidering the arguments for and againft their volcanic origin, the circumftance of the obfidian and pumice-ftone giving in fire exactly the fame products, fhould not be difregarded; and alfo, that both thefe foffils, not only accompany each other at *Lipari*, but likewife frequently occur actually blended.

As the chemical analyfis in the humid way is embarraffed with many difficulties, that check the progrefs of our knowledge of the conftituent parts of foffils; the fpeedier examination, by means of fire, of a foffil, not yet analyfed, may ferve as a previous hint for affigning to it its proper place in the fyftematical arrangement. It may alfo tend to correct the claffification of feveral minerals whofe characters are not fufficiently diftinct, or perhaps have led to error. So, for inftance, the above refults plainly fhew, that the *Cats-eye* is not a fel-fpar (No. 48, 49); that the *Leucite* does not belong to the garnets, and as little to the fel-fpar (No. 55); that the *Telkebanya-ftone*, or *brown-red Semi-opal*, is not allied to the vitrifiable pitch-ftones, among which it has been ranged on account of its perfect opacity (No. 65); and that the *Granatite* cannot be claffed under the garnets (No. 41); nor the *Cyanite* under the ftriated fhörls (No. 28); nor the *Chlorite*, under the varieties of mica (No. 23.)

However, the inferences drawn from thefe experiments, fhould not be carried too far; nor fhould a decifive conclufion be made on the conftituent parts of a foffil, merely from its changes in the fire. For, in this refpect, the *analyfis in the humid way* is abfolutely the only fafe guide.

II. ANALYSIS

II.

ANALYSIS

OF THE

BLACK-GREY FLINT.

(Common Flint; *Feuerſtein* of the Germans.)

In order to reduce to the requiſite moſt ſubtle pulverulent ſtate the harder kinds of ſtones, which are to be ſubjected to a chemical analyſis, I make uſe of a grinding concave ſhallow veſſel or bowl, wrought, as well as its appropriated mullar, of black-grey flint. The body, which is to to be finely ground in it, being previouſly pulverized in a poliſhed ſteel-mortar, gently ignited and accurately weighed, I moiſten with water, and continue the trituration, until the ſtone is reduced to an impalpable powder. A ſhorter or longer time is neceſſary for this operation, according to the degree of hardneſs; ſo that 100 grains of the more indurated ſpecies of gems often require triturating for three or four hours. After the finely powdered maſs is again deſiccated in the air, or in a gentle warmth, I ignite the powder, carefully collected from the triturating-diſh, in a ſilver or porcelain-crucible, with a low heat, and weigh it once more.

Stones, the hardneſs of which does not ſurpaſs that of flint, weigh then no more than at firſt. But ſuch as are harder than flint, acquire an increaſe of weight; which in ſome gems, as the ſapphire, adamantine-ſpar, and chryſo-beryl, often amounts to from 10 to 13 *per cent.*

Therefore, as this addition of weight muſt, of courſe, be again ſubtracted from the ſum of the conſtituent parts of the decompoſed body, an exact chemical knowledge of the ſubſtance, of which the grinding veſſel conſiſts, is indiſpenſable. And, no doubt, common flint would be little eligible for the grinding of hard ſtones, if, beſides the ſilex, its chief ingredient, it contained other earths in that quantity, which is ſtated by mineralogiſts; and of which aluminous earth is ſaid to make up from 18 to 20 parts in the hundred.

But from an exact and repeated analyſis of this flint, I am convinced that the quantity of foreign earths, which are here combined with the ſilex, is far leſs conſiderable, and that in general the ſum of them only amounts to *one grain.* On this account, and conſidering the ſmall number of grains abraded from the flint mortar, it would appear a ſuperfluous nicety, to bring into calculation the ſmall fractional parts of the other earths, beſides the ſiliceous.

a) *Five hundred* grains of common flint, coarſely bruiſed, were ignited for half an hour in a covered crucible. They loſt, by this, five grains of weight, and turned greyiſh-white.

b) *A Hundred* grains of flint, reduced to the fineſt powder, were mingled with three times their weight of cauſtic pot-aſh, and expoſed to a red-heat in a ſilver-crucible for

half

half an hour; by which management, however, the mixture did not fuſe, but continued a looſe, friable maſs. When covered with water, it was all diſſolved, without any reſidue, and afforded a ſomewhat turbid liquor.

c) By over-ſaturating this ſolution with muriatic acid, the *ſiliceous earth* was precipitated; which, after a due digeſtion, was ſeparated, waſhed, and ignited.—It weighed 97 grains.

d) The acid fluid, thus ſeparated, when ſaturated with carbonat of ſoda, let fall a browniſh earth; which re-diſſolved in muriatic acid, and left ſiliceous earth, weighing one grain after ignition.

e) The remaining muriatic ſolution afforded, with cauſtic ammoniac, a brown, mucilaginous precipitate; which, when added, while yet moiſt, to cauſtic lye, depoſited *oxyd of iron*, weighing after ignition one quarter of a grain.

f) When this portion of iron had been ſeparated, I mixed the cauſtic lye with muriatic acid to exceſs. Being then ſaturated with mild ſalt of tartar, it was put in a warm place. A ſmall portion of earth fell down; which, after gently drying, weighed one half grain, and its ſolution in ſulphuric acid afforded aluminous cryſtals. This aluminous earth would have weighed one quarter of a grain in its dry ſtate.

g) The edulcorating waters, after being collected, evaporated to dryneſs, and the reſidual ſaline maſs, again diſſolved in freſh water, depoſited three quarters of a grain more of an earth, which diſſolved in muriatic acid, with effervеſcence, and yielded ſelenite or gypſum, on dropping ſulphuric acid into it. It was conſequently *calcareous earth*,

which,

which, if free from carbonic acid, would have amounted to half of a grain.

Hence the constituent parts of common flint amount in *one hundred* to

Ignited *silex* - -	c) . 97	} . 98,	
	d) . 1		
— — — *Lime* .	g) . . .		0,50
— — — *Alumine* .	f) . . .		0,25
Ignited *oxyd of iron* . .	e)		0,25
Parts volatile in fire . .	a) . . .		1,
			100

III. CHEMICAL

III.

CHEMICAL EXPERIMENTS

ON THE

ADAMANTINE SPAR.

*FIRST SECTION**.

NATURE, inexhauftible in its riches, has intended, as it were, to keep in activity the ardour of Naturalifts, in the difcovery, examination, and arrangement of the foffil products, by prefenting new fpecies that have remained hitherto unknown, and whofe proper place has been too frequently miftaken in artificial claffifications. This truth has been confirmed, in an eminent degree, by the *adamantine fpar*.

The native places of this ftone are *China* and *Bengal*; and from each of thefe countries it was firft brought to Europe, for the celebrated cabinet of *Charles Francis Greville*, Efq. in London. The denomination of *adamantine fpar*, given to it by Englifh Naturalifts, is grounded not only on its uncommon hardnefs, fimilar to that of diamond;

* Read in the Royal Acad. of Sciences at Berlin. See *Recherches chymiques fur le Spath adamantin*; in the *Memoires de l'Acad. royale etc, Août* 1786, *jufqu' à la fin de* 1787. Berlin 1792.

but

but alfo on its application ; for the Chinefe and Indian lapidaries make ufe of the powder of this ftone inftead of the real diamond-powder for grinding.

The firft public notice taken of the adamantine fpar which I know of, is contained in the fecond Volume of *Sage's Analyfe chymique et concordance des trois regnes* ; where this writer ftates the above foffil to be a granite, compofed of fel-fpar, black-fhörl, and quarz. A more accurate account of it, together with a defcription of its external appearance, was afterwards given by *de la Metherie* and *Abbé Hauy* in *Rozier's Journal de Phyfique*, for January and March 1787.

But as no Chemift has ventured to undertake its chemical analyfis, *Mr. Greville* was fo obliging as to facrifice a quantity of this fubftance, in his poffeffion, fufficient for its examination, and to fend it me for that purpofe.

The adamantine fpar prefents two diftinct varieties, according to the two different countries which give it birth. The firft, which is found in China, when regular, affumes a columnar form of fix fides, without terminating points. The fize of the fpecimens which I have feen, was from an half to a full inch in height, and three quarters of an inch in thicknefs.

The colour of this ftone is grey, of various fhades, partly verging to the brown of hair. The entire pieces are opake ; but in thin lamellas, and on the edges tranfparent. Its fracture is gloffy, and exhibits a fine fpatofe or foliated texture ; on account of which, even its outer furface appears finely ftriated. Its lateral facets are moftly coated with a delicate, firmly adhering cruft of micaceous fcales of a filvery luftre, and in fome places intermingled with parti-

cles

cles of red fel-ſpar.—One ſpecimen was alſo covered with a delicate yellow *ſulphur pyrites.*

This ſtone is exceedingly hard. For this reaſon, it not only cuts glaſs with as great facility as diamond, but it alſo ſcratches rock-cryſtal and other hard ſtones, and is employed, as already mentioned, for cutting and poliſhing even gems.

Its ſpecific gravity I found to be 3,710.

An accidental characteriſtic mark of this Chineſe adamantine ſpar is, that it contains magnetic iron, diſſeminated in ſmall cryſtalline grains, which are eaſily ſeparable by means of the load-ſtone, if the ſtone has previouſly been bruiſed to a moderately fine powder.

The ſecond variety, or Indian adamantine-ſpar, from Bengal, called by the natives *Corundum*, is diſtinguiſhed from the Chineſe by a whiter colour, by a more decidedly ſparry texture; and by the magnetic iron, which it likewiſe contains, conſiſting of ſtill ſmaller grains, but not interſperſed within its ſubſtance, but merely adhering to its ſurface.

With the *Chineſe Adamantine Spar* I made the following Chemical Experiments.

By ſtrong ignition for an hour it loſt $1\frac{1}{6}$ *per cent.* of weight; but ſuffered no alteration, except having become a little whiter. Before the blow-pipe upon charcoal, it was not

not in the leaſt attacked, either by ſoda, or by borat of ſoda; or by the compound of phoſphat of ſoda and ammoniac (*phoſphoric ſalt of urine.*)

In order to guard againſt accidental impurities, I bruiſed the ſtone on the anvil, between many ſheets of ſtrong paper. I then picked out the pureſt pieces; heated them to redneſs, and quenched them in water. However, this operation being ſeveral times repeated, was found uſeleſs; and the hardneſs of the ſtone was not at all thereby diminiſhed. It was next triturated in an agate mortar to the fineſt powder; and upon 300 grains, or five drachms of this powder, introduced into a retort, twice its weight of aqua regia was poured. By ſtrong digeſtion, I obtained from it a golden-yellow tincture of iron. This digeſtion was once more repeated with a freſh quantity of the ſame acid. I then precipitated the diſſolved iron by cauſtic ammoniac; which precipitate, after edulcoration and ignition, was all attracted by the load-ſtone.

My next ſtep was to examine whether the decanted fluid contained calcareous earth.—For this purpoſe I combined it with mild ammoniac; but no trace of this earth appeared. Therefore the acid had only extracted that portion of iron, which is ſimply diſſeminated in the adamantine ſpar; but does not belong to its compoſition.

The powder remaining after the extraction of the iron was of a bright aſh-grey. This I mixed with double its weight of ſalt of tartar*, and ignited it in a ſilver-crucible, during two hours in a briſk fire. But on ſoftening again this maſs by diſtilled water, I ſoon perceived, that no *reſolution*,

* Pot-aſh, or vegetable alkali, prepared from tartar.

or ſeparation of parts, had taken place in the intrinſic mixture, or compoſition of the ſtone: nor did the alkaline ſolution let fall any precipitate, when ſaturated with acids.

Convinced by other experiments, that the cauſtic fixed alkalis have a ſtronger *reſolvent* power, than the mild over ſtones of a firmer texture, I reſolved to repeat the operation with the cauſtic alkali. With this view I prepared cauſtic ſoda, with all the precaution neceſſary for obtaining it in a perfectly pure ſtate.

Equal parts of this cauſtic ſalt, and of the powder of adamantine ſpar, were ſubjected to ignition in a ſilver-crucible for the ſpace of two hours. After this, the calcined maſs, which had become very compact and hard, was triturated with diſtilled water; ſuper-ſaturated with muriatic acid, and digeſted. The acid extracted merely a pale yellow tincture, which ſtill contained a ſlight ferruginous impregnation; but nothing of an earthy nature. When the reſidual powder was again waſhed, and ignited, it was of a light grey-white colour, and weighed 240 grains. So that 60 grains, making the fifth part of the firſt weight of the crude ſtone, muſt be taken for the iron diſſeminated in, and now ſeparated from it by acids.

Theſe 240 grains I mixed with four times their weight of cauſtic mineral alkali; and ignited them in a crucible made of ſilver, as long as the veſſel would bear it, without itſelf fuſing. After refrigeration, the maſs was ſo firm and ſo hard, that in order to bring it on the filter, I was under the neceſſity of ſoftening it by long tedious boiling in diſtilled water. The alkaline ſolution, ſaturated with muriatic acid, now dropped a white, very looſe earth; which, from previous conjecture, I then imagined to be ſiliceous. But this was not the caſe, for it was rapidly and clearly re-

difdiſſolved by a ſlight exceſs of acid, and proved to be rather aluminous on farther trial. And by accurately ſaturating the ſolution with ſalt of tartar, I reproduced it again in the form of a precipitate, and collected it.

The powder, left on the filtering-paper, had an iſabella-yellow colour, and had become looſer. I poured upon it four parts of aqua regia; but it ſoon formed with it a thick gelatinous coagulum. Having added four parts more, I digeſted the mixture in a boiling heat. Which being done, it was diluted with hot water, and, after filtration, ſaturated with ſalt of tartar. By this management a white looſe earth precipitated, and was aluminous, like the preceding.

I next repeated the ſame operation with the 140 grains of the powder of this ſtone that remained in the laſt-mentioned proceſs: that is to ſay, I added four parts of cauſtic ſoda, and heated it to redneſs for five hours in a ſilver-crucible. As in the preceding experiment, ſo in this, the maſs became exceedingly hardened, and of difficult ſolution, even in boiling water. Its filtered lye likewiſe depoſited, on the addition of muriatic acid, a white looſe earth; which, in the ſame manner, entirely diſſolved without any turbidneſs, by an exceſs of the acid. Having been again precipitated by mild alkali, I collected and added it to that which was obtained in the laſt proceſs.

In the ſame manner, as mentioned above, I treated the reſidue that remained behind on the filter after the ſeparation of the alkaline lixivium, by digeſting it in aqua regia; and the ſmall portion of earth, extracted from it, was likewiſe precipitated by ſalt of tartar.

The undecompoſed part of the powder, which at this period weighed 103 grains, I ſubjected a ſecond time to calci-nation,

nation, during five hours, being previoufly mixed with a quadruple proportion of cauftic alkali. The refult agreed with that of the foregoing procefs. From the filtered alkaline folution of the mafs, foftened with difficulty, acids threw down a flight quantity of loofe earth; which was re-diffolved when the acid was added to excefs. Having been again precipitated by the addition of alkali, it was then collected.

I next put the edulcorated refidue, weighing now but 92 grains, in digeftion with fix parts of nitric acid. The powder of the undecompofed adamantine fpar continued, as before, lying at the bottom, like an heavy fine fand. But when the mixture had begun to boil, I perceived an unexpected alteration. The powder fwelled; rofe from the bottom of the matrafs towards the furface of the liquid, and changed its fandy appearance to that of a flocculent precipitate, nearly of the fame form, with recently precipitated muriat of filver; but, on continuing the digeftion, it again fell down in the form of an incoherent powder. This laft acid likewife extracted a fmall portion of alumine; which I collected, after precipitating it by pot-afh.

The remaining powder of the adamantine fpar, whofe weight after ignition amounted to 74 grains, was treated in precifely the fame manner as before, only with this difference, that I increafed the proportion of cauftic alkali, of which I now took a fextuple weight. After the mafs had been ignited for five hours, and refrigerated, it was found, as in every previous operation, to be very difficulty foluble in boiling water. At this time, by the addition of an acid to the filtered folution, a lefs quantity of loofe earth, than before, was precipitated; but which even now was not filiceous earth. Boiling nitric acid likewife extracted from the refidual powder a little aluminous earth.

 When

When the adamantine powder, remaining after thefe repeated ftrong calcinations with alkali, was put on the balance, its weight was found to be 60 grains. It appeared now in the form of a fine, filiceous earth; and in order to examine it as fuch, I mingled it with one ounce of mild foda; upon which it was ftrongly calcined in a fmall filver-crucible, and at length urged to fufion. The crucible was left uncovered; becaufe I intended to watch attentively, whether the blended mafs would effervefce, during the action of the carbonated alkali, and thus betray a filiceous nature. The fufion, however, went on without the leaft frothing; and by this I was fufficiently convinced, that the earth under trial was not yet purely filiceous.

The melted mafs proved, after refrigeration, to be as difficult of folution in water, as before. This alkaline lye, paffed through the filter, fhewed no appearance of having taken up any foreign fubftance. It remained perfectly clear and limpid, when faturated with acids; fome few, hardly perceptible flocks, excepted.

I now endeavoured to feparate fomething from the refidue, again edulcorated, by means of ftrong fulphuric acid. Eight times its weight of this acid was accordingly poured upon it, and again with proper precaution diftilled off from it to drynefs. The refidue, foftened by hot water, was put on the filter, and the acid liquor, which paffed through the paper, was faturated with pure vegetable alkali. Yet, even with this treatment, I only obtained a very flight indication of alumine.

On confidering this great obftinacy of the remainder left from the adamantine fpar, which by the laft operation hardly loft one grain of weight, I again recurred to the cauftic mineral alkali. The powder, mixed with a tenfold quantity

tity of foda, was firft ignited for four hours; increafing afterwards the intenfity of heat, until the mafs entered into a thin fufion, in which ftate it was kept two hours. The filver-crucible would not longer refift the action of the fire; it was injured, though without detriment or lofs of the mafs, which was again with difficulty liquified in water, and then filtered.

The alkaline lixivium, thus obtained, depofited a tender earth, upon faturation with acids. But even this earth was not yet filiceous. It difappeared by a flight excefs of the acid; and feparated again, as foon as the point of faturation was reftored, by the addition of alkali. When thus recovered, it was freed from adhering faline particles by wafhing, and added to the precipitates, obtained in the preceding operations.

Upon the remaining portion of adamantine fpar in a pulverulent ftate, which in this procefs again had affumed an ifabella-colour, I then affufed four parts of nitric acid. The mixture thickened to a jelly; on which account I added four parts more of nitric acid, and digefted it in a boiling heat. The folution being diluted with water, and filtered, was faturated with falt of tartar; and the precipitate which it afforded, added to the preceding ones.

At this period, the quantity of adamantine fpar, which had hitherto refifted decompofition, weighed 34 grains; which were mixed with 15 times their weight of cauftic foda, and ignited in a brifk fire, during five hours. Yet, notwithftanding this, the alkaline lye, procured from the re-diffolved mafs, and faturated, depofited only a trifling quantity of a flocculent earth; and for this reafon no diminution of weight was obfervable in the refidue.

Digefted with eight parts of nitric acid, the mixture again acquired a gelatinous confiftence: and the acid, feparated by filtering, likewife afforded only a fcanty precipitate, on being faturated with alkali.

The powder, ftill undecompofed, weighed now 27 grains; which I blended again with 15 parts of cauftic foda, and treated in the manner oftentimes ftated. But I obferved that the alkali, as well as the fubfequent digeftion in acids, extracted from it ftill lefs than before; fince the remaining undecompofed part amounted yet to 24 grains.

I then refolved to try, whether perhaps a ftronger degree of heat, than the filver-veffel was capable of bearing, might not give additional force to the action of the alkaline falt, and thus effect the farther decompofition of this ftubborn refidue. I therefore fubftituted an iron-crucible to that of filver. This refidue, being mixed with four parts of mild pot-afh, and introduced into the iron-crucible, was expofed to a heat fufficiently intenfe to caufe it to melt, and it was then kept for two hours in red fufion. This obftinate body, however, could not be maftered. The liquor, feparated from the diffolved mafs, held no atom of earth in folution; but remained clear, when faturated with acids.

After the refidue, left on the filtering paper, had been freed by means of the muriatic acid from the particles of iron which it had acquired from the melting-veffel, and after it had been edulcorated and dried, I found it poffeffed of the fame nature as before; and only one grain of its weight was wanting, which I fuppofe was not diffolved, but loft.

Having thus *eleven times* calcined and fufed this ftone, with alkali in various proportions, I at laft gave up all hopes of conquering this refidue, which at each operation proved

proved more and more refractory. And not expecting ſucceſs, even from repeating theſe tedious proceſſes, that exhauſted all patience, I turned my attention to the examination of the ſeveral precipitates that had been collected.—But I found that thoſe which were obtained, by means of acids, from the ſolutions of the maſſes calcined with alkali, were of nearly the ſame nature as the precipitates, thrown down by alkalis from the acids, in which the adamantine ſpar was digeſted or extracted after every calcination. For this reaſon I mixed them all together, and choſe the ſulphuric acid, as the proper teſt for their examination. This menſtruum, conſiſting of one part of the concentrated acid, diluted with four parts of water, immediately diſſolved a conſiderable part of the earthy precipitate; but another portion remained undiſſolved, though the acid had been added to exceſs, and was aſſiſted by a boiling heat. Upon this undiſſolved earth, when ſeparated by filtration, edulcorated, dried, and introduced into a retort, I poured four times its weight of concentrated ſulphuric acid; and having again abſtracted this laſt, by diſtillation, to dryneſs, in a ſand-bath, I ſoftened the reſiduum with boiling water, placed it on the filter, and edulcorated the earth remaining on the paper. I found, however, that by this treatment, nothing of importance could be extracted from this earth; for the ſolution, ſaturated with alkali, yielded only one half grain of precipitated aluminous earth, which I re-diſſolved in ſome drops of ſulphuric acid, and added to the preceding ſolution

A ſmall proportionate quantity of pure vegetable alkali being added to this ſolution, it was made to cryſtallize by repeated gentle evaporations; after which it ſhot into regular cryſtals of alum, which were collected.

I obſerved, however, that on every cryſtallization of this ſolution of alum, a white ſlimy earth was ſeparated.

 I therefore

I therefore collected it carefully, and treated it in the fame manner as the earth mentioned before: that is—I diftilled from it four times its weight of ftrong fulphuric acid; foftened the refiduum in the retort with water; filtered the liquid which had diftilled over, and faturated it with alkali. But hardly one half grain of earth fell down, and this was ftill aluminous. The earth which remained undiffolved, exactly refembled that which has been mentioned before, and was accordingly added to it.

Thus I at length fo far fucceeded, as to decompofe the adamantine fpar into two different fpecies of earth. But though the firft evidently fhewed itfelf to be aluminous, the nature of the fecond was doubtful. On fuperficial confideration, this laft might well be taken for filiceous earth; but its habitudes contradicted this fuppofition.

Encouraged by the hope of coming nearer to the difcovery of its true nature, I repeated the operation fo frequently noticed, of heating it to intenfe rednefs for fome time, with fix parts of cauftic foda in the filver-crucible, and increafing at laft the ftrength of the fire fo as to affect its thorough fufion. The melted mafs had then acquired a ftriated cryftallic texture. Yet the alkali took up but a fmall portion of it, as I found by the weight of the undiffolved earth, recovered from the calcined mafs, after liquefying it by water. The refidue, wafhed and dried afrefh, was boiled for an hour with ten times its weight of ftrong nitric acid; from which, when feparated again, and faturated with alkali, only an inconfiderable trace of alumine fell down.

I then faturated with nitric acid the alkaline folution obtained from the melted mafs. It let fall a flight quantity of fine a fine earth; not a particle of which was diffolved by nitric acid boiled upon it for fome time.

This portion of earth, which was precipitated, and recovered by filtration, ought at laft, agreeably to theory, to have affumed the character of pure filiceous earth. To make trial of it, I expofed it with foda to the action of the blow-pipe, in a quantity not exceeding three grains. But it did not prove to be filiceous; on the contrary, I found it to be of the fame nature with the whole of the remaining earth, from which it was feparated by the mineral alkali during the fufion.

However, in order to make a comparative experiment with real filiceous earth, I mingled a drachm of this laft, precipitated from liquor of flints, with four drachms of cauftic foda, and expofed them together, in a filver-crucible, to only a moderate ignition. Although this mafs was hardly agglutinated by the operation; yet it eafily afforded a clear folution in diftilled water. And when this was faturated with an acid, the filiceous earth fell down, in its ufual manner, in the form of a jelly-like fubftance, highly intumefced.

From all thefe proceffes it is fufficiently obvious, that the adamantine earth in no manner acts like the filiceous. If it were fo, it fhould diffolve in fixed alkalis, by means of a red heat; more efpecially when cauftic alkalis are employed, as was here the cafe: and it likewife fhould be recoverable from them by affufion of acids. But the earth, which after the firft fufions, was thrown down by acids from the alkaline folutions, was not filiceous, but aluminous, which was immediately and entirely re-diffolved by adding more of acid. And in proportion as the alumine was feparated from the mixture of the adamantine fpar, by

 alkalis

alkalis as well as by acids, the unknown earth in queftion more and more refifted each folvent medium.

If filiceous earth, blended with equal parts, or with only one half of its weight of fixed alkali, be expofed to a melting heat, it unites with ftrong effervefcence to the alkali, and affords a clear glafs. And this refult enfues both in the crucible, and before the blow-pipe, in fmall experiments. But this is not the cafe with the other earth. When brought before the blow-pipe in a fmall filver fpoon, a little effervefcence feems indeed to take place at the beginning of the fufion; but neither is the effervefcence fo ftrong, nor is there a clear vitreous globule formed, as in the firft inftance. Only a fcorious mafs, of difficult fufion, remains.

A frit, compofed of twenty grains of this earth, with as much carbonated foda, was expofed in a luted clay-crucible, to the ftrongeft heat of the porcelain-furnace, which is fo intenfe, that carrara-marble, or any other calcareous earth, if inclofed in a clay-crucible, melts without any addition, into a very hard, clear, and green glafs. The refult of this experiment was, an opalefcent, very hard, greenifh-white glafs; the fracture of which, however, exhibited figns of a texture, in divergent lines, radiated from a common centre at the bottom of the melted mafs. Whereas filiceous earth, precipitated from the liquor of flints, when mingled with equal parts of foda, as was to be expected, yielded a clear glafs in the fame degree of heat.

What am I then to think of this earth? Shall I, perhaps, take it for a mixture as yet not totally decompofed, of two or more fimple earths, perhaps the aluminous and filiceous?—This opinion is *not without probable ground.* The extreme obftinacy with which the adamantine-fpar refifts all attempts to decompofe it, fhews us the high degree

gree of attractive power, by which nature has moft intimately mixed and united the conftituent parts of this ftone. Hence, in proportion as the aluminous earth was forced out and feparated from the mixture of this ftone, feemed the laft refidue, which, for a moment, I will fuppofe to be filiceous, to be more ftrongly attracted, and fecured againft farther folution, by its other remaining conftituent parts, in the fame manner, perhaps, as filver is defended by gold from the attack of nitric acid, when the firft is united with the latter by fufion, in a proportion fmaller than two to one.

But this *analogy* fubfifts only in appearance, and it might be applied only in the decompofition of the adamantine fpar, by means of acids. For, in that cafe, the filiceous earth, becaufe itfelf infoluble in acids, might protect the alumine which is moft intimately combined with it; in the fame way as gold, by its infolubility in nitric acid, preferves the filver againft the action of the fame acid, which in general fo readily diffolves it. On the contrary, this example does not feem very applicable to the decompofition of this ftone, in the dry way, by means of alkali; fince, in this cafe, both earths, the alumine as well as the filex, are foluble in fixed alkalis.

Befides, the above conjecture is oppofed by another circumftance. We are taught, by experience, that mixed bodies, whofe conftitutent parts are ftrongly attracted by each other, may certainly, for a long time, refift the force of folvents; but we alfo know, by experience, that, whenever the folution has actually taken place, efpecially when in the humid way, the reciprocal attractive power of the conftituent parts is then either totally deftroyed, or, at leaft, fo far diminifhed, that nothing impedes their feparation.

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This is the case with the earth of the adamantine spar: for it has actually been dissolved, conjunctively with the aluminous earth, partly in acids, partly in the alkaline lyes. And it has also been recovered, in the form of a precipitate, from both kinds of solvents.

What inference, therefore, remains?—This earthy substance would not give any further indications of a mixture; and yet it presented none of the specific characteristic marks by which the other simple earths, at present known, are distinguished. Are we not, then, authorized to regard this body as a *new*, *distinct*, *simple* earth?—However, I do *not* venture, at this time, positively to decide on this point. Before this can be done, *repeated experiments must throw more light on the nature of this earth*. Yet, considering the scarcity of adamantine spar, and its discouraging resistence to chemical analysis, there is little hope for a speedy success.

It now remains, to state the *proportion* of the parts found in the adamantine spar.—The grains of *magnetic iron* disseminated through it, constituted the fifth part of its whole weight; for when they had been separated, there remained 240 grains of the 300 employed. But this iron cannot be brought into the computation as a constituent part of the stone.—Its proper constituent parts are, *aluminous earth*, and the above *yet undetermined earth*. After all the aluminous earth, collected in this analysis, had been dissolved in sulphuric acid, and properly crystallized, I obtained from it 2 ounces 6 drachms of alum, in regular crystals. As, therefore, the alumine contained in one ounce of this neutral salt, amounts, when ignited, to 56 grains, it is manifest, that those 2 ounces 6 drachms of crystallized alum contain 154 grains of aluminous earth, free from water.

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The other yet undetermined earth weighed, after ignition, 53 grains. To thefe muft be added the refidue of 24 grains, which remained at laft, on the decompofition of the ftone, and was infoluble, and perfectly like the other portion. Hence this earth amounts, in the whole, to 77 grains; which, with the 154 grains of aluminous earth, give the fum of 231 grains.

SECOND SECTION.

The circumftantial defcription of my firft analytical attempt refpecting the adamantine fpar (communicated in the foregoing fection), may ferve as an example to fhew the difficulties chemifts have but too often to contend with, when examining unknown natural bodies. If the method of decompofing hard ftones, purfued in my former enquiry, be compared with the procefs which will be explained in the prefent fection, it will alfo appear from thence, how feemingly unimportant the caufes often are which at one time enfure fuccefs to the undertaking, at another time render it difficult.

By the refults of the above experiments, I was induced to enquire, whether that earthy body, which was obtained befides the aluminous earth, did not deferve to be confidered as a new, peculiar earth. However, I accompanied this conjecture with the exprefs declaration, that I did not then mean to affert any thing certain; but, on the contrary, that farther experiments could alone decide that queftion. Neverthelefs, I find this fubftance mentioned by feveral authors as an earth, the exiftence of which has been already proved, and named by them *Earth of Adamantine Spar*, *Corundum-earth*, *&c.*

On this account, I thought myfelf the more bound to make new refearches on the adamantine fpar, and to give, if poffible, a *complete decompofition* of it, inftead of the former preliminary and unfinifhed examination. Two reafons impofe upon me this tafk; either to throw full light upon its nature if it fhould, on farther examination, prove to be really a diftinct and new earth; or, if the contrary be the cafe, to prevent in time the fpread of an error, occafioned againft my intention.

The want of a fufficient additional quantity of this foffil, which ftill continues to be fcarce in Europe, has, however, retarded the execution of this purpofe for a confiderable time; but other experiments, conducted during that period, have made me acquainted with a fhorter and more certain method of analyfing gems, and other fimilar foffil bodies, of difficult decompofition.

A.

Decompofition of the Chinefe Adamantine Spar.

a) *Hundred and fifty* grains of hair-brown adamantine *fpar*, from *China*, containing interfperfed particles of magnetic iron, were powdered by gentle blows in a mortar of polifhed fteel, and the grains of iron extracted with the load-ftone. The feparated iron weighed 18 grains.

b) *Hundred* grains of the powder from this ftone were then weighed, and moft finely levigated, moiftening them with water, in a triturating-difh, made of flint. After deficcation the powder appeared of a grey colour, refembling that of wood-afhes, which paffed into a brown-red, after gentle ignition. It now weighed $110\frac{1}{2}$ grains, and confequently had received an increafe of $10\frac{1}{2}$ grains of filiceous earth from the grinding-veffel.

c) After

c) After this it was mixed in the filver-crucible with 4 ounces of cauftic lixivium, prepared from the pureft vegetable alkali, the faline contents of which lye amounted to one half of its weight; and after this the fluid was again evaporated, till the mafs was dry. This done, the crucible was removed into the wind-furnace; applying at firft a moderate heat, and increafing it gradually, until the crucible was red-hot; in which ftate it was kept for 3 hours.

d) Upon the refrigerated mafs, which had acquired a brown colour and confiderable hardnefs, I repeatedly poured hot water, to foften it by degrees. The feveral wafhings being collected in one glafs, there fell down a loofe earth of a deep ochre-yellow tinge, which, when feparated by filtration from the clear liquid, and dried in a gentle heat, weighed 58 grains.

e) Muriatic acid threw down from this alkaline folution a copious precipitate, which was again wholly diffolved by a flight fuper-faturation with the acid. When decompofed by a boiling folution of carbonat of pot-afh, it produced a white loofe earth, the quantity of which amounted, after gentle deficcation, to 201 grains.

f) The above 58 grains of yellow earth (*d*) were covered with muriatic acid, and committed to digeftion. It diffolved in it to a yellow liquid, fomewhat turbid, which foon after formed a gelatinous coagulum. After being diluted with more water, and digefted, ftirring it now and then, it depofited *filiceous earth*, which, when ignited, gave $4\frac{1}{2}$ grains in weight.

g) I then added mild vegetable alkali to the clear yellowifh folution, feparated from the filiceous earth by filtering. The brownifh precipitate, which I thus obtained,

was

was fufficiently edulcorated, and, while yet moift, boiled with cauftic lye. There remained a brown refiduum, confifting of 15½ grains, after a gentle drying.

h) Thefe 15½ grains diffolved in the cold, in the muriatic acid poured upon them, and afforded a faffron-yellow folution, but which fpeedily congealed to a jelly. From this laft, diluted in heat with water, there feparated *filiceous earth*, whofe weight, after ignition, was 3 grains.

i) From the muriatic folution (*h*) I now precipitated, by cauftic ammoniac, the iron which it contained. It fell down in brown-red flocks, and weighed 7½ grains, after being expofed to a red-heat.

k) From the alkaline folution (*g*), faturated to excefs with muriatic acid, the addition of mild vegetable alkali precipitated, in a boiling heat, a white loofe earth, which, being gently dried, weighed 29½ grains.

l) Upon thefe 29½ grains of earth (*k*), added to the above 201 (*e*), dilute fulphuric acid was affufed. When gently warmed, the earth was entirely diffolved; but when the folution had been concentrated by evaporation, it coagulated into an uniform clear jelly. This was again copioufly diluted with water, in a warm temperature, and with repeated ftirring; upon which *filiceous earth* feparated, amounting, when dried and expofed to a red-heat, to 9 grains.

m) The clear folution by fulphuric acid (*l*) was now combined with the requifite quantity of vegetable alkali, and by flow evaporation made to cryftallize. It conftantly yielded, until the end, regular cryftals of alum. The

laft

laſt remaining liquor, which conſiſted only of a few drops, I dried to a ſlimy conſiſtence, which, upon dilution with water, ſtill depoſited ½ grain of *ſiliceous earth.*

n) After all the cryſtals of alum, collected from the ſeveral liquors, had been re-diſſolved in boiling water, I precipitated their earth by carbonat of pot-aſh, waſhed, and dried it. But as the aluminous earth is much diſpoſed, even after the moſt diligent edulcoration, firmly to retain a portion of the ſalts, that before were combined with it, more eſpecially the vegetable alkali, whereby its own weight is neceſſarily increaſed; I took care to reſtore it in its true purity, by affuſing upon it twelve times its weight of diſtilled vinegar, digeſting it for ſeveral hours with this fluid; then adding as much cauſtic ammoniac as would ſaturate the acetic acid to exceſs; and laſtly, by a perfect edulcoration of the precipitated *alumine.* When it was afterwards deſiccated and ignited, its weight was found to be 84 grains.

o) At laſt, the *ſiliceous earth* was put to trial. For this purpoſe I heated it to redneſs with four times its weight of mild vegetable alkali, and poured water on the maſs which was obtained. It was completely diſſolved, leaving only a ſlight portion of a ſlimy reſidue; and depoſited again, during ſaturation with muriatic acid, the ſiliceous earth in its uſual form.

Thus the decompoſition of the adamantine ſpar was fully effected; and every uncertainty reſpecting the true nature of its conſtituent parts, that had remained after its firſt examination, is totally removed.

Hence, when we reflect that the magnetic iron, diſſeminated in the Chineſe adamantine ſpar, is merely to be con-

confidered as a foreign fubftance mingled with it, and therefore cannot be confidered as a conftituent part, the following will be the *conftituent parts of adamantine fpar*, together with their proportions in the *hundred.*

Alumine	*n*)		. . . . .	84,
Oxyd. of iron . . .	*l*)		. . . . . .	7,50
Silex	*f*)	$4\frac{1}{2}$		
	h)	3		
	l)	9		
	m)	$\frac{1}{2}$		
		17		
From which fubtract	*b*)	$10\frac{1}{2}$		
There remain . .		$6\frac{1}{2}$	. . . .	6,50
				98
			Lofs . .	2
				100

B.

Decompofition of the Adamantine Spar from Bengal.

THE *Bengal Adamantine Spar*, or *Corundum Stone*, differs from the Chinefe; *firft*, in containing no interfperfed magnetic iron, of which only now and then fome few grains adhere to its external furface; and, *fecondly*, in this, that the ferruginous part, belonging to its chemical mixture, is lefs confiderable. For this reafon the whitifh grey colour of of that ftone is brighter, its thin lamellas more tranfparent, and, as it appears, the hardnefs of the ftone is in fome degree greater.

a) When pounded in the fteel-mortar, it afforded a white powder, inclining to pearl-grey. One *hundred* grains of it, triturated with water in the flint-mortar, I found, after drying and ignition, to have increafed 11 grains in weight.

b) Upon thefe 100 grains, four ounces of cauftic lixivium, containing one half its weight of cauftic alkali, were affufed in the filver crucible; and the fluid evaporated to drynefs. The mafs being then ignited for three hours, with the neceffary precaution, it was again foftened by drenching it with water, and afterwards filtered. There remained a grey-white refidue, weighing 47 grains when dry.

c) The alkaline fluid (*b*) let fall, during faturation with muriatic acid, a copious, white, and loofe earth; which was immediately re-diffolved by a flight excefs of the acid.

d) The above-mentioned 47 grains of earth (*b*) completely diffolved in the muriatic acid. When this folution was mixed with cauftic ammoniac, it afforded a flimy and very puffy precipitate. Mild ammoniac was then added to the liquor, which had been immediately feparated from this precipitate by filtering, but it produced no farther precipitation.

e) I then put into cauftic lye the flimy precipitate (*d*), moift as it was, and digefted them together. The mixture affumed the appearance of a thickifh folution of gum-arabic. On adding more cauftic lye, the whole was dif-

 folved

ſolved into a limpid liquor, except ſome brown flocks, which, in the dry ſtate, conſiſted of 2 ¼ grains.

f) Muriatic acid being affuſed upon this flocculent precipitate (*e*), a ſmall portion of *ſiliceous earth* ſeparated, and cauſtic ammoniac precipitated from the clear ſolution an *oxyd of iron*, weighing, after ignition, 1 ¼ grain.

g) From the alkaline ſolution (*e*), the muriatic acid threw down a quantity of ſlimy earth, which was entirely rediſſolved by a ſmall over-proportion of that acid.

h) Both the ſolutions (*g*) and (*c*), were next united and precipitated by carbonated pot-aſh in a boiling-heat, and the dried precipitate was again diſſolved in dilute ſulphuric acid. When this ſolution, after the addition of a ſufficient quantity of vegetable alkali, had been evaporated to the point of cryſtallization, it readily afforded clear and regular cryſtals of alum, or ſulphat of alumine.

i) The remaining part of the ſolution in ſulphuric acid (*h*) thickened ſpontaneouſly to a clear jelly, on ſubſequent evaporation. This gelatinous matter, after being digeſted with an abundant quantity of water, and repeatedly agitated, again liquefied by degrees. Upon this, ſome *ſiliceous earth* ſubſided; which, when ſeparated by means of a filter, dried up in a raiſed temperature, in the form of tranſparent ſhining grains. It was levigated, together with the foregoing (*f*), and once more boiled with ſulphuric acid. When dried again, and ſubjected to a red-heat, its weight amounted to 15 ½ grains.

k) The above ſolution in ſulphuric acid (*i*), was then evaporated for further cryſtallization It continued to the end to yield ſucceſſively regularly cryſtallized ſulphat of alumine: but the very laſt portion was ſtill contaminated with *ſiliceous earth*, amounting to 1 grain after ignition.

l) All theſe ſeveral portions of alum were diſſolved in water, and precipitated in a boiling heat by carbonat of pot-aſh: and when the earthy precipitate which they afforded had been depurated by means of acetic acid, as explained in the preceding ſection, they gave 89½ grains of ignited *aluminous earth*.

Therefore, the products obtained by the decompoſition of the *Adamantine Spar from Bengal* conſiſt of

Alumine	*l)*	. . . . .	89,50
Oxyd of iron . . .	*f)*	. . . . .	1,25
Silex	*i)*	15½	
	k)	1	
		16½	
	Subtract *a)*	11	
	Remain .	5½ . . .	5,50
			96,25
		Loſs . .	3,75
			100

The very predominant proportion of the aluminous over the ſiliceous earth, exhibited by this decompoſition of both varieties of the adamantine ſpar, affords a new proof, that alumine is ſuſceptible of a greater coheſive power than ſilex is poſſeſſed of. Hence nature may form ſtones of extreme hardneſs almoſt entirely from aluminous earth; of which my lysis of the *Sapphire* will give, in the sequel, a very striking instance. On the contrary, it is evident that this does not hold good with respect to the siliceous earth, as appears from *rock-crystal*, its purest form; for, how inferior is this last in hardness to the sapphire, as well as to the adamantine spar!

On analysing the Chinese adamantine spar, we find that it was siliceous earth that remained, when muriatic acid was poured upon that portion, which was not dissolved by the alkali during ignition. But, on analysing the Bengal diamond-spar, this earth did not appear before the solution of the aluminous earth in sulphuric acid was prepared for crystallizing by evaporation; and at that period this acid caused it to coagulate into an uniform, colourless, gelatinous substance. This last circumstance is frequently attended by a phenomenon which seldom occurs, and is quite different from those which we usually observe on the efflorescing of salts. It is, that the mass, when coagulated to a clear jelly, branches out in several places, and forms separate, unconnected figures, often in the shape of four, five, and six, sided longish pyramids, and often merely as conical points.

Similar phenomena take place, whenever the aluminous earth has entered into intimate union with a small portion of the siliceous, as will be seen by the following experiment:—I mixed 2 drachms of liquor of flints, the siliceous earth of which amounted to 10 grains, with 2 ounces of a solution of alumine in caustic lye; and saturated the mixture with muriatic acid. The earth, thus precipitated, again dissolved into a limpid liquor, on the affusion of a small excess of acid. When a second time precipitated by carbonat of pot-ash, and dried, it weighed 70 grains. I then poured upon it dilute sulphuric acid, and found it entirely dissolved, without depositing the siliceous earth

with

with which it was combined. After being in ſome degree evaporated, part of the ſolution ſhot into ſeparate cryſtals of alum ; and the remaining part coagulated in the form of a clear jelly, on the ſurface of which, after ſome days, cryſtalline pyramids ſprouted out. And when I had afterwards digeſted this jelly with a large quantity of water, the ſiliceous earth ſubſided ; and, being waſhed and ignited, it weighed again very nearly 10 grains.

However, this jelly, which is frequently colourleſs, and is formed by a ſolution of ſulphat of alumine, in intimate chemical combination with finely diſſolved ſiliceous earth, and gently evaporated, ſhould not be confounded with the coagulum, which always takes place whenever the ſolution of aluminous earth in ſulphuric acid has not been blended with the quantity of pot-aſh requiſite to the formation of perfect cryſtals. This laſt forms an opake maſs, of a foliated texture, and ſoft, greaſy conſiſtence.

It yet remained to enquire into the cauſes which rendered my firſt analyſis of the adamantine ſpar ſo very difficult. That one day is improved by another, is a truth which any attentive chemiſt has often had opportunity to experience in a very conſpicuous manner. The method of preparing hard ſpecies of ſtones, recommended by *Marggraf*, *Bergmann*, and others, in order to weaken the coheſion of their parts, conſiſts in igniting them, mingled with a mild fixed alkali. But when I obſerved, that this way of preparing them would not anſwer the purpoſe in moſt of the ſtones belonging to the claſs of gems ; and when I conſidered that, in the ſtrict ſenſe, it was only the portion of alkalis free from carbonic acid, which is active in this operation, I tried to ſubſtitute cauſtic alkalis to the carbonated, and found that, by their aſſiſtance, I attained my end with greater facility and certainty. The application cauftic alkalis, in the dry ftate, is, neverthelefs, attended with feveral inconveniences. One, and not the leaft of them, is, that by triturating them with the body to be fubjected to analyfis, no very accurate mixture will be obtained. Another circumftance, which embarraffed my firft analyfis of the adamantine fpar, is, that in every attempt I fubjected it to ignition in a brifk fire, with the view of afcertaining immediately the quantity of any portion which remained undiffolved, or which was precipitated from its folution. But in this way the ftone was rendered progreffively more incapable of farther folution; and not only its folubility, in fo far as it had been promoted by ignition with alkali, but alfo the advantage obtained in leffening the cohefive force of its conftituent parts, have been again loft.

How greatly the decompofition of the harder gems is promoted by the ufe of cauftic fixed alkalis in the liquid ftate, combined with the other requifite methods of treatment, may be proved by the fecond analyfis of both the Chinefe and Bengal adamantine fpars.

IV.

EXAMINATION

OF THE

ORIENTAL SAPPHIRE.

It ſeems to be yet doubtful, whether the modern *ſapphire* be the ſame gem which the ancients have denoted by this name. For we do not perceive in our ſapphire the diſſeminated golden points, mentioned by them as one of its eſſential characteriſtic marks; whence *Theophraſtus** calls it χρυσόπαστος, and *Epiphanius*†, χρυσοστιγής. It is, however, certain, from a paſſage of *Pliny*, that the ancients did not underſtand by it the κυανος, or *lapis lazuli*, which uſually contains interſperſed ſpeckles of a golden luſtre; but they have well diſtinguiſhed both ſpecies of ſtones. *Ineſt ei* (Cyano) *aliquando et aureus pulvis, non qualis in ſapphirinis. Sapphirus enim et aureis punctis collucet.* Plinius, libr. 39. c. 9.

The gem that we call *ſapphire*‡ is remarkable by its blue colour, which is ſo very pleaſing to the eye, by its extreme hardneſs, and the high brilliancy which it ſhews when poliſhed. Its ſpecific gravity I have found to be 3,950, in thoſe

* de Lapidibus.

† de XII. gemmis, quæ erant in veſte Aaronis.

‡ For the ſake of the leſs informed, I add, (perhaps not quite ſuperfluouſly) that the foſſil, which is ſold by Dutch druggiſts for

thoſe ſpecimens, which were the ſubject of the following analyſis, and conſiſted of clear, longiſh-round, abraded grains, of a pure azure colour.

According to the ſtatement of the conſtituent parts of the ſapphire hitherto given, and grounded on *Bergmann's* analyſis, an hundred parts of it are ſaid to contain:

35	*Silex*
58	*Alumine.*
5	*Lime.*
2	*Iron.*

But the following analyſis, begun and ended with the greateſt poſſible accuracy and precaution, will ſhew that the above ſtatement was very incorrect.

a) *Hundred* grains of ſapphire, previouſly pounded to a moderately fine powder in a poliſhed ſteel mortar, were moſt finely triturated with water in a grinding-diſh of flint. When this ſapphirine powder had been dried, carefully collected, and ignited, I obſerved, that its weight had increaſed 12½ grains from the ſiliceous earth of the grinding veſſel.

b) Two ounces of muriatic acid were poured upon theſe 112½ grains in a phial ſo as to cover them, and the whole was repeatedly digeſted with a moderate heat. The filtered acid, mixed with the edulcorating water, was then

for *ſapphire*, in the ſhape of ſmall, heavy, black-grey, and internally reſplendent grains, and which, ſince the belief in the medicinal virtues of gems, has loſt ground, is now kept in the ſhops merely as an uſeleſs drug, is nothing elſe but *magnetic octahedral iron*, which in Ceylon accompanies the ſapphire, hyacinth, and other gemmeous ſtrata, and, together with thoſe ſtones, is collected by waſhing off the ſand.

ſaturated,

ſaturated, in a boiling heat, with mild alkali prepared from tartar, by which there ſeparated yellow flocks, weighing two grains when dry. Theſe being again diſſolved in muriatic acid, and precipitated by cauſtic ammoniac, I tranſferred the precipitate, while yet moiſt, into boiling cauſtic lixivium. It depoſited *oxyded iron*, which, after ignition, weighed *half* a grain. The aluminous earth, taken up by the cauſtic lye, was again ſeparated from it, and found to weigh *one* grain.

c) After this extraction by muriatic acid, as much cauſtic lye was affuſed on the ſapphirine powder, placed in the ſilver crucible, as was neceſſary to make the cauſtic alkali, contained in it, amount to ſix times the weight of the powder. It was next evaporated in a ſand-heat, till the maſs was dry; upon which the crucible was placed in the furnace, ſurrounded with charcoal, and ſubjected to a red heat for two hours. The contents of the crucible returned from the fire in the form of a whitiſh, looſe, and friable maſs.

d) This maſs was ſoftened with hot water, and put on the filter. There remained a bluiſh-grey, ſlimy reſidue, which, being dried, gave a powder of little coheſion, weighing 34½ grains. On adding muriatic acid, it readily diſſolved; but congealed ſoon after to a turbid jelly. By dilution with water, and digeſtion, ſome earthy particles were depoſited, which, after waſhing and drying, amounted to 14 grains.

e) When theſe flocculent particles had been removed, the muriatic ſolution was ſaturated with cauſtic ammoniac; and the reſult was an intumeſced, tranſparent precipitate, which, being previouſly edulcorated, was digeſted, while yet moiſt, in cauſtic lye. It readily diſſolved in it; with the exception of a few brown flocks, which, when collect-ed and ignited, weighed one fourth of a grain, and were *oxyd of iron.*

f) The alkaline folution *(e)* was decompofed by muriatic acid; and the precipitate which it afforded re-diffolved by a flight excefs of that acid. Upon this, the earth was again precipitated by mild vegetable alkali, in a boiling heat. The weight of the earth obtained in this part of the procefs was 16 grains, after it had been wafhed and dried.

g) In the fame manner I combined with muriatic acid the preceding alkaline folution *(d)*, obtained by foftening the ignited mafs. There refulted from it a copious white precipitate; but which was again totally diffolved, by a flight over-faturation with muriatic acid. The earth was then precipitated afrefh by mild vegetable alkali, affifted by a boiling heat; and was found to weigh 289 grains, when wafhed and deficcated.

h) To this earth I added the above 16 grains *(f)*, as alfo the one grain of *(b)*; and poured upon the whole dilute fulphuric acid. The folution, which was eafily brought about in a moderate temperature, again depofited *eight grains* on cooling.

i) Thefe eight grains, together with the 14 of *(a)*, being then mixed with fix times its quantity of cauftic lye, were infpiffated, and heated to rednefs. The mafs, thus obtained, and afterwards liquefied in water, left, on filtering, a grey refidue, weighing 17 grains after deficcation, which foon were diffolved by the affufion of fulphuric acid, leaving fome few, inconfiderable particles behind. The alkaline folution, when faturated with muriatic acid, continued

at

at firſt limpid; but it depoſited *four grains* of ſiliceous earth, when evaporated in a warm temperature.

k) I now mixed the ſolutions in ſulphuric acid, mentioned at (*h*) and (*i*); added to them a proportional quantity of carbonated pot-aſh, and, by gentle evaporation, cauſed them to ſhoot into cryſtals. At firſt, fine, pure, and regular cryſtals of ſulphated alumine were formed: but the remaining liquor, while further evaporating, congealed into a clear, gelatinous matter, without any diminution of its tranſparency. Having poured upon it a quantity of water, I ſubjected it to continued digeſtion, ſtirring it now and then. By this management I effected the thorough ſeparation of the finely divided ſiliceous earth, which was the cauſe of the coagulation; inſomuch, that I was enabled to collect it on a filter. This *ſiliceous earth*, carefully collected, together with the above four grains (*i*), weighed 11¼ grains.

l) The remaining ſulphuric ſolution, freed from its ſiliceous contents, was now ſet to cryſtallize. However, the laſt portions of alum indicated, by their lemon-yellow tinge, that they ſtill contained ſome metallic ſubſtance. In conſequence of this, I re-diſſolved them in water, together with the few reſidual drops of their mother-liquor, and combined them with pruſſiat of pot-aſh (blood-lye). A blue precipitate ſubſided; but in ſo ſmall a quantity, that the *portion of iron*, thus ſeparated, could hardly be eſtimated at one fourth of a grain. The ſupernatant fluid, freed from it, afforded pure ſulphat of alumine to the laſt drop.

m) The cryſtals of alum, obtained in the ſeveral foregoing operations, being dried on a porcelain ſaucer in open air, amounted in the whole to 856 grains. They were then diſſolved in boiling water, decompoſed by carbonat of pot-

pot-aſh in the heat of ebullition, and the precipitated earth was edulcorated and dried. But, in order to free this earth perfectly from thoſe ſaline particles, which ſtill adhered obſtinately, and augmented its weight, I ſubjected it to gentle digeſtion, with ſix ounces of diſtilled vinegar. Which done, I neutralized the acetic acid by cauſtic ammoniac; edulcorated afreſh the *aluminous earth*, then precipitated, and laſtly, expoſed it to a briſk red-heat, after drying. It weighed now 98½ grains.

n) It ſtill remained to examine the edulcorating water. Being evaporated to dryneſs, and the reſidue re-diſſolved in little water, there remained a ſlight portion of grey earth, which, when examined by ſulphuric acid, proved to be calcareous. The ſolution yielded, during evaporation, ſelenitic cryſtals; which, when carefully collected, weighed 1½ grain, the *calcareous* earth of which ſhould be eſtimated at one half grain.

What principally demands our conſideration, in the reſult of this analyſis, is the remarkable and unexpected circumſtance of the total abſence of the ſiliceous earth, from among the conſtituent parts of the ſapphire. For the 11¾ grains of ſilex which were obtained (*k*), muſt undoubtedly be aſcribed merely to the flinty triturating veſſel, from which the ſapphire had, on grinding, abraded 12½ grains (*a*), and at the ſame time had united with it ſo intimately, that I could not recover it without great difficulty, and even not without a ſmall loſs of three fourths of a grain.

Hence, the following alone can be reckoned among the conſtituent parts of the ſapphire, procured by decompoſition:

Alumine			98,50
Oxyd of iron	*b)*	$\frac{1}{2}$	
	e)	$\frac{1}{4}$	1,
	l)	$\frac{1}{4}$	
Lime	*n)*		0,50
			100.

Since on analyſing foſſils, even with the moſt cautious management, there is always ſome unavoidable loſs, it is probable, that the preſent perfect agreement of the ſum of theſe conſtituent parts, with the original weight of the ſapphire employed, is merely accidental. And the reaſon of this agreement muſt be ſought for, in the variable ſtate of dryneſs, communicated to the aluminous earth by heating it to redneſs.

Whence, ſubtracting the unimportant, and perhaps only caſual portion of calcareous earth, as well as the ſlight quantity of ferruginous matter, we find in the ſapphire, the nature of which is now developed, nothing elſe than a ſimple aggregate of pure aluminous earth.

But, what a high degree of coheſive power, and moſt intimate chemical combination, muſt nature be able to command, in order to be capable of transforming ſuch a common ſubſtance, as the *aluminous earth*, into a body, ſo eminently diſtinguiſhed and ennobled, as we find the *ſapphire* to be, by its hardneſs, denſity, brilliancy, and reſiſtance to the actions of acids and fire, as well as to natural decay in the courſe of all-conſuming time!—It is, therefore, not the *identity*, or preciſe ſameneſs of the conſtituent parts alone, but alſo the *peculiar nature of their chemical combination*, which conſtitutes the *metaphyſical eſſence* of the products formed from them by nature.

V.

V

EXAMINATION

OF THE

CAT'S-EYE.

THE ſpecies of precious ſtones, known by the name of *Cat's-eyes*, has received that denomination from its property of reflecting, in certain directions, a changeable whitiſh effulgence, in which it reſembles the eyes of a cat.

As this ſtone is ſtill a rarity in Europe, the deſcription of its external characters, met with in the lateſt introductions to Mineralogy, could only be taken from the poliſhed ſpecimens which are brought to us from *Ceylon*. As I have in my collection rough cat's-eye from the coaſts of *Malabar*, for which I am indebted to the kindneſs of *Francis Greville*, Eſq. in London, and which, beſides, is one of its more unuſual varieties, I think the following addition to the deſcriptions of its external characters, already publiſhed, will not be uſeleſs.

The largeſt ſpecimen conſiſts in a fragment, notably quadrangular, of *one* inch in *length*, three-fourths of an inch in *breadth*, three-fourths ditto in *height*, and three and a half drachms in weight. Its croſs-fracture exhibits a brown-red colour of various ſhades, a moderate greaſy

luſtre,

luſtre, and minute ſharp-edged prominences. On the longitudinal fracture, its colour is lighter, its luſtre ſtronger, and it reflects variegated yellowiſh rays of light; at the ſame time, that an imperfectly foliated texture, ſpreading in various directions, is perceivable. On two contiguous ſides it ſtill retains its natural ſurface, or cruſt, which is formed lengthways of convex, roundiſh ſtriæ; and its colour, which was at firſt brown-red, has faded into a dull browniſh-yellow. Its edges and ſmall ſplinters alone are faintly tranſparent.

I found the ſpecific gravity of this rough cat's-eye to be 2,625; whereas that of the whitiſh, greeniſh, and yellowiſh ſpecimens from Ceylon is 2,660.

In the *Eſſay on the Habitudes of ſeveral Stones and Earths in ſtrong Fire*, I have already ſhewn that the cat's-eyes are perfectly infuſible in the ſtrongeſt degree of heat produced in the porcelain-furnace; therefore I ſhall at preſent mention only the change which they undergo in a weaker fire. For this purpoſe I ignited to redneſs in a crucible ſome of the common poliſhed cat's-eyes, of a greeniſh and greyiſh-white colour, and quenched them in cold water. I found them afterwards abſolutely unaltered in form, hardneſs, and ſplendour; but they were rendered totally opake, and acquired an extremely fine marbled jaſper-like appearance, variegated with brown, reddiſh, grey, and white ſpots.

A.

a) *Two hundred* grains of finely levigated *Cat's-eyes from Ceylon*, were mingled with 400 grains of carbonat of ſoda

(mild

(mild mineral alkali), and the blended mafs was expofed in a filver-crucible to gentle ignition for four hours, but without urging the heat to fufion. In the next place I foftened the mafs with water; faturated it to excefs with muriatic acid; and fuffered it to ftand for fome time in digeftion. A confiderable quantity of *filiceous earth* then feparated, which was collected on the filter, wafhed, dried, and laftly expofed to a ftrong red-heat. In this ftate it weighed 189 grains.

b) The muriatic folution, mixed with the edulcorating water, and concentrated by evaporation, was faturated while yet hot with carbonated foda; and I obtained a precipitate, which, when wafhed and dried, weighed 15 grains.

c) Thefe entirely diffolved, with effervefcence, in the muriatic acid. Only a flight portion of *filiceous earth* remained, which after ignition amounted to one grain.

d) After the grain of filiceous earth had been feparated, cauftic ammoniac was added to the folution. A yellowifh-white, flimy precipitate was thrown down; which being immediately feparated by filtration, wafhed, and afterwards diffolved, while yet moift, by cauftic lye, left behind an *oxyd of iron*, weighing one half grain, when wafhed and ignited.

e) I then, by means of muriatic acid, feparated the earth taken up by the cauftic lye; but being re-diffolved by a flight excefs of this acid, it was again precipitated by carbonat of foda. When edulcorated, and diffolved in fulphuric acid, it fhot into cryftals of *alum*. This fulphat of alumine was then diffolved in water, and its earth again precipitated

precipitated by carbonat of soda. This alumine, when edulcorated, and ignited after desiccation, was found to weigh 3½ grains.

f) The liquor which remained, after the precipitation had been effected by caustic ammoniac (*d*), was then combined in a warm temperature with mild mineral alkali; by which treatment, *calcareous earth* subsided, which formed selenite (sulphat of lime) with sulphuric acid. The lime thus separated from this compound, and ignited, weighed three grains.

Since, therefore, 200 grains of these cat's-eyes afforded

Silex	*a*)	189	190
	b)	1	
Alumine	*e*)		3½
Lime	*f*)		3
Oxyd of iron	*d*)		½
			197 grs.

it follows, that it contains in *one hundred*,

Silex		95
Alumine		1,75
Lime		1,50
Oxyd of iron		0,25
		98,50
	Loss	1,50
		100

B.

a) *Hundred grains* of the crude *red cat's-eye* from *Malabar*, defcribed as above, yielded a grey friable mafs; after being finely pulverized, mingled with 300 grains of cauftic pot-afh, and ignited, but without fufion, for an hour in the filver crucible. It foon diffolved in water, and formed a turbid liquor. Upon fuper-faturating it with muriatic acid, and fubfequent digeftion and filtration, there remained a delicate, white *filiceous earth*, which, after wafhing and drying, amounted to 115 grains, but after half an hour's ignition weighed only 93 grains.

b) The muriatic folution (*a*), mixed with the wafhings, and previoufly concentrated by evaporation, was then precipitated by carbonated pot-afh, in the heat of ebullition. The yellowifh precipitate, which fubfided, weighed 8½ grains after deficcation.

c) Thefe 8½ grains completely diffolved in muriatic acid. Cauftic ammoniac threw down from this folution a flimy earth; which only partially diffolved in the cauftic lixivium, with which it had been digefted, and left five grains on the filter.

d) When the earth, taken up by the cauftic alkaline lye, had again been feparated from it, and wafhed and ignited, its weight amounted to two grains. It alfo afforded *cryftals of alum*, on being treated with fulphuric acid.

e) The above five grains (*c*), digefted with fulphuric acid, ftill depofited *filiceous earth*, which, having been ex-

I pofed

pofed to a red-heat, weighed 1½ grain. The .olution, freed from this earth, while evaporating, yielded *felenite-cryftals*. The yellowifh liquid, rinfed off from them with dilute or weak ardent fpirit, and combined with pruffiat of pot-afh, produced a deep blue precipitate; the quantity of which was fo fmall, that the *oxyd of iron* thus indicated, could not with propriety be eftimated higher than at one fourth of a grain. Mild alkali ftill feparated from the remaining liquor an inconfiderable portion of alumine.

f) Mild vegetable alkali, added at a raifed temperature to the fluid, from which the cauftic ammoniac feparated the above-mentioned muddy precipitate (*c*), threw down another portion of earth, which united with fulphuric acid into fulphat of lime. The *calcareous earth* contained in this felenite, as alfo in that of (*c*), was reproduced, or feparated from its accompanying acid, by boiling with a folution of mild alkali; and its quantity was found, after ignition, to amount to 1½ grain.

According to this analyfis, the conftituent parts of this red variety of cat's-eye, confift in the *hundred* of

Silex	*a*)	93	94,50
	c)	1½	
Alumine	*d*)		2,
Lime	*f*)		1,50
Oxyd of iron	*e*)		0,25
			98,25
		Lofs	1,75
			100

 There-

Therefore, this *proportion of the conftituent parts*, which in both varieties is to be confidered as perfectly conftant, together with their *abfolute infufibility*, (not to mention the difference in the external character) afford fufficient reafon for diftinguifhing *cat's-eye* from *fel-fpar*, under which this foffil has been claffed by feveral Mineralogifts.—On the contrary, it would be more proper, in my opinion, to clafs it with the opals; among which alfo it was formerly reckoned under the names of *Pfeudopal*, *Cat's-eye-opal*.

VI.

ANALYSIS

OF

CHRYSOBERYL.

THE *Chryfoberyl*, found in the Brafil, paffed for a variety of the Chryfolite, until M. *Werner*, Counfellor of the mines, was induced, by a more accurate comparifon of their refpective external characters, to feparate the former from the latter; and to range it in the mineralogical fyftem as a diftinct fpecies, with its prefent denomination. This Chryfoberyl, however, muft not be miftaken for the *Chryfoberyl of the ancients*, which really was the fubftance indicated by this name; that is to fay, the *golden-yellow beryl*; as may be concluded from its defcription, given by *Pliny*. Libr. XXXVII. Cap. V. *Probatiffimi funt ex iis*, (namely Beryllis), *qui viriditatem puri maris imitantur. Proximi, qui vocantur* Chryfoberylli, *et funt paulo pallidiores, fed in aureum colorem exeunte fulgore.*

The modern chryfoberyl has hitherto been met with only in fhivery, loofe, rounded grains *, of the fize of fmal-

* *Gefchiebe* in German. *Rachill* by the miners; or fuch loofe, fmall, fhivery ftones, as moft commonly lie on the top of the rock, or immediately under the vegetable earth. See *Hoofon's Miner's Dictionary.*—Tranfl.

ler and larger peas, of a pale-yellow colour, inſenſibly verging to green. The ſurface of theſe grains, which is ſomewhat rough, ſtrongly glitters, and uſually reflects variegated colours, like moonſtone (adularia). But the fracture of chryſoberyl poſſeſſes a great ſplendour, which, in conjunction with a very conſiderable hardneſs, gives it a high brilliance when poliſhed: and hence it may eaſily be confounded with the yellow diamond. Some few ſpecimens exhibit ſome remaining traces of an originally cryſtalline figure.

The ſpecific gravity of this ſtone I have found to be 3,710; which therefore agrees with that mentioned by *Werner*, from 3,698 to 3,719, and is preciſely the mean between theſe two extremes.

The firſt analytical attempts upon it, which I made before I was acquainted with thoſe ſkilful proceſſes which I learned from later experiments, gave me a good deal of trouble, and at the ſame time deſtroyed a conſiderable part of my ſtock of theſe ſtones. But I paſs them over, and confine myſelf merely to that analyſis, the reſult of which was the complete decompoſition of the chryſoberyl.

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a) *Hundred grains* of chryſoberyl, previouſly reduced to a moderately fine powder, by pounding them in a mortar of poliſhed ſteel, were levigated with water to perfect fineneſs in the flint grinding-diſh. After the powder had become dry, I ſubjected it to gentle ignition, for the purpoſe of freeing it from all moiſture. However, its weight was increaſed 13 grains.

b) Upon theſe 113 grains, introduced into a ſilver-crucible, I poured ſo much cauſtic lixivium, that the proportion

of

of alkali which it contained amounted to 800 grains, and evaporated the liquid again till the maſs was dry. Upon this I placed the crucible with its contents in a wind-furnace, on a ſtand of porcelain clay, ſurrounding it with coals. Attention was carefully paid to prevent the maſs, which greatly ſwelled in bulk, from flowing over the veſſel. The heat applied was at firſt rather low; but it was gradually urged until the maſs became red-hot. In this degree of heat it was kept for two hours; but it did not enter into actual fuſion.

c) When this maſs had cooled in ſome degree, I ſoftened it in the crucible with water, and poured the ſolution upon the filter. When the fluid parts had paſſed through, there remained on the paper a looſe, light-grey powder, which, when edulcorated and dried, weighed 66½ grains.

d) The alkaline lye that had been ſeparated, together with the edulcorating water, was firſt evaporated, to leſſen its bulk, and then ſaturated with muriatic acid. An abundant white precipitate fell down, but was inſtantly and clearly re-diſſolved, by a ſmall exceſs of acid. Carbonat of pot-aſh, added over a low fire, again precipitated this earth; which being waſhed, and dried in a gentle warmth, was looſe, as white as ſnow, and weighed 138½ grains.

e) The light-grey pulverulent reſidue, mentioned at (*c*), amounting to 66½ grains, being digeſted with muriatic acid, left again a reſidue; which, after waſhing, drying, and ignition, weighed 24½ grains, and was found, upon farther examination, to be pure *ſiliceous earth*.

f) This muriatic ſolution (*e*), ſeparated from the ſilex, was next decompoſed, in a boiling heat, by means of cauſtic ammoniac, and the yellowiſh precipitate, thus produced, was edulcorated; and, while yet moiſt, was boiled with cauftic lye. It entirely diffolved therein, fome brown particles excepted. This refidue was *oxyd of iron*, and weighed, after ignition in a gentle heat, $1\frac{1}{2}$ grain.

g) The alkaline folution (*f*) was faturated with muriatic acid. The refult of this procefs was a white precipitate, which, by a flight fuperfaturation, again formed a limpid folution. The earth was then a fecond time precipitated, by boiling with mild vegetable alkali. Its weight amounted, after deficcation, to 29 grains.

h) Thefe laft 29 grains, together with the preceding $138\frac{1}{2}$ grains of earth (*d*), to which I alfo added the two grains, which were collected from the edulcorating water by evaporation, were digefted with diluted fulphuric acid. The whole was diffolved, excepting fome *filiceous earth*, which weighed 4 grains after ignition.

i) When this folution, now perfectly clear, was a little evaporated at a low temperature, tender, fpicular, or fpear-fhaped cryftals, gradually feparated from it; which I collected with proper care. They prefented all the marks of felenite; and, on decompofition by a folution of carbonat of pot-afh, in boiling heat, they afforded 11 grains of mild *calcareous earth* (carbonat of lime). This calcareous conftituent part of the chryfoberyl was, doubtlefs, before contained in the precipitate of (*d*); and, previous to it sfalling down, it was held in folution merely by the water, as it was then in the cauftic ftate.

k) This fulphuric folution I now combined with the proportion of carbonated pot-afh requifite to the formation of alum*; which fhot, by degrees, into regular cryftals.

* On the neceffity of pot-afh, and its proportion in the formation of alum, fee *Hildebrandt's paper* in *Nicholfon's Journal*, vol. IV. page 49.—Tranfl.

Towards the end, however, a ſlight portion of *ſiliceous earth* appeared, which, after ignition, was not more than 2½ grains. The weight of all the ſulphat of alumine obtained amounted to 604 grains.

l) This alum was again re-diſſolved in boiling water, and afterwards decompoſed by means of carbonat of potaſh, at the heat of ebullition. After the precipitated earth had been waſhed, dried, and gently ignited, I digeſted it with diſtilled vinegar; which being neutralized by cauſtic ammoniac, the earth was again precipitated by this treatment, and again waſhed, deſiccated, and heated to redneſs. It proved now to be perfectly pure *aluminous earth*, weighing 71½ grains.

We may, therefore, infer, that the conſtituent parts of the chryſoberyl, exhibited by this analyſis, conſiſt in the *hundred*, of

Alumine	*l*)	. . . . .	71,50
Lime	*i*)	. . . . .	6
Oxyd of iron . . .	*f*)	. . . . . .	1,50
Silex	*e*)	24½	
	h)	4	
	k)	2½	
		31	
To be ſubtracted	*a*)	13	
Remain .		18 . . .	18,00
			97
		Loſs	3
			100

From

From comparing the preſent analyſis of *chryſoberyl* with the following decompoſition of *chryſolite*, it is evident how greatly their reſpective conſtituent parts differ, and conſequently, how neceſſary it was to ſeparate them from each other, in the ſyſtematical arrangement of the ſpecies of gems.

VII.

VII.

EXAMINATION

OF

CHRYSOLITE.

The *Chryfolite* affords a fingular inftance of change in names; fince, at prefent, we call the fame gem *Topaz*, which the ancients underftood by the denomination *Chryfolite*; for it is evident, from the following words of Pliny, that the *Topazius* of the ancients is not our modern Topaz; but, on the contrary, the Chryfolite of the prefent times: *Ejus tota fimilitudo ad porri fuccum dirigitur. Eft autem amplifſima gemmarum. Eadem fola nobilium limam fentit: cætera Naxiis cotibus poliuntur. Haec et ufu atteritur. Pliny* Hift. Nat. Lib. XXXVII. Cap. VIII.—The caufe of this change of name is fo much the more unaccountable, as the denomination Chryfolithus (golden-ftone) undoubtedly more applies to the Topaz, which is of a golden-yellow colour, than to our Chryfolite, which is green.

The more detailed external defcription of the *Chryfolite*, given by *Werner** with that degree of accuracy we are en-

* *Bergmännifches Journal*, 3d *year*, 1790, *Vol.* 2, *page* 54.

titled

titled to expect from fuch a mafter, comprehends all, that, in the prefent ftate of our knowledge, can be faid on the natural hiftory of that ftone, refpecting its external characters, and the marks by which it is to be diftinguifhed from the other fpecies of ftones, with which it has been fo often confounded. But, on the other hand, an accurate chemical analyfis, and hence alfo the knowledge of its proper place in the mineralogical fyftem, have, till now, been fo much the more wanting : a deficiency which I hope to remove, by now publifhing the experiments to which I have fubjected it.

To remove all doubts, I previoufly mention that the Chryfolites analyfed by me, as well as thofe from which *Werner* has drawn up their external defcription, were bought by *John Hawkins*, Efq. in the Levant, on his travels for promoting the knowledge of Natural Hiftory, and were fent to me by him for that purpofe.

The fpecific gravity of Chryfolites I have found to agree with the ftatement of *Werner*, namely, 3,340.

A.

a) I took *two hundred* grains of rough chryfolite, and at firft bruifed them in the fteel-mortar, and afterwards reduced them to a fine powder by trituration with water in the flint grinding-difh. This powder, when dried by heat, I obferved had not increafed in weight. I poured upon it *two ounces* of pure cauftic lye, the alkaline contents of which amounted to one half of its weight, and evaporated the whole to drynefs in the filver-crucible, and ignited

nited it afterwards for thirty minutes. There remained a friable mafs, which, after cooling, was of a dufky olive-green.

b) When this mafs had been foftened with water, the folution affumed the fame colour, and a brown, undiffolved portion fell to the bottom, of a flimy appearance. The folution being faturated to excefs with muriatic acid, and fufficiently digefted, acquired a faffron-yellow colour: upon which it was diluted with water, and filtered. A pure filiceous earth then remained, which, after ignition, amounted to $72\frac{1}{2}$ grains.

c) The muriatic folution, when decompofed in a boiling ftate by mild vegetable alkali, prepared from tartar, afforded an abundant, light-brown-red precipitate, which, upon deficcation, again entirely diffolved in muriatic acid, and by the affufion of cauftic ammoniac, formed a brown-red precipitate; which was directly feparated by filtering, then wafhed, and digefted with cauftic lye, while yet moift. However, only a fmall portion feemed to diffolve by this treatment.

d) After the undiffolved matter had been feparated from the alkaline folution (*b*), I fuper-faturated this laft with muriatic acid, and added carbonated pot-afh, for the purpofe of obtaining a precipitate. However, only a little earth feparated, which, when collected, and tried for alumine by fulphuric acid, did not diffolve in it; but, on clofer examination, proved to be *filiceous earth*, weighing $3\frac{1}{2}$ grains after ignition.

e) The brown precipitate, which had been digefted with cauftic lixivium (*c*), when dry and expofed to a red-heat, gave 38 grains in weight. It confifted of a pure *oxyd of iron.*

iron. The whole was attracted by the magnet. Upon being diſſolved in muriatic acid, and again precipitated by pruſſiat of pot-aſh, it yielded 88 grains of very deep-coloured Pruſſian-blue.

f) The muriated fluid, after the ferruginous contents had been ſeparated from it by ammoniac (*c*), gave a copious white and looſe earth, by adding carbonat of pot-aſh. The mixture having been kept boiling for ſome time, this earth was ſeparated by filtration, well waſhed, and dried. It amounted to 198 grains of *carbonated magneſia* (mild magneſian earth), which I divided into two parts. One half of it was ſtrongly ignited for the ſpace of an hour, and left $39\frac{1}{2}$ grains, which produced a briſk ebullition upon the affuſion of ſulphuric acid. The other half was introduced into dilute ſulphuric acid. It directly afforded a clear ſolution, and pure ſulphat of magneſia (Epſom ſalt), by cryſtallization.

Note. It was by mere accident that, on the precipitation at (*c*) no more ammoniac had been added than was juſt neceſſary to ſeparate the oxyd of iron; ſince otherwiſe, in all caſes, the magneſian earth is alſo precipitated by ammoniac.

According to this decompoſition, the conſtituent parts of the chryſolite ſhould be in the *hundred*,

Ignited *Silex* . .	*b*)	$36\frac{1}{4}$	. . 38
	d)	$1\frac{3}{4}$	
Ignited *Oxyd of Iron*	*e*)	. . . .	19
Ignited *Magneſia*	*f*)	. . . . .	39,50
			96,50
		Loſs .	3,50
			100

B.

B.

For a ſecond analyſis of chryſolite I choſe poliſhed ſpecimens, which, beſides a pure tranſparency, poſſeſſed alſo a brighter colour: whereas the crude chryſolites, employed in the foregoing proceſs, were in ſome parts inclining to brown. As I intended, at the ſame time, to learn whether acids alone were capable of decompoſing this ſtone, without previous treatment with alkali, I made uſe of the ſulphuric acid, according to the manner in which *Marggraf* has employed it for decompoſing the ſerpentine.

a) I poured ten drachms of concentrated ſulphuric acid, mixed with double that quantity of water, upon *two hundred* grains of moſt finely-powdered chryſolite, placed in a retort, and abſtracted again the fluid, in a moderate diſtilling heat, until the remainder in the retort appeared a dry maſs. The liquor which came over, emitted a moderate ſulphureous ſmell. When cold, I collected the maſs from the retort, the upper part of which I cut off, and lixiviated it with boiling water. The ſolution exhibited a greeniſh colour, but ſo faint as to be hardly perceptible.

b) The undiſſolved reſidue was boiled a ſecond time, in a matraſs, with two drachms of concentrated ſulphuric acid, and two ounces of water. After this it was again collected on the filter, waſhed with an abundance of boiling water, deſiccated, and heated to redneſs. It proved to be pure, white *ſiliceous earth*, weighing 78 grains.

c) Both the ſulphuric ſolutions (*a*) and (*b*) were evaporated to dryneſs in a porcelain-ſaucer. The reſidual maſs had a greeniſh-grey tinge: it was firſt gently heated

in

in a porcelain pot, during which operation it emitted ſtrong fumes; and after this it was thoroughly ignited in a briſk fire for the ſpace of one hour.

d) The ignited maſs had then acquired a brick-red colour. It was levigated, lixiviated with hot water, and the red *oxyd of iron*, which it contained, was ſeparated by filtration, and ſubjected to ignition. This oxyd weighed 39 grains: but as, in the preſent ſtate, it was combined with a greater quantity of oxygen than when forming a conſtituent part of the chryſolite, in order to free it from that exceſs, it was immerſed in melted wax, in a ſmall crucible; and, after the wax had been burnt off, the oxyd was kept for ſome time longer in a low red-heat, the veſſel being then covered. Its red colour had now changed into a blackiſh brown; it was alſo readily attracted by the magnet, and weiged 38 grains.

e) After the colourleſs ſulphated ſolution (*d*) had been evaporated for cryſtallization, it yielded, to the laſt drop, pure ſulphat of magneſia. This neutral ſalt being diſſolved, and decompoſed in the heat of ebullition by carbonated pot-aſh, afforded 213 grains of white and looſe *magneſian earth*, the weight of which, after an hour's ignition, was only 87 grains.

From this ſecond analyſis, which exceeds the foregoing in the accuracy of its reſults, it appears that the conſtituent parts of chryſolite, proportioned to each other in the *hundred*, are as follows:

Ignited *Magneſia* . . .	*c*) . . .	43,50
Silex	*b*) . . .	39
Ignited *Oxyd of Iron* . .	*d*) . . .	19
		101,50

Note,

Note. The reafon why, in the prefent decompofition, there is a flight excefs of weight in the fum of the conftituent parts, inftead of the ufual lofs in moft other cafes, undoubtedly depends in the variable degrees of drynefs which thofe ingredients acquire on ignition.

In the quarries near *Leutfchau*, in Hungary, we meet with a pale-green ferpentine, mixed with grey, and croffed by tender veins of afbeftus. It alfo contains, copioufly diffeminated, refplendent grains, of a high green colour, which, in fome parts of my fpecimen, exhibit a rhomboid cryftallization. *Born** and *Fichtel*†, who have given a more circumftantial information refpecting this ftone, call thefe grains *Chryfolite*. *Fichtel*, however, is uncertain whether they fhould not rather be confidered as Chryfoprafe. But this conjecture is too little favoured by the external characteriftic marks; while, on the other hand, the minutenefs of thefe grains, and the impoffibility of feparating them from the ftone, which ferves them for a matrix, will not admit of a chemical examination. Notwithftanding this, their prefence in the ferpentine affords a *geognoftic* argument for confidering them as chryfolite, fince the conftituent parts of each have been difcovered to be the fame.

*   *   *

A loofe ftony matter (*rachill*), which is found near *Moldauthein*, in Bohemia, has likewife, for fome time paft, been held out to be chryfolite: but, on judging from the

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* Catal. meth. et raifon, de la collect. des Fofs. Tom. I. p. 69.

† *Mineralog. Bemerk.* v. d. *Karpathen*, I. Th. Wien. 1791, page 60. 61.

ſpecimens, rough and poliſhed, which I have ſeen at *Prague*, I cannot conſider them as ſuch; becauſe the external appearance of the rough pieces, and eſpecially the fine air-bubbles obſervable in the poliſhed ſpecimens, are rather an indication of a volcanic product. Herein I alſo find the opinion of *Lindacker** to agree with mine.

* See his *Beitrag zur* Geſchichte der böhmiſchen *Chryſolithe: in den Saml. phyſikal. Aufſätze beſonders die böhm. Naturgeſchichte betreffend.* 2 *Band Dreſden*, 1792.

VIII.

VIII.

EXAMINATION

OF

OLIVIN.

To the various ſtones which were formerly conſidered as a ſubordinate ſpecies, or rather variety of chryſolite, alſo belongs the foſſil known by the name of *Baſaltic*, or *Volcanic Chryſolite.*

On giving the external deſcription of this ſtone, together with that of the true chryſolite, *Werner* has not only accompanied it with the moſt inſtructive obſervations, but likewiſe, from his *oryctognoſtic* inquiries, he has ſhewn the neceſſity of diſtinguiſhing the *baſaltic* from *true* chryſolite. Whence alſo he conſiders the former as a diſtinct ſpecies, with the name *Olivin*, taken from its colour.

As it is the office of Chemiſtry to aſſiſt the *Oryctognoſtic Science** in the further improvement of its ſyſtem, by

* By *Oryctognoſy*, *Werner* underſtands the *ſcientific* knowledge or diſcrimination of foſſils from each other, conſidered as ſimple, that is, not compounded aggregates of various different minerals; and their *ſcientific* arrangement, or *claſſification*, into a regular ſyſtem, according to certain *orders*, *claſſes*, *genera*, *ſpecies*, *varieties*, &c.—Tranſl.

communicating certain facts relative to the conftituent parts of minerals, it is for the Chemift to examine whether, and how far, the conjectures refpecting the effential ingredients in any foffil, inferred from its external properties, are founded in nature: and, confequently, to determine with what propriety it had obtained the place previoufly given to it in the fyftem, on account of thofe fuppofed conftituent parts.

For this reafon I have thought it expedient to join the analyfis of the Olivin with that of Chryfolite.

FIRST SECTION.

Analyfis of the Olivin; from Unkel.

To difcover the conftituent parts of Olivin, I firft chofe that from the *Bafalt of Unkelftein*; in which rock it occurs in its perfect and undecayed ftate, in pretty large clufters, of a thoroughly equal, pale leek-green colour, and without any admixture of extraneous matters. Its fpecific gravity was 3,265.

A

a) *Two hundred* grains of finely pulverized Olivin were covered with two ounces of cauftic lye, the alkaline part of which conftituted half its weight. After the liquid had been evaporated, the dry mafs was ignited for half an hour. It

It aſſumed a grey colour, and was then liquefied or ſoftened with water, and filtered.

b) Upon ſaturation with muriatic acid, the alkaline lixivium let fall a white earth, which, being collected and dried, was boiled with ſulphuric acid. But this earth did not impart any foreign taſte to the acid; and when this laſt had again been decanted off, and ſaturated with mild alkali, it continued clear. Therefore the above earth was of the pure *ſiliceous* kind. When ignited, it weighed 49 grains.

c) The aſh-grey reſidue, ſepatated from the alkaline lye (*a*), coagulated to a thickiſh brown maſs, upon the afſuſion of muriatic acid. After this coagulum had been diluted and digeſted with ſufficient water, there remained a copious, light, ſlimy, and brown reſidue, which, upon deſiccation, weighed 152 grains.

d) The muriatic ſolution, ſeparated from this reſidue by filtration, was colourleſs. By the addition of mild alkali, prepared from tartar, it was decompoſed with the aſſiſtance of boiling heat, and 181 grains of a very white, looſe earth, were precipitated.

e) When the brown reſidue, mentioned at (*c*), after trituration, was digeſted with muriatic acid, it diſſolved into a yellow liquid, leaving, at laſt, *ſiliceous earth* behind, weighing 43 grains after ignition.

Note. It was undoubtedly this ſiliceous earth, ſtill intimately united with the ferruginous part of the ſtone, which in (*c*) prevented the muriatic acid from exerting its action on the oxyd of iron: yet this circumſtance, at the ſame time, furniſhed the means of exhibiting, free from iron, that portion of the earth which the acid had diſſolved.

 f) The

f) The ferruginous portion of the yellow muriatic ſolution (*e*) I precipitated by cauſtic ammoniac. It was then collected and waſhed; and, while yet moiſt, boiled with cauſtic lye. The lixivium was then again ſeparated by filtration, combined with muriatic acid to ſuper-ſaturation, and afterwards precipitated by carbonated alkali. Only a ſmall portion of earth fell down, which, upon trial, proved to be *ſiliceous*, and weighed 4 grains, after it had been expoſed to a red-heat. The liquor remaining, after the precipitation of the iron, was mixed with carbonat of pot-aſh; but no further precipitation nor turbidneſs enſued.

g) The *oxyd of iron*, that was again collected after the boiling with muriatic acid (*f*), was put into melted wax, in a ſmall crucible, and heated to redneſs; after this laſt had been burned off, it obeyed the magnet, and amounted to 25 grains.

h) Upon the above 181 grains of earth (*d*) I poured dilute ſulphuric acid; in which it diſſolved with efferveſcence. When the ſolution had been reduced within a ſmaller compaſs by evaporation, it depoſited minute ſpicular cryſtals, conſiſting of $1\frac{1}{2}$ grain of ſelenite, the pure *calcareous earth* of which is to be eſtimated at $\frac{1}{2}$ grain.

i) The ſolution, on further evaporation, yielded pure ſulphat of magneſia; which, being re-diſſolved, and precipitated at the temperature of boiling, by carbonat of potaſh, depoſited a very pure and looſe *magneſian earth*, whoſe weight, after ignition for an hour, amounted to 74 grains.

It follows, from theſe operations, that the conſtituent parts of the Olivin from Unkel are, in the *hundred*,

Ignited

Ignited *Silex* . . .	*b*)	$24\frac{1}{2}$	. . 48
	e)	$21\frac{1}{2}$	
	f)	2	
Magnesia . .	*i*)	. . . .	37
Lime . . .	*h*)	. . . . . .	0,25
Ignited *Oxyd of Iron* .	*g*)	. . . .	12,50
			97,75
		Lofs .	2,25
			100

B.

With the view of confirming thefe refults, I undertook another decompofition of the fame *Olivin from Unkel.* In this inftance I treated it immediately with fulphuric acid, in the fame manner as I did with the chryfolite, without previous ignition, in conjunction with alkali.

a) I put *two hundred* grains of moft finely pulverized olivin in a retort, pouring upon them *ten* drachms of fulphuric acid, together with a fufficient quantity of water; and again diftilled the liquid over to drynefs. Upon this I foftened the remaining grey-white mafs with hot water, and boiled afrefh the undiffolved earth, feparated from the fluid, with 2 drachms of fulphuric acid, and fufficient water. The liquid, filtered off from the refidue there left, was added to the firft folution. What remained was mere *filiceous earth*, whofe weight, after ignition, amounted exactly to 100 grains.

b) The

b) The ſulphuric ſolution (*a*) left, upon evaporation, a greyiſh-olive-green ſaline maſs, which I evaporated ſtill farther in a porcelain-crucible, urging it at laſt to a red-heat in a ſtronger fire. The maſs retained at firſt its whitiſh colour, but at length it aſſumed a pulverulent ſtate, and turned brick-red. When triturated, drenched with hot water, and filtered, it left a red *oxyd of iron*, which, after being treated with wax and ignited, weighed 24 grains.

c) After the clear ſolution of (*b*) had been evaporated in order to cryſtallize, it ſhot wholly into ſulphat of magneſia: but, when it was re-diſſolved in a moderate proportion of water, ſome cryſtals of ſulphated lime appeared, the quantity of which indicated one half grain of pure *calcareous earth*. Theſe laſt having been ſeparated, the remaining ſolution was decompoſed, by means of carbonated pot-aſh, in boiling heat. The *magneſian earth*, thus obtained, was pure, white, and looſe. When deſiccated at a ſomewhat raiſed temperature, its weight amounted to $188\frac{1}{2}$ grains; but it was reduced to only 77 grains, by ignition for the ſpace of an hour.

By this method of analyſing, which, with regard to magneſian ſtones, is not only the moſt commodious, but alſo indicates the reſults with the greateſt exactneſs, the conſtituent parts of the *Olivin from Unkel* were found to be, in the *hundred*, as follows:

Silex . . .	*a*)	50
Oxyd of Iron .	*b*)	12
Magneſia	*c*)	38,50
Lime . . .	*c*)	0,25
		100,75

Note.

Note. The fame obfervation applies to the agreement of this fum with the weight of the fubftance employed, and the flight excefs, as has been already mentioned, at the end of the fecond analyfis of chryfolite.

SECOND SECTION.

Analyfis of the Olivin from Karlsberg.

THE Olivin from the Bafalt of *Unkel*, employed in the foregoing examination, was, as has been mentioned, in its frefh and unimpaired ftate: but as moft olivins fhew more or lefs evident marks of decay, it ftill remained to enquire, whether, in thofe fpecies of olivin that are more difpofed to decay, any difference exifted in their conftituent parts. For this inveftigation I chofe the *olivin* from the Bafalts of the *Karlsberg*, near *Caffel*, in *Heffia*. I comminuted it coarfely, and wafhed off with water the yellow iron-ochre that invefted its furface and its chinks. It then confifted, for the moft part, of fmaller grains of a faint greenifh-yellow colour, but in part alfo of larger grains, whofe colour was a fomewhat frefher leek-green. In thefe latter I obferved black-grey particles, of a metallic luftre, imbedded in, or concreted with, their fubftance. When I had ftrongly ignited fome of thefe upon charcoal, I found that the green ftony matter of the olivin had thereby become grey, dull, and opake; while the differminated black-grey particles had fuffered no change. This fhewed, that they were not minute cryftals of horn-blende, but iron, and efpecially of the nature of the fpecular, or grey iron-ore, becaufe they were not attracted by the magnet.

a) Up-

a) Upon *three hundred* grains of this olivin, finely pulverized, I poured 4 ounces of ſtrong ſulphuric acid, together with 2 ounces of water, and again diſtilled from it the fluid, which emitted a ſlight ſmell reſembling ſulphureous acid, until the reſidue became a dry maſs. The *ſiliceous earth*, remaining after this maſs had been boiled with water, was a ſecond time boiled with half an ounce of ſulphuric acid, and ſufficient water. After this it was collected and ignited. It weighed 156 grains.

b) In order to learn whether *aluminous earth* was one of the extracted conſtituent parts, I took the third part of the whole of the ſulphuric ſolution, and precipitated, by carbonated pot-aſh, at the degree of ebullition, all that it held in ſolution. The freſh precipitate had a dirty, bluiſh colour; and I put it into cauſtic lixivium, as ſoon as it was edulcorated, digeſting it with the lye for ſome time. The mixture was next diluted with more water; the lye, ſeparated from it by filtering, was ſaturated with muriatic acid; and, after a ſlight ſuper-ſaturation, again combined with alkali. But this produced neither a precipitate nor muddineſs.

c) Being thus convinced of the total abſence of aluminous earth, I evaporated the remaining two-thirds of the ſulphuric ſolution (*b*) to a dry ſaline maſs, which I expoſed to a ſtrong red-heat in a crucible, for the purpoſe of decompoſing the ſulphat of iron which it contained. I then re-diſſolved the ignited maſs in water, and ſeparated the red *oxyd of iron* by filtration; which, by ignition with wax, was rendered attractible by the magnet, and weighed, in that condition, 21½ grains.

d) The ſolution, freed from the oxyd (*c*), cryſtallized by degrees into ſulphat of magneſia. When this had again been diſſolved in a ſmall quantity of water, light, delicate, need-

needled cryftals of felenite were left, the quantity of which hardly amounted to $\frac{3}{4}$ of one grain, which indicates $\frac{1}{4}$ grain of pure *calcareous earth*. To the diffolved fulphat of magnefia, corbonat of pot-afh was added in a boiling heat; and thus its *magnefian earth was precipitated*, amounting, after ignition, to $75\frac{1}{2}$ grains.

Whence the conftituent parts of the *Heffian* olivin, and their reciprocal proportions in the ignited ftate, confift, in the *hundred*, of

Silex	*a*)	52
Magnefia . . .	*d*)	37,75
Oxyd of Iron . .	*c*)	10,75
Lime	*d*)	0,12
		100,62

* * *

From thefe refults, it is plain that the olivin and chryfolite are very nearly related to each other; and, as the conftituent parts of each other are fo much the fame, and their refpective proportions not too diffimilar, it feems to me proper that thefe two ftones fhould no longer be divided into two different fpecies; but that the difference, deduced from their external characters, can only juftify the fubdividing them into two *varieties* of *one fpecies*. Moreover, fince no greater difference appears to take place between them, than, perhaps, that by which the bafaltic horn-blende is diftinguifhed from the common, it follows, that the olivin might be entitled to claim its former denomination of *bafaltic chryfolite.*

According to the habitudes of the chryfolite and olivin in the heat of the porcelain-furnace, (mentioned in the firft

firft Effay, n. 25, and 61-64), the former returned from the fire unaltered in form; but the fecond appeared in concreted grains, which were cemented together by the heat with more or lefs force of adhefion. From this circumftance I was induced to repeat the experiment with the chryfolite; with this difference, however, that I broke it into pieces of the fize of the grains of olivin, before I inclofed it in the charcoal. After thofe pieces had undergone the action of the fire, I found them, like ignited olivin, of an iron-black colour, opake, thinly glazed, and conglutinated. Yet both the glazing and concretion were fomewhat lefs in degree than what took place in the *Heffian* and *Greenland* olivins.

IX.

CHEMICAL EXAMINATION

OF VARIÓUS

*SILVER-ORES**.

AT the time when Philofophical Chemiftry was yet in its infancy, and when it was not known how to decompofe natural bodies otherwife than by fire, with very few exceptions, the knowledge of the conftituent parts of the bodies, belonging to the mineral kingdom, could not but be imperfect. Chemifts were fatisfied with the products obtained in the dry way, as it is called, and either paid no attention at all to the other fubftances contained in thefe bonies, or, confiding in groundlefs hypothefes, have fancied certain conftituent parts, of which nothing could be difcovered by the light kindled by Philofophical Chemiftry, the bafis of which is real facts.

Only, while this latter was advancing in its progrefs, the learned began to perceive, and ferioufly to attend to this great deficiency of knowledge refpecting the foffil kingdom, as well as to the tottering foundation of the mineralo-

* Read in the Royal Acad. of Scienc. at Berlin.—See the *Collect. of Germ. Treatifes* of that Acad. Berlin, 1793 and 1794.

gical

gical fyftems thereon eftablifhed. Accordingly, this part of Natural Philofophy was enabled, by the laudable exertions of *Schwab*, *Brand*, *Cronftädt*, *Wallerius*, *Marggraf*, *Scheele*, *Bergmann*, and feveral chemifts now living, to rife from obfcurity; and chemical mineralogy has now obtained the place, which is due to it among her fifter fciences.

Yet, all that has hitherto been done in this fcience, is nothing more than a fplendid beginning. Our acquaintance with the conftituent parts of foffils is ftill confined within narrow limits. Not only are we ftill ignorant of the compofition of a multitude of foffils; but, even with refpect to thofe, with which we appear to be already acquainted, further confirmation is required: for nothing is more detrimental to the progrefs of a fcience, than to adopt errors as undoubted and long-eftablifhed truths; to transfer them from one fyftem, and from one elementary treatife, into another, and to multiply them by conclufions which muft be as groundlefs as the premifes, from which they are inferred, are falfe.

If, therefore, a fyftematical mineralogy, arranged according to the chemical conftituent parts, (which, as yet, has hardly been eftablifhed), is to be fupported by a more folid foundation, and brought nearer to perfection, it is neceffary that a long feries of fucceffive analytical experiments fhould be made. But fince, for this purpofe, a found chemical knowledge, accompanied by patience, leifure, accuracy in management and obfervation, as well as a frequent facrifice of fcarce and coftly foffils, are required; and fince thofe circumftances do not ufually coincide, this branch of natural fcience cannot hope for a fpeedy and plentiful harveft. It muft ftill, therefore, as hitherto, only look for detached and occafional improvements.

Among

Among the numerous productions of the foffil kingdom, of which an exact chemical knowledge is yet wanting, the *genus of the filver-ores* feemed to me to require, in a high degree, a re-examination and amendment. For this reafon I have fubjected its chief fpecies to analytical treatment; the refults of which are communicated in the following fections.

FIRST SECTION.

Native Hornfilver, or Corneous Silver-ore. (Hornerz).

(Vitriolico-muriated Silver-ore, by *Kirwan.)*

THE *Corneous* is remarkable among the rarer *ores of filver*, not only from its richnefs, but alfo from the fubftance by which nature has mineralized that noble metal.

The name *Hornerz* appears to be of a later date than our knowledge of that ore, fince feveral writers on metallurgy, of the 16th century, have already mentioned it with the appellation of *Glaferz*; for it is obvious, from the defcriptions which thofe authors have given of it, that they did not mean our modern *Glaferz*, namely, the fulphurated filver-ore. *Matthefius**, noticing feveral of its varieties, calls them *white*, *grey*, *yellow*, *green glaferz*; and fays, "*it is tranfparent like horn in a lanthorn, and fufes in the flame of a candle.*"—*Fabricius*† mentions a liver-coloured filver-ore, "*which in lumps, viewed againft the light, is obfcurely*

* *Matthefius* Sarept. 1585. Norimb.
† *Fabricius* de rebus metall. Zürch, 1566.

tranſparent like horn, and in ſmall parts is entirely tranſparent like ice."—From this it may reaſonably be conjectured, that the *glaſerz* of the ancients has, in later times, been erroneouſly confounded with our modern one, as this denomination is, indeed, more ſuiting the *hornerz*, or corneous ſilver-ore, than ſilver, mineralized by ſulphur; and, on the other hand, no reaſon can be found for giving that name to the latter.

During the 16th century, in which the Saxon and Bohemian mines yielded vaſt treaſures, the revenues ariſing from this ſilver-ore often amounted to ſeveral hundred marks (8 ounces each): but, in the progreſs of time, it became ſcarcer and leſs known, until the celebrated Saxon maſter of the mines, Mr. *Pabſt of Ohain*, diſcovered it, as it were, anew, and gave it the name *Hornerz*, becauſe reſembling the factitious *horn-ſilver* (muriat of ſilver.)

It occurred formerly at *Joachimsthal*, *Annaberg*, *Schneeberg*, *Freiberg*, and in greateſt quantities at *Johann-Georgenſtadt*. At preſent, it is alſo found in ſome mines of the *Altaic mountains* in Siberia; and, according to *Sage*, likewiſe in the province of *Guamanga* in *Peru*, together with the native ſilver.

With reſpect to external form, I have met with the following varieties of the corneous ſilver-ore.

1) *Maſſive (Derbe)*. As ſuch it has been worked, in the times of its abundance, in the above-mentioned Bohemian and Saxon mines, copiouſly, and ſometimes in pieces of upwards of an hundred marks in weight. There may yet be ſeen, in the electoral-mineral cabinet, at *Dreſden*, a piece of that kind, cut in a cubical form, weighing ſeveral pounds; and alſo a ſmaller one,

one, which has fome impreffions of ftamps. Both thefe ores are probably remnants of that century, which have been fortunately faved. The colour of this corneous-ore is a dirty brown, though its proper hue feems to be the pearl-grey, and the brown tinge to arife from the interfperfed iron-ochre. It is foft; and may, like wax, be cut with the knife into thin chips; is poffeffed of a waxen glofs, and tranfparent on the edges and thin places.

2) In *lamellar pieces (fchaalig)*, incumbent on meager quarz, in the form of a cruft; from the *Schlangenberge.*

3) In ftill thinner layers, in part only incrufting, (*angeflogen*, or lying fuperficially), at times accompanied by native gold, or alfo by *lead-fpar*, or fpathofe lead-ore, from the fame place.

4) *Cryftallized* in minute regular cubes, of a pearl-grey colour; from *Johann-Georgenftadt.*

5) In fine *fcales*, or *flakes*, of a whitifh colour. In this manner the corneous filver-ore, even now, fometimes occurs at *Johann-Georgenftadt*, upon brown iron-ochre *Eifen bräune*).

6) In an *earthy* form, mingled with argil. This is the genuine *butter-milch filver* (argillo-muriated filver-ore) of the former mineralogifts, and which *Veltheim** has defcribed. The fpecimen which I have feen was dug up in the year 1617, on the old St. *George* mountain, at *Andreafberg*, and is now preferved at Berlin, in the royal department of the

* *Crell's* German edition of *Kirwan's* Mineralogy. Berlin, 1765, page 281, feqq. in the notes.

mines. It confifts of an *aëtitic*, kidney-formed nodule of calcareous fpar, the cavity of which is filled with this *butter-milch filver*, in the form of a deficcated earth, externally of a flate-blue, but of a brownifh white on the recent fracture; with which ore, likewife, the outer fides of the fpecimen are for the moft part coated.

7) In grey lime-ftone, but *imperceptible* to the eye; from *Annaberg*, in Lower Auftria. This laft is the foffil mentioned by *Jufti* *, under the name of *alkaline filver-ore*.

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* * *

The following are the principal chemical refearches that have been made into the corneous filver-ore, as well as its effential ingredients, and are communicated to the fcientific public.

1) That of *Lommer* †, mafter of the mines in Saxony, who has alfo given the beft information refpecting the hiftory and external properties of this mineral. This author eftimates the argentine portion of this ore, when in pure ftate, at 28 *per cent.*; but the violet-ore of this kind he fuppofes to contain alfo a portion of alkalized fulphur.

2) *Woulfe* ‡ is of opinion, that he has difcovered, in the corneous filver-ore, befides the muriatic acid, the fulphuric, as a mineralizing medium. It is upon the authority of this ftatement of *Woulfe* that *Kirwan*, *Bergmann*, and other *mineralogifts*, affert, that the filver is mineralized in the cor-

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* *Jufti, Chemifche Schriften.* I. Th.

† *Abhandl. vom.* Hornerz, von *Lommer.* Leipzig, 1776.

‡ *Experiments* on the mixture of fome minerals.

neous

neous-ore by the fulphuric as well as by the muriatic acid.

3. *Sage**, of *Paris*, has examined the corneous filver-ore from Peru; and ftates the *maximum* contained of filver, in the *hundred*, to be from 70 to 74. He adds, that the metal is mineralized by muriatic acid; and, befides, combined with a peculiar fattifh matter.

4) *Laxmann* †, of *Peterfburg*, on the contrary, maintains, that no muriatic acid is contained either in the Siberian or Saxon corneous filver-ore; and that in it the metal is mineralized by fulphur, in the fame manner as in the glaferz, viz. the vitreous or fulphurated filver-ore.

On confidering this difcordance among the learned, refpecting the nature of the fubftance which mineralizes the filver in the corneous-ore, I think that it will not be fuperfluous if, to the enquiries of thefe chemifts, I add the experiments which I had the opportunity of making with feveral varieties of this filver-ore.

A.

The above-mentioned *maffive corneous filver-ore*, from the larger fpecimen in the Electoral collection at Drefden, was the principal fubject of my analyfis, a fufficient quantity of it having been given me for that purpofe with the greateft liberality.

* Analyfe Chim. et. concord. des trois regnes. Paris, 1786.
† Nov. Comment. Acad. Scient. Petrop. 1774.

) If the artificial horn-ſilver (muriat of ſilver), be melted by itſelf on the ſpoon before the blow-pipe, it ſoon and readily fuſes into a globule; and, when combined with mineral alkali, the ſilver is immediately reduced. But the native corneous ſilver-ore does not melt ſo eaſily; it rather runs into the conſiſtence of pap, and at the ſame time ſeparate metallic grains tranſude. Its reduction, by means of ſoda, is ſomewhat more difficult than that of the artificial horn-ſilver, and the reaſon of this difference depends on the portion of iron contained in this ore.

b) Upon *two hundred* grains of the corneous ſilver-ore I poured three times their weight of pure nitric acid; but no action took place, either in the cold or in the heat of boiling; only a ſubtle brown-red iron-ochre was ſeparated, which, being waſhed off from the remaining ore, and dried, amounted to 4 grains. Cauſtic ammoniac, added to the nitric acid employed, precipitated 5 grains more of iron. When it was afterwards mixed with muriatic acid, only a pale milky colour was produced, but no real corneous ſilver-ore depoſited. It followed from this, that neither any free native ſilver, nor any portion of it mineralized by ſulphur, had been contained in that ore. The horn-ſilver, after treatment with nitric acid, was reduced by twice its weight of ſalt of tartar, and yielded 133 grains of reguline ſilver.

c) 1ſt. For the purpoſe of finding out, more accurately, its conſtituent parts, I mixed 200 grains with 600 grains of the pureſt alkali prepared from tartar, and brought the mixture into the ſtate of fuſion in a glaſs retort, applying the neceſſary degree of heat. After refrigeration, I broke off the upper half of the retort, ſoftened the fuſed maſs, which was of a light-brown colour, with hot diſtilled water, filtered the whole, and edulcorated the reſidue.

2dly.

2dly. This refidue was then diffolved in nitric acid. The folution acquired a brown tinge, and the fcum floating upon the liquor affumed the colour of bricks. When the argenteous parts were completely diffolved, there remained $8\frac{1}{2}$ grains of a brown-red powder, which imparted a golden yellow colour to the aqua regia, with which it was digefted, and left a white refidue behind. This laft confifted of horn-filver, mingled with a flight portion of the *gangue*, or *matrix* of the ore, and afforded, on reduction, 2 grains more of *filver.* Cauftic ammoniac precipitated from the yellow folution 7 grains of *oxyded iron.*

3dly. The nitric folution of the filver was precipitated by common falt; and the muriat of filver thus obtained weighed, after reduction by means of foda, $134\frac{1}{2}$ grains of reguline filver.

4thly. The fluid, left after the feparation of the horn-filver, had a pale-yellow colour, owing to a *portion of iron*; which, precipitated by pure ammoniac, weighed 5 grains.

5thly After this, I proceeded to examine the faline mafs, diffolved in diftilled water, and feparated from the filver, after the corneous-ore had been fufed with pure alkali (*i*). On faturating this mafs with diftilled vinegar, the folution was rendered turbid, and a loofe white earth depofited, which, collected and dried, amounted to $3\frac{1}{4}$ grains of *argillaceous earth.*

6thly. The argil being feparated, the folution was reduced to a dry falt by evaporation, and the alkohol, affufed upon it, took up the acetite of pot-afh. The neutral falt, which was left behind by this procefs, and which confifted of the mineralizing muriatic acid and the alkali employed, I diffolved in water, and obtained from it, by repeated evaporation and cryftallization, 117½ grains of *muriat of pot-afh*.

7thly. In order to learn whether and in what proportion *fulphuric acid*, which by fome writers has been mentioned as one of the conftituent parts of the corneous filver-ore, were really prefent in it, I again diffolved that falt in diftilled water, and dropped into it liquid muriat of barytes. The mixture became turbid, exhibiting that appearance which indicates the prefence of only a flight quantity of fulphuric acid. I continued to add the barytes, until no more turbidnefs appeared. The weight of the precipitate thus obtained was 3 grains: but, as in thefe three grains of fulphated barytes the acid cannot properly be eftimated to be more than half a grain, I think this quantity is too trifling to be confidered as one of the effential conftituent parts of the corneous filver-ore. But if that half grain of fulphuric acid be eftimated equal to 1½ grain of fulphat of pot-afh, and be fubtracted from the above 117½ grain of digeftive falt, or muriat of pot-afh, there will remain of the latter only 116 grains, in which the concentrated muriatic acid amounts to 42 grains. Therefore,

One *hundred* parts of this corneous-ore contain

Silver	67,75
Muriatic acid . . .	21
Oxyd of iron . . .	6
Argil	1,75
Sulphuric acid . . .	0,25
	96,75

B.

B.

I likewiſe examined the *corneous ſilver-ore* found in the *Schlangenberge.* *One hundred* grains of it, mixed with 300 of ſoda, were fuſed in a ſmall retort; and, after the ſaline contents of this maſs had been diſſolved in hot water, the remaining ſilver was diſſolved in nitric acid. I then fully ſaturated with muriatic acid the aqueous alkaline ſolution, which contained the common or culinary ſalt, formed by the muriatic acid of that ore, and put it to the teſt with muriat of barytes. The portion of ſulphat of barytes, thus generated, was as inſignificant as that from the Saxon corneous-ore; ſo that alſo, in this caſe, the ſulphuric acid may be conſidered only as an accidental conſtituent part.

To the nitric ſolution of the ſilver I added common ſalt; and thus I produced again the muriat of ſilver, which weighed $91\frac{1}{2}$ grains, and afforded 68 grains of *ſilver*, reduced to the reguline ſtate. What was wanting to make up the firſt hundred grains of the corneous-ore, conſiſted of ferruginous ochre and quarzoſe matrix.

Hence it is obvious, that the *Siberian* corneous ſilver-ore here examined, almoſt perfectly agrees with the preceding *Saxon* one in its exterior characters, as well as in the conſtituent parts.

C.

The experiments made with the argillo-muriated ſilver-ore *(butter-milch ſilver)*, deſcribed before (page 113), are the following:

a) Ignited by itſelf upon charcoal before the blow-pipe, it feebly conglutinated together, at the ſame time that minute globules of metallic ſilver were oozing through the maſs. When fuſed with glaſs of borax, it diſſolved into a clear, light-green, vitreous globule, and yielded a button of pure fine ſilver.

b) Upon 35 grains of that ore I poured nitric acid, and made it boil. Neither effervefcence nor red vapours appeared; as, upon the whole, the acid ſeemed to attack it but weakly. The reſiduum aſſumed the form of a precipitate, reſembling a cheeſy coagulum. When the acid, then tinged of a faint blue, was ſeparated through a filter, it admitted of combination with common ſalt, without being rendered turbid, or yielding any precipitate. By the addition of corbonat of ammoniac to exceſs, argillaceous earth was thrown down, and the liquor appeared of a rather deep blue. But, after it had been ſuper-ſaturated with ſulphuric acid, and iron immerſed into it, it depoſited a thin coppery cruſt.

The dried reſidue weighed 30 grains. It was extracted by repeatedly pouring upon it cauſtic, or pure ammoniac, agitating it frequently. Nitric acid being added to a few drops of it, ſome horn-ſilver immediately precipitated. The whole of this ſolution, when evaporated by a gentle heat, dried up to cryſtalline flexible membranes of a pearl-grey, which tarniſhed into blue by expoſure to air; and, when gently melted in a ſmall ſilver-cup, ran into a waxy ſubſtance. The weight of this fuſed muriat of ſilver amounted to 10½ grains.

When the argil, that was left behind after the extraction of the horn-ſilver by ammoniac, was melted with ſoda, it ſtill afforded a bead of ſilver of ¾ of a grain. As this is equal to one grain of muriat of ſilver, the above 36 grains of this foſſil

foſſil contained $11\frac{1}{2}$ grains of muriated, or $8\frac{5}{8}$ of metallic ſilver, and $2\frac{7}{8}$ grains of concentrated muriatic acid.

Hence *one hundred* parts of the argillo-muriated ſilver ore contain,

Silver	24,64
Muriatic acid	8,28
Argil, with a ſlight trace of *copper* .	67,08
	100

It is owing to the argil contained in this ore that it does not aſſume the ſame appearance when heated on charcoal as the common horn-ſilver, but that the metal tranſudes in the reguline ſtate in ſmall globules; for as that earth deprives the muriated ſilver of its acid when heated, the ſilver is enabled to aſſume the metallic ſtate. And it is on this account that the ſame phenomenon took place when I mingled artificial horn-ſilver with argillaceous earth, and ſubjected it to ignition upon a piece of charcoal, with the aſſiſtance of the blow-pipe.

D.

With the view of inveſtigating the nature of the *ſilver-ore*, called *alkaline* by *Juſti*, I diſſolved *one ounce* of it in pure nitric acid, and mixed the filtered ſolution with muriatic acid. It, indeed, turned ſomewhat opaline; but no muriat of ſilver was ſeparated by this proceſs, nor was there any reguline ſilver precipitated upon immerſing into it a ſmall lamina of copper. Finding, therefore, that the portion of ſilver contained in the lime-ſtone could not be diſcovered in the nitric ſolution, I ſearched for it in the brown muddy reſidue of the filtered ſolution. This emit-

emitted an empyreumatic ſmell on being gently ignited, weighed afterwards 2 grains, and yielded with pure alkali a bead of fine ſilver. Hence it is probable, that in this foſſil the ſilver is combined with muriatic acid; and, reckoning upon this reſult, the quantity of muriated ſilver which it ſeems to contain, may be eſtimated at from *one and a half* to *two* ounces in hundred pounds. *Juſti* boaſted of a method of extracting the ſilver from that mineral, known to himſelf alone; as, when treated by any of the uſual proceſſes, this metal could never be procured from it.

As ſilver, notwithſtanding its great affinity with muriatic acid, enters into no combination with it while in the perfect reguline ſtate; and ſince that metal, as far as we know, is never found in the bowels of the earth in an oxyded ſtate, it is difficult to aſcertain the operation of nature in producing the corneous-ore. *Bergmann** was of opinion, that *Woulfe* had ſolved that doubt by aſſerting, that in the above-mentioned ore he had traced the ſulphuric acid, beſides the muriatic: for ſilver unites readily with ſulphur; and, ſince ſulphurated ſilver not unfrequently undergoes a decompoſition, more eſpecially when, as in this caſe may be conjectured from the preſence of ferruginous ochre, ſome pyrites diſpoſed to diſintegration intervenes, the ſulphur paſſes over into the ſtate of a free acid, and forms ſulphat of ſilver. If now muriatic acid interferes, it will, by virtue of its greater affinity to ſilver, decompoſe the ſulphat, and inſtead of it form corneous-ore.

* *Torb. Bergmann* on the generation of natural corneous, or muriated metals. *Crell's Chemiſche Annalen*, 1784. Number 4, page 377.

I Of

Of that corneous ſilver-ore which is found in regular cubic cryſtals, *Bergmann* had already conjectured that it might be conſidered as pure, and free from all ſulphuric acid. He alſo wiſhed to convert this conjecture of his into an eſtabliſhed truth, by duly examining that foſſil; *for*, as he very juſtly ſays, *it is better to ſacrifice ſuch a ſpecimen, ſcarce as it yet is, to inveſtigation, rather than to deprive the ſciences of a means of enlarging our knowledge by preſerving it.*

The wiſh of the immortal *Bergmann* is in ſome degree accompliſhed, and his conjecture, for the moſt part, confirmed by the preſent enquiry; with the unimportant difference, however, that, inſtead of cryſtallized corneous-ore, I have employed a ſpecimen of that which occurs in lumps, or *maſſive*.

In order to comprehend how nature can generate the corneous ſilver-ore, without the interpoſition of ſulphur or ſulphuric acid, we may receive ſome light from the following intelligence, taken from a letter of *Prouſt*, in *Rozier's Journal de Phyſique.* It is there ſtated, that the coined ſilver of the Spaniſh ſhip San Pedro d'Alcantara, that was wrecked on the coaſt of Portugal, became coated with a blackiſh cruſt of $\frac{1}{48}$ of an inch thickneſs, during the ſhort time before it was recovered from the ſea. This cruſt broke off in ſcales, and was a true muriat of ſilver. Moreover, *Pallas** relates, that he has found on the Jaik, in Siberia, ſeveral old Tartarian ſilver coins, which in that tract of ſaline land were converted into true muriat of ſilver, ſome throughout their whole maſs, and others on the ſurface only.

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* *Nordiſche Beytraege,* III. Vol.

From

From this knowledge of the conftituent parts of the corneous-ore, art is enabled to imitate nature pretty nearly. If muriat of filver be made to fufe uniformly at a moderate heat, an artificial corneous-ore is produced, which may be made more fimilar to the natural one by adding, before the fufion, a proportional quantity of iron-ochre. And if muriated filver be diffolved in cauftic ammoniac, and the fluid evaporated in a gentle warmth, the horn-filver remains in fmall glittering fcales, refembling thofe with which the native corneous-ore is found in part covered. But, if this folution be left to fpontaneous exhalation in the air, the horn-filver will fometimes fhoot into folid regular cryftals, of the fame appearance with the cubic cryftals of the corneous-ore.

SECOND SECTION.

Red Silver-ore (Rothgültigerz).

THE principal character by which this beautiful genus of filver-ores is externally diftinguifhed from others, confifts in a peculiar red colour, on account of which it is fubdivided into two fpecies, the *light*, and the *deep-red* filver-ore. The colour of the firft varies from a bright ruby to a garnet red; that of the fecond inclines more or lefs to a fteel-grey, but the characteriftic crimfon tint is foon made to appear by fcraping or rubbing the ore. The deep-red filver-ore is ufually opake; the light-red, on the contrary, is in various degrees tranfparent.

With refpect to external form, the red filver-ore is found *maffive*, *diffeminated*, *inverting* or fuperficial, *dendritic*; and at times regularly cryftallized. Its cryftals ufually poffefs the form of hexahedral columns, without any pointed ter-

termination, or ending in trihedral or hexahedral pyramids. The light-red ore alſo occurs in ſix-ſided pyramids.

The denomination of *Rothgültig*, or *Rothe gültiges Erz*, given by the older German miners to this genus of ſilver-ores, was intended to ſignify that it contained a portion of that noble metal, and thus to diſtinguiſh it from other ores, which reſemble it in form and colour; but, with reſpect to their argenteous contents, are *deaf* (*ungültig*), or of no value; inſtances of which are afforded by the native red ſulphuret of arſenic, red-blende, and garnet. In proceſs of time, this appellation has degenerated into *Rothgülden*, by which the unexperienced might be miſled to ſuſpect in this ore ſome portion of gold.

Concerning its conſtituent parts, it is the common opinion and doctrine, that the ſilver is mineralized in it by *arſenic*, as well as by ſulphur. Theſe three, *ſilver*, *ſulphur*, and *arſenic*, are in all elementary books of mineralogy, and by all authors, ſtated as the conſtituent parts of this ore, to which ſome add only a portion of iron. Among thoſe writers which, in *chemical mineralogy*, are reckoned claſſical, *Henckel* ſeems to be the firſt who mentions arſenic as one of the chief conſtituent parts of the red ſilver-ore, when he ſays, "*The high-red ore, beſides ſilver, conſiſts merely of arſenic; the deep-red contains ſulphur alſo.*" After him, *Wallerius* introduces it by the name "*Argentum arſenico et ſulphure mineraliſatum.*" *Cronſtedt* adopts this ſtatement, adding only ſome ferruginous ingredient. *Bergmann*, likewiſe, is of the ſame opinion, in his *Sciagraphia**, calling it "*Argentum cum arſenico ſulphure*

* Torb. *Bergmann*, Sciagraphia regni mineralis. Lips. et Dreſd. 1782, page 108.

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mineralisatum:" and, in his dissertation de *Arsenico**, he says, "*Arsenicum cum argento sulphurato mineram argenti rubram conficit*:"—and at the same time he states their proportion to be, of *silver* 60, of *arsenic* 25, and of *sulphur* 13†. It was on the authority of these eminently learned men that all the other writers have received the above-mentioned component principles of this ore as unquestionable facts, and have transferred them into their works.

Yet, upon the whole, arsenic is not so general a mineralizer as has been hitherto supposed. Hence all the hypotheses grounded on its pretended presence, and according to which arsenic was considered as a principle necessary to the generation or maturation of metals, especially silver, can no longer subsist. This supposition, which has never before been questioned, that most genera of silver-ores contain arsenic, has occasioned the *prize question* of the *Royal Academy of Sciences at Berlin*, 1773, "*To what purposes does* "*Nature employ the arsenic contained in metallic ores?* "*Can it be proved, by experience, that it effectually serves* "*to bring the metals to maturity? And if so, in what man-* "*ner, and how far is this effected?*"—However truly Mr. *Monnet*, whose paper has been honoured with the prize, has demonstrated that arsenic has no essential share in the generation of metals, he might as well have deduced his demonstration in the shortest and most solid way, *a priori* from the non-existence of arsenic in the red and white silver-ores, and in the grey copper-ore *(Fahlerz)* abounding in silver—(for these the above Academy seems principally to have had in view on making their question)—had he convinced himself of the falsehood of the premises by a previous enquiry duly instituted.

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* Ejus'd. Opuscul. Phys. et Chem. Vol. II. page 298.

† *Loc. cit.* page 303.

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It is probable the red-arfenic, which externally refembles the deep-red filver-ore, and, according to *Henckel's* teftimony, ufed to be called *unripe red filver-ore*, has firft fuggefted the idea of the prefence of arfenic in thofe ores of filver.

After this digreffion, I now proceed to the chemical analyfis itfelf. This, however, was particularly performed with the light-red filver-ore, of which I had an opportunity of felecting, for my repeated experiments, a fufficient number of fragments, pure and free from extraneous matter, from the mines of the *Upper-harz*, and thofe of *Saxony*.

A.

a) Upon *five hundred* grains of bright, cryftalline, red filver-ore, from the pit *Catharina Neufang*, at *Andreafberg*, moft finely pulverized, I poured fix times their quantity of a mixture of equal parts of nitric acid of 1,350 fpecif. grav. and diftilled water. The phial was kept for feveral hours in a low digefting heat, fo that the agency of the acid could be but moderate. I then diluted the folution with water; caufed it to boil; and, after the refiduum had fubfided to the bottom, I decanted the clear folution. Upon the remaining pulverulent ore, a quantity of nitric acid and water, equal to the preceding, was again affufed; and, in the fame manner, proceeded with as at firft. The ore appeared now to have been effectually decompofed; and for this reafon the folutions, together with the refiduum, were put on the filter, and the latter properly wafhed.

b) The filtered nitric folution had no colour at all, having been very much diluted by the water by which the refidue had

had been edulcorated. I fubjected it to evaporation to one eighth part, and found the bottom of the evaporating glafs-veffel, after cooling, covered with copious, finely-grained, refplendent, and heavy cryftals of a grey-white. To afcertain their nature, I procured, by a feparate procefs, a quantity of a folution of the fame red filver-ore, fufficient for this enquiry, and found that they were *fulphat of filver*. Being affured of this, I diffolved that fulphat by a proportionate quantity of water, affifted by heat, added it again to the nitric folution, and combined this laft with muriatic acid, as long as any muriat of filver would precipitate; which, when collected, edulcorated, and dried, was found to weigh 391½ grains.

c) The fluid, from which the horn-filver had been thus feparated, was then reduced to a fmaller bulk, by diftillation from a retort. This concentrated fluid became turbid, and left another grain of muriated filver on the filter. At this ime it contained no other foreign fubftance, except a confiderable portion of fulphuric acid.

d) What remained undiffolved by the nitric acid, confifted of an afh-grey, pretty loofe, or flocculent powder, of 202 grains in weight. When this had been gently digefted for half an hour, with a mixture of 5 parts of muriatic acid, mixed with 1 part of the nitric, and then diluted with half its quantity of water, there remained, after filtering, careful edulcoration, and drying, 65 grains; which were the fulphureous contents of the ore. When this refidue had been gently heated, the fulphur deflagrated, leaving 6½ grains of muriated filver behind. This *fulphur*, therefore, confifted of 58½ grains.

e) After the filtered folution had been evaporated in part, it was poured into a large quantity of water. By this

ma-

management, a white precipitate immediately enfued, which being feparated by the filter, edulcorated, and dried, and laftly heated in a porcelain cup, gave 133 grains in weight. But I could not find the leaft trace of arfenic in it, though I had fubjected it to all the trials deemed proper for difcovering its prefence. On the contrary, it was manifeft, that this precipitate wholly confifted of *oxyd of antimony*, quite of the fame nature with that which is produced when muriatic folutions of antimony are precipitated by water. On expofing it to heat, a fmall portion of moifture ftill evaporated, attended with a muriatic fmell, which was hardly perceptible. When again put on a teft, and mingled with a third part of charcoal duft, the coaly powder was flowly confumed, by burning, without any arfenical fmell, and left behind it the metallic oxyd, poffeffed of a grey colour, and partly blended, partly covered with a quantity of fine, grey-white, fhining, acicular cryftals, or the flowers of antimony, as they are called. But when it was fufed in a covered crucible with tartar and powdered charcoal, it was completely revived into *reguline antimony*, which being blown off with the bellows, a *bead of filver* was left, weighing half a grain.

f) The liquor alfo, from which the antimonial oxyd was feparated, contained free fulphuric acid. On this account I put it into a retort, together with the nitric acid, from which the filver had been precipitated in the ftate of horn-filver, by means of muriatic acid, and continued the diftillation until, at this temperature, nothing more would pafs over; but, on raifing the heat, thick white vapours had begun to rife. The fluid left behind in the retort was found, upon trial, to be concentrated *fulphuric acid*. Upon diluting this laft with water, and fubfequent affufion of muriated barytes, the fulphat of barytes from thence pro-

duced,

duced, amounted, after edulcoration and deficcation, to 194 grains.

Confequently, the conftituent parts difcovered by thefe refearches, are, *filver*, *antimony*, *fulphur*, *and fulphuric acid.* It remained yet to inveftigate, what are the proportions and the manner of combination of thefe principles, which conftitute the red filver-ore.

Firft, concerning the quantity of filver contained in this ore here examined, the muriat of filver (*b*) together with thofe portions that were left behind on the deflagration of the fulphur (*d*), and the concentration of the fluid from which the former had been feparated (*e*), amounted, in the whole, to 399 grains. Thefe being reduced, (including the one half grain obtained on driving off the antimony), yielded 300 grains of pure filver. This ftatement alfo perfectly agreed with the refult of another experiment, which, by way of collateral proof, I performed in the dry way: for having, with this view, divided one *docimaftic centner* of that ore into two parts, and carefully refined each of them on the cupel, inclofed in four times their weight of hammered lead, I recovered in each cupel a bead of fine filver of 30 pounds weight.

I endeavoured to afcertain, by the following counter-experiments, the metallic portion of the *oxyd of antimony*; which, after deducting, by guefs, one grain for the half grain of filver which was contained in the ore, amounted to 132 grains. Upon *one hundred* grains of pure reguline antimony I poured four parts of muriatic acid; and, when warmed, I continued dropping nitric acid into this fluid, until all the metal was diffolved. After the folution had been concentrated by gentle evaporation, I added water to precipitate the diffolved metal. The precipitate thus obtained, after

 lixi-

lixiviating the faline parts, and deficcation, weighed 130 grains. Hence the above 132 grains are equal to 101½ grains of metallic antimony.

With regard to the *fulphuric acid*, it may be doubted, whether the acid here difcovered, had really previoufly exifted as fuch in the red filver-ore, forming, with the metal, fulphat of filver; or whether that acid ought not rather to be confidered as a product, arifing from the oxygenation of the fulphur, while the ore was diffolving in nitric acid. But even the external properties of that ore, efpecially its tranfparence, and the abfence of metallic luftre, will fufficiently prove, that the latter is not the cafe: for, with regard to the mineralization, ores may be conveniently divided into two claffes. The *firft* comprehends the true ores in the ftrict fenfe; that is, thofe only in which the metallic portion is either in the perfect, or very nearly perfect, reguline ftate, and whofe mineralizer is fulphur. A metallic luftre, and abfolute opacity, are effential properties of fulphurated ores of this kind. To the *fecond* clafs belong thofe ores, the metallic part of which is acidified by oxygen, either alone, or in combination with fulphur and acids. The exterior characters of the ores of this clafs are various. Some of them are *tranfparent* even to *pellucidity*; others, on the contrary, exhibit only an earthy appearance. But all thefe are particularly diftinguifhed from the genuine or true ores, by the total abfence of metallic fplendour. Among the filver-ores, therefore, the *vitreous filver-ore (glaferz)*, the *black filver-ore (fprödglas-erz)*, and the *white filver-ore*, belong to the firft clafs, or fulphurated ores; but the *red*, and the *corneous filver-ore*, belong to the fecond clafs, or ores mineralized by acid principles.

The peculiar manner in which the nitric acid exerts its diffolving power on the red filver-ore during the digeftion, affords another argument to ſhew, that in this ore the portion of ſilver does not exiſt in its perfect metallic ſtate, and mineralized by ſulphur; but, on the contrary, is combined with oxygen, at leaſt for the greater part; and hence, that it there exiſts in a calciform ſtate. The nitric acid acts upon it much too weakly, to oxygenate the ſulphur in any conſiderable degree; in conſequence of which, only a proportionally ſmall quantity of nitrous gas is produced in this ſolution. This fact is ſtill more confirmed by the following experiment. Some finely pulverized red ſilver-ore, together with a large quantity of ſtrong muriatic acid, were ſubjected to digeſtion for ſome hours, at a boiling heat. The acid, ſeparated by filtration, was examined after cooling, and was found to contain, not only ſilver, and antimonial particles, but alſo ſulphuric acid. Now, as muriatic acid alone is incapable of converting ſulphur into a free or uncombined acid, it follows, that the ſulphuric acid muſt already before have exiſted in that ore, in the capacity of an acid. Even *Henckel*, whoſe great merits in chemical mineralogy are at preſent almoſt totally diſregarded, has already ſtated it as a certain fact, that the ſilver may be extracted from its red-ore, by muriatic acid alone, aſſiſted by ſucceſſive digeſtions at the degree of boiling. It is alſo probable, that the ſulphuric acid, preſent in that ore, contributes to the ſolubility of the metal in the muriatic acid.

The ſulphuric acid, contained in the above 500 grains of the red ſilver-ore, produced 194 grains of ſulphated barytes. Other comparative experiments proved to me that this acid amounted to $85\frac{1}{2}$ grains of 1,850 ſpecific gravity. But as this acid muſt be ſuppoſed to be combined in this ore with the ſilver in a concrete ſtate, or *freed from* water, and not in the ſtate of liquid ſulphuric acid, I hope to come pretty near the mark, if, till a more accurate computation can be made,

made, I allow 40 grains for the fulphuric acid of that degree of concentration.

In order to afcertain whether any volatile parts, and of what kind, were difcharged by the red filver-ore, when treated in fire with exclufion of air, *one ounce* of it, coarfely triturated, was placed in a fmall glafs-retort, which, being connected with the pneumatic quickfilver-apparatus, I continued to heat till the ore was in fufion. However, nothing paffed over into the jar filled with mercury, excepting that portion of atmofpheric air, which was expelled from the retort by the heat. In the intermediate glafs-balloon *volatile fulphureous acid* collected, in the form of fine drops of dew; in the neck of the retort there appeared a flight trace of fublimed yellow fulphur; but the ore in the retort did not lofe fo much as one entire grain of its weight.

Thefe fame experiments, made for the purpofe of difcovering the ingredients in the red filver-ore, I repeated with another fpecimen from the fame mine; but, as the refult of thefe laft, excepting fome unimportant deviations, agreed with the former, I am fatisfied with the conftituent parts refulting from the inveftigation of the above-mentioned 500 grains, and which are:

Silver	300
Reguline antimony	101,5
Sulphur	58,5
Concrete *fulphuric acid*	40
	500 grs.

Therefore, *one hundred* parts of this *red filver-ore*, from *Andreasberg*, contain:

Silver	60
Reguline antimony	20,3
Sulphur	11,7
Concrete *ſulphuric acid*	8
	100.

B.

The ſecond ſpecies of the red ſilver-ore, which I have analyſed, is the *bright-red and cryſtalline*, from *Churprinz Friedrich Auguſt*, near *Freiberg*. But, as I treated theſe in the ſame manner as the preceding, I ſhall confine myſelf to the reſults only; according to which, *one hundred* parts of this ore contain:

Silver	62
Reguline antimony	18,5
Sulphur	11
Concrete *ſulphuric acid*	8,5
	100.

This *Saxon* foſſil, therefore, perfectly agrees with that from the *Harz*, with regard to its conſtituent parts, and likewiſe very nearly as to their proportions. The quantity of ſilver alſo was found to be the ſame, when the proceſs was performed in the dry way; ſince 100 pounds of this ore, properly dreſſed or mingled with four times its weight of lead, and ſubjected to cupellation, likewiſe afforded 62 pounds of metallic ſilver.

In

In this *Saxon* red ſilver-ore, as in the foregoing, there was no veſtige of arſenical matter to be found, although arſenic conſtantly accompanies the ores dug out from that mine.

In the preceding analytical reſearches, concerning the red ſilver-ore, I have indeed mentioned *ſulphur*, and *ſulphuric acid*, as two particular products; yet I do not mean to ſay by this, that they are two ſeparate and really diſtinct conſtituent parts, actually exiſting in the ore. It is rather more probable, from the nature of the ſubject, to ſuppoſe, that in the undecompounded ore, both together conſtitute only one homogeneous ingredient part, and that the oxygen, by which the ſulphuric acid was generated in this proceſs, had before been uniformly diffuſed over the whole maſs of the ſulphur. But, if ſo, there is no doubt, but that the red colour of the ore, which in general is erroneouſly aſcribed to ſome arſenical matter, depends on that ſtate of ſulphur in its firſt degree of oxygenation, which by ſome is rightly called *oxyd of ſulphur*. On this account, the *ſilver*, *antimony*, *ſulphur*, and *oxygen*, are, in the ſtrict ſenſe, the genuine conſtituent parts of the red ſilver-ore, taken in its natural ſtate.

Laſtly, I did not think it neceſſary to re-examine what *Bergmann* aſſerted, in his Eſſay de *Arſenico*, concerning the red ſilver-ore. He ſays—"*Minera argenti rubra egregie* "*aquâ forti decomponitur, argentum et arſenicum ſuſcipiente,* "*adeo, ut tandem ſolum ſulphur in fundo reſtet.*" From this it might be inferred, that *Bergmann* had employed for this experiment a ſpecimen of the red ſilver-ore, which had no antimony, but really ſome arſenic, among its conſtituent parts; otherwife, by the eftablifhed principles of chemiftry, the antimoniacal part of the ore muft of courfe, together with the fulphur, have remained behind as a metallic oxyd, infoluble in nitric acid. In order to fet this contradictory point in a proper light, I boiled five parts of ftrong nitric acid upon 100 grains of this red ore for fome time; after which the mixture was diluted with water, and the folution filtered while yet warm. This extraction by ftrong nitric acid was fucceffively repeated, until only a fmall portion of fulphur remained. The folution procured by the firft digeftion, depofited, in the cold, granular fulphat of filver; but thofe of the fucceeding digeftions yielded alfo fome particles of antimony, which fubfided in delicate, light fcales, of a filvery luftre. By this experience, therefore, I learn, that reguline antimony, inftead of being corroded by nitric acid into an indiffoluble oxyd, makes an exception from that rule when in combination with fulphuric acid, as was here the cafe. And, for this reafon, I found that a folution of this metal was effected, when, by way of a comparative trial with pure reguline antimony, I ufed a menftruum compofed of ftrong fulphuric and nitric acids. This fact has already been mentioned by *Wenzel**. Upon this property of antimony, that its folubility in nitric acid is promoted by the fulphuric, is founded the rule that ought to be obferved in performing proceffes on the red filver-ore; which is, that for the purpofe of extracting its filver, weak nitric acid, and only a gentle digeftion, fhould be employed.

* See his *Lehre von der Verwandtfchaft der Koerper.* Drefden, 1777. page 182.

THIRD

THIRD SECTION.

Vitreous Silver-ore. (Silberglanzerz.)

THE appellation *glaſerz*, which the German miners have given to this richeſt ſort of all ſilver-ores, is inconſiſtent with its real natural qualities, and can only have been retained from the antiquity of the term. Not only is the abſolute opacity of this ore, but alſo its ſoftneſs, and ductility, (on account of which it may be cut, hammered, and coined, as eaſily as lead) are abſolutely incompatible with the notion of *glaſs*. An inſtance of the laſt mentioned property is afforded by thoſe medals, which were made of it under the reign King *Auguſtus* I. (of Poland,) and had the impreſſion of his portrait. *Henkel** was therefore fully entitled to ſay—" Glaſerz *is meant to ſignify the ſame as* " glanzerz, *which name it probably has received at thoſe* " *mines, where no other ore, conſtantly poſſeſſing luſtre, was* " *to be found; and, in particular, it ſeems, that the miner* " *who gave it firſt that name, happened to meet with a ſpe-* " *cies of glaſerz of variegated colours.*" Supported by this authority, and ſtill more ſo by the nature of that ore, I ſhall make uſe of the more ſuitable denomination, *ſilberglanzerz.*

That this ſpecies of ore is a mere *ſulphuret of ſilver*, is too well known to need farther confirmation. Only the proportion of its conſtituent parts, as ſtated by mineralogical writers, appeared to me to require correction. This, upon *Bergmann's*† authority, is generally ſaid to be 75 parts

* *Henkel redivivus.* page 51.
† *Sciagr. reg. min.* § 163.

of

of *ſilver*, and 25 of *ſulphur*. The portion of the ſilver is rated much higher by *Brünnich**: namely, at 180 marks, or at *ninety* in the *hundred*. On the contrary, *Sage*† eſtimates the ſulphur at 16 parts in the hundred of this ore, and conſequently the ſilver at 84. By the following experiments it will be ſeen, that of theſe two, the opinion of *Le Sage* is the neareſt to truth. That this more accurate ſtatement was before known among the earlier authors in mineralogy is proved by theſe words of *Lazarus Erker*‡ "*Thus* "*we may reckon among the ſilver ores of eaſy fuſion, the* "*moſt eminent of theſe, the glaſerz, which is compact, of a* "*lead colour, in quality nearly equal to native ſilver, and* "*loſes in the fire little more than one ſixth part, all the* "*reſt being good pure ſilver, &c.*"

A.

a) *One hundred grains* of cubically cryſtallized vitreous ſilver-ore (from the mine *Himmelsfürst*, near *Freiberg*), previouſly cut into ſhreds, were digeſted, in a low heat, in eight times their weight of nitric acid, of 1,350 ſpecif. grav. diluted with half its quantity of water. The activity of the acid proved to be but moderate, partly becauſe, as the ore was not capable of being pulverized, on account of its ſoftneſs and ductility, the ſhreds preſented a conſiderably ſmaller ſurface to the acid. After the ſolution had been

* *Cronſtedt's* Mineralogie, verm. d. *Brünich*. 1780. page 186.

† Analyſe. Chim. et concord. de trois regnes. par M. *Sage*. Paris, 1776. Tom. III. page 250.

‡ *Erker* Probierkunſt. Francfort, 1598. page 3.

been accompliſhed, the remaining browniſh-yellow ſulphur, when ſeparated, waſhed, and dried, weighed 13 grains; but, on being burnt on a porcelain teſt, it left one grain and a half of ſulphated ſilver, which, fuſed with mineral alkali, gave a ſilver-button of one grain.

b) The colourleſs nitrous ſolution, when combined with common ſalt, edulcorated, and highly deſiccated in a warm temperature, yielded 122 grains of horn-ſilver, the metallic portion of which amounted to 84 grains. By this, including the above-mentioned *one* grain, the proportion of the ſilver contained in 100 parts of that ore is determined at 85.

c) The fluid decanted from the muriat of ſilver, contained nothing but a ſmall proportion of diſengaged ſulphuric acid. This, however, ſhould not in this inſtance be conſidered as a conſtituent part of the ore, but was undoubtedly formed during its long digeſtion in nitric acid. Hence thoſe 15 grains, which, after deducting the 85 of ſilver, remain to make up the 100 of the ore employed, may all be ſafely put into our account, as its ſulphureous part.

B.

Next, in order to examine the truth of the preceding reſult, in the dry way, I took the vitreous ſilver-ore from *Joachimsthal*, in Bohemia. An hundred grains of it were divided into two parts, and each of them placed in a ſeparate aſſaying teſt, well dried beforehand under the muffle. Heat was then applied, at firſt moderate, to drive the ſulphur

phur ſlowly off, and only towards the end its intenſity was increaſed to the requiſite degree. The beads of ſilver obtained from each teſt, were of equal weight, and their ſum amounted to $84\frac{1}{16}$ grains.

In conſequence of the approximation of this laſt reſult to that of the foregoing experiments, the conſtituent parts of pure, ductile, vitreous ſilver-ore, taken upon an average, are proved to be:

Silver	85
Sulphur	15
	100

FOURTH SECTION.

Brittle Vitreous Silver-ore.

(Sprödes Silberglanzerz.)

THAT ſilver-ore, which occurs in the Saxon mines, with the name of *ſpröd-glaserz*, and to which the *röschgewächs*, as it is called in Hungary, ſeems to belong, is diſtinguiſhed, as to its external properties, from the ſpecies laſt mentioned, both by its darker colour, and by its brittleneſs, or want of ductility. *Wallerius* and others aſcribe that friability to an admixture of arſenic; but without reaſon, ſince this property is owing to an antimonial ingredient.

For the ſubject of my preſent analyſis, I ſelected the lamellated, friable, vitreous ſilver-ore, from the mine *Alte Hoffnung Gottes*, at *Groſsvoigtbserg*, near *Freiberg*, which is there found in thin tables, for the moſt part cellularly accumulated, of a black iron-colour, and is aſſociated with a

ſort

sort of calcareous ſpar, cryſtallized in low ſix-ſided columns, with trihedral terminations, which is met with in the clefts of a rock of *Gneiſs*.

a) If ductile vitreous ſilver-ore be fuſed upon a piece of charcoal, by the aſſiſtance of the blow-pipe, its ſulphur is quickly volatized, and a button of pure ſilver remains. But it is otherwiſe with the brittle ore: for the bead left after the evaporation of the ſulphur is brittle, and cannot be purified by the addition of borax. However, if a little nitrat of pot-aſh is added to the red-hot bead, it will deſtroy the portion of baſer metal which it contains, and then the borat of ſoda cauſes it to yield a pure button of ſilver.

b) *One hundred* grains of ore, previouſly levigated, were gently boiled in a ſufficient quantity of nitric acid, diluted with an equal quantity of water. This operation was repeatedly performed, till the black colour of the powdered ore diſappeared, and the inſoluble portion had become of a looſe texture, and had acquired a grey-yellow colour. When filtered and dried, this reſidue weighed 26 grains.

c) On adding a ſolution of common ſalt to the above filtered ſolution, which had aſſumed a pale-greeniſh colour, a copious precipitate of horn-ſilver enſued, which, edulcorated and dried, gave 88½ grains. Four parts of this afforded three of *ſilver*, by fuſion with ſoda.

d) The remaining ſolution was next combined with ſulphat of ſoda; but neither any turbidneſs, nor any indication of the preſence of lead, appeared. Upon this, cauſtic ammoniac was affuſed to exceſs; and the grey precipitate, which then fell down, and which the volatile alkali could not again render ſoluble, weighed five grains. Urged by heat, it melted into a conſiſtence, like pap, at the ſame time that

that a weak arſenical ſmell was perceived. After this precipitate had been once more diſſolved in nitric acid, the addition of ſoda cauſed it to yield a whitiſh-yellow, alkaline ſulphuret, a dirty brown, and Pruſſian alkali, a deep-blue precipitate, liable to the attraction of the load-ſtone, after ignition. Therefore, it conſiſted of *iron*, with a ſlight trace of *arſenic*.

e) The proportion of copper, indicated by a blue colour, in conſequence of the addition of ammoniac, and which ſtill remained in the ſolution, was but ſlight. For, after the ſolution had been ſaturated with ſulphuric acid, poliſhed iron immerſed in it, was inveſted with ſo ſlight a coppery cruſt, that no copper to any amount could be collected.

f) Thoſe 26 grains, which continued inſoluble in the nitric acid (*b*), were digeſted in nitro-muriatic acid, till nothing appeared to remain but the mere *ſulphur*. Its weight amounted to 13 grains; but, after deflagration, it left behind it about one grain of *quarzoſe matter* of the mine.

g) From this it is obvious, that 13 grains, or one half of the above 26 grains, were held in ſolution by the nitro-muriatic acid; and theſe were precipitated entirely in the form of a white powder, upon the affuſion of 20 parts of water. When ignited, this precipitate aſſumed a yellowiſh colour; but there was nothing, either of arſenic, or any other volatile ſubſtance, perceivable. By combination with ſoda, it became reduced to pure reguline *antimony*; which, as ſuch, admitted of being blown off without leaving any reſidue, in its uſual form of a thick white ſmoke, adhering to the contiguous bodies in the form of needle-ſhaped flowers *(oxyd)* of antimony. Thoſe 13 grains of oxyded antimony

mony are equivalent to ten grains of that metal in the reguline ſtate.

One hundred grains, therefore, of this foliated, brittle, vitreous ſilver-ore, contain:

Silver	*c*)	. . . . .	66,50
Reguline antimony .	*g*)	. . . .	10
Iron	*d*)	. . . .	5
Sulphur	*f*)	. . . . .	12
Copper and *arſenic*	*d*) *e*)	about . .	0,50
Extraneous matter from the *mine*		. . .	1
			95.

Conſidering the minute quantity of arſenic and copper, they can be reckoned only as caſual ingredients; and the ſame holds good with reſpect to the quarzoſe matrix. But, as the antimony exiſts in that ore, intimately combined with the ſilver and ſulphur, it muſt be conſidered as one of its eſſential conſtituent parts.

FIFTH SECTION.

White Silver-ore. (Weiſsgültigerz.)

NATURE has not confined herſelf to one certain determined law, in fixing the proportions that obtain among the conſtituent parts of the *white ſilver-ore*. This fact accounts for the difference of colour, luſtre, and fracture, obſerved in the various ſpecimens of this ore; which alſo, for the ſame reaſon, has been often confounded with the brittle vitreous ſilver-ore, the grey copper-ore, the compact plumoſe antimonial-ore (*dichtes federerz*), and the compact galena, or potter's lead-

lead-ore (*bleyſchweif*), &c. It is owing to this difference in the proportions of its component principles, that it is found, at one time, bright, and of a light grey; at another, of a lead-grey, and only glittering; of a fracture compact and even, ſometimes finely grained, or even paſſing into the fibrous texture. Hitherto it has not been met with, except in lumps and diſſeminated.

Of its conſtituent parts, few particulars have been given by former authors. *Henkel** ſeems to be the firſt who enumerates them:—" *Weiſſgültiges Erz*," ſays he, " *is pro-*" *perly a light, or bright-grey ſilver-ore, which yields* 14 " *marks of that metal, if it be perfectly pure and compact.* " *It contains, beſides, a little copper, arſenic, and ſulphur,* " *of which, however, it is difficult to aſcertain the propor-* " *tions.*" It is probably upon this authority of *Henkel*, that late writers unanimouſly ſuppoſe the eſſential ingredients of this ore to be *ſilver*, *copper*, *arſenic*, and *ſulphur*; to which *Cronſtedt*, *Bergmann*, *Kirwan*, and ſeveral others, add *iron*. *Wallerius* mentions two varieties of it: the one *without*, the other *with iron*. *Lehman*, on the contrary, ſuppoſes ſome *lead* inſtead of iron.

Yet, how little theſe ſuppoſed conſtituent parts agree with the real ones, will be manifeſt from the following experiments, made with the two principal ſpecies of the white ſilver-ore.

---

* *Henkel redivivus.* Dreſd. 1747. page 57.

A

A.

Light white ſilver-ore.

a) Among various minerals, dug in the mine *Himmelsfürſt*, behind *Erbisdorf*, near *Freyberg*, I ſelected thoſe that contain the bright white ſilver-ore in ſolid maſſes. From theſe, when pounded, I picked out a ſufficient quantity of fragments, unmixed with the coarſe-cubical galena, which accompanies this ore. It was eaſily levigated, and afforded a blackiſh powder, ſoiling the fingers.

b) Upon *four hundred grains* of this powder, I poured four ounces of nitric acid, of the ſtrength before mentioned, and two ounces of water. After ſufficient digeſtion in a gentle heat, the ſolution was decanted, and the reſidue again expoſed to a warm temperature, with two ounces of that acid. This mixture I next diluted with eight parts of water, and continued to digeſt it for ſome time. I then ſeparated the undiſſolved reſidue, conſiſting of a greyiſh-white powder, which, after waſhing and drying, weighed 326 grains.

c) The ſolution, which was nearly colourleſs, was combined with common ſalt, by which a conſiderable quantity of muriated ſilver was immediately produced. The next day were found over the horn-ſilver, which lay at the bottom of the veſſel, tender needled cryſtals, which, upon cloſer examination, proved to be muriat of lead. On this account I boiled the whole precipitate in a large quantity of water, by means of which the muriated lead was re-diſſolved, and ſeparated from the muriat of ſilver, collected on the filter. This laſt, when reduced by fuſion with ſoda, yielded 81½ grains of reguline *ſilver.*

d) What remained of the ſolution, together with the liquor obtained by the decoction of the horn-ſilver, I evaporated in part; and by adding a ſaturated ſolution of Glauber's ſalt, I obtained from it 45 grains of ſulphat of lead, which, upon reduction, afforded 32 grains of *lead* in the metallic ſtate.

e) The remaining part of the ſolution I now ſaturated with pure ammoniac; upon which a light-brown precipitate fell down, weighing 40 grains, when edulcorated and ignited in a low heat. As that precipitate had the appearance of a mixture of iron and argil, I diſſolved it again in nitric acid, and precipitated, firſt, the iron by means of Pruſſian alkali, and afterwards, by the addition of ſoda, a looſe earth, which, when deſiccated and ignited, weighed 28 grains, and, upon trial with ſulphuric acid, was found to be *aluminous earth.* This, being ſubtracted from the above 40 grains, leaves 12 for the *oxyd of iron*, which may be eſtimated at nine grains of metallic iron.

f) After this, the reſidue, that remained from the ſolution of the ore diſſolved in nitric acid (*b*), was ſubjected to a cloſer examination. I attempted to decompoſe it by muriatic acid, repeatedly poured upon it, and in every inſtance digeſted over it in a heat of ebullition. The proceſs was rendered ſomewhat difficult by the fine needled cryſtals, which were depoſited from the ſolution as ſoon as the heat fell below the boiling point. Similar cryſtals likewiſe ſhot on the paper, through which the ſolution, though yet boiling, was filtered, and I gradually re-diſſolved them again in warm muriatic acid. At laſt there remained 51 grains of ſulphur, leaving, after deflagration upon a teſt, two grains of a grey refidue, one of which diffolved in muriatic acid, and was added to the preceding folution. The other grain was *filiceous earth*. The true quantity of the *fulphur*, therefore, amounted to 49 grains.

g) While the muriatic folution was cooling, it depofited a quantity of acicular cryftals. Thefe being feparated, one half of the remaining fluid was diftilled over in a fmall retort, and, from the folution thus concentrated, more cryftals, fimilar to the firft, were depofited. This treatment was continued until no more cryftals would form. When thefe cryftals, collected together, were mingled with twice their weight of black flux, and reduced in an affay-crucible, thinly lined with charcoal-duft, they afforded $160\frac{7}{8}$ grains of lead. This lead, fubjected to cupellation, emitted, at the firft application of heat, a few antimonial vapours; it then fined quietly, and left a *button of filver*, weighing $\frac{1}{8}$ of a grain. —This determines the proportion of *lead* at $160\frac{3}{4}$ grains; from which, however, a trifling quaintity fhould be deducted for the portion of *antimony* before mentioned; though it could not be well determined, befides that it could not weigh much above half a grain.

h) The fluid feparated from the muriat of lead, concentrated, and covered with a large quantity of water, depofited its metallic part, which, in the form of a fubtle, white powder, was only oxyded antimony, and being kneaded into a mafs with foap, was reduced in a luted affaying-crucible, by means of black flux, into $28\frac{1}{2}$ grains of pure *reguline antimony*. Some more fmall globules were found adhering to the lid of the veffel, of which I collected three grains; but ftill a fmall portion appeared to have efcaped through the joinings, and for this reafon, the true amount of antimony, which I obtained, may be reckoned at fomewhat more than the $31\frac{1}{2}$ grains.

 Hence

Hence the product of the 400 grains of the *light white silver-ore*, here analysed, consisted of:

Silver	c)	$81\frac{1}{2}$	$81\frac{5}{8}$ grs.
	g)	$\frac{1}{8}$	
Lead	d)	32	$192\frac{1}{4}$
	g)	$160\frac{1}{4}$	
Reguline antimony	h)	$31\frac{1}{2}$ grs.	
Iron	e)	9	
Sulphur	f)	49	
Alumine	e)	28	
Silex	f)	1	
		$392\frac{3}{8}$ grs.	

Which, in *one hundred* parts, makes:

Silver	20,40
Lead	48,06
Antimony	7,88
Iron	2,25
Sulphur	12,25
Alumine	7
Silex	0,25
	98,09

With respect to the argillaceous earth, found in the mixture of this ore, it may be questioned: Whether it be merely adventitious, or one of its constituent parts. If, at the same time, there had been discovered in it a proportionate quantity of the siliceous earth, they might both together be taken for a clayey matter of the mine, accidentally intermingled with that ore. But, considering the wide difference in the proportion of one part of silex to 28 of of argil, the latter appears to be one of its actual conſtituent parts, though not eſſential.

B.

Dark White Silver-ore.

a) As of late this variety of the white ſilver-ore has but ſeldom occurred in pure maſſes in the Saxon mines, I ſacrificed to analyſis a ſpecimen, which was procured in the year 1720, from the pit *Junger Himmelsfürſt*, at Freyberg, and conſiſted of a ſolid, very pure, white ſilver-ore, of an inch in thickneſs, that croſſed lamellar galena.

b) From *two hundred* grains of this pure ore, finely pulverized, I obtained a colourleſs ſolution by the affuſion of three ounces of nitric acid, and an equal quantity of water. It was at firſt gently digeſted with the ore, then diluted with water, and, after a ſecond digeſtion, ſtrained through the filter. The ſilver, thus diſſolved, was precipitated by means of common ſalt. The muriat of ſilver, thus produced, and dried in a warm temperature, amounted to $24\frac{3}{4}$ grains, which are equal to $18\frac{1}{2}$ grains of reguline ſilver.

c) Afterwards, on combining this ſolution of the ore with Glauber's ſalt, ſulphat of lead was generated; the quantity of which, when edulcorated and dried, amounted to 93 grains, or to 66 grains of metallic *lead*.

d) Liquid cauſtic ammoniac ſeparated from the remaining fluid a browniſh, looſe precipitate, which, upon ignition, weighed $6\frac{1}{2}$ grains, and, upon farther treatment, yielded $4\frac{1}{2}$

 grains

grains of oxyded iron, (equal to $3\frac{1}{2}$ grains of the regulino *metal*), and, befides, two grains of *aluminous earth*.

e) By adding nitric acid, a greyifh-white refidue of $132\frac{1}{2}$ grains was left; which, when extracted with the neceffary quantity of muriatic acid, left another refidue of 52 grains; of which, after its fulphureous parts had undergone a flow combuftion, only eight grains remained. Hence the proportion of *fulphur* confifted of 44 grains.

f) Thefe eight grains, digefted with muriatic acid, were diffolved by it, except $1\frac{1}{2}$ *grain* of *filiceous earth*.

g) All the preceding muriatic folutions were then fo far reduced by flow evaporation, as to form numerous cryftals. After cooling, I caufed the fluid which ftill remained to drain off from the cryftals; any foreign matter, that might have adhered to them, I wafhed off with a mixture of one part of muriatic acid, and two of alkohol; and, after deficcation, I found their weight to be $22\frac{1}{2}$ grains. They confifted of *fulphat* of *lead*, the metallic portion of which amounted to 16 grains.

h) The liquor, feparated from them, ftill contained the *antimonial* ingredient of this ore. By dilution with a fufficient quantity of water, a white oxyd of antimony was thrown down; whofe weight, upon drying at an increafed temperature, proved to be 56 grains, and for which 43 grains of reguline *antimony* muft be allowed.

It appears, then, that the dark, dull white filver-ore contains in *one hundred* parts:

Silver

Silver	*b*)	. . .	9,25
Lead	*c*) and *g*)	. . .	41
Reguline antimony . .	*h*)	. . .	21,50
Iron	*d*)	. . .	1,75
Sulphur	*e*)	. . .	22
Alumine	*d*)	. . .	1
Silex	*f*)	. . .	0,75
			97,25

Confequently, this analyfis of the above two varieties of the *white filver-ore* renders it evident, that it is neither *arfenic*, nor *copper*, but *lead* and *antimony*, which conftitute the characteriftic conftituent parts of this fpecies of metallic ore; and that the two laft, for the future, fhould be mentioned as fuch.

Though thefe ores are ufually accompanied by galena, the lead found in them fhould not, on this account, be confidered as accidental; fince it there exifts in intimate mixture. It is a particular and remarkable phenomenon, and an anomaly in our knowledge of the elective attractions of bodies, that, even in the repeated digeftions of the ore, neither the ftrong nor dilute nitric acid is capable to diffolve the whole of the admixed lead, and to deftroy its combination with the antimonial ingredient.

Modern mineralogifts have been induced, by the external and fenfible differences of colour, luftre, and fracture, which exift between the above two varieties of the white filver-ore, to regard them as two diftinct fpecies, and have introduced the fecond into the fyftematical arrangement as the only genuine white filver-ore; feparating from it the firft, which is of a brighter hue, and has been ranked with the brittle vitreous filver-ore, treated of at *Sect. IV.*

 But

But as the reaſon for this claſſification was merely founded on ſome varieties of the external characteriſtic properties, it could only ſubſiſt as long as there was wanting a chemical inveſtigatirn of theſe two varieties of the white ſilver-ore, as well as the chemical knowledge of their component principles, which depends on that enquiry.

This deficiency being removed by the preſent analytical proceſſes, and it being demonſtrated that the conſtituent parts of both are of the ſame nature, differing only in their proportions, they ſhould be no longer deſcribed in ſyſtems of mineralogy as particular ſpecies, but only as varieties of *one* and the ſame ſpecies. For this reaſon, the *ſolid*, *brittle*, *vitreous ſilver-ore*, as it is called, ſhould be again removed from the claſs of the laſt-mentioned ſpecies, and ſhould reſume the place which it formerly occupied among the *white ſilver-ores*.

SIXTH SECTION.

Grey Silver-ore (Graugültigerz).

That ore of ſilver which I here introduce with this new name, is erroneouſly called *white* ſilver-ore *(Weiſſgülden)*, at *Kremnitz* in *Hungary*, where it is dug up both in maſſes and in white quarz. This laſt appellation is the more improper, as, with regard to luſtre and the colour of its fracture, it approaches nearer to the grey copper-ore *(Fahlerz)*, than the white ſilver-ore *(Weiſgültigerz)*.

a) *Three hundred* grains of the fragments ſelected from the pounded ore, though not perfectly ſeparable from the quarzoſe gangue,

gangue, with which they are firmly concreted, were levigated to a ſubtle powder, and digeſted with four times their weight of nitric acid. The digeſtion was renewed with the reſidue, in an equal quantity of the ſame acid; and the portion which ſtill remained undiſſolved then aſſumed a greyiſh-yellow colour, and weighed 188 grains.

b) By the addition of muriat of ſoda to the bright-green nitric ſolution, its ſilver was thrown down; and this precipitate, collected and reduced by means of ſoda, yielded 31½ grains of metallic *ſilver*.

c) The ſilver being thus ſeparated, I tried the ſolution for lead; but neither the neutral ſulphats, nor free ſulphuric acid, could diſcover the leaſt ſign of it.

d) After this I added cauſtic volatile alkali, ſo as to ſuperſaturate the acid; upon which a brown-reddiſh precipitate, of a looſe coheſion, appeared, that by ignition became of a black-brown, and weighed 9¼ grains. It diſſolved in nitric acid, leaving behind it half a grain of *ſiliceous earth*. Pruſſiat of pot-aſh produced from the filtered ſolution a deep-blue precipitate of iron; and after this was ſeparated, 1½ grain of *alumine* were obtained from it by means of ſoda. Therefore, ſubtracting the ſiliceous and argillaceous earths, the portion of *iron* attractible by the magnet amounted to 7¼ grains.

e) To the ſolution, which had before been over-ſaturated with pure ammoniac, and exhibited a blue ſapphirine colour, ſulphuric acid was now added to exceſs. A poliſhed piece of iron was then immerſed into the fluid, from which it precipitated 69 grains of copper.

f) The

f) The above greyiſh-yellow reſidue (*a*) was now to be examined. I digeſted it with ſix times its quantity of muriatic acid in a heat of ebullition. When filtered, the reſidue which was left on the paper being firſt waſhed with muriatic acid, then with a little alkohol, and laſtly dried, was found to weigh 105½ grains.

g) From the ſolution which was obtained by the laſt proceſs, and was of a ſtraw yellow, the greater part of the fluid was drawn off by a gentle diſtillation in a retort. The remaining concentrated ſolution then depoſited ſome cryſtalline grains, which were carefully collected, and proved, upon inquiry, to be muriated ſilver, that afforded a bead of ſilver, weighing ¼ of a grain. A large quantity of water being next poured into the ſolution, a copious precipitate ſubſided, weighing, after deſiccation, 97¼ grains. It proved, by every teſt, to be oxyd of antimony, for which, as I have found by comparative experiments, 75 grains of reguline *antimony* muſt be allowed.

h) The reſidue obtained at (*f*), weighing 105½ grains which compriſed the ſulphureous part of the ore, I expoſed to a low heat, by which treatment the ſulphur was conſumed, and 80¼ grains of ſiliceous earth remained. Hence the quantity of the *ſulphur* was equal to 25¼ grains.

i) The ſiliceous earth was next fuſed with four times its weight of black flux. The melted maſs entirely diſſolved in twice its quantity of water into liquor of flints; ſome minute particles of ſilver, weighing ¾ of a grain, excepted. According to this, the proportion of *ſilex* amounted to 79½ grains.

Whence the conſtituent parts here obtained are:

Sil-

Silver	*b*) . . . $31\frac{1}{2}$		
	g) . . . $\frac{1}{4}$	. .	$32\frac{1}{2}$ grains.
	i) . . . $\frac{3}{4}$		
Copper	*e*)	. .	69
Reguline Antimony	*g*)	. . .	75
Iron	*d*)	. .	$7\frac{1}{4}$
Sulphur	*h*)	. .	$25\frac{1}{4}$
Alumine	*d*)	. .	$1\frac{1}{2}$
Silex	*d*) . . . $\frac{1}{2}$		
	i) . . $79\frac{1}{2}$	. .	80
			$290\frac{1}{2}$ grains.

But as the filiceous earth does not belong to the real mixture of the ore, but only arifes from the admixed particles of quarz, it follows, that, when thefe are excluded from the computation, the true conftituent parts of the grey filver-ore here examined, are, in the *hundred*, as follows :—

Silver	14,97 parts
Copper	31,36
Reguline Antimony .	34,09
Iron	3,30
Sulphur	11,50
Alumine	0,30
	95,32

As, therefore, the foregoing analyfis plainly fhews that no lead is contained in this *filver-ore* from *Kremnitz*, it cannot be any longer claffed with the white filver-ores. For the fame reafon it would be equally improper to reckon it among the grey copper-ores : but, from the confiderable proportions of noble metal which it contains, it has a juft claim to the rank of a filver-ore, more fo than even the white

white and poorer ores of that metal. Therefore, from analogy with the generic appellation, I have given it the name of *grey* ſilver-ore.

When it is conſidered that all the ſilver procured from the ores in Lower Hungary contains a portion of gold, and that this portion uſually amounts to one drachm (4 *denarien*) in the mark of the refined ſilver, which, in *Kremnitz*, is coined into money, there remains no doubt that the ore here analyſed likewiſe contains gold, as, indeed, ſome traces of it appeared in the courſe of this inveſtigation. But it would have required a diſtinct proceſs, performed too with a greater quantity of the ore, to have aſcertained the proportion of gold contained in it; which, however, was beyond the limits of the preſent inquiry.

According to an information given to me as authentic, this ore is ſaid likewiſe to contain mercury. Therefore, though no indication of this metal occurred to me during thoſe experiments, I thought it worth while to inſtitute a particular inquiry on that point. For this purpoſe I mingled 200 grains of the ore with 100 of quick-lime; and having put this mixture into a ſmall retort, connected with a receiver, filled with water, I expoſed the veſſel to the fire, increaſing the intenſity of heat until it became red-hot: but no perceivable trace of mercury appeared.

SEVENTH SECTION.

Native Amalgam of Silver.

Beſides the ſulphurated ores of ſilver, various other metallic mixtures are found in the mineral kingdom, in which

which the ſilver, unaccompanied by ſulphur, enters as a conſtituent part. To theſe, among others, belongs the ſolution of ſilver in mercury, or the native *ſilver-amalgam*, which occurs chiefly in the quick-ſilver mines, and, in various forms, in the Duchy of *Deux-ponts*.

In order to aſcertain the proportion of theſe two metals to each other, I employed the amalgam, which is found in ſolitary, garnet-like cryſtals in the mine called *Vertrauen auf Gott*, at *Moſchellandsberg*. Some pure cryſtals of this amalgam, weighing together exactly $33\frac{1}{3}$ grains, were inſerted into a barometer tube, of a diameter ſomewhat larger than uſual, the lower end of which had been cloſed by fuſion. This end being placed in ſand, within a ſmall crucible, I applied heat to it, increaſing its intenſity gradually and ſlowly to the degree of ignition. After cooling, I cut off the lower end from the tube, and found that it contained the ſilver, which had undergone ignition, in its former cryſtalline form, and weighing 12 grains. On collecting the mercury that had been ſublimed in the tube, I obtained 21 grains. Therefore, ſince the deficiency of $\frac{1}{3}$ of a grain may be reckoned as a loſs of quickſilver, the following will be the proportion of the parts in one *hundred* of this *cryſtallized amalgam of ſilver*: namely,

Silver . . .	36
Mercury . . .	64
	100

EIGHTH

EIGHTH SECTION.

Arfenical Silver.

Another example of a metallic mixture, containing filver free from fulphur, is the native *arfenical filver*. Its proportion of filver varies from a few half ounces to feveral marks (of 8 ounces) in the centner, or one hundred pounds. Among the richer forts of this ore, I felected the fpecimen, the analyfis of which is here given, and which was dug up from the mine *Samfon*, at *Andreasberg*. Its gangue confifts of white, coarfely-lamellated calcareous fpar, in which the arfenical filver is contained, partly in lumps, partly diffeminated in coarfe grains, but without any other kind of extraneous ores.

a) At firft I feparated from the general mafs, coarfely pounded in the mill, thofe pieces of calcareous fpar which contained no portion of metal. Then I continued pouring diftilled vinegar on the picked ore, till the calcareous fpar that ftill adhered was entirely diffolved and feparated. Laftly, when the ore had again become dry, I reduced it into a fine powder.

b) Upon *two hundred* grains of the ore, thus purified and pulverized, I poured nitric acid of moderate ftrength, by which it was attacked with great vehemence. When fufficiently digefted, the folution was feparated, by digeftion, from the dirty yellow refidue, which, upon drying, weighed 71 grains.

c) On combining it with common falt, diffolved in water, muriat of filver precipitated from the folution. This horn-

horn-filver was then freed from moifture, and fufed in a fil-ver-crucible over a gentle fire; during which procefs it emitted fome arfénical vapours. Its weight was 28 grains, equal to 21 grains of *metallic filver*.

d) The filver being thus removed, I faturated the folution with vegetable alkali, procured from tartar. A light-red and very intumefcent precipitate fell down, which, on drying, was rendered of a deep-brown. Ignition made the brown colour difappear, and the precipitate now exhibited a light greenifh-grey powder, inclining to white, and which weighed 160 grains. Being convinced that it was arfeniated iron, I put it on a roafting teft, mingled with one fourth part of powdered charcoal; and applied a low red-heat. By this treatment the arfenic became revived, and efcaped in white vapours. The remaining iron was again repeatedly roafted, with the addition of charcoal-duft, till no arfenical fmell could be any longer obferved. The iron which at laft remained had a black colour, weighed 106 grains, and perfectly obeyed the magnet.

e) The 71 grains (*b*), that continued undiffolved in the nitric acid, were digefted with muriatic acid, and towards the end were once more combined with a few drops of the nitric acid. Nearly all the powder was diffolved, excepting a fmall refidue, coagulated like curds of cheefe; which proved to be muriated filver, and by reduction with foda furnifhed a button of *filver*, of 4½ grains.

f) By dilution with water, this muriatic folution was rendered turbid, without any precipitation. But by faturating it with falt of tartar, a yellowifh-green fediment appeared, which, when collected, dried, and ignited, was found to weigh 32 grains. Upon diffolving it again in a fmall quantity of muriatic acid, a white precipitate was pro-

duced

duced by the affufion of water; the quantity of which, when dried in a warm temperature, amounted to $10\frac{1}{2}$ grains. On farther trial, it proved to be unqueftionably an antimonial oxyd; ftill containing, however, a flight trace of arfeniated iron. I eftimate that oxyd at 8 grains of *reguline antimony*.

g) What remained of the muriatic folution afforded, by combination with the above vegetable alkali, a precipitate, which, when dried and roafted, like the preceding (*d*), with pulverized charcoal, yielded 18 grains of *oxyded iron*.

h) Defirous of affuring myfelf of the abfence of fulphur, I fubjected 200 grains of the powdered ore to fublimation, in a fmall retort. Nothing but pure reguline arfenic was raifed; which, as ufual, fixed in the neck of the retort, in the form of a cruft of a metallic luftre, compofed of an accumulation of fmall cryftals.

i) It is then evident, that this ore confifts of filver, iron, arfenic, and antimony. However, when we reflect that the arfenic, during the treatment of the ore with acids, combines with oxygen; and farther, that part of it is driven off in the oxyded ftate, on the procefs of roafting, and that part of it is taken up by the water employed for wafhing the precipitates, the acid of arfenic being of eafy folution in water, it is obvious that there exifts a degree of uncertainty in the attempt to afcertain, with accuracy, the proportions in which thofe ingredients are united. Neverthelefs, the proportion of arfenic may be computed, with propriety, from the lofs of weight requifite to make up the whole weight of the three remaining conftituent parts, in the following manner:

Sil-

Silver c) . . .	21	}		$25\frac{1}{2}$
e)	$4\frac{1}{2}$			
Iron,				
Oxyd of iron attractible by the magnet *d*)	106	} 124		
g)	18			
which gives of metallic iron				$88\frac{1}{2}$
Reguline antimony				8
				122
The arfenic, therefore, would make (200—122=78)				78
				200

However, fince, in the proceffes of chemical analyfis of this as well as of other fpecies, fome lofs always unavoidably occurs in the fum of the products, amounting from 2 or 3 to 5 or 6 in the hundred, regard muft here be had to this circumftance. Therefore, if the mean number of the lofs, which is 4, be fubtracted, 70 will be left for the arfenic.

Hence, according to thefe premifes, the *arfenical filver* examined in this analyfis contains, in an hundred parts,

Silver	12,75
Iron	44,25
Arfenic, ...	35
Reguline antimony .	4
	96

Befides the above eight fpecies of filver-ores, the analyfis of which have made the fubject of the prefent effay,

 other

other kinds of argentiferous ores and metallic mixtures occur. But the greateſt part of theſe cannot be fairly conſidered as ſpecies of the genus of ſilver-ores; becauſe the proportion of the noble metal which they contain is too inconſiderable, when compared with their other conſtituent parts.

In general, I ſhould not wiſh to recommend the method hitherto uſed in the ſyſtematic arrangement, of denominating ores by the conſtituent part, which is of the greateſt mercantile value; though, on the other hand, I do not venture to aſſert, that, at the preſent period, the *predominant conſtituent part* alone ſhould ſerve as the principle, upon which to eſtabliſh the claſſification of foſſil bodies. If it were ſo, we ſhould only retain under the genus of ſilver (beſides the *native ſilver*) the *corneous*, the *red*, the *vitreous*, and *brittle vitreous ſilver-ores*; together with the black ſilver-ore (*ſilver-mulm*), which I had no opportunity to examine. And, on the contrary, the *white ſilver-ore* would then neceſſarily come under the genus of lead; the *grey* under that of antimony; the *ſilveramalgam* under that of mercury; and the *arſenical ſilver* under the genus of iron.

It is only by increaſing our knowledge of the chemical compoſition of individual ſpecies of foſſils that we ſhall be able to erect, on the relics of the preſent ſyſtem of mineralogy, another, which ſhall poſſeſs a more ſolid foundation, and ſhall be more conformable to nature.

X.

EXAMINATION

OF THE

ORIENTAL LAPIS LAZULI.

THOUGH the refearches of Marggraf have refuted the opinion, formerly received, that the blue colour of the *Lapis Lazuli* originated from an admixture of copper; and though it has been demonftrated that the colour of this foffil is owing only to iron, yet its other conftituent parts have not yet been determined with due accuracy. For this reafon, I thought that a farther examination of it would not be fuperfluous.

*Marggraf** mentions, indeed, and very juftly, *lime*, *gypfum*, and *filex*, as the other conftituent parts of the lapis lazuli, befides a quantity of *iron*: but this account is ftill incomplete, as he takes no notice of their refpective proportions, and has, befides, entirely overlooked the *aluminous earth* which it contains.

Rinmann† affures us, that this ftone, befides iron, calcareous earth, and quarz, contains alfo *fluoric acid.* Never-

* *Marggraf,* Chim. Schriften I. Theil. Berlin, 1768, page 121.
† *Rinnmann,* Gefchichte des Eifens, 2 B. Berlin, 1785, page 136.

the-

thelefs, I could not afcertain the prefence of the latter. *Rinmann*'s fuppofition was probably occafioned only by the phofphorefcent light which iffues from the lapis lazuli, when heated.

Cronftedt, and others likewife, fuppofe the exiftence of filver in this mineral, amounting to two *ounces* in 100 *pounds*; but neither could I difcover any clear indication of this ingredient. I chofe, for the following inquiries into the nature of the lapis lazuli, a pure fpecimen of a deep-blue; and I firft endeavoured, as much as poffible, to free the fragments from the white fpots, and the particles of fulphur-pyrites with which this ftone is always mixed.

a) *Hundred* parts of lapis lazuli loft two parts in weight, by being ignited for half an hour in a porcelain crucible. Its colour fuftained no change.

From this confiderable permanence of the beautiful blue colour, I was induced to try whether it would admit of being employed as an enamel colour, efpecially as *Bergmann* had already conjectured that the Chinefe and Japanefe probably ufed the lapis lazuli to impart the blue colour to their porcelain. With this view, I caufed the powder, finely ground with a fuitable flux, to be put upon porcelain, and had it baked in an enamelling furnace. My expectation, however, proved abortive; for the colour was altered, and had paffed to an afh-grey.

b) But in a ftronger and more continued fire, the lapis lazuli becomes completely vitrified, and lofes 12 *per cent*; as has been already mentioned in No. 51 of my Effay *on the Habitudes of various Species of Earths and Stones in Fire*. The two parts that efcaped from the hundred, during ignition for half an hour, cannot well be taken for any

thing

thing elſe than water. But the other 10 parts, which the ſtone loſes in a more intenſe heat, probably conſiſt of carbonic acid; ſince the efferveſcence of the lapis lazuli, when covered with any acid, weak as it is, ſhews that a part of its calcareous ingredient is diſſolved in that menſtruum.

c) *Two hundred* grains of finely levigated lapis lazuli were digeſted in a retort with muriatic acid, weakened by an equal quantity of water. The blue colour of the pulverized ſtone gradually turned to aſh-grey. When the mixture had reached a boiling heat, the powder was acted on with greater vehemence by the acid, and, after ſome ebullition, it formed a cheeſy-coagulum. I then diluted it with more water, added one part of nitric acid, and kept it boiling till the inſoluble reſidue had aſſumed a white colour. The ſolution, afterwards ſeparated by filtration, was of a pale yellow.

d) The reſidue had a ſandy appearance, and weighed 138 grains after drying. It was ſubjected to ignition with three parts of cauſtic, or pure pot-aſh. The greeniſh maſs which reſulted thence, when ſoftened with water, afforded a colourleſs ſolution, from which muriatic acid, added to exceſs, precipitated *ſiliceous earth*, weighing 57 grains when ignited.

e) This ſame ſolution (*d*), mixed with the above (*c*), and decompoſed in a boiling heat by carbonat of pot-aſh, yielded a yellowiſh-white precipitate, which, upon deſiccation, weighed 221 grains, and entirely diſſolved in muriatic acid.

f) Cauſtic ammoniac threw down from this ſolution a gelatinous precipitate, which, when digeſted with cauſtic alkaline lye, was not totally diſſolved, but left a yellowiſh-white reſidue, of 113 grains, in its dry ſtate.

g) By combining the liquid that remained from the precipitation by ammoniac, with carbonat of pot-aſh, in a boiling heat, 59 grains of carbonat of lime, or mild *calcareous earth*, were obtained.

h) Upon the 113 grains, not taken up by the cauſtic lye, I poured dilute ſulphuric acid. The mixture coagulated in heat to a gelatinous conſiſtence. When covered, and digeſted with a large proportion of water, there ſeparated from it *ſiliceous earth*, the quantity of which, after being heated to redneſs, was 29 grains.

i) After the ſilex had been ſeparated, the ſolution was mixed with ammoniac, and the precipitate thus formed was conveyed, while yet moiſt, into boiling cauſtic lye. A brown flocculent precipitate remained, which weighed, when dry, 13 grains. After they had been diſſolved in muriatic acid, cauſtic ammoniac precipitated *oxyd of iron*, weighing 6 grains. After deſiccation, by adding carbonated ammoniac to the remaining fluid, 5 grains more of *calcareous earth* were thrown down.

k) The alkaline ſolution (*f*) and (*i*) were then ſaturated with muriatic acid. By this all that the alkali had taken up was ſeparated; and this, when re-diſſolved, by an additional portion of the ſame acid, I again precipitated by carbonated pot-aſh. On re-diſſolving this laſt precipitate, in dilute ſulphuric acid, there appeared another portion of ſilex, which, after ignition, was found to weigh 6 grains. The ſulphuric acid, when poured off, and combined with a due proportion of pot-aſh, afforded cryſtals of alum, which were re-diſſolved, and their *aluminous earth* precipitated by by means of mild, or carbonated alkali. After the alumine had been properly purified, deficcated, and expofed to red heat, its weight amouted to 29 grains.

l) I had before convinced myfelf, that in the lapis lazuli the whole of its calcareous earth is not combined with carbonic acid, but a portion of it with the fulphuric acid. For this purpofe I boiled a portion of pulverized lapis lazuli with a large quantity of water; which, when filtered, had an opaline appearance. Muriated barytes being then added as a teft, fome fulphat of barytes was formed. In order to difcover the proportion of the fulphat of lime, or gypfum, contained in this ftone, I took the fluid remaining from the precipitate mentioned at (*c*), together with the edulcorating water, and, after fuper-faturation with muriatic acid, I examined it with a folution of muriat of barytes. The refult was a precipitation of fulphat of barytes which, collected and highly dried, amounted to $19\frac{1}{2}$ grains.

It was reafonable to conjecture, that not only the gypfum contained in the lapis lazuli, but alfo an accidental admixture of fulphat of pot-afh, in the cauftic and mild alkali employed in the proceffes (*d*) and (*e*), might have contributed to the formation of the fulphated barytes. Therefore, to afcertain this point, I diffolved a fimilar quantity of each, adding then muriatic acid, fo that the acid predominated; and, laftly, I combined the whole with muriat of barytes, In the refult, there appeared $1\frac{1}{2}$ grain of fulphat of barytes. collected with care. An equal quantity, therefore, is to be deducted from the above $19\frac{1}{2}$ grains. On this account, the above-mentioned 18 grains of fulphated barytes were the proper fcale, or meafure, by which to determine the proportion of the gypfum fought for in the prefent inftance; and, calculating upon this ground, it followed, that the above 200 grains of decompofed lapis lazuli contained

8,18 grains of free ſulphuric acid of 1,850 *ſpec. grav.*; or, if taken in combination with the lime which enters into that ſtone, 13 grains of gypſum. This computation is founded on the reſults of my experiments: *firſt*, that, diſregarding minute fractions, 100 parts of ſulphuric acid of the above-mentioned ſpecific gravity, when ſaturated with barytes, yield 220 of ſulphat of barytes; and, *ſecondly*, that the ſame quantity of ſulphurie acid, when ſaturated with calcareous earth, forms 160 parts of gypſum: obſerving, however, that 100 parts of crude calcareous earth, or carbonat of lime, are required to ſaturate the acid; but only 55 parts of pure, or burnt lime.

Conſequently, theſe 200 grains of *Lapis Lazuli* give the following *remote conſtituent parts:*

Lime . . .	*d*) . . .	57	
	b) . . .	29	. 92 grains.
	k) . . .	6	
Silex . . .	*g*) . . .	59	
	i) . . .	5	
		64, ignited	35
Alumine . .	*k*)	. . . .	29
Oxyd of iron	*i*)	. . . .	6
Sulphuric acid	*l*)	. . . .	8
Carbonic acid	*b*)	. . . .	20
Water . .	*a*)	. . . .	4
			194
		Loſs .	6
			200 grains.

But

But fince the calcareous earth, in the prefent fubject of inquiry, is combined partly with fulphuric acid, partly with the carbonic, the following muft be reckoned as the *proximate conftituent parts* of the lapis lazuli:

Silex	46
Alumine	14,50
Carbonat of lime	28
Sulphat of lime (gypfum) . .	6,50
Oxyd of iron	3
Water	2
	100

The reafon of this exact agreement of the fum of the conftituent parts with the weight of the whole, is, that I have fuppofed the carbonat of lime to be *completely* faturated with the carbonic acid; which, however, does not feem entirely to be the cafe.

XI.

XI.

EXAMINATION

OF

*A SMALT-BLUE FOSSIL, from Vorau**

AMONG the mineralogical notices, given in a letter from Vienna, inferted in the third volume of the *Obfervations and Difcoveries in Natural Hiftory*, page 352, mention is made of a newly-difcovered blue foffil from *Vorau*, in Auftria. It was, at firft, taken for *native fmalt*, then for native *Pruffian-blue*, and, laftly, for *mountain-blue*, or azure copper-ore.

This foffil is of a deep fmalt-blue, accompanied with a grey-white quarz, of an imperfectly conchoidal fracture, *(Fettquarz)*, with which it is firmly concreted, and croffed by a band of *fhiftofe mica*, from ¼ to ½ inch thick, confifting of grey-white granular quarz, and a little mica of a filvery-white. It partly forms the feam, or joint *(falband)* of this fmall vein; partly it is finely diffeminated through the quarz, and fometimes it approaches to the fize of a hazel-

* *Beobachtungen und Entdeckungen aus der Naturkunde* 4 Band. Berlin, 1792. Seite 90.

nut,

nut. When in the latter ſtate, a cryſtalline form of quadrilateral flattened columns, or tables, is obſerved; though, on account of the quarz, which is perfectly concreted with it, the exterior, unbroken ſurface only, in ſome parts, exhibits the cryſtalline form. On theſe facets the foſſil is even, and of a moderate luſtre; but in the fracture, which is compact and rough, it is only glittering. It is opake; its ſtreak of a ſomewhat lighter blue; its hardneſs nearly that of quarz.

No ſign of any volcanic product preſenting itſelf in this foſſil, it was obvious, from the very mode of its appearance, that it could not, by any means, be a native ſmalt: for, muſt not the agency of fire have been preſent, to form a ſtony matter, naturally coloured blue by means of *cobalt?*

The following ſhort narrative of my reſearches concerning this foſſil, will alſo prove, that it is as far from being a *mountain blue*, or containing oxyded *copper*; notwithſtanding that this is given as the reſult of the chemical experiments made with it at Vienna.

Finding that all the acids which I poured upon this mineral, previouſly reduced into fine powder, and freed as much as poſſible from the aſſociated quarz, would not attack it with the requiſite force, I ſubjected it to a low red-heat, combined with twice its weight of pot-aſh, procured from tartar. After refrigeration, I obſerved that the blue colour had entirely diſappeared, and the maſs had aſſumed a yellowiſh-white. When this had been triturated, ſoftened in water, then ſaturated to exceſs with nitric acid, digeſted and filtered, there remained undiſſolved *ſiliceous earth.* The ſolution had no colour. In one part of it I immerſed poliſhed iron; but neither copper, nor any other metallic

I ſub-

ſubſtance would precipitate. To the remaining portion pruſſiat of pot-aſh was added, and thus a deep-blue precipitate was produced, which, after ignition, was attracted by the magnet. From the ſolution, ſeparated from this laſt by filtering, liquid cauſtic ammoniac threw down ſome *aluminous earth* in a ſlimy ſtate. But the remaining fluid ſuffered no change, on the addition of carbonat of pot-aſh.

Silex, *alumine*, and *oxyded iron*, are then the conſtituent parts here diſcovered. But their reſpective proportions remain to be aſcertained by new experiments, to be performed with a greater quantity of this foſſil.

As, therefore, not the ſlighteſt trace of copper can be found in this foſſil, it is obvious that it cannot in any reſpect be conſidered as a mountain-blue.

Nor can I take it for a native Pruſſian blue, which it was conſidered to be, in conſequence of an inquiry made into its nature at Chemnitz. Its portion of iron affords no argument to the contrary; and the grounds of my opinion reſt upon the following obſervations.

1. *a*) The native Pruſſian blue is found only in mooriſh grounds or fens, and in thin ſtrata. It occurs immediately under the vegetable mould, and appears in the form of a looſe white earth, that becomes blue only when expoſed to air.

b) This blue foſſil, on the contrary, is concreted with a hard vein of quarz, which is incloſed in a ſtony matter of equal hardneſs. Beſides, its blue colour ſhews itſelf directly on every recent fracture; which indicates that the foſſil was previouſly poſſeſſed of it.

2. *a*)

2. *a*) Native Pruſſian blue is immediately deprived of its colour by fire; at firſt it becomes brown, then of a brick-red, and laſtly it melts into globules of a metallic luſtre.

b) The foſſil from Vorau falls inſtantly in pieces, when urged by the fire. Its coheſion is thereby looſened, and it aſſumes the form of a light-grey flocculent earth; but without ſhewing the leaſt diſpoſition to fuſe.

3. *a*) With borat of ſoda, and with the phoſphats, the native Pruſſian blue runs into a black untranſparent ſcoria.

b) But the foſſil from Vorau yields, when fuſed with borax, a clear, faint, topaz-yellow glaſs; and with a neutral phoſphat*; a clear, colourleſs glaſs.

4. *a*) The native Pruſſian blue directly liquefies in acids, when poured upon it.

b) On the contrary, the foſſil from Vorau is with difficulty acted upon by acids.

5. *a*) Cauſtic alkaline lye inſtantaneouſly changes the colour of the native Pruſſian blue into a brown.

b) But the colour of the above foſſil is not at all altered by it.

---

* The author conſtantly uſes the expreſſion *Phoſphorſalz*, whereby *concrete phoſphoric acid* might be underſtood: but moſt probably he means a neutral phoſphat, and eſpecially the *phoſphat of ſoda*, which, on account of its property of promoting fuſion in an eminent degree, is chiefly employed by mineralogiſts and chemiſts in examining ſubſtances with the blow-pipe.—Hence, the tranſlator ſubſtitutes, in all ſimilar caſes, the term *neutràl*, or *alkaline phoſphat*. Tranſ.

In

In the native Pruſſian blue, the oxyd of iron is combined with phoſphoric acid; as I have proved in another place*. But it is ſtill unknown, by what ſubſtance the oxyd of iron, contained in the foſſil from Vorau, is modified ſo as to acquire the blue colour.

Another inſtance of a ſimilar blue colour imparted by iron, is afforded by the *Oriental lapis lazuli.* It differs, however, from the preceding, in this, that its blue colour is conſiderably more permanent in the fire; for, ſo long as the ſtone is but moderately ignited, its colour continues unaltered, and is changed only when the ſtone is urged by a ſtronger heat, and is brought into the ſtate of fuſion. The lapis lazuli is alſo diſtinguiſhed from the foſſil from Vorau, beſides its other conſtituent parts, by a proportion of calcareous earth, which is the cauſe of its melting in fire.

If the above foſſil likewiſe contained lime, I ſhould not heſitate to range it as a variety of the lapis lazuli; as has been already done by Mr. *Stütz* †, with the name of *ſpurious lapis lazuli.* Perhaps may the denomination *lazulite* be not quite improper.

Note. I have once mentioned that foſſil, as a particular ſpecies of ferruginous earth, or oxyded iron, with the name of *iron-blue from Vorau*; but its proportion of iron ſeems to be too ſmall to entitle it to that place.

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* Chemiſche Annalen. 1784. 5tes Stuck. Seite 396.

† *Neue Einrichtung der K. K. Naturalienſammlung zu Wienn.* Wienn, 1793. Seite 49.

XII.

XII.

CHEMICAL EXAMINATION

OF THE

CIRCON, OR JARGON OF CEYLON.

*FIRST SECTION**.

AMONG the rough or uncut precious ftones coming from Ceylon, there occurs a particular genus, hitherto little noticed; which is diftinguifhed from other gems by the following characters.

Its colour confifts of various fhades of pale yellow-green, and reddifh, altogether inclining to a dim fmoke-grey. Externally, a greafy glofs is obferved, and it feels fmooth. The fize of the individual ftones is inconfiderable; commonly 20 or 30 of them weigh only one drachm. The primitive figure of their cryftals is a rectangular four-fided column (*parallelopipedon*), with tetrahedral terminations, the furfaces of which reft on thofe of the column. However, this form of cryftallization is diftinctly perceptible in

* *Auszug aus den Beob. u. Entdeck. aus der Naturkunde.* 3 B. 2 St. Berlin, 1789.

very

very few ſpecimens only; as for the greateſt part they are merely looſe, minute, rounded grains (*abgerundete geſchiebe* *.)

But this kind of gems is eminently diſtinguiſhed by its ſpecific gravity, which I have found to be 4,615 †.

Romé de l'Iſle was the firſt, to my knowledge, who mentions theſe gems as a particular ſpecies of ſtones; giving them the name, *Jargon of Ceylon*, and ſtating their weight, according to *Briſſon*'s experiments, at 4,416. Other mineralogiſts and writers, who notice this ſtone, claſs it—ſome with the ſapphire, others with the topaz, others with the ruby, others with the diamond, and ſome with the hyacinth. But *Werner* has aſſigned to it a peculiar place in the mineralogic ſyſtem, immediately under the diamond, and the chryſoberyl, and called it *Zircon* (*Silex cirnonius.*)

The jargons do not loſe much of their weight by ignition; for, upon igniting 300 grains for the ſpace of one hour and a half, and with the greateſt intenſity of heat, I found the loſs to be only one fourth of a grain. This ignition I repeated three times, and quenched them after each proceſs in water. The ſtones became by this rifty: the brighter ones loſt their ſmoke-grey appearance, and were rendered ſimilar to cloudy white-grey quarz; but ſome of the darker ſpecimens, as well as ſome parts of the brighter, turned reddiſh. Their natural hardneſs, however, did not ſeem to have been impaired.

* A more circumſtantial deſcription has been given by *Emmerling*, in his *Lehrbuch der Mineralogie, I. Th. Gieſſen*, 1793; and by *Widenmann*, in his *Handbuch der Mineralogie, Leipzig*, 1794.

† Yet I have afterwards found a difference in the ſpecific gravity of the various ſpecies; however, the leaſt weight that I obſerved was as high as 4,530.

A.

A.

a) By way of a preparatory analyfis, 200 grains of jargon were levigated in a flint-mortar to a very fubtle powder of a white colour, inclining to a pale flefh-red, which I mingled with equal parts of carbonated pot-afh, expofing it to a red-heat for one hour in a filver-crucible. It then formed a conglutinated mafs, which, upon trituration, I faturated to excefs, and digefted with muriatic acid. But this did not at all appear to attack it, as I obtained again the jargonic powder without the leaft alteration, and with the lofs of only half a grain.

b) For this reafon I afterwards blended the fame powder with fix times its quantity of the above alkali, prepared from tartar, and ignited it ftrongly during five hours. The mafs was rendered compact, and brought to the point of fufion: yet, when foftened with water, and digefted with muriatic acid added to excefs, the powder of the ftone was likewife found but little altered; and, after wafhing, drying, and ignition, I recovered it with no more lofs than two grains.

c) Upon this, I once more added 1200 grains of the above alkali, and kept the mafs in an ignited ftate, until it actually fufed; which, after being again fuper-faturated with muriatic acid, left behind it 197 grains of undecompofed jargon.

d) I next put this powder into a retort, and poured upon it five times its quantity of ftrong fulphuric acid, adding to it one ounce of water; and when the liquor had been diftilled off to dryneſs, I ſoftened the reſidue with water. But even by this proceſs the ſtone underwent no obſervable change. The reſidue, when lixiviated and dried, reſembled, as before, a fine ſandy powder, and weighed 196 grains. From the acid fluid, ſaturated with alkali, one grain of a white earth fell down.

The obſtinacy with which the jargon reſiſted every attempt to decompoſe it in the above manner, abated my ardour in purſuing farther this experiment. But, having in the mean time become acquainted with the powerful efficacy of cauſtic fixed alkalis in looſening the coheſion of particles in the various ſpecies of gems, I reſolved to employ them alſo for the jargon, and proceeded to the following new experiment.

B.

a) *Two hundred grains* of finely pulverized jargon were ignited for two hours in a ſilver-crucible, with four times their weight of cauſtic ſoda, and with ſuch an intenſity of heat, that the maſs continued in a ſtate of pulpy or thick fuſion. Upon refrigeration, the maſs proved to be very hard, and was gradually ſoftened by repeated affuſion of boiling water. The alkali ſeemed to have totally loſt its former cauſticity, the ſolution taſting like a weak carbonated lixivium. When it had been ſufficiently ſuper-ſaturated and digeſted with muriatic acid, I did not obſerve that any ſiliceous earth ſeparated; and the undiſſolved reſidue remained behind on the filtering paper in the form of a fine ſand-like powder, weighing, after deſiccation and ignition, 172 grains.

b) That

b) That refidue, when again treated in the fame manner with four times its weight of cauftic foda, afforded a very firm porous mafs, which, after being digefted with muriatic acid, in the manner related, left behind 148 grains of jargonic powder.

c) The fame procefs of adding to it four times its weight of cauftic foda, and fubfequent digeftion in muriatic acid, was repeated with this laft. After this treatment, there ftill remained 127 grains.

d) This, treated again for the fourth time in the fame manner, left 97 grains.

e) As my ftock of cauftic foda was now exhaufted, I prepared, inftead of it, a cauftic vegetable alkali, and added to the above undecompofed 97 grains of jargon fix times their weight of the above alkali, and kept the mafs, during feveral hours, in as intenfe an ignition, as the filver-crucible was able to bear without melting. However, its fufion went on but flowly, and was of a pulpy confiftence. Even boiling water would but difficultly liquefy the refrigerated mafs. But, when it had been faturated to excefs, and digefted with muriatic acid in the degree of boiling heat, a total folution of the jargon enfued.

f) I now poured together all the feveral preceding folutions. The whole of them exhibited a tranfparent fluid, but fomewhat opalefcent, and with a few light flocculent particles floating in it. I then faturated this liquor with carbonated, or mild pot-afh. The earth, which feparated by this management, gave to the mixture an appearance of milk. But when collected on the filter, and wafhed, it firft affumed the form of pafte made of ftarch, and afterwards dried up to lumps of a vitreous appearance, and of a

 whitifh

whitifh colour, verging upon the grey-green. The fluid filtered off from it, together with the wafhings, ftill depofited in a warm temperature a fmall portion of earth, which I added to the above precipitate.

g) This precipitate contained now all the conftituent parts of the jargon under examination, but deprived of their native cohefion. *One half* of it I digefted with one ounce of ftrong muriatic acid, in a heat of confiderable intenfity, and thus I obtained a turbid yellowifh folution, from which the undiffolved part flowly fubfided upon dilution with water. After the fuperincumbent liquor had been decanted, and the refiduum digefted with an equal quantity of boiling muriatic acid, I filtered the folution, and dried the undiffolved refidue, which ftill remained.

h) As, in this inftance, it was my principal defign to difcover, whether any calcareous earth was prefent, I precipitated the diffolved portion from the muriatic folution by means of cauftic ammoniac. It fell down as an extremely loofe fubftance, refembling a tranfparent flime. But neither carbonated ammoniac, nor carbonated pot-afh, would produce the leaft turbidnefs, when added to the feparated clear liquor. This fhews, that it contained no calcareous earth; which was alfo confirmed by feveral other tefts or re-agents employed for that purpofe.

i) Upon the *fecond half* of the above precipitate (*g*) I affufed a triple quantity of concentrated fulphuric acid, and abftracted it again by diftillation to drynefs. From the refidual mafs again foftened with water, and which looked like diffolved ftarch, I feparated the undiffolved part by filtration. But the filtered fulphuric folution, which was as limpid as water, when combined with various precipitating media, exhibited

exhibited precifely the fame phenomena with thofe fhewn by the foregoing folution, prepared with muriatic acid.

k) The whole of the earth, which remained from both folutions (*g*) and (*i*), weighed, after ignition, 86½ grains, and refembled a fine fandy powder. It was then mingled with four times its weight of carbonated pot-afh, and fubjected to ignition in a filver-crucible, until it entered into complete fufion. When the mafs was again foftened in water, it was found ftill hard, and of difficult folution. However, a very fubtle, heavy, and, apparently, tenacious earth, was depofited, which, collected and ignited, was found to weigh 28½ grains.

l) The clear and colourlefs alkaline lixivium I divided into two parts. *One half* of it I faturated with muriatic acid; by which treatment, a white, puffy, gelatinous earth feparated, no portion of which, however, would re-diffolve, by adding a fuperabundant quantity of the fame acid. The *other half* I firft diluted with plenty of water, and then gradually faturated it to excefs with muriatic acid. It continued clear and limpid; and by this I was convinced, that the above was *merely filiceous earth*; which, therefore, after deducting the 28½ grains of earth from the 86½ grains that were fufed with the pot-afh (*k*), amounted to 58 grains.

Note. This is the order of examination in which I proceed, with refpect to thofe earths, which, on analyfis, I have fome reafons to confider previoufly as belonging to the filiceous genus. By this method I moft furely avoid the error, perhaps not unfrequent, of immediately calling any earth, that on the firft attempt does not appear to diffolve in acids, merely filiceous. I likewife largely dilute with water the alkaline folution of the filiceous earth, and combine it to excefs with any acid—(in which cafe, however, no precipitate enfues, becaufe the fili-

 ceous

ceous earth thus circumſtanced is really ſoluble in water.)— And when upon this I evaporate it to dryneſs, with the aſſiſtance of heat, and ſoften again the dry ſalt with water, I find the ſiliceous earth, that was before held in ſolution, at the bottom of the veſſel, in the form of fine cryſtalline grains of ſand.

m) Thoſe $28\frac{1}{2}$ grains of earth, that were left behind on the treatment with alkali (*k*), I digeſted in a boiling heat, with an abundance of nitro-muriatic acid. A reſidue was left, weighing, upon ignition, 16 grains.

n) Theſe undiſſolved 16 grains, blended with ſix parts of cauſtic pot-aſh, were expoſed for ſome hours to a red heat. The colourleſs fluid, which was filtered off from the maſs when again liquefied with water, was not rendered turbid by the addition of ſulphuric acid. But when expoſed to a raiſed temperature, it formed a gelatinous maſs, which, after thorough deſiccation, and the ſeparation of the remaining ſalt by ſubſequent affuſion of water, left three grains of *ſiliceous earth* behind, in the form of ſand.

o) The remainder of the alkaline ſolution (*n*), was ſubjected to digeſtion with boiling aqua regia. The earth, contrary to cuſtom, ſwelled into a ſlimy matter, and the liquor acquired a greeniſh tinge. I filtered the ſolution previouſly diluted with water; mixed it with the preceding, which was likewiſe prepared with nitro-muriatic acid (*m*), and added pruſſiat of pot-aſh. The greyiſh-green precipitate thus produced, when heated to redneſs, weighed no more than half a grain. The portion of *oxyded iron*, thus detected in the jargon under examination, may therefore be eſtimated at one fourth of a grain.

Note. Some phenomena which appeared on examining this precipitate, obtained by means of pruſſiated pot-aſh, led me to ſuſpect fufpect a flight trace of the prefence of Nickel. However, fince, on every fubfequent examination of the jargon, no fuch indication any more occurred to me, I think the above appearance to have been merely accidental.

p) Carbonated vegetable alkali, being then added to the nitro-muriatic folution, precipitated of a white colour the remaining portion of earth, which it ftill contained. This earth, upon examination, was found to be of exactly the fame nature with that obtained from the firft folutions.

q) After the refidual undiffolved earth had been ignited, it weighed five grains. I confider this as the remainder of the rough jargon, which had eluded the attempts to decompofe; it the farther analyfis of which, from the minutenefs of its quantity, could not be undertaken.

C.

I now proceeded to the clofer examination of that part of the jargon, which was found to be foluble in acids.

a) According to the eftablifhed rule, the above fulphuric folution (B. *i*) fhould be fuppofed to contain either magnefian, or aluminous earth, or a mixture of both. However, the tafte gave not the leaft indication of either. On the contrary, it was hardly diftinguifhable from that of pure fulphuric acid, and but gently aftringent. In endeavouring to cryftallize it, I expelled a part by evaporation, combined the remainder with a proportionate quantity of pot-afh, and waited to fee whether aluminous cryftals would form. It is true, on farther evaporation, there feparated a cryftalline milk-white cruft; which, however, could not be taken for alum, but only fulphat of pot-afh, together with which a portion of the diffolved earth was depofited.

b) To carry the experiment farther, I diffolved the above-mentioned faline fediment in water; and in order to collect the whole quantity of the jargonic earth, I likewife diffolved that portion of it, which I had recovered from the muriatic folution (B. *g*), by means of ammoniac, as well as that which I had precipitated by vegetable alkali, from the nitro-muriatic folution (B. *p*). Both thefe laft I diffolved in dilute fulphuric acid, and added the folutions to the preceding.

c) I now once more directed my attention to the metallic ingredient in the jargon, to detect which, I could employ only the pruffiat of pot-afh. The firft portion which was added, produced in the colourlefs folution a dirty olive-green; but fubfequent additions, made by degrees, tinged the mixture of a deep-blue. After the blue precipitate had fubfided, it was collected and dried. It weighed three grains; of which the proportion of *iron* may be eftimated at a fourth part, that is, three fourths of a grain.

d) Upon this I faturated the whole of the fulphuric folution with cryftallized alkali, prepared from tartar; on which the earth, which feparated, imparted to the mixture an uniform, milky appearance. The earth thus depofited and wafhed, was fubjected, while yet moift, to the following experiments.

e) In diluted and gently warmed fulphuric acid it diffolved without any effervefcence, though it had been precipitated by carbonated alkali; which fhews, that this earth has no affinity with carbonic acid. The fulphuric acid took up a large quantity of it. I continued adding this earth to the

the acid, until the laſt portion gave the ſolution an opaline appearance; but this again diſappeared on the addition of a ſlight quantity of ſulphuric acid, ſo that the ſolution then became clear. After cooling, it congealed into a milk-white, pulpy ſubſtance. For this reaſon I again added a little ſulphuric acid, which, aſſiſted by a low heat, rendered the ſolution again limpid, ſo that it no longer coagulated in the cold. I then left it ſtanding at reſt in a low temperature, and after ſome days I found the greateſt part of it ſhot into ſmall, detached, and clear cryſtalline groups, in radii of a flattened quadrilateral columnar form, diverging from a common centre, and terminating in ſharp points. Their taſte was but little ſour, and left on the tongue a ſlight aſtringency. When thrown into water, they ſoon and eaſily diſſolved, at the ſame time that they loſt their limpidity and became turbid. The remainder of the ſolution ſtill afforded ſome cryſtals of a fine granular form; and the laſt portion thickened into an irregularly ſhaped maſs.

f) Diſtilled vinegar, concentrated to a fourth part of its bulk by freezing, diſſolved the earth with equal readineſs, receiving from it the peculiar taſte already mentioned. This acetic ſolution dried by heat into a pulverulent reſidue, deliqueſcing in the air.

g) I likewiſe boiled a portion of the jargonic earth with a lye of concentrated and cauſtic lixivium of pot-aſh, previouſly heated to boiling. The earth merely ſubſided in it in a looſe, flocculent form, without being diſſolved.

h) It is, then, manifeſt, from the foregoing experiments, that the *Jargonia*, or jargonic earth, is entirely different from the aluminous. That it is equally diſtinct from the magneſian earth, has already been proved by the total abſence of all magneſian taſte in the ſulphuric ſolution,

tion, as well as by its incapability of abſorbing carbonic acid. However, that no circumſtance might be left unexplored in this examination, I re-diſſolved in ſulphuric acid the portion that yet remained; and having ſaturated with carbonat of lime the ſolution heated to boiling, I filtered the fluid from it after cooling. But neither the taſte, nor any other re-agents, could diſcover the ſmalleſt ſign of magneſia.

i) When this earth was tried with the blow-pipe upon charcoal, the phoſphoric ſalt proved unable to diſſolve any part of it, although its action was long continued; for the earth remained in the clear globule of that ſalt without any alteration. Nor was it found in any way attacked, when fuſed with ſoda in the ſmall ſilver-ſpoon. However, it diſſolved by degrees, completely, and without bubbling, in glaſs of borax; and the bead, thus produced, continued perfectly clear and colourleſs.

From the reſult of theſe experiments concerning the properties and relations of the earth extracted from the jargon, I think myſelf juſtified in conſidering it as a *new, diſtinct, ſimple earth*, before unknown; and at preſent I give it the name of *Zircon-earth* (*Terra Circonia**), until it may, perhaps, be found in other ſpecies of ſtones, or poſſeſſed of other properties, that may give riſe to a more appropriate denomination.

In the mean time, I wiſh that the above facts may excite that attention which I think they deſerve: in order to induce one or more eminent chemical analyſts to repeat

* In this country JARGONIA. Tranſl.

theſe

thefe refearches, whereby the refults of my own may be either confirmed or corrected.

The proportion of the ingredients, conftituting the jargon, is yet left to be determined. But it is obvious, that, whenever new conftituent parts are difcovered, the nature of which is as yet entirely unknown, and which do not admit of being treated by the methods hitherto practifed, the determination of their proportions cannot be brought to that high degree of accuracy, which may be expected when the Chemift purfues a beaten path, and cannot want a chemical knowledge of the conftituent parts which he meets with in the fubject under his examination.

Hence, as from the *two hundred* grains of the jargon, fubjected to this analyfis, I obtained

Silex . . B. *l*) . . .	58 grs.	}	61 grs.
n) . . .	3		
Oxyd of iron . *o*) . . .	$\frac{1}{4}$	}	1
C. *c*) . . .	$\frac{3}{4}$		
Remainder of undecompofed *jargon* . B. *q*)			5
The quantity of this newly difcovered JARGONIA may be eftimated at			133
			200

And fuppofing that thefe remaining undecompofed five grains contain the fame proportion of conftituent parts, we may eftimate the ingredients in 100 parts of the jargon to be the following:

Silex

Silex	31,50
Oxyd of iron . . . . : . .	0,50
Jargonia	68
	100

SECOND SECTION.

SINCE repeated experience has ſhewn me the powerful influence which the cauſtic alkali, when employed in the liquid ſtate, exerts in promoting a more complete decompoſition of the harder ſpecies of ſtones, I could not avoid ſubjecting the jargon likewiſe to this method of treatment. But to avoid ſuperfluous prolixity in this eſſay, I ſhall confine the circumſtantial detail of theſe new experiments to that analytical proceſs only, which I have found the moſt convenient.

A.

a) *One hundred* grains of ſelected jargons, previouſly comminuted in the ſteel-mortar, were ground with water to a moſt ſubtle powder, in the triturating diſh made of flint. When dried and ignited, they were found to have acquired *one half grain* of additional weight.

b) The powder of theſe ſtones was next ſtrongly digeſted in a menſtruum, compounded of $1\frac{1}{2}$ ounce of muriatic acid, and half an ounce of the nitric. Cauſtic ammoniac, poured into the filtered bright-yellow fluid, produced a yellowiſh-white precipitation, weighing two grains after drying. The iron, which this precipitate contained, was re-diſſolved in moderately ſtrong muriatic acid, poured upon it in the cold;

cold; another part of it remained undiſſolved, and was ſeparated by filtration. The ferruginous contents of this laſt yellowiſh ſolution were again thrown down, in the form of brown, flocculent particles, by means of cauſtic ammoniac; after which they were collected and ignited upon charcoal. The precipitate appeared then in black, ſhining grains, which obeyed the magnet, and weighed $\frac{1}{2}$ grain.

That portion which would not again diſſolve, and which ſtill preſerved its former yellowiſh-white hue, I likewiſe heated to redneſs, upon a piece of charcoal. By this management it acquired a faint, dark-brown colour at the firſt moment of ignition:—a phenomenon which does not uſually take place, except in the white oxyd of manganeſe. This portion weighed $\frac{3}{4}$ of a grain.

c) Upon the pulverized jargon, after treatment with acids, and adding the above-mentioned reſiduum of $\frac{3}{4}$ of a grain (*b*), I poured two ounces and a half of a cauſtic lye, in which the ſaline part made half the weight. The whole was then inſpiſſated in a ſilver-crucible to dryneſs, and moderately ignited for two hours; by which treatment the maſs preſerved a pap-like conſiſtence. When refrigerated, I ſoftened the indurated, grey-white maſs with water. The powder of the ſtone, thus ſeparated from the alkaline lye, when waſhed and dried in a low-heat, now reſembled elutriated chalk, and weighed 128 grains.

d) I then ſaturated the clear alkaline lixivium (*c*) with ſulphuric acid. By this it was not rendered turbid; but only after it had been evaporated to dryneſs, and the ſaline maſs again ſoftened with water, there appeared *ſiliceous earth*, amounting to three grains after ignition.

e) The

e) The above jargonic powder (*c*), being now prepared for folution in acids, I firft affufed upon it eight times its weight of water; and upon this mixture, which had affumed a milky appearance, I poured a fufficient quantity of dilute fulphuric acid. In this menftruum, affifted by heat, the whole of the powder (a few impurities excepted), diffolved into a limpid, colourlefs liquor. After cooling, there fettled around the fides and bottom of the glafs-veffel an irregular cruft, confifting of white cryftalline grains; which again diffolved upon affufing more water of a warm temperature. This being done, the colourlefs folution was evaporated with a low heat. At the beginning of the procefs it remained clear, but afterwards it coagulated into an uniform, pellucid jelly.

f) When this gelatinous coagulum had again been digefted with a large quantity of water, it diffolved into the form of tranfparent, vifcid grains; which, collected on the filter, and deficcated, refembled glaffy fand. Thefe being expofed to a red heat, with four parts of mild vegetable alkali, and the mafs re-diffolved in water, left behind 3 grains of earth. Sulphuric acid precipitated the *filiceous earth*, which was diffolved in the alkaline folution, in its ufual flimy form. Its quantity amounted, after ignition, to 24 grains.

g) After thofe three grains of earth (*f*), had been rediffolved in fulphuric acid, and, along with their folvent, added to the remainder of the foregoing folution, I precipitated the *jargonic earth* contained in that fluid, by means of a boiling lye of carbonated pot-afh. The precipitated earth, edulcorated and dried in the air, was of a moderately loofe cohefion, of a white colour, a little inclining to that of flefh, and weighed 122 grains. One fourth part of it,

 when

when ignited, amounted to $17\frac{1}{2}$ grains; which gives 69 for the whole.

Therefore, the conſtituent parts of the *jargons*, analyſed, are, *in one hundred*,

Jargonic earth . . .	*g*)	. . . .	69,
Silex	*d*)	. . 3	
	f)	. . 24	
		27	
From which ſubtracted	*a*)	. . $\frac{1}{2}$	
		$26\frac{1}{2}$.	26,50
Oxyd of iron	*b*)	. . . .	0,50
			96
		Loſs .	4
			100

B.

I ſhall farther mention ſome of my other analytical proceſſes, repeated on that ſubject under circumſtances ſomewhat diverſified, and alſo the obſervations which have occurred to me concerning the chemical habitudes, or relations of jargonic earth.

a) Both the accurate diſcovery of the proportion of the ſiliceous earth, and its thorough ſeparation from the earth of jargon, are rendered highly difficult by their intimate union, as well as by their reciprocal ſolution of each other. This end I have attained, in the ſureſt way, by the method juſt now

now defcribed : and for this reafon I recommend this as the beft among feveral that I have attempted. However, there feems to obtain fome little difference in the proportion of the filiceous earth, depending on the nature of the feveral varieties of the jargon; which is likewife made probable by the fmall differences in the fpecific weight of various fpecimens of this ftone.

b) If, upon the mafs obtained by foftening the jargon with water, after its ignition with cauftic alkali, muriatic or fulphuric acid be immediately poured, to a flight degree of fuper-faturation, the whole is directly diffolved, clearly, and without refidue. The earth precipitated by means of alkali from this folution, hardens, during deficcation in warmth, into tranfparent, vitreous, heavy, folid, and brittle lumps; which, in the moment they are removed from the heat, fly into fmall pieces, with vehemence and noife; fome of which, if not inclofed in paper, are often thrown to a great diftance. The higher the temperature in which the earth has been dried, the greater is the refidue left behind undiffolved, when again conveyed into acid menftrua, for folution.

c) It does not feem that the boiling of rough, pulverized jargon, in acids, is fully competent to extract completely their proportion of iron. If, therefore, the prepared earth of jargon be again diffolved in an acid, and combined with prnffiat of pot-afh, the ferruginous remainder will appear in the form of a precipitate, fometimes of a Pruffian-blue; at others, of a bright mountain-blue. But this precipitate is unable to indicate the true quantity of iron which it exhibits; for it confifts not only of a fmall portion of oxyded iron, but alfo of a much greater part of jargonic earth, thrown down along with it, which afterwards refifts a farther feparation. It is, from the prefence of this earth, united

united with the precipitated iron, that the above precipitate acquires a pale, reddifh colour after ignition, and is hardly attracted by the magnet.

Cenfequently, not fo much with the view of afcertaining the proportion of the conftituent parts, as to produce the *jargonia* abfolutely free from iron, it is advifeable to rediffolve the earth firft obtained, in an acid, and to feparate that fmall remainder of iron by pruffiated alkali. The iron being thus got rid of, the earth of circon, now perfectly pure, fhould be at laft precipitated by means of an alkali, in a heat of ebullition.

d) To obtain the circon-earth in a ftate of eafy folution in acids, it is neceffary that, after precipitation and wafhing, it fhould be dried in a gentle heat only. Strongly ignited earth of jargon will not diffolve in acids, unlefs again previoufly prepared for that procefs by igniting it along with cauftic alkali.

e) When the jargonia is to be precipitated from acid folutions, by means of carbonated pot-afh, the point of faturation fhould not be exceeded; fince, otherwife, in proportion to the excefs of alkali added, it will, either in part or wholly, be re-diffolved in the fluid, and can only then be made to re-appear by adding frefh acid to the fuperfluous alkali. However, this earth is not re-diffolved, if the precipitation is performed by cauftic vegetable alkali, though the fluid fhould happen to be fuper-faturated with the falt.

f) Of all the acid folutions of jargonic earth, that which is prepared with muriatic acid has the greateft tendency to cryftallize. If committed to fpontaneous evaporation, the *muriat of jargonia* fhoots into very flender, acicular cryſtals, radiated in a diverging direction, which continue dry on expoſure to air.

g) The jargonia is not at all diſpoſed to vitrifaction; which is proved by the following experiment. A glaſs frit, compoſed of 60 grains of jargonia, and 40 grains of mild alkali prepared from tartar, was expoſed, in a crucible made of clay, to an intenſe and long continued fire. But by this proceſs not only was no union of theſe two ſubſtances effected, but they even entirely ſeparated. The alkali fixed itſelf on the ſides of the veſſel in indurated grains; and in the middle the jargonic earth lay by itſelf, in the form of a coarſe, harſh, and looſely conglutinated powder, of a yellowiſh-white colour.

XIII.

XIII.

CHEMICAL EXAMINATION

OF

HYACINTH.

ON giving the firft information of the new fimple earth difcovered in the Jargon of Ceylon, I declared, at the fame time, my earneft defire of feeing this difcovery farther purfued, and confirmed by probatory refearches of able chemifts. That wifh, however, remained unfulfilled, with the exception of fome few experiments made by *Gmelin*. It is probable that the few opportunities, which have hitherto occurred of obtaining jargon pebbles in a fufficient quantity, have prevented chemifts from inftituting a particular inquiry into their nature. They will, therefore, it is hoped, find pleafure in hearing, that the fame earth is likewife contained in another gem, the *Hyacinth*, which may be eafily obtained, and in fufficient quantity. This information will, perhaps, caufe furprize, fince the analyfis of the Hyacinth, publifhed by *Torb. Bergman*, appears to have been long fince confirmed by its general reception. According to this, the Hyacinth is fuppofed to confift of,

40	. . .	*Argil*,
25	. . .	*Silex*,
20	. . .	*Lime*, *and*
13	. . .	*Oxyd of iron.*

Therefore, to obviate all doubts that may arife concerning the correctnefs of my prefent analyfis, I declare before hand, that it is not merely the refult of one fingle and fuperficial decompofition of the Hyacinth, but of feveral analyfes of that gem, performed at different intervals of time, and in every refpect complete.

The native country of the Hyacinth, which was the fubject of the following experiments, is *Ceylon.*—Whether thofe fpecies of ftones, which in European countries, in *Bohemia*, *Italy*, and *France*, for inftance, are indicated by this denomination, are true Hyacinths, I have not, as yet, been able to convince myfelf by any fatisfactory proof.

I have found the fpecific gravity of the genuine Hyacinth for the moft part to agree with that of the Jargon; that is, according to its varieties, from 4,545 to 4,620.

The detail of the experiments, which, with fome variations, I repeated with the Hyacinth, may be the lefs circumftantial, fince, in effential points, the fame holds good with refpect to this gem, as what I have ftated in the fecond fection of the preceding effay to belong to the Jargon, its analyfis and its conftituent parts.

a) *One hundred grains* of Hyacinth received, by levigation in the flint-mortar, an increafe of weight of $\frac{1}{2}$ grain; which fhews that its hardnefs is not materially different from that of the jargon

b) This

b) This pulverized hyacinth, digefted with two ounces of nitro-muriatic acid, yielded, upon faturating the folution with pot-afh, a light-brown precipitate, of $3\frac{1}{2}$ grains, when dried. Ammoniac, added to it, diffolved nothing; and it remained colourlefs. After the precipitate had been again feparated from the volatile alkali, I put it into muriatic acid, which diffolved its ferruginous contents, leaving a white earth behind, which, when ignited, weighed $1\frac{1}{2}$ grain. The portion of *iron*, precipitated by cauftic ammoniac from the muriatic folution, weighed $\frac{1}{2}$ grain, when ignited, and became black and refplendent. I fufed it with a neutral phofphat, upon charcoal, in order to find whether it contained manganefe; but no trace of it was perceptible.

c) The above $1\frac{1}{2}$ grains of earth *(b)* were now added again to the hyacinth, after treatment with acids. The ftone was then fubjected to red-heat, with fix times its quantity of cauftic alkali, in the manner explained in the effay on the jargon of Ceylon; the ignited mafs was again liquefied with water; and the earth remaining after this procefs weighed 123 grains, when collected, edulcorated, and dried.

d) The alkaline lixivium was then faturated with muriatic acid, and evaporated. At firft it continued clear; but towards the end *filiceous earth* feparated, the quantity of which, after ignition, amounted to 6 grains.

e) Upon thofe 123 grains, previoufly well wafhed with water, I poured a fufficient quantity of muriatic acid; which, with the affiftance of heat, diffolved nearly the whole, a trifling refidue excepted. This muriatic folution, evaporated in a moderate heat to a fixth or eighth part, loft its fluidity, and formed a limpid gelatinous coagulum.

It was then covered with water, and expofed, with repeated agitation, to a digefting heat. By this management, the *filiceous earth* feparated in flimy, intumefced grains, and weighed, after ignition, 23½ grains.

f) The folution, thus freed from its filex, was now faturated with a boiling lye of mild alkali; and the precipitate was wafhed and dried in the air. This laft weighed 114 grains, proving, upon every trial, to be *jargonic earth*. A fourth part of it, heated to rednefs, weighed 16½ grains; which make the whole amount to 66 grains.

g) The above 6 grains *(d)*, with the 23½ grains *(e)* in the whole 29½ grains of filiceous earth, were ignited with a quadruple weight of vegetable alkali. When this mafs had been again foftened with water, it left a refidue, which I extracted by muriatic acid. From this muriatic folution, alfo, when faturated with pot-afh, jargonic earth fell down, weighing 4 grains after ignition. Hence, fubtracting thefe, the quantity of filiceous earth is reduced to 25½ grains.

One hundred parts of *hyacinth*, therefore, have given

Jargonia . .	*f*) . .	66 }	. . 70
	g) . .	4 }	
Silex . . .	*g*) . .	25½	
Subtract .	*a*) . .	½	
		25 . .	25
Oxyd of iron .	*b*)		0,50
			95,50
		Lofs	4,50
			100

What

What I have already mentioned, when treating of the jargon of Ceylon, both with refpect to the variation in the proportion of the filex, and the fmall quantity of iron ftill remaining, which may be feparated by means of Pruffian alkali, applies likewife to the hyacinth.

Hence, the *jargon* of Ceylon, and the *hyacinth*, fhould, in future, be ranked in the feries of natural bodies as *two fpecies*; or, if it be preferred, as *two genera*, under *one* peculiar and diftinct *order of ftones*. But which of thefe two is entitled to preference, in giving its name to the genus?—The jargon has, indeed, already obtained that diftinction; but ought it not to be transferred to the hyacinth, being a gem much older, longer known, and more efteemed?—If fo, the denomination *hyacinth-earth* fhould then be adopted, and fubftituted to that of *circonia*, or *jargonia*.

XIV.

CHEMICAL EXAMINATION

OF THE SUPPOSED

HUNGARIAN RED SHÖRL.

THE foſſil, found at *Boinik* *, in Hungary, and called *red Shörl*, is there dug up from a bed of quarz, ſtratified with ſhiſtoſe mica. Its colour is a pale browniſh-red. Its figure is a column ſtrongly furrowed, or channelled, lengthways, which, in my ſpecimens, exhibits a rectangular parallelopipedon. The larger ſpecimens which I poſſeſs are ½ inch thick; but theſe ſhörls are commonly thinner, and form only needle-ſhaped cryſtals, the external ſurfaces of which are ſtriated, and, as well as thoſe of the fragments, ſtrongly ſhining. Their croſs fracture is foliated; the longitudinal fracture of a medium between the foliated and uneven, and in ſome parts of the minute conchoidal. The ſplinters of this foſſil, and thin edges, are tranſparent, like the light-red ſilver-ore, which, in general, it very much

* *Born* mentions *Rhoniz* as the place where it is found. See his *Catalogue Meth. et Rais. de la Collect. d. Foſſil.* Tom. i. p. 168.

re-

reſembles when in fragments. It breaks into ſmall acute-angular pieces, which, however, ſhew a very great hardneſs on trituration; and the colour of the powder is between the orange and brick-red. Its ſpecific gravity I have found to be 4,180.

It was undoubtedly the oblong form, together with the ſtriated, fluted ſurface of its cryſtals, which occaſioned this foſſil to be claſſed under the tribe of ſhörl: whereas other mineralogiſts think themſelves entitled, from its colour and fracture, to reckon it a garnet.

But it will be made evident by the reſults of the following analyſis, that this mineral body belongs neither to the one nor to the other of thoſe ſpecies of ſtones, nor at all to the claſs compriſing the genera of earths and ſtones. On the contrary, it will appear that it conſiſts of a *peculiar, diſtinct, metallic ſubſtance**.

A.

a) I expoſed a piece of this mineral, in a *crucible made of clay*, to the heat of the porcelain furnace. By this it ſuffered no change as to figure and luſtre; but the colour paſſed into a deep brown-red.

b) Another ſpecimen, that was ſubjected to a porcelain heat in a *charcoal-crucible*, burſt into angular grains; while

* For the quantity of this rather ſcarce foſſil, requiſite to this analyſis, I am indebted to the kindneſs of *Count Würben*, of Vienna.

its

its colour changed to a faint light-brown, and fcarcely any of its original luftre remained.

c) When fufed with an alkaline phofphat, upon charcoal, before the blow-pipe, no folution enfues. The globule acquires a pale reddifh-grey, and turns opake. A gentle preffure makes it fall afunder, in the form of fand.

d) Melted borat of foda (borax) diffolves it, uniting with it to a clear vitreous bead of an hyacinthine red.

e) If the powder of this foffil be fufed in the filver fpoon with *foda*, it gradually diffolves, and the globule becomes untranfparent, and of a reddifh white colour, after cooling.

B.

In order to examine the agency of acids on this mineral, when finely pulverized, I inferted feveral portions of it in *four* feparate phials, and poured upon one *fulphuric*, upon the other *nitric*, upon the third *muriatic*, and upon the laft *nitro-muriatic* acid; fubjecting them all to long digeftion in a ftrong heat. No action enfued in either; for the foffil was again taken out of each acid without any alteration.

C.

Having blended *one hundred grains* of the foffil, finely levigated with four times its weight of cauftic pot-afh, I expofed it to a red-heat for one hour. When removed from the fire, I foftened it by water, fuper-faturated with muriatic acid, and fubjected it to digeftion. There feemed

 but

but little of it diſſolved, and the undiſſolved part lay at the bottom of the veſſel, as a white, tenacious, and heavy earth. When the mixture was thrown upon the filter, in order to ſeparate the fluid, it paſſed through the pores of the paper in the form of milk. For this reaſon, I put the whole again together into one maſs, diluting it with a greater quantity of water; and the earth having ſubſided after 24 hours, the water was decanted, and the ſediment dried in a warm temperature. By this management it again acquired a reddiſh colour.

This ſeemed to indicate that the coheſion of this ſhörl was not yet perfectly looſened. I therefore ignited it once more with 200 grains of the cauſtic ſalt, and again digeſted, with muriatic acid, the maſs previouſly ſoftened. Even in this caſe the mixture reſembled milk, and continued ſeveral days in this ſtate, without becoming clear. I diluted it then with more water, and made it boil: upon which the earth ſeparated in detached, flocculent particles, which then admitted of being collected on the filter. But they adhered to it very firmly and clammily; which, upon exſiccation, rendered its ſeparation difficult.

I inſtituted ſeveral preliminary experiments with that portion which could be collected; by which I learnt, that, in this inſtance, I was engaged with a peculiar *metallic oxyd.*

D.

I repeated the decompoſition of the foſſil with ſuch a variation of the proceſs, as to avoid the difficulty in ſeparating and collecting the precipitate, which took place in the preceding attempts.

Two

Two hundred grains of the foffil, finely pulverized, and mingled with five times their quantity of carbonated alkali, were ignited in a porcelain-pot. The mixture entered into a thin fufion ; but when poured out, it coagulated to a greyifh-white, denfe mafs of acicular cryftals, at the upper furface, and of a fibrous fracture. This I triturated and liquefied in boiling water. A white precipitate foon fubfided, from which the fupernatant liquor was filtered off, and faturated with muriatic acid. By this management, a white, flimy earth fell down, that weighed eight grains after drying, and confifted of a mixture of argillaceous and filiceous earths.

The refiduum, wafhed, and deficcated in a gentle heat, appeared as a white loofe earth, and weighed 328 grains.

E.

This white earth was fubjected to a number of experiments; the refults of which were, as follows.

1. *Its relations to acids.*

a) It foon diffolved in *dilute fulphuric acid*, and afforded a clear folution, which, when expofed to the air, evaporated, leaving a white, turbid, pafte-like fubftance behind it.

b) *Nitric acid* likewife formed with it a limpid folution. By fpontaneous evaporation, this acquired an oily confiftence, and depofited minute tranfparent cryftals, the primitive figure of which was an oblong rhomb, and feemed to change into an hexahedral plate, or table, by the truncation of its two oppofite acute angular ends.

c) When the ſolution of this earth in *muriatic acid* was left to evaporate of itſelf, it thickened to a bright-yellow, clear, gelatinous ſubſtance, beneath which there ſhot a quantity of very ſmall, clear, cryſtalline grains, of a cubical form.

In theſe acid ſolutions there remained between five and ſix parts of *ſiliceous earth* in the hundred. However, a quantity of *ſiliceous earth*, to appearance ſtill more conderable, was yet left behind, in combination with the white earth, and entered with it into the ſolutions. It is by this circumſtance that theſe ſolutions are reduced to a gelatinous coagulum, and that a more regular cryſtallization is impeded.

2. *Relations of theſe ſolutions to the precipitating media.*

a) *Carbonat of pot-aſh* precipitates the diſſolved earth in a white, light, flocculent form.

b) *Cauſtic ammoniac* produces the ſame effect.

c) *Pruſſiat of pot-aſh* affords a large precipitate, mixed of graſs-green and brown.

d) *Tincture of galls*, or *gallic acid*, throws down a brown-red precipitate, of very conſiderable bulk. If the ſolution has not been previouſly diluted with much water, it congeals like blood. Alkalis ſeparate nothing from the decanted fluid. The precipitate, when collected, waſhed, and dried, has the appearance of *Kerme's mineral* (red ſulphurated oxyd of antimony). When I expoſed 15 grains of this powder to a weak heat, upon coals, in a ſmall crucible, it immediately glimmered, and turned white. After this degree of ignition, it was found to weigh 6 grains.

e) When

e) When combined with *acid of arſenic*, a white precipitate enſues.

f) The ſame is occaſioned by *phoſphoric acid.*

g) *Acid of tartar* produces a white precipitate, but which ſoon entirely re-diſſolves.

h) The ſame takes place upon the addition of *oxalic acid.*

i) A ſmall *ſtick of tin* was immerſed in a phial, full of a muriatic ſolution of the foſſil, and provided with a ſtopper. After ſome minutes a faint roſe-colour ſhewed itſelf around the ſtick of *tin*, paſſing, at laſt, into a beautiful amethyſtine red.

k) Another phial, capable of being cloſed with a ſtopper, was filled with this muriatic ſolution, but diluted with ſix times the quantity of water; and into this I put a ſmall ſtick of zinc. The ſolution at firſt changed to a violet, but afterwards to a deep indigo-blue. When placed in a warm temperature, in an uncovered diſh, the ſolution gradually loſt its colour, and depoſited a white, bulky precipitate; which, when ſeparated by filtration, and again diſſolved in muriatic acid, retained the ſame properties as the earth did before the ſolution.

l) But the muriatic ſolution, when combined with *Hahneman's acidulous liquor*, *impregnated with ſulphureous gas* *, remained unaltered.

m) However, *Beguin's ſulphuret of ammoniac*, added to that mixture, gave it a dirty, green colour, and produced a blueiſh-green precipitate. If the white earth, in the *dry*

* Hahneman's *Wine Proof.* See *Gren's* Principles of Chemiſtry, vol. ii. page 253. *note.*—Tranſl.

ſtate,

state, be covered with this fluid, it is immediately tinged of a brownish-green.

3. *Habitudes of the above-mentioned earth in the dry way.*

a) *Fifty grains* of the white earth, mentioned above, when ignited in a crucible, were afterwards found to weigh 38 grains. As long as it continued warm, it exhibited the yellow colour of sulphur; which, however, disappeared upon cooling. This earth, after ignition, is no longer acted on by acid menstrua.

b) But if the earth be heated to redness upon charcoal, it first becomes reddish, and then of a slate-blue. By this treatment it also fuses into an ill-shaped globule, which, after refrigeration, presents a finely radiated surface. However, this melting is effected, perhaps, only by a small portion of alkali, which still adheres to the earth.

c) The same earth, when fused upon charcoal, with a neutral phosphat and *borax*, or with *soda*, in the small spoon, yields the same results as does the rough fossil, when treated with these fluxes. (A. c. d. e).

d). This white earth, also, mixed and conveyed with a proper *enamel-flux*, upon porcelain, and baked, produced a pure straw-yellow colour, of a good body. This colour was likewise obtained by the raw mineral.

e) At last I attempted to reduce it to the reguline state. For this purpose I blended 60 grains of the white earth, ignited, with 30 grains of pulverized *colophony* (the residue after the distillation of the etherial oil from turpentine), and caused this last to burn away by means of a gentle fire. No sooner had the flame ceased, than the earth appeared

peared again as white as before. It was next divided into two parts. The one half of it was mingled with 20 grains of pulverized white glafs and 10 grains of calcined borax, and inclofed together in a crucible made of charcoal. The other half was introduced—alone—into the cavity of the charcoal-crucible, covered only with a mixture of glafs and borax. Both crucibles, well fecured, were then put into the porcelain-furnace; and both afforded the fame product; which confifted of an irregularly fufed flag, or fcoria, brownifh at top, light-blueifh-green below, and of a finely porofe fracture, with fome detached large air-holes, the interior fides of which feemed to be confufedly ftriated.

This foffil, therefore, belongs to thofe *metallic fubftances* which appear to be incapable of being exhibited in the ftate of a fufed metallic bead.

F.

The fum of thefe refults furnifhes feveral arguments, upon the ftrength of which I do not fcruple to confider the *red fhörl*, as it has been hitherto called, of *Boinik in Hungary*, as a natural *metallic oxyd*. The phenomena, upon which I ground my conclufion, are: That the white earth, fubjected to ignition, becomes yellow, reddifh, and, in contact with charcoal, blueifh; that it produces a yellow enamel colour; that it is precipitated from its folutions in acids, by Pruffian alkali, gallic acid, and alkaline fulphuret; that, when treated in the humid way with tin and zinc, it is recovered in dark flakes, the folution then acquiring a red and blue colour; and, laftly, that it fhews a very ftrong tendency to combine with oxygen. It is on account of this laft property, that the crude foffil, as being fully fatu-

rated

rated with that acidifying principle, is inſoluble in acids, and is rendered capable of ſolution only when, by ignition with an alkali, it is deprived of a part of its oxygen. For this reaſon, likewiſe, when I ignited the rough foſſil, in a ſubſequent analytical experiment, with only two parts of vegetable alkali, the earth obtained did not prove ſo white and looſe as that fuſed with five or ſix parts. It alſo diſſolved but imperfectly, in muriatic acid, and not at all in the ſulphuric and nitric.

To theſe facts muſt be added the phenomenon, that the muriatic ſolution of that ſubſtance became changed into a blue tincture by zinc; but when decanted, and expoſed to open air, in a warm place, it again loſt its colour, by imbibing oxygen, and depoſited a white earth.

Another phenomenon, probably the conſequence of ſuper-ſaturation with oxygen, took place when I endeavoured to promote the cryſtallization of a complete muriatic ſolution, by evaporating it in a ſand-bath. This was, that the liquor, which had before been perfectly clear, acquired a turbidneſs and reſemblance to milk, by the heat: nor could it any more be rendered a limpid ſolution by the freſh addition of acid.

It is ſufficiently ſhewn, by ſeveral of its properties, that this metallic ſubſtance does not belong to any of thoſe at preſent known, but rather deſerves to be reputed a new, peculiar genus of metals. Among theſe, the copious *brown-red precipitate*, produced by the gallic acid, furniſhes an eaſy teſt and ſpecific means of diſtinguiſhing it from other metals.

We are yet to give this new metallic ſubſtance an appropriate name.

P When

Whenever no name can be found for a new foſſil which indicates its peculiar and characteriſtic properties (in which ſituation I find myſelf at preſent), I think it beſt to chooſe ſuch a denomination as means nothing of itſelf, and thus can give no riſe to any erroneous ideas. In conſequence of this, as I did in the caſe of the Uranium, I ſhall borrow the name for this metallic ſubſtance from mythology, and in particular from the *Titans*, the firſt ſons of the earth. I therefore call this new metallic genus TITANIUM*; of which this *Titanium*, mineralized by oxygen, or *oxyd of Titanium*, is, indeed the *firſt*, *but perhaps not the only ſpecies*, as is made probable by the following eſſay.

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* The metal called *Menachanite*, by *Kirwan*, Mineralogy, vol. II. part iv. chap. 21, is the ſame, or analogous to Klaproth's Titanium. See *Gren's Principles of Modern Chemiſtry*, 1800. Lond. 8vo. vol. ii. page 425.—Tranſl.

XV.

XV.

CHEMICAL EXAMINATION

OF

A NEW FOSSIL, from the Diſtriſt of Paſſau.

AMONG the various and hitherto unknown cryſtallizations of ſome foſſils, which profeſſor *Hunger* has diſcovered in the biſhopric of Paſſau, and whoſe external characters he has deſcribed*, there is one particularly remarkable, as even its conſtituent parts are not yet known.

The cryſtals of that foſſil are ſmall quadrangular rhombic columns, of a reddiſh, greyiſh, and blackiſh-brown colour. Their ſize varies from $\frac{1}{48}$ to $\frac{1}{4}$ of an inch. Their lateral facets are joined alternately, under angles from 135 o 45 degrees. Both their ends form very ſharp angles; and the inclining ſides iſſue from the obtuſe lateral edge. Their ſurface is ſmooth and reſplendent. Their croſs-fracture is dim, but their longitudinal fracture exhibits a middling luſtre. The ſmalleſt cryſtals of that mineral, and ſometimes its edges, are tranſparent; but it is often totally

* *Beobachtungen und Entdeckungen aus der Naturkunde.* 5ter. Band, 2tes St. Berlin, 1794.

opake. Though its cryſtals are brittle, and eaſily friable, yet they ſhew a conſiderable hardneſs when grinding, and then afford a whitiſh-grey powder.

It is met with in ſeveral places in the neighbourhood of *Paſſau*, and alſo, though ſeldom, in the *Innviertel*, in Bavaria. Thoſe cryſtals almoſt always occur diſperſed in a ſpecies of coarſely-grained ſtony matter, the predominant part of which conſiſts of a greyiſh, or greeniſh-white felſpar, mingled with hornblende, quarz, mica, ſemi-indurated ſteatites, of which ſometimes all together are united with it; and, at other times, only one or two*.

A.

a) The ſpecific gravity of this foſſil is 3,510.

b) Its cryſtals, when ignited upon charcoal, before the blow-pipe, ſuffered no remarkable change, except that here and there very minute bubbles were produced on their ſurface.

c) Expoſed in a *crucible made of clay*, to the moſt intenſe heat of the porcelain furnace, they likewiſe continued without farther alteration; but in the *charcoal crucible* they concreted into a ſcoria, half-fuſed, black, opake, ſomewhat porous, and of a moderate luſtre.

d) On being treated in the humid way with muriatic acid, and repeatedly digeſted with it, one third part of their

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* Profeſſor *Hunger* had the kindneſs to ſend me ſome of his cryſtals, which had been collected with great trouble, in quantity ſufficient for inveſtigating the conſtituent parts of this mineral.

weight

weight was diſſolved. This ſolution had a ſtraw-yellow colour; and the addition of cauſtic ammoniac, in exceſs, afforded a precipitate, whoſe appearance and conſiſtence reſembled paſte made of ſtarch; but which, when dried and ground, exhibited a looſe, yellowiſh powder. The remaining fluid contained, alſo, ſome *calcareous earth*, which I precipitated from it by carbonat of ſoda.

What remained, after the extraction by means of the acid, I ſubjected to ignition, together with four times its weight of mild alkali, prepared from tartar. It was next ſaturated to exceſs, and digeſted with muriatic acid, and filtered. *Siliceous earth* was then left behind on the paper. Cauſtic ammoniac threw down from this ſolution a precipitate perfectly reſembling the foregoing; to which, therefore, it was added.

The external appearance of this precipitate led me to ſuſpect in it the preſence of aluminous earth, impregnated with iron. However, it was not found to be ſo upon farther examination: for, after I had again diſſolved it in muriatic acid, and once more precipitated it from this laſt ſolution, the cauſtic alkaline lye, with which the precipitate was digeſted after edulcoration (while yet in a pulpy ſtate), would diſſolve only a very trifling portion of it.

I then fuſed, with glaſs of borax, a ſmall portion of the precipitate, again waſhed and dried; and obtained a ſmall topaz-yellow glaſs-globule. Another portion, fuſed with phoſphoric ſalt, produced one of a pale amethyſtine colour.

Again; another ſmall portion of it, which was diſſolved in dilute ſulphuric acid, ſhewed no ſenſible taſte of alum, and dried to a whitiſh maſs, without ſhooting into cryſtals.

 The

The remainder of that precipitate I re-diſſolved in muriatic acid, and treated the ſolution with the following teſts, or re-agents.

Pruſſian alkali produced a dark-green precipitate.

Gallic acid afforded a precipitate of a lively brown-red colour, but paſſing into a pale yellow-red, as it cooled.

A little ſtick of zinc was immerſed into that part of the ſolution which yet remained; and a ſubtle greeniſh-black ſlime was obſerved ſettling around it, at the ſame time that the ſolution itſelf aſſumed the colour of amethyſt. The fluid again loſt that colour after ſome days, and white, flocculent particles, mingled with the ſlime, fell down.

B.

Guided by theſe previous obſervations, I proceeded to the following new experiment.

a) *One hundred grains*, finely ground, were ſubjected, for one hour, to ignition, with a quadruple weight of cauſtic alkali. The maſs, ſoftened by water, yielded a weak graſs-green ſolution; but this colour diſappeared again, as ſoon as more water was added a-freſh. Upon digeſting it with muriatic acid, added to exceſs, and ſubſequent filtration, *ſiliceous earth* was left behind, which, when ignited, amounted to 12 grains.

b) The diſſolved part was next precipitated, by means of carbonated pot-aſh. Upon the dried precipitate, I added a new portion of muriatic acid, and a notable ſmell of oxygenated muriatic acid gas was emitted. During the di-

digeſtion, there again ſeparated ſome *ſiliceous earth*, the quantity of which, after ignition, amounted to 23 grains.

c) At this time, I combined the ſolution with cauſtic ammoniac. The yellowiſh-white precipitate, obtained thereby, weighed 62 grains, upon deſiccation. One *fourth* part of it, heated to redneſs, was found to weigh $8\frac{1}{4}$ grains; whence its whole quantity makes 33 grains.

d) To the remaining fluid, mild vegetable alkali has been added, at a boiling heat. It thereby yielded *calcareous earth*, to the amount of 33 grains, when ignited.

C.

Having, in this manner, diſcovered the proportion of the conſtituent parts, I next examined, a ſecond time, the precipitate obtained (B. c.).

a) When ignited alone upon charcoal, it turned browniſh-yellow, and, at laſt, blackiſh.

b) By fuſing it with *borax*, a tranſparent globule of an hyacinthine colour was produced.

c) *Phoſphoric ſalt* did not diſſolve it, but only divided it minutely. If any trace of manganeſe had remained in this precipitate, it would have manifeſted itſelf by a faint amethyſt-colour, with which it tinges phoſphoric glaſs.

d) The portion diſſolved in acids was thrown down by *tincture, or acid of galls*, of a lively, brown-red hue.

 e) *Pruſ-*

e) *Pruſſiat of pot-aſh* afforded with it a green precipitate, inclining to brown, and thereby reſembling ſap-green. This, however, when dried, appeared again with its original green colour. The liquor, ſeparated from it by filtration, was not altered by re-agents.

f) The addition of *ſulphuret of ammoniac*, prepared after *Beguin*'s manner, produced a flocculent precipitate, of a dark muddy-green.

g) *Phoſphoric acid*, as well as

h) *The acid of arſenic*, produced a white precipitate.

i) Laſtly, this precipitate, when combined with a proper quantity of enamel-flux *(glaſs-paſte)*, and thus laid upon porcelain, and fuſed, gave to its ſurface a *yellow* colour, verging to brown.

Therefore, ſince theſe reſults not only indicate, in an unqueſtionable manner, the metallic nature of this conſtituent part, but, moreover, ſince its habitudes, upon the whole, very much correſpond with thoſe of the Titanium (the new metallic ſubſtance treated of in the laſt eſſay); and, finally, ſince the trifling varieties in the various phenomena ſeem to originate merely from accidental circumſtances, I do not heſitate to reckon this conſtituent part as an *oxyd of Titanium.*

And, in order that this foſſil itſelf may be diſtinguiſhed by a particular name, as a *diſtinct ſpecies*, the denomination *Titanite*, derivated from the above new metallic ſubſtance, does not ſeem to be altogether improper. Its conſtituent parts have been found to exiſt in it in the following proportions:

Si-

Silex . . . B.	*a*) 12	} . .	35
.	*b*) 23		
Lime	*d*)	. . . . .	33
Oxyd of Titanium	*c*)	. . . . .	33
Manganeſe, a ſlight trace.			
			101

Now, what place ought to be aſſigned, in the mineralogical ſyſtem, to this new foſſil? Since mineralogiſts are not yet agreed as to the principles, according to which the ſyſtem of mineralogy ſhould be arranged, thoſe who direct their principal regard to the *ſpecifical* conſtituent part, will readily claſs the *Titanite* as a *ſecond ſpecies* of the *Titanium genus*. Such, on the contrary, as inſiſt more ſtrictly on the predominant part, with regard to quantity, will, perhaps, decide for its inſertion under the head *ſiliceous genus*.

XVI.

XVI.

EXAMINATION

OF THE SUPPOSED

MOLYBDENOUS SILVER.

A FEW years ago a metallic foffil was met with at *Deutſch-Pilſen*, in the *Comitatus Hontenſis*, in *Hungary*, which by *Born* has been introduced as a new ſpecies of ſilver-ores.—He gives the following deſcription of it*.

ARGENT MOLYBDIQUE.

Silver combined with ſulphurated Molybdena.

" *This combination or alloy of ſilver with ſulphurated* " *molybdena has been till now unknown. It is no where* " *found, except at* Deutſch-Pilſen *in* Hungary, *where it* " *was met with in inſulated kidney-form nodules* (rognons), " *from one to two inches in thickneſs, enveloped in a common* " *grey clay. Theſe nodules ſeparate in pretty large and* " *ſhining laminas, that admit of a new diviſion into ſmaller* " *lamellas, perfectly reſembing ſulphurated molybdena, and* " *ſtaining the paper with grey traces. By cupelling this* " *ſulphurated molybdena, there are obtained* 23 *marcs of ſil-* " *ver* (184 oz.), *from one centner*."

As, from the peculiar ſcarcity of this mineral, few chemiſts only may have opportunity of examining it, I undertook this taſk the more readily: and I found by theſe reſearches, that it contains neither *ſilver*, nor *molybdena*, and that it conſiſts of *biſmuth*, *mineralized by ſulphur**.

* See his *Catalogue de la Collection des Foſſiles de Mlle de Raab.* Tom. II. p. 419.

A.

A.

a) If this ore be tried *per ſe* upon charcoal, with the aſſiſtance of the blow-pipe, it runs into a globule, as ſoon as it comes in contact with the point of the flame. That globule may be gradually blown off by means of the bellows, in which caſe it gives out a metallic vapour, which in part ſettles on the coal, of a yellow colour. But if borax, or a neutral phoſphat, be added, it ſeparates from the melting ſaline pearl, and leaves the latter colourleſs behind it.

2) *Twenty-five* docimaſtic pounds of this ore † ſubjected to cupellation under the muffle, with four times their weight of lead, left behind them a globule of ſilver, only viſible by the microſcope; but this, undoubtedly, muſt have been furniſhed by the lead.

B.

a) Upon *fifty* grains of the triturated ore I poured moderately ſtrong nitric acid. It was immediately attacked and diſſolved by it, with extrication of red vapours; and the reſiduum conſiſted of 2½ grains of ſulphur.

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* That I may not be ſuſpected of having beſtowed my labour not upon the genuine *argent molybdique* of *Born*, I here declare, that the ſpecimen which I examined was a fragment of the very individual piece, of which Born has deſcribed the above external characters.

† About 24½ drachms *Troy-weight*. The German docimaſtic centner, or one drachm, is equal to 72 *French* grains of the former *poid de marc*, which correſpond to 59,0677 *Engliſh grains Troy*. Tranſl.

b) I

b) I afterwards diluted the ſolution with a large quantity of water; upon which the mixture inſtantaneouſly aſſumed the appearance of milk, and depoſited a fine, white, and heavy precipitate, conſiſting of pure *oxyd of biſmuth.*

c) The fluid ſeparated by filtration was mixed with muriat of ſoda. It continued at firſt perfectly clear, but gradually it was rendered ſomewhat milky; and at the bottom there collected a ſubtle, ponderous precipitate, the dazzling whiteneſs of which ſuffered not the leaſt change by the day's light, and was likewiſe merely *oxyd of biſmuth.* Had there exiſted in it any trace of muriated ſilver, however ſmall, it would have diſcovered itſelf by tarniſhing the white colour of that precipitate, on expoſure to the light of the day.

Conſequently, *one hundred* parts of this ore contain:

Biſmuth	95
Sulphur	5
	100

From this ſmall proportion of ſulphur, it ſeems that the biſmuth is but imperfectly mineralized; hence that ore nearly approaches to native biſmuth. And probably on this circumſtance depend its whiter colour, and brighter luſtre, which ſo much reſembles that of ſilver recently poliſhed; and by which it is diſtinguiſhed, in external character, from the ſulphurated biſmuth of *Riddarhyttan*, in *Weſtmanland*, which is more of a lead-grey colour.

XVII.

EXAMINATION

OF THE

NATIVE ALUMINOUS EARTH

FROM SCHEMNITZ.

IN the pit called *Stephani-Schacht*, at *Schemnitz*, in *Hungary*, an earth was lately dug up, which is there reckoned to be aluminous earth, naturally quite pure and free from ſilex. It is as white as ſnow, light, crumbling, very friable; it ſtains but moderately, and adheres to the tongue*.

I put this earth to the trial in the following manner:

a) *One hundred* grains of it were expoſed to a ſtrong red heat for one hour in a covered crucible. After refrigeration, I obſerved in it a loſs of weight of 42 grains; which, it is obvious, was only the weight of the particles of water driven out by the fire. No alteration was effected by this in the exterior appearance of the earth; except that the pieces were made a little rifty, and diminiſhed in ſize.

b) Another *hundred* grains of this earth were gradually conveyed into dilute ſulphuric acid. They diſſolved in it without effervescence, yet accompanied by an obſervable diſengagement of caloric. The ſolution proved perfectly limpid; but upon evaporation it formed a clear and tranſparent coagulum, the ſurface of which, after a few days, appeared to be covered with a quantity of ſolitary, pyramidal, cryſtalline ſhoots. The maſs was next drenched

* A fuller deſcription of it has been given by *Fichtel*, in his *Mineralogiſche Aufsätze*. Vienna, 1794. page 170.

and digested with an abundance of water; and then *siliceous earth* separated, weighing 14 grains, when collected by filtering, and ignited.

c) When the solution, thus freed from the silex, had been combined with the requisite portion of pot-ash, and crystallized, it afforded pure alum; from which the aluminous earth was afterwards precipitated by means of pot-ash, and purified in the manner frequently mentioned.

Hence the discovered constituent parts of this earthy fossil amount to:

Ignited Alumine	*c*)	45
Silex	*b*)	14
Aqueous particles lost by ignition		42
		101

The chemical knowledge of this earth is chiefly remarkable on this account, that hitherto, with the exception of some gems, no other mineral substance has been known, which consists of alumine and silex in such proportions that the quantity of the first so far exceeds the second. Whereas in the species of clay, strictly so called, for instance in the porcelain clay, the alumine which they contain is usually but equal to a *fourth*, or at most a *third* part of the silex. Whence it follows, that in the above fossil, the two constituent parts of clay are to each other precisely in the inverse ratio of that, in which they commonly exist in clay.

From the above results it is likewise evident, that this earth is by no means *absolutely pure alumine*, as has been supposed. As the only instance of alumine of that degree of purity, therefore, we must still consider that earth which is found at *Glaucha*, near *Halle*, on the river *Saale*, in single kidney-form pieces; although its true origin yet remains a problem to be solved.

XVIII.

XVIII.

CHEMICAL RESEARCHES

INTO

STRONTIANITE,

COMPARED WITH

*WITHERITE**.

SEVERAL properties, which *Strontianite* has in common with thofe of *Witherite*, feemed to juftify its being taken, when firft difcovered, for a fpecies of the native carbonat of barytes. However, by the circumftance of paper, dipped in a nitric folution of ftrontianite and dried, burning with a red flame, I was induced to conjecture, that this foffil might, perhaps, be diftinguifhed from witherite by other properties. This fuppofition was ftrongly fupported by the refult of the chemical examinations inftituted by *Sulzer* upon this fubftance, as well as by the experiments which *Blumenbach* has made upon animals.

It was probably the difficulty of obtaining ftrontianite in fufficient quantity, that has prevented the repetition and confirmation of thofe experiments; in confequence of this, the prefent additional effay, tending to procure a more accurate knowledge of it, may be deemed not fuperfluous.

But in order the better to compare the properties and chemical relations or habitudes of ftrontianite compared

* *Chemifche Annalen*, 1793. 2 B. page 189. and *ditto*, 1794. 1 B. page 99.

with

with thofe of witherite, I have thought it proper to place together the refults of an examination into each.

Both thefe foffils belong to thofe products of nature, that have been difcovered only within the laft ten years.

a) The place at which the *ftrontianite* was found the firft time is *Strontian*, in *Scotland*; where this foffil breaks in a vein of lead, together with ponderous fpar (fulphat of barytes), in a mountain chiefly confifting of gneifs*. It is found maffive, in oblong coarfely fibrous pieces, accumulated in bundles. It is of a light green, a little tranfparent, fhining, and moderately hard.

Its fpecific gravity I found to be 3,675.

According to the experiments which *Blumenbach* has made with regard to the effects of ftrontianite upon animal life, it was found to poffefs nothing of the deleterious properties of witherite; as the former was eaten by animals without injury.

b) The *witherite*, or native carbonat of barytes, is dug in the lead-mines at *Anglezark*, in *Lancafhire*; where, together with the foliated fparry barytes, it forms the *gangue*, or earthy matter, ferving as a matrix to the galena. The miners and inhabitants of that vicinity have been long ago acquainted with this mineral, denominated by them *Rats-ftone*, as containing a poifon fatal to animals. The reafon, why the geognoftic fituation and the true native place of witherite (falfely ftated to be *Alfton-Moor*, in *Cumberland*)

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* This mountain is faid by others to be granitic; however, the ftony matter adhering to my fpecimens of ftrontianite proves it rather to be gneifs.

con-

continued for fome time mifunderftood, was the conceal-ment practifed by the miners of that place, who, from its weight, fufpected it to contain fome noble metal; and per-haps alfo to the bafe intereftednefs of the ufurious dealers in foffils.

The colour of witherite is grey-white. It ufually occurs in confiderable maffes, and only occafionally in fix-fided prifms, terminated by hexahedral pyramids. Thin frag-ments of it tranfmit the light. Its longitudinal fracture is gloffy, and feebly ftriated; but its crofs-fracture is only glittering and uneven. Its hardnefs is but middling; and its fpecific gravity is 4,300, and therefore more confiderable than that of ftrontianite.

A fecond place at prefent known, where native carbonat of barytes occurs, is the *Schlangenberg*, in *Siberia*. There it is met with of a grey-white colour, in the form of a fta-lactitical incruftation, refembling chalcedony.

FIRST EXPERIMENT.

a) *One hundred* grains of *ftrontianite* in coarfe fragments, and put into a porcelain-veffel, were ignited during the fpace of two hours in a wind-furnace. Their figure was not fenfibly altered by this; but their bright-green colour, their luftre, and tranfparency, were deftroyed. On weigh-ing them, while yet hot, I obferved a lofs of weight of no more than half a grain; and this lofs feems to be merely that of the moifture expelled.

This experiment I repeated with another 100 grains; but expofing them for five hours to a fire of fuch intenfity, as to be capable of converting white marble into quick-lime, in but half that time. By this much ftronger and more lafting red-heat, they loft $6\frac{1}{2}$ grains of weight. Hence, fubtracting the above half grain, which, on account of the previous ignition, may be deemed watery parts, it follows, that fix grains of *carbonic acid* were thus driven out. This burnt ftrontianite gave a cauftic tafte. I triturated and boiled it with four ounces of water, which I feparated again by filtration. The tafte of this much refembled that of frefh and ftrong lime-water. Two ounces of it were put afide in a flightly covered glafs. After a few minutes it was already covered with a white earthy pellicle; which continued to form anew for feveral days, as foon as the preceding had been broken by agitation, and thereby caufed to fall down in thin lamellas. When no more was produced, I collected thefe lamellas; and they weighed feven grains after drying. Diffolved vegetable alkali was then added to a part of the water, which had been boiled with burnt ftrontianite. The mixture became milky, and depofited carbonated ftrontian-earth in a fine pulverulent ftate. Into another part of that water I inftilled fulphuric acid, whereby a flocculent fediment of fulphat of ftrontian-earth immediately precipitated. A third portion of this water was mixed with corrofive muriat of mercury (corrofive fublimate), which was immediately decompofed; fo that the metallic oxyd exhibited at firft a brown-red, and, upon farther affufion of water, an orange-yellow-colour.

Therefore, notwithftanding the violent ignition which it had fuftained, only a fmall part of ftrontianite had been deprived of its carbonic acid by this experiment; while the other portion ftill effervefced with acids as ftrongly as the frefh unburnt ftrontianite.

b) For a comparative experiment, I fubjected *one hundred* grains of *witherite* in a porcelain-crucible to the fame degree of red-heat, and for the fame time of five hours.

Its

Its form was no otherwiſe changed thereby, than that its bulk became ſomewhat increaſed; but its tranſparency was entirely gone; and its colour then inclined to a blueiſh milk-white. Nor was its weight found to be conſiderably diminiſhed, by weighing it while yet hot. The water, that had been boiled with it, as in the foregoing experiment, could not be diſtinguiſhed from pure water, neither by the taſte, nor by re-agents. Corroſive ſublimate diſſolved in it without turbidneſs; and it likewiſe continued perfectly limpid, on dropping ſulphuric acid into it. The ignited witherite alſo yielded, on the ſubſequent affuſion of muriatic acid, the ſame quantity of carbonic acid gas, which is extricated from it, when in the crude ſtate.

SECOND EXPERIMENT.

a) I cauſed a piece of *ſtrontianite*, of about half an ounce in weight, to be expoſed, in a clay-crucible, to the moſt vehement heat of the porcelain-furnace. When the veſſel had been returned to me, the ſtrontianite was found to have attacked and diſſolved the clayey maſs of the crucible, and to have run with it into a clear chryſolite-green, very hard, and denſe glaſs.

b) The piece of *witherite*, which, by way of reciprocal experiment, had been expoſed in the ſame manner to the ſame fire, and under the ſame circumſtances, had likewiſe ſtrongly acted on the crucible, and was converted into a hard, greeniſh glaſs, which, however, was not perfectly compact, but held ſome air-bubbles.

I repeated this experiment, but with this variation, that I weighed accurately 100 grains of each of theſe two foſſils; and I alſo exactly noted the weight of the clay-cruci-

 bles,

bles, which had previoufly fuftained a violent ignition. By this vitrification the *ftrontianite* loft 30, and the *witherite* 22 grains; which lofs of weight exactly agrees with the proportion of carbonic acid contained in each of thofe minerals, as will appear from the fequel.

THIRD EXPERIMENT.

a) In order to afcertain the habitudes of *ftrontianite*, when expofed to the degree of heat requifite to the baking of porcelain, and debarred from immediate contact with the crucible, I inferted one piece of it, weighing 160 grains, into a cavity made in a compact piece of charcoal, and clofed that cavity with a ftopper, likewife made of charcoal. This piece of charcoal was then fecured in a well luted melting-pot, which I ordered to be put upon that part of the porcelain furnace, where the fire acts in the moft intenfe degree. Upon opening the pot, which was brought to me from the furnace while yet warm, I found the outfide of the coal in part confumed*, and hence leffened in its volume; but the middle and inner part was not in the leaft impaired. The ftrontianite which had been inclofed in it and burned, re-appeared in its former fhape, without any mark of fufion; but with fome diminution of its brightnefs. Its hardnefs feemed to have increafed, rather than decreafed, and the colour was outwardly changed to a grey. The lofs of weight amounted to 49½ grains, making 31 in the hundred; and by this it appears, that the ftrontianite

* This phenomenon I have always obferved, when employing a fimilar apparatus. The pores of the crucible are probably more opened by the vehemence of the heat; fo that fome confumption of the coal may take place on the outfide.

had

had now been entirely deprived, both of its ſlight portion of water, and likewiſe of all its carbonic acid; as will be confirmed by the ſucceeding experiments.

When it had been reduced to powder, and twice boiled with water (one pound of the fluid each time), it entirely diſſolved in it; leaving only an inconſiderable reſidue, which, beſides ſome adhering coal-duſt, chiefly conſiſted of lamellas of carbonated ſtrontian, which was rapidly regenerated.

In the *firſt* of theſe decoctions, which immediately after filtration had been preſerved in a ſtopped glaſs bottle, there appeared cryſtals in half an hour's time, which viſibly increaſed, and formed an exceedingly beautiful group. Theſe cryſtals were clear and tranſparent, of a needle-ſhaped figure, and aggregated in filiform, knit, or interwoven planes. The whole of them bore reſemblance to the cryſtals of muriated ammoniac: or rather, conſidering the moſtly upright and cellularly implicated facets, which are formed by the accumulation of plumoſe cryſtals, it reſembles the native ſilver of Potoſi, dendritically cryſtallized in large laminas.

However, this cryſtallization of calcined ſtrontian-earth in ſimple water, without the acceſs of other extraneous ſubſtances, is on its own account highly remarkable; even without noticing the beauty of its cryſtals. This phenomenon is entirely new, and the firſt inſtance of an artificial cryſtallization of a ſimple earth in mere water.

The *ſecond* decoction of the burned ſtrontianite, that was kept in another glaſs, likewiſe afforded, after a few days, ſome ſolitary cryſtals. Theſe, however, had not the plumoſe appearance of the foregoing, but were minute, oblong, quadrangular plates, ſharpened on the edges.

The water decanted, proved ſtill of a ſtrong cauſtic taſte, and depoſited carbonat of ſtrontian, when carbonated alkali had been dropped into it. The cryſtals themſelves affected the tongue with the like corroſive taſte. By expoſure to air, they turned opake and milk-white. A part of them, immerſed in muriatic acid, diſſolved in it; yet no air at all was developed; and at the ſame moment I obſerved acicular cryſtals of muriated ſtrontian-earth ſhooting in the ſolution.

By treating *witherite*, on ſeveral repeated experiments, in crucibles formed of charcoal, for the purpoſe of depriving it entirely of its carbonic acid, I could never completely ſucceed. That foſſil penetrated, and in ſome manner conſumed the ſubſtance of the charcoal; and it was again found at the bottom of the outer clay-crucible, in a ſtate of ſemi-fuſion.

FOURTH EXPERIMENT.

a) As, in theſe experiments, I had given the preference to muriatic acid, I firſt endeavoured to aſcertain what quantity of it would be required to diſſolve a certain portion of *ſtrontianite*. With this view I mixed 100 grains of muriatic acid, of 1,140 ſpecific gravity, with 50 grains of water, and introduced into this menſtruum pure fragments of ſtrontianite, weighing, in the whole, 62½ grains. After the acid had been fully ſaturated with it, without the aſſiſtance of heat, there remained ſeven grains; hence 55½ grains were diſſolved and ſpent in the ſaturation of the acid. The action of the acid was vigorous, and the ſolution proceeded with a pretty

pretty ſtrong effervefcence. It was neceſſary to weaken the muriatic acid with half its quantity of water, becauſe, when concentrated and alone, it ſhews but a weak operation.

Guided by this experiment, I took a quantity of muriatic acid ſufficient to diſſolve 100 grains of ſtrontianite, and having diluted it with half its quantity of water, I put it upon the balance, and equipoiſed it on the other ſcale. Theſe 100 grains of ſtrontianite were then gradually conveyed into the menſtruum, and thus the weight of the carbonic acid, diſengaged, was found to be 30 grains.

Therefore, *ſtrontianite* contains, in an *hundred* parts,

Strontian earth	69 $\frac{1}{2}$
Carbonic acid	30
Water	$\frac{1}{2}$
	100

b) To find in the comparative experiment, which I intended to make with *witherite*, the proportion of muriatic acid requiſite to its ſolution and ſaturation, I prepared a mixture of 100 grains of muriatic acid with 200 of water; this degree of dilution being neceſſary, to render that acid capable of acting with full energy upon that mineral, and producing a clear ſolution. Into this mixture were then put 76 grains of witherite, in coarſe pieces. The ſaturation of the acid was accompanied by a ſtrong effervefcence, and only three grains remained undiſſolved. One hundred grains of muriatic acid, therefore, required 73 grains of witherite, to be completely ſaturated; and, conſequently, 17$\frac{1}{2}$ grains more of it than of ſtrontianite.

In confequence of this proportion of muriatic acid to witherite, I now introduced 100 grains of this foffil into a fufficient quantity of that menftruum, which alfo I previoufly brought to an equilibrium upon the balance. When its folution was accomplifhed, the quantity of carbonic acid gas efcaped amounted to 22 grains.

Hence, in *hundred* parts of *witherite* are contained,

Barytes	78
Carbonic acid . . .	22
	100

FIFTH EXPERIMENT.

a) If the muriatic folution of *ftrontianite* be in part evaporated by a low heat, the *middle*, or earthy falt, will fhoot in it into fine, longifh, needle-fhaped, but often, likewife, into larger prifmatic cryftals, which continue perfectly dry in the air, but readily diffolve in water.

If, upon thefe cryftals, a fufficient quantity of ardent fpirit, not too much dephlegmated, be poured, and put in a warm place, they are diffolved by it. The alkohol acquires, by them, the property of burning with a pleafing carmine-red flame, if printing-paper, cotton, and fuch loofe bodies are moiftened with it, and fet on fire.

b) The muriatic folution of *witherite*, on the contrary, yields oblong hexagonal tables of a much more confiderable fpecific gravity; and likewife thefe cryftals require a greater quantity of water to be diffolved than the others. Their folution, in weak fpirit of wine, when fet on fire, does not

ex-

exhibit the leaſt trace of the red colour in the flame, by which that of ſtrontianite is ſo remarkable. The ardent ſpirit burns, in this caſe, only with a yellowiſh-white flame.

SIXTH EXPERIMENT.

a) The ſolution of *ſtrontianite*, in nitric acid, is likewiſe eaſily effected. Out of 100 grains of the foſſil employed, 30 grains of carbonic acid gas were diſengaged, as took place in the fourth experiment, by means of the muriatic acid. The nitrat of ſtrontian, which is afforded by this ſolution, when brought within a ſmaller compaſs, by a ſlow evaporation, forms cryſtals, which are clear and permanent in the air, the fundamental figure of which ſeems to be the double quadrilateral pyramid (octahedron), with its uſual variations.

b) Nitric acid, employed for the ſolution of *witherite*, muſt be more liberally diluted with water, to prevent the too rapid formation of the cryſtals, which would otherwiſe take place. Theſe, likewiſe, ſeem to be nearly octahedrons; they are, however, leſs diſtinct, and, in part, more of a tabular figure. They are, beſides, diſtinguiſhed from thoſe of ſtrontianite, by being leſs clear, and by their dull and opake appearance.

SEVENTH EXPERIMENT.

a) By acetic acid *ſtrontianite* is acted upon with little energy. I boiled vinegar, diſtilled and concentrated by freezing, upon finely ground ſtrontianite, and gently evaporated the liquor filtered off from the undiſſolved reſidue. It afforded ſmall and clear cryſtals, that did not deliqueſce in the air, and the figure of which appears to conſiſt of thin rhombic tables.

b) An

b) An acetic folution of *witherite*, prepared in the fame manner, affumed, at a raifed temperature, a tenacious confiftence, and congealed upon cooling into a mafs, refembling zeolite of the fine fibrous texture. Another folution of this kind, which I left to evaporate fpontaneoufly in a fhallow difh under free accefs of air, I obferved to have cryftallized in recumbent, very beautiful, ramified dendritic figures of a milk-white colour; or, ftrictly fpeaking, it dried in that form. When this *acetite of barytes* had been rediffolved in water, it then fhot into regular and permanent cryftals, forming long, thin, quadrilateral columns, obliquely truncated at their ends.

EIGHTH EXPERIMENT.

a) Upon 60 grains of pulverized *ftrontianite*, introduced in a retort, I poured, by degrees, two ounces of concentrated fulphuric acid. The firft portion that was affufed caufed a great frothing. The contents of the retort were then brought to boiling in a fand-heat. After cooling, the earth was found entirely diffolved, and the folution colourlefs. But it is again decompofed, as foon as any water is added. If only a few drops of water are inftilled into it, it coagulates, and becomes milk-white. One fingle drop of this folution, thrown into four ounces of water, renders this laft turbid, and fulphated ftrontian-earth falls down.

The concentrated folution afforded, after fome days, fmall, bundled, and ftellated cryftallizations, the radii of which, as it feemed, were formed by minute quadrangular columns.

b) In like manner, 60 grains of *witherite* were combined with two ounces of ftrong fulphuric acid. A great effervefcence enfued; and, with the affiftance of boiling heat, a complete folution, as clear as water, was likewife, in this

 cafe,

cafe, produced. Some days after, the greateft part of this folution formed a cryftalline mafs, of very tender fibres. This folution was alfo immediately decompofed by the admixture of water, and fulphat of barytes precipitated.

NINTH EXPERIMENT.

a) I decompofed a folution of 100 grains of *ftrontianite* in muriatic acid, previoufly diluted with fufficient water, by means of mild vegetable alkali. The earth again took up from the precipitating medium that quantity of carbonic acid, of which it was deprived during its folution in the muriatic acid. When edulcorated and dried, it again appeared with its former weight of 100 grains.

b) *Witherite* exhibits the very fame habitude in this point. From 100 grains of it, diffolved in that acid, and afterwards precipitated by carbonat of pot-afh, I likewife recovered 100 grains.

TENTH EXPERIMENT.

It is, however, to be obferved, that in thefe combinations of the refpective earths of the *ftrontianite* and *witherite* with carbonic acid, made by art, this laft conftituent part is not fo obftinately retained by them in a read-heat, as it is when both exift in their natural ftate.

a) For, when I expofed 100 grains of precipitated *ftrontian-earth* to intenfe red-heat during two hours, when upon this I boiled it in two ounces of water, and triturated two grains of corrofive fublimate, with the water filtered off from that decoction, the mercurial oxyd would not diffolve in it, but feparated of a yellow-brown colour.

The

The lofs of weight, fuftained by the ignited ftrontian-earth, I could not determine with certainty, part of it having united with the body of the crucible. But the diminution of weight cannot have been of great importance; fince the torrefied earth ftill vehemently effervefced with acids.

b) Thofe 100 grains of earth that had been precipitated from the folution of *witherite*, and were ignited in the fame manner, adhered to the crucible with ftill greater force. The water, with which that earth was boiled after its ignition, nearly in the fame manner (*a*) precipitated the metallic oxyd from the fublimed corrofive muriat of mercury. Likewife the folution of the precipitated earth in an acid, when poured upon it, was ftill attended with effervefcence.

ELEVENTH EXPERIMENT.

Neither the folution of *ftrontian earth*, nor that of *witherite*, is rendered turbid in the leaft degree, or otherwife altered by cauftic ammoniac, even when affufed in great excefs. But as foon as the flighteft portion of an alkaline carbonat is afterwards fuperadded, an immediate precipitation takes place.

TWELFTH EXPERIMENT.

a) Into a muriatic folution of 100 grains of *ftrontianite* I dropped concentrated fulphuric acid, adding it, by degrees, and till no more precipitate fell down. This, when duly wafhed, and deficcated in the air, amounted to 114 grains. Of this fulphat of ftrontian-earth I digefted 40 grains, in a boiling heat, with eight ounces of water. The undiffolved refidue, collected after cooling and dried, was found to weigh $37\frac{1}{2}$ grains. Therefore, $2\frac{1}{2}$ grains were diffolved by eight

eight ounces of water, which folution, upon the addition of carbonated alkali, yielded a tender precipitate.

b) *One hundred* grains of witherite diffolved in muriatic acid, and precipitated by the fulphuric, furnifhed 120½ grains of fulphat of barytes, after being wafhed and dried in the air.

It is, then, evident, by the refults of thefe experiments, that there fubfifts an abfolute and natural difference between the earth of *ftrontianite* and that of *witherite*, or of barytes in general. For, although both thefe fpecies of earth feem to be nearly of the fame nature, with refpect to their relations to the fulphuric acid, as well as to the force with which they retain the carbonic acid in the fire; neverthelefs many more circumftances exift, which indicate their effential difference. Thefe are, principally,—the lefs fpecific gravity of ftrontianite compared with that of witherite; the difference of the habitudes of the carbonic acid combined with both of them; the various form of the cryftals produced by the combination of thefe earths with the nitric, acetic, and, above all, with the muriatic acid; the power of ftrontian-earth to cryftallize in fimple water; and principally, alfo, the red colour, which the earth of ftrontian imparts to flame in various ways of preparation.

Since, therefore, the *ftrontian-earth* is peculiarly diftinguifhed by the above enumerated properties, as well as in other refpects, there is nothing that can prevent it from being acknowledged and eftablifhed as a *new*, *diftinct*, and *fimple earth*.

XIX.

XIX.

CHEMICAL EXAMINATION

OF

LEPIDOLITE. *

THE foſſil brought into notice, by the name *Lilalite*, was firſt taken for a ſpecies of gypſum, and then for a ſpecies of Zeolite. The firſt account publiſhed of it is that of *Born*, in the *Chemiſche Annalen*, 1791, B. 2. S. 196, where he writes of it as follows.

"At *Rozena*, in Moravia, there are found, between blocks "of granite, uncommonly large and heavy maſſes of a "denſe violet zeolite, whoſe texture, like that of the aven-"turino, exhibits white ſhining lamellas, that, at the firſt "view, might be looked upon as micaceous particles. But "theſe, on more accurate inveſtigation, are found to be "nothing elſe but white lamellas of zeolite, having the "luſtre of the mother of pearl. When ignited between "coals, it fuſes to a porous ſlag. In a ſtrong fire it runs "into a denſe, white glaſs, reſembling wax. At an in-"creaſed heat its colour diſappears, which laſt ſeems to "originate from manganeſe. Some pieces of this foſſil are firmly implanted on quarz; others are traverſed by granite; but, for the moſt part, it is perfectly pure, and its chief conſtituent part is ſilex.

* *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v. 1 St. S. 59.

To

To this defcription, given by *Born*, I may add, that the hardnefs of this ftone is but inconfiderable, as it may be fcraped with the nail of the finger. Notwithftanding this, it is capable of fome polifh when cut into plates.

Its fpecific gravity is but middling, viz. 2,816 *

The opinion of thofe, who thought it to be a fpecies of gypfum, (fulphat of lime) I found totally unfupported. But how juftly this foffil may be ranked with the zeolites, will be underftood from the refult of the prefent analyfis, the fubject of which was its amethyft-red variety.

A.

a) When this foffil is heated to rednefs upon charcoal, before the blow-pipe, it firft frothes up moderately, but foon after it runs into a perfectly fufed milk-white pearl, which, in moft of its parts, is tranfparent; but, if broken by the hammer, yields fragments entirely clear.

b) By a neutral phofphat it is gradually diffolved, and then it fufes into a femi-tranflucid white pearl.

c) Vitrified boracic acid (glafs of borax) diffolves it more readily, and fufes with it into clear colourlefs fpherules.

d) On melting it with foda, in the filver fpoon, it moderately boils, and a mafs, fpeckled red and blue, is produced.

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* The external characters of Lepidolite are defcribed by *Karften*, loc. cit. pag. 71.

e) Expofed

e) Expofed to red-heat, in a fmall crucible, for half an hour, it lofes its amethyftine colour, and that of a light ifabella fucceeds *.

B.

a) *Four hundred* grains of the levigated foffil, mixed with the fame quantity of carbonated pot-afh, were expofed to a moderate red-heat, in a porcelain crucible, for two hours. They did not fufe, but concreted into a confiderably firm mafs, which, being removed from the veffel before cooling, had a dark verdigris colour, and in fome parts an amethyft red. Water which was poured upon it, after grinding, became tinged of a deep grafs-green. A few drops of nitric acid changed this green colour to a rofe-red. But as foon as fulphureous acid has been added, it immediately deftroyed this laft colour, and the fluid, under examination, was rendered colourlefs. This change of colour, therefore, indicated, that the red colour of the foffil is owing to a portion of manganefe.

b) I faturated that alkaline fluid with muriatic acid, added to excefs, and the folution of the foluble parts was affifted by digeftion. This muriatic folution, exhibiting a bright yellow colour, was feparated from the *filiceous earth* by filtration; which laft proved very much inflated, and, when wafhed, deficcated, and ignited, weighed 212 grains.

c) After the muriatic folution had been concentrated, by diftillation from a retort, it ftill depofited fome *filiceous earth*, amounting to four grains after ignition. By its fubfequent

* Concerning the habitudes of Lepidolite, in the fire of the porcelain-furnace, fee N. 54 of the 1ft Effay.

combi-

combination with Pruſſian alkali, a dirty blueiſh precipitate, of a woolly flocculent form, was thrown down, which, upon ignition, gave a reſidue of four grains, conſiſting of intermingled light-brown and grey-white particles. This reſidue was little, if at all, attracted by the magnet. When fuſed with phoſphated alkali, it formed a milk-white and ſemi-tranſlucid pearl. Glaſs of borax gave it firſt a green, and then a garnet red colour. Soda produced with it a black ſcoria, in which, with the help of the microſcope, extremely minute, ſilver-white metallic globules could be ſeen.

The portion of iron that was contained in the quantity of pruſſiated pot-aſh, requiſite to effect that precipitation, makes *one* grain; which being ſubtracted, there remain three grains for the iron and the mangaueſe, conſtituting the metallic contents of the ſtone.

d) I now mixed the ſolution with cauſtic (pure) ammoniac. A copious precipitate, in the form of flour-paſte, fell down, which I directly ſeparated by filtering. When edulcorated, dried, and expoſed to gentle red-heat, it was found to be aluminous earth, of 152 grains in weight.

e) The fluid remaining, after the ſeparation of the argil, was combined with carbonated alkalis; but no new precipitate enſued. Therefore, I evaporated the liquor to dryneſs, diſſolved again the ſaline maſs in water, and collected the ſlight portion of earth which then ſeparated. It weighed three grains, conſiſting of two grains of *ſilex* and one grain of alumine.

In the above decompoſed 400 grains of the foſſil, therefore, exiſted:

R Ignited

Ignited *silex*	B. *b*)	212		
	c)	4	218 gr.	
	e)	2		
Alumine	*d*)	152	153	
	e)	1		
Manganese and oxyded *iron*	*c*)		3	
			374	

Which gives for *one hundred* parts,

Silex	54,50
Alumine	38,25
Manganese and *oxyd of iron*	0,75
	93,50
Loss in *aqueous particles*	6,50
	100

C.

As the fusibility of lepidolite, without addition of any extraneous substance, induced me to suspect, that, among its constituent parts, some *calcareous earth* might be found, I resolved to repeat its analysis.

For this reason, I again subjected 400 grains of it to the same analytical process. Having separated the siliceous earth, the quantity of which was the same in proportion with that of the first process, I treated the solution, then obtained, with mild vegetable alkali, and at a raised temperature. The precipitate produced in the process, and washed, was divided into four equal parts while yet moist.

a) Upon one fourth part I affused *dilute sulphuric acid*, which soon dissolved it into a weak reddish liquor. After a ſhort repoſe, a reddiſh-grey ſediment fell down, which, carefully collected and dried, weighed half a grain, and readily fuſed upon charcoal to a black-grey ſcoria. When a ſmall portion of this laſt had been thrown into melted phoſphoric ſalt, it gradually diſſolved, and gave a green tinge to the ſaline bead. But when the whole of it was put in, the ſmall globule loſt its tranſparency and aſſumed a blue colour. At the ſame time a very minute grey-white metallic grain became diſcernible, which, when ſeparated from the ſpherule, would not obey the magnet. As that metallic bead hardly weighed $\frac{1}{32}$ of a grain, it would not admit of farther inveſtigation. Perhaps it was *phoſpat of iron.* The ſaline bead, by imbibing moiſture, was again diveſted of its blue colour, and turned brown-red.

The ſulphuric ſolution, left in a colourleſs ſtate, after the ſeparation of the above depoſition, was committed to ſpontaneous exhalation; and it then ſhot, by degrees, into perfect cryſtals of alum. At laſt there remained a thickiſh reſidue, which, previouſly diluted with water, and warmed, I combined with vegetable alkali. A ſlight quantity of a looſe, whitiſh precipitate fell down of $\frac{1}{3}$ grain in weight, when edulcorated and dried. By expoſure to air, it acquired a brown colour, and by ignition upon charcoal it became black. Treated with a neutral phoſphat, with the aſſiſtance of the blow-pipe, it ſoon melted to a ſmall globule, which, by turns, appeared colourleſs, when acted on by the inner flame, and amethyſt-red, by the outer-flame. Thus it proved to be *mangane ſe.*

b) Upon another fourth-part of the precipitate, vinegar, diſtilled and concentrated by freezing, was affuſed, and decanted again from it, after 12 hours. In order to try this acetous liquor for calcareous earth, it was divided into three parts, each of which was ſeparately treated; one, with

 oxalic

oxalic acid; another, with *oxalat of pot-aſh*; the third with *ſulphuric acid*. But in no caſe any indication of lime was obſervable; all theſe three trials remaining perfectly clear. The acetous ſolution merely contained ſome of argil, which I precipitated from it by pot-aſh.

c) The third portion of the precipitate, likewiſe before drying, was introduced into heated *cauſtic alkaline lye*: it liquefied in it, leaving a ſmall browniſh reſidue, conſiſting of the above mentioned metallic ingredient of the ſtone, together with a ſlight trace of ſilex.

d) Laſtly, the remaining fourth-part of the yet moiſt precipitate I ſuffered completely to deſiccate in a warm place. The earth was of a milk-white, and weighed 54 grains. It loſt nothing of its colour, and but little of its bulk, by a ſtrong ignition for two hours in a ſmall and covered crucible. But its weight was the more diminiſhed, as it then weighed $37\frac{1}{2}$ grains only.

Therefore, the reſult of the firſt analyſis was confirmed, as to the main point, by this ſecond decompoſition of lepidolite.

But the total abſence of *calcareous earth*, in the mixture of this foſſil, is highly worth remarking. For ſilex and argil, when in their pureſt ſtate, are abſolutely infuſible in any proportion of the mixture; but become fuſible, when lime in a proportionate quantity enters into the combination. On the contrary, the lepidolite, conſiſting merely of ſilex and argil, and without any portion of lime, is of ſo eaſy fuſion, that it properly may be reckoned among the moſt fuſible ſtones.

In many caſes, the metallic oxyds, indeed, likewiſe act as powerful fluxing media; yet, in the preſent inſtance, the metallic

metallic portion is too ſmall to be capable of being conſidered, with any degree of probability, as the cauſe of the fuſibility of this foſſil.

Is there, perhaps, in thoſe argillaceous ſtones that fuſe in the fire, without any admixture either of abſorbent earths or of metallic calces being found in them, ſome hidden principle, promoting their fuſion, which is hitherto unknown, and is of a volatile nature? Fel-ſpar affords an inſtance of them. This ſtone, while continuing in its natural unaltered ſtate, runs into a glaſs; whereas porcelain-clay, which reſults from its decay, is infuſible in the higheſt degree. Therefore, it might not ſeem unreaſonable to ſuppoſe, that during this tranſition of vitrifiable fel-ſpar into infuſible clay, ſome volatile ſubſtance, as yet unknown, and capable of promoting fuſion, might eſcape; did we not, on the contrary, find, by experience, that vitrified fel-ſpar, if again expoſed to fire, enters again into fuſion, in the ſame manner as it did the firſt time.

It remains yet to inveſtigate, whether the lepidolite is juſtly ranked, as *Born* would have it, among the zeolites. When we attempt, in the mineralogical ſyſtem, to ſeparate and to determine the various ſpecies of foſſils, not in a vague manner, but according to fixed characters; the queſtion is, then, in which of its properties does the ſpecifical character of zeolite conſiſt? I think, in the following: that it is moderately hard, and gives no ſparks with ſteel; that, urged by the flame upon charcoal, it is rendered milk-white and opake, ſwelling much at the ſame time, and forming ramoſe excreſcences, yet without actually fuſing into a globule; and that, beſides the ſiliceous and aluminous earths, the calcareous, likewiſe, is an eſſential conſtituent part of it. The mother-of-pearl-like luſtre, the gelatinous coagulum, which it forms with acids, and its phoſphoreſcent nature on ignition, cannot be confidered as any of its effential properties.

Since, therefore, the prefent foffil does not fhew the fame appearances upon charcoal as the zeolite, but as it intumefces but moderately, while, at the fame time, it fufes into a perfect, and, in part, tranflucid, round globule; and, moreover, as it is abfolutely deftitute of lime for one of its conftituent parts, thefe facts afford fufficient ground to diftinguifh it from zeolite, in the fyftematical arrangement of foffils, and to rank it as a diftinct fpecies.

As I entertained fome doubts whether the name *Lilalite*, given to that foffil at its firft introduction into public notice, would bear found criticifm, I recommended, in its ftead, the denomination of *Lepidolite* (fcale-ftone), for its *fpecific name*; becaufe this foffil fhines on its fracture like an aggregate of minute fifh-fcales*.

A particular foffil has lately been difcovered in the vicinity of the lepidolite, which confifts of long columnar

* A more accurate account of the native place of Lepidolite, together with a full defcription of its external characters, may be feen in *Fichtel's Mineralogifche Aufsaetze*, Vienna, 1794, page 226. There the author alfo endeavours to defend the name *Lilalite*, given to this ftone by its firft difcoverer, the Abbé *Poda*, of *Neuhaus*, againft mine, *Lepidolite*. But, in my opinion, that appellation is erroneous: 1ft, becaufe it is againft the common rule to derive the names of *fpecies* from colours, fince thefe are changeable, and fince even this very foffil has already been met with, in various fhades, of *violet blue*, *amethyft red*, and *white*, befides the *lilac* colour, of which the difcoverer firft found it. 2dly, Becaufe the word *Lilalite*, being compounded of the Arabic *(Lilac, Lilach)*, and the Greek *(Lithos*, ftone), is a *nomen hybridum*.

cryfcryſtals, longitudinally ſtriated, and tranſverſing grey-white quarz, and occurs, with various degradrations, of a pale-red colour, in ſome ſpecimens paſſing into the iſabella, and into green. This mineral was pretended, by ſome, to be *cryſtallized lilalite*: but, even without having yet performed a perfect analyſis of it, I am already convinced, that it by no means belongs to that foſſil, but to the *ſhörlaceous beryl*, (ſhörlite,—by Kirwan); with which it agrees not only in its extarnal appearance, but alſo in its habitudes, in the dry way.

XX.

CHEMICAL EXAMINATION

OF

CIMOLITE.

THE *Cimolic earth* (Cimolia Plinii), or the *Cimolite*, as I ſhall call it for the ſake of brevity, belongs to thoſe bodies of the mineral kingdom, of which an hiſtorical knowledge has, indeed, reached our age, from the writings of ancient claſſics, ſuch as *Theophraſtus*, eſpecially, *Dioſcorides* and *Pliny*; but a familiar acquaintance with them has gradually been loſt ſince the time of thoſe authors. We learn from the works of thoſe old naturaliſts, that the Greeks, as well as the Romans, beſides its medical uſe, employed the cimolic earth for technical purpoſes, in the preparation and cleaning of their ſtuffs and wearing apparel. This is ſhewn, among others, in the following paſſage of Pliny* :— *Cretæ plura genera. Ex iis* Cimoliæ *duo ad medicos pertinentia : candidum et ad purpuriſſum inclinans.* And having firſt mentioned its various applications in medicine, he thus continues : *Eſt et alius uſus in veſtibus. Nam ſarda, quæ adfertur e Sardinia, candidis tantum adſumitur, inutilis verſicoloribus : et eſt viliſſima omnium Cimoliæ generum. Pretioſior* Umbrica, *et quam vocant* Saxum.—*Primum abluitur* veſtis Sarda, *dein ſulphure ſuffitur : mox deſquamatur Cimolia, quæ eſt* coloris veri. Fucatus *enim deprehenditur, nigreſcitque, et funditur ſulphure.*' Veros *autem et* pretioſos

* Hiſt. Natural. lib. xxxv. chap. lvii.

co-

colores *emollit Cimolia, et quodam nitore exhilarat contriſtatos ſulphure.*

What later writers have mentioned concerning cimolite (*Agricola**, for inſtance), are mere compilations taken out of thoſe ancient authors. *Tournefort*, however, is to be excepted, who certainly ſaw it in his travels through the Levant, but has erroneouſly taken it for an earth of the calcareous kind, diſtinguiſhed from common calcareous earth, as he thought, by its ſoapy fatneſs.

It is by the kind communication of *John Hawkins, Eſq.* who, in his voyage to the Grecian iſlands, made for the advancement of Natural Hiſtory, has collected the genuine cimolic earth on the iſland *Cimolo* itſelf, or *Argentiera*, as it is called at preſent, that I have been enabled to revive the knowledge of this foſſil, hitherto loſt both to Natural Hiſtory and Technology, and, at the ſame time, to undertake its chemical analyſis.

The *colour* of cimolite is a light greyiſh-white, inclining to pearl-grey. But this colour is ſomewhat changed by expoſure to air, where it acquires a reddiſh tint. It is, therefore, probable, that the *cimolia ad purpuriſſum inclinans*, of *Pliny*, as well as his *candida*, are both one and the ſame ſpecies; ſince the firſt, or the externally reddiſh one, is, on the fracture, as white as the ſecond.

Cimolite is found *maſſive*, and probably it occurs in vaſt ſtrata. Its fracture is *earthy*, *uneven*, and its texture more or leſs *ſlaty*. It is thoroughly *opake*, and does *not ſtain*

* *De Natura Foſſilium*, lib. ii.

confiderably. When fcraped with a knife, it yields fhavings, like fteatites, and the abraided furface is *fmooth*, and of a *greafy luftre.* It adheres pretty firmly to the tongue.

Yet this ftone, though it is fo foft as to be fcraped by the nail, is but with difficulty broken, and, in confequence of this tenacity, not eafily pulverized.

Its fpecific gravity I found exactly double that of water; that is, 2,000.

Small milk-white cryftalline grains of quarz are found here and there fingly diffeminated in its fubftance.

The flaty texture, which, in the dry pieces of cimolite, is often but confufedly, perceived, appears moft diftinctly when they are fteeped in water. Cimolite is immediately penetrated by water, and it then developes itfelf into thin laminæ, of a curved-flaty form.

Cimolite, if triturated with water, diffolves into a foft, pap-like mafs, though not flippery in the ftrict fenfe. *An hundred* grains of it, ground with three ounces of water, affumed the appearance and confiftence of a thickifh cream. When this mafs is left to deficcate in the grinding-difh, it detaches itfelf from its fides, in hard-dried, ribbon-like, and fomewhat flexible bands. In this ftate, cimolite is pulverized with ftill greater difficulty than before.

In order to obtain fome knowledge of the efficacy and utility of cimolite, in a technical view, I partially greafed fmall pieces of filk and woollen cloth with oil of almonds, and covered thofe oily fpots, on both fides, with cimolite, work-

worked by grinding with water to the thicknefs of a liniment. They were then expofed to dry in the air. The next day I dipped thofe ftuffs in water, and faw, with furprize, that, by a flight wafhing, the cimolite, together with all the greafy fpots to which it had been applied, were removed, without leaving the flighteft trace. After drying, the ftuffs were again found poffeffed of their former cleanlinefs, and the original beauty of their colours completely reftored.

Trivial and imperfect as this experiment was, it ferved, however, fully to confirm the technical ufe of cimolite, extolled by the ancient writers: and hence, too, it appears much to furpafs the beft Englifh fuller's earth. To revive the importation of cimolite, as an article of merchandife, would therefore be very defirable for the manufactures fubfervient to our clothing, as well as for common ufe; efpecially for precious ftuffs of delicate colours, that will not well bear the agency of acids and alkaline foaps. Whence, alfo, the inhabitants of *Argentiera* make as much ufe of it, in the wafhing and bleaching of their ftuffs, at this very day, as in remote ages.

To acquire a chemical knowledge of cimolite, I made the following experiments.

A.

a) *Hundred* grains of cimolite, in entire pieces, were expofed, for half an hour, to the fire of the wind-furnace, in a covered crucible. After cooling, it was found grofsly fplit into flaty fragments, of uneven furfaces. This was accompanied, at the commencement of ignition, with a furprifingly ftrong noife. The cimolite acquired, at firft, a brown-

brownifh-grey colour, which, however, again difappeared. It loft 12 grains in weight.

b) Ignited, alone, upon charcoal, before the blow-pipe, it firft turns dark-grey; but, after complete ignition, it again becomes white.

When cimolite is conveyed into *phofphoric falt*, already fufed, it is gradually diffolved by it, and runs into a colourlefs pearl.

Glafs of borax, likewife, diffolves cimolite; but is tinged by it of a light-brown.

Soda fufes with it into a milk-white globule *.

B.

Hundred grains of cimolite were triturated with water, and treated with 300 grains of ftrong fulphuric acid, by which management the white colour of the blended mafs was changed to a pale flefh-red. For the purpofe of feparating the filiceous earth, I evaporated the mixture in a warm temperature, covered it again with water, and fubjected it to digeftion. However, it continued turbid and muddy; fo that I could not fully fucceed in feparating the filex. I, therefore, employed that mixture to convince myfelf of the abfence, or prefence, of magnefia, among the conftituent parts of that foffil. With this view, I faturated it, with the affiftance of heat, with mild calcareous earth,

* The habitudes of cimolite, in the fire of the porcelain-furnace, have been mentioned at No. 27 of the firft effay.

and

and reduced the fluid, when filtered, to a ſmaller bulk, by evaporation; carefully removing, at the ſame time, the ſelenite, as it appeared. Yet no trace of ſulphat of magneſia was perceptible.

C.

a) *Two hundred* grains of cimolite, mixed, and ignited with thrice their quantity of cauſtic pot-aſh, afforded, after cooling, a blueiſh, and greeniſh-white maſs. From this, when ſoftened with water, the undiſſolved part was ſeparated by filtering.

b) The alkaline liquor had no colour. It at firſt continued clear, on being ſaturated with ſulphuric acid; but, at a raiſed temperature, it coagulated to the conſiſtence of jelly. Upon the affuſion of more water, and proper digeſtion, *ſiliceous earth* ſeparated, weighing 44 grains, when ignited.

c) The earth, which was not taken up by the alkali (*a*), was of a grey white, and weighed 220 grains. It diſſolved, by degrees, in ſulphuric acid, which was added to it, and left behind ſome *ſiliceous earth*, which weighed five grains, after ignition.

d) Both the ſulphuric ſolutions (*b*) and (*c*) were next added together, and partly evaporated; after which, cryſtals of alum appeared, as the liquor cooled. The remainder of the fluid congealed, on farther evaporation, to a jelly. When mixed with water, digeſted, and filtered, there remained *ſiliceous earth*, in the form of pellucid vitreous grains, the weight of which, after grinding and ignition, was 64 grains.

e) I

e) I now combined the ſolution with Pruſſian alkali, which produced a deep-blue precipitate; by the quantity of which the proportion of the ferruginous ingredient, in the form of *oxyd of iron*, attractible by the magnet, was determined at 2½ grains.

f) When the portion of iron had been ſeparated, I added a ſmall quantity of vegetable alkali to that part of the ſolution which yet remained. By this treatment, and ſubſequent evaporations, I obtained aluminous cryſtals, in ſucceſſion, to the end. But, at the ſame time, there ſtill ſeparated ſome *ſiliceous earth*, amounting to 13 grains, when heated to redneſs.

g) The whole of the alum (ſulphat of alumine) obtained, was re-diſſolved in water, and the argillaceous earth ſeparated by vegetable alkali. This argil, depurated and gnited, gave 46 gr ains in weight.

Therefore, the above 200 grains of *cimit e* produced:

Ignited *Silex* .	C. *b*)	. 44	126 grains.
	c)	. 5	
	d)	. 64	
	f)	. 13	
Alumine .	*g*)		 46
Ignited *oxyd of iron*	*e*)		. . . . . . 2½
Loſs by ignition	A. *a*)		 24
			198½ grains.

Whence, *one hundred* parts of *cimolite* contain:

Si-

Silex	63
Alumine	23
Oxyd of iron . . .	1,25
Water	12
	99,25

With regard to thefe conftituent parts, and their proportions to each other, the *cimolite* might properly be placed in the mineralogical fyftem along with the common fpecies of clay: but its diftinguifhing character, on which, alfo, its other phyfical properties depend, undoubtedly confifts in the minutely divided ftate of the filiceous ingredient, as well as the moft intimate mixture of this laft with the argillaceous part.

XXI.

CHEMICAL EXAMINATION

OF THE

MAGNESIAN-SPAR (Bitterſpath.)

(Cryſtallized Muricalcite, *Compound Spar*, of Kirwan.)

A*.

AMONG the Tyroleſe foſſils, and thoſe of Salzburg, ſo remarkable by their variety, there occur certain rhombic cryſtals, which are moſt frequently found ſingly interſperſed in a ſlaty chlorite (*Schneideſtein*), mixed with ſilver-grey magneſian lamellas. Thoſe cryſtals have been called *rhomboidal ſpar* on account of their figure, or *magneſian-ſpar* (*Bitter-ſpath*) on account of this ſuppoſed conſtituent part.

The colour of thoſe cryſtals is greyiſh-white, paſſing more or leſs into yellow or reddiſh. They commonly form regular rhombs, from one half to three fourths of an inch thick; but they are alſo found of a greater ſize. Their external ſplendour is only moderate; but internally they poſſeſs a high luſtre. Their fracture is of the ſtraight foliated kind; but the figure of their fragments is rhomboidal. They are moſtly *tranſparent* in a great degree; but the fragments of the larger cryſtals are nearly *pellucid*; and if held againſt the light, they exhibit changing rainbow-

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* *Beobachtungen und Entdeckungen aus der Naturkunde*, vol. v. page 51.

rainbow-colours. Their hardnefs is a medium between that of calcareous-fpar and that of fel-fpar; as the firft may be fcratched by them, but they themfelves may be fcratched by the fecond *.

Their fpecific gravity I have found to be 2,480.

a) An entire piece, weighing 100 grains, was ignited in a covered crucible for two hours; yet, notwithftanding its fparry texture, it remained entire, without flying in pieces. It was rendered afh-grey, and wholly opake, though preferving fome luftre. At the fame time its weight was leffened 45 grains †.

b) The action of mineral acids upon magnefian-fpar, while in grofs fragments, is not perceptible; but if pulverized, they attack and diffolve it gradually, attended with a continued gentle effervefcence. With the fulphuric acid, felenite is generated, and the fupernatant folution is of a pale-reddifh colour. Nitric acid produces a colourlefs folution, and the muriatic acid a yellow one.

But when pieces of calcined magnefian-fpar are employed, the folution goes on rapidly. And in that cafe the nitric acid leaves a metallic refidue behind, which feparates of a brown-red colour.

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* More circumftantial defcriptions of the external characters of this foffil have been given by *Karften* in Beob. u. Entd. a. d. Naturk. vol. v. page 56.—*Born* Catal. d. l. Collect. d. Foffils, vol. i. page 386, with the name, *Chaux magnefiée*;—and *Fichtel.* Minerl. Aufsätze, page 189.

† For the habitudes of *magnefian fpar* in a porcelain-heat, fee N. 16 of the firft Effay.

c) *Three hundred* grains of finely powdered magnefian-fpar, mixed with an equal quantity of pot-afh, were ignited for two hours in a crucible. The mafs returned black out of the fire, except that its middle part was rendered of a dark afh-grey. When triturated, and covered with water, it became light-green. Muriatic acid affufed upon it, in fufficient quantity, diffolved the whole, forming a clear golden-yellow tincture.

d) This folution was decompofed by means of carbonated pot-afh, and with the affiftance of heat. Sulphuric acid was poured upon the precipitate, previoufly diluted with water, in fuch a quantity that the acid was predominant. Abundance of felenite (*fulphat of lime*) was thus produced; which feparated from the remaining fluid.

e) I next evaporated the folution, that remained after the feparation of the felenite, and which contained fulphat of magnefia, and a fmall portion of fulphated oxyd of iron; carrying on the operation, until the faline mafs appeared in a dry ftate. This laft I fubjected to a red-heat for two hours, re-diffolving it afterwards in hot water. Upon the filter there remained a fubtle red-brown oxyd of iron, weighing nine grains, and wholly obeying the magnet.

f) The folution, now freed from the iron, afforded, by cryftallization, a pure fulphat of magnefia; which, when properly decompofed by pot-afh, and with the affiftance of heat, yielded 133 grains of *carbonated magnefia*.

g) The fulphat of lime (*d*), decompofed by diffolved carbonat of pot-afh, furnifhed 160 grains of crude calcareous earth. To examine whether this laft ftill contained any magnefia, I diffolved it again in nitric acid, mixed the folution with cauftic ammoniac, and filtered the precipitate

then

then formed. This immediately diſſolved in ſulphuric acid, which was added, and being precipitated by carbonated pot-aſh, it ſtill yielded three grains of magneſian earth; which ſubtracted, leaves, therefore, 157 grains for the quantity of crude calcareous earth, or *carbonat of lime.*

Conſequently, I obtained from the above 300 grains of the *Tyroleſe magneſian-ſpar:*

Carbonat of lime . .	*g*)	. . . .	157 grs.
Magneſia	*f*) 133 *g*) 3	. .	136
Oxyd of iron, containing ſome manganeſe .	*e*)	. . . .	9
			302 grs.

As no loſs of weight, but rather an exceſs, appears in the ſum of the conſtituent parts, given ſeparately, we may conclude, that thoſe ingredients might, perhaps, have been capable of undergoing a ſtill greater degree of deſiccation.

Therefore *a hundred* parts of *magneſian-ſpar* conſiſt of:

Carbonat of lime	52
Magneſia	45
Oxyd of iron, *impregnated with manganeſe* .	3
	100

B.

Although it is only a few years ſince this foſſil was brought to Vienna by ſome Tyroleſe dealers in minerals of their country, and from thence brought into farther notice; yet it ſeems that Woulfe has already been acquainted with it at an earlier period. For the foſſil, which he examined, and deſcribed in the *Philoſoph. Tranſ.* for 1779* by the name of *compound ſpar*, agrees with the Tyroleſe.

It is alſo proved, that the magneſian-ſpar is found not only on the borders of the Tyroleſe and Salzburg mountains, but likewiſe in other places, by the following examination of a ſpar of that kind, coming from *Taberg*, in *Wermeland*, a province of Sweden.

It occurs in the foſſil, in which I have found it of a grey-white colour, with a ſtrong luſtre, nearly reſembling that of the mother of pearl, in ſemi-pellucid and rhomboidal fragments. With regard to its fracture, it can hardly be diſtinguiſhed from that variety of the Tyroleſe magneſian-ſpar, which furniſhed the ſubject of the foregoing analyſis. The only difference conſiſts in its external form; that is, it does not occur in ſingle interſperſed cryſtals, like the laſt, but in maſſes; and it is accompanied by a green, compact, indurated clay, and a groſs-foliated, deep verdigris-green *talc* (magneſian earth.)

a) A ſmall piece of it, ignited *per ſe* upon charcoal, turns brown without ſplitting. It diſſolves, by fuſion, in a neutral phoſphat, and forms a clear, colourleſs bead. Nearly the ſame effect is produced by *glaſs of borax*. When heated to redneſs with ſoda on the melting-ſpoon, it fuſes into a dull, blueiſh-green globule.

b) *Two hundred* grains, reduced to powder, diſſolved gradually, and with effervеſcence, in the muriatic acid. Cauſtic ammoniac, added to the yellow ſolution, produced a light flocculent precipitate of a dirty green, which on the fil-

* *Kirwan's* Elements of Mineralogy, Lond. 1794. vol. i. p. 92.

tering

tering paper changed to a brown, and, heated to rednefs, yielded $4\frac{1}{2}$ grains of *oxyd of iron*.

c) The folution, now rendered colourlefs, was evaporated to a fmaller compafs, mixed with one third part of alkohol, and combined with as much fulphuric acid as was neceffary to precipitate the filiceous earth from the felenite or gypfum (*fulphat of lime*), which was then feparated, and wafhed with a mixture of alkohol and water.

d) When the whole of the liquor had been again reduced by evaporation, I precipitated its magnefian earth, by means of carbonated pot-afh, affifted by a boiling heat. It did not prove to be as loofe as it ought to have been, and thus it fhewed, that it was not yet pure. Hence, on the affufion of fulphuric acid upon this precipitate, more felenite was depofited, which I added to the firft. The folution, thus freed from it, then afforded pure fulphat of magnefia (*Epfom-falt*), which, re-diffolved and decompofed in a boiling heat, by alkaline carbonat, afforded 50 grains of *carbonated magnefia*.

e) The felenite alfo was decompofed, by boiling with water and carbonated pot-afh. Thus I procured from it 146 grains of mild, or *carbonated calcareous earth*.

This *Swedifh* magnefian-fpar, therefore, contains much lefs magnefia than the *Tyrolefe*; and the proportion of its conftituent parts in one *hundred* is the following:

Carbonat of lime	73
Magnefia	25
Oxyd of iron, containing a little manganefe . . .	2,25
	100,25

 XXII.

XXII.

EXAMINATION

OF THE SUPPOSED

MURIACITE.

THE review of our prefent knowledge of mineral bodies would undoubtedly be much more extenfive, and at the fame time require much fewer corrections, if every newly difcovered foffil were immediately put to the chemical teft, and not received into the fyftematical arrangement, till it had been ftamped with the authentic feal of truth.

The *muriacite* does not feem to be as yet fo generally known, that I may not hope to be able to prevent its farther introduction to the public in an erroneous fhape, by means of the examination which I am going to defcribe.

*Fichtel** gives the following account of it.

Abbé Poda *has lately difcovered a new fpecies of calcareous earth, which, by reafon of its conftituent parts, he calls* muriated lime, or muriacite, *according to the new method of nominating foffils; becaufe that mineral is compofed of calcareous earth, muriatic acid, and water. The miners in the falt-pits at* Hall, *in* Tyrol, *call it* fcaly gypfum (*fchuppiger gyps-ftein.*) *But, befides this difference in its conftituent parts, it is alfo farther diftinguifhed from the compact gypfum:* 1ft, *by its greater hardnefs*; 2dly, *by the quadrilateral,*

---

* See his *Mineralogifche Aufsaetze.* Vienna, 1794, page 228.

rectangular

rectangular ſcales or laminas, of which it is entirely compoſed; *and* 3dly, *by its much more difficult ſolution in water, of which, at a mean temperature, it requires* 4300 *parts. We expect to receive from the Abbé himſelf the circumſtantial deſcription of this new ſpecies of calcareous earth.*

This foſſil the more deſerved a chemical examination, as hereby we might be enabled to underſtand by what means Nature could produce a combination of the earthy ſaline kind, which in the dry as well as in the cryſtallized ſtate is ſo much diſpoſed to deliqueſcence; but which, as here is ſuppoſed, exiſts in a dry and compact ſtate, and at the ſame time requires ſuch an exceſſive quantity of water to be diſſolved.

That ſpecimen, which has been ſent me from *Vienna*, as *genuine muriacite* of *Hall*, in *Tyrol*, is an aggregate of rectangular, four-ſided plates, of a light-grey, black-grey, and in part reddiſh colour, with bright ſpecular ſurfaces; and hence not ill reſembing groſs-foliated hornblende. By the taſte, and partly even by bare inſpection, it betrays an admixture of ſome portion of rock-ſalt. Trituration reduces it to a white-grey powder.

a) Upon *five hundred* grains of it alkohol was poured; which, after 24 hours, I again ſeparated by filtering. The ardent ſpirit continued colourleſs; and when evaporated, it left pure common ſalt, or muriat of ſoda, behind, in the ſtate of dry cryſtals.

b) This being done, water was affuſed upon the powder, until all the ſaline parts were lixiviated. This aqueous ſolution, which was likewiſe colourleſs, being evaporated to dryneſs, left alſo *common ſalt* behind; but contaminated with *gypſum.*

 c) The

c) The falt obtained in both extractions, and added together, weighed 91 grains. By the affufion of *one* part of alkohol, mixed with three of water, all the falt was diffolved, and the refidual *gypfum* amounted to 17 grains. This determines the quantity of the *muriat of foda* at 74 grains.

d) I next treated the powder (which had been previoufly extracted both by alkohol and water) with dilute nitric acid; digefting it gently. Carbonated pot-afh, added to the nitrated fluid which was again feparated, threw down an earth, weighing 26 grains when dried, and confifting of *calcareous earth*, impregnated with iron.

e) The refidue was boiled with water and carbonated pot-afh. The fluid, filtered off, was then faturated with nitric acid. By the addition of muriated barytes, a precipitate was obtained, confifting of fulphat of barytes.

f) Upon the edulcorated refidue I poured again fome nitric acid, which produced a great effervefcence. After due digeftion I feparated the fluid by filtration; and, while yet boiling, I combined it with alkali, by which treatment I obtained 76 grains of *carbonated lime*. But as this laft had exifted in the foffil, in a ftate of combination with the fulphuric acid, mentioned at (*e*), we muft only reckon 120 grains of gypfum, or *fulphat of lime*.

g) What remained, after the extraction with nitric acid, weighed now 265 grains. It was a minute, light-grey, micaceous fand.

In thefe 500 grains of the foffil, therefore, have been found:

Muriat

Muriat of ſoda	*c*)		74
Gypſum	*c*)	17	
	f)	120	137
Carbonat of lime	*d*)		26
Sandy reſidue	*g*)		265
			502 grs.

Hence, the exiſtence of a *native muriat of lime* in the *concrete ſtate*, and alſo the name of *muriacite*, which has been given to it, are incompatible with this reſult.

XXIII.

XXIII.

EXAMINATION

OF THE

NATIVE ALUM

From Mifeno.

THE alum cavern (*grotta di alume*) at the Cape *Mifeno*, near *Naples*, which, as it were, ferves as a laboratory, where Nature alone, unaffifted by art, is conftantly producing perfect alum, has been mentioned only by few of the Naturalifts who have vifited that country. Profeffor *Spallanzani** fays of this remarkable grotto:—*Before the traveller reaches the promontory* Mifeno, *he meets with its harbour, which, there is no doubt, is likewife a crater; as it is furrounded on all fides with eminences. Thofe elevations confift of tufas, and on one fide of them, a little above the fea, there is feen an aperture, made by art, which is called* grotta di Mifeno; *and where fulphat of alumine* (alum) *continually efflorefces. This falt is not known by the natives, or at leaft they pay no attention to it.*

The fubject of the following analyfis has been a portion of the alum of *Mifeno*, collected on the fpot itfelf, and given to me by that worthy naturalift, *John Hawkins*, Efq.

All faline efflorefcences agree in this, that while they continue in the dry ftate, they give no fign of the cryftalline figure, that is *peculiar* to each particular fpecies of falt. They always appear of a fibrous form. For this

* Travels in the Two Sicilies, vol. i.

reafon,

reafon alfo, this efflorefced native alum does not prefent its appropriate octahedral form, but is found in fmall, detached, and roundifh accumulations, of very thin and fhort fibres, poffeffed of a white colour, and filky luftre, though in part intermingled with minute cryftalline grains.

a) *One thoufand* grains of this native alum, diffolved in 10 ounces of boiling water, left 120 grains of a yellowifh-grey earth on the filtering paper.

b) The clear folution, when evaporated for the purpofe of cryftallization, gradually, and alone, afforded 470 grains of pure, clear alum, in octahedral cryftals; although their formation had not been promoted by the addition of pot-afh. At the fame time 25 grains of *felenite* (gypfum) appeared.

c) Thofe 470 grains of cryftallized alum, re-diffolved in water, were decompofed, while yet boiling, by carbonated lime. After the feparation of the gypfum then generated, I evaporated the remaining fluid, along with the wafhings, to a fmaller bulk, and freed it from the felenite, which ftill continued to appear. It yielded 27 grains of *fulphat of pot-afh*.

d) After this, the remainder of the folution of the crude alum, that would no longer fhoot into folid cryftals, was infpiffated, by farther evaporation, to a grey-white, unctuous mafs; being but an imperfect fulphat of alumine. This fubftance might, in the prefent cafe, be confidered as a true *mineral butter* (*Bergbutter*). By affufion of water it formed a fomewhat turbid folution; and, by being then treated with a fmall portion of pot-afh, it yet afforded 290 grains of concrete *cryftals of alum*.

e) The

e) The above 120 grains of earthy refidue (*a*) were boiled with mild vegetable alkali and water. The filtered liquor was then faturated to excefs with muriatic acid, and combined with muriated barytes. Upon which fulphat of barytes fell down.

f) I now drenched in muriatic acid the refidue, that had been boiled with alkali. This laft, again feparated from it by the filter, was next faturated with carbonated pot-afh. *Eleven* grains of a yellowifh earth were then precipitated; which, upon clofer examination, were found to confift of two grains of *oxyd of iron*, and nine grains of *carbonated lime*; which laft, together with that which had been indicated in combination with fulphuric acid by the muriated barytes (*e*), amounted to 15 grains of *felenite*.

g) The final remainder, which had refifted the attack of the muriatic acid, weighed 92 grains, and was a fandy earth, of a greenifh-grey colour, meager, and harfh to the feel.

From 1000 lbs. therefore, of this rough, native *alum from Mifeno*, may be produced, barely by folution in water, and fubfequent cryftallization:

1) *Alum, provided by Nature herfelf with the requifite quantity of pot-afh* . . .	470
2) *Alum, whofe cryftallization is promoted by adding pot-afh*	290
	760 lbs.

When, therefore, *Spallanzani* cenfured the natives for not knowing, or for difregarding this natural product, which is fo eafily procured, and which, with fo little ex-

 pence,

pence, may be made a profitable article of commerce, he was not unſupported by reaſon. This alum of *Miſeno*, it ſhould ſeem, might be of the ſame good quality as that of *Tolfa*; as it can be rendered as free from iron as this laſt, and, as beſides, the proportion of ſulphated pot-aſh would not be greater in it than in the Roman alum.

This portion of ſulphat of pot-aſh, contained in the *alum* from *Miſeno*, occaſions the following queſtion; which indeed it will be ſtill difficult to anſwer at this time.—It is: As this grotto conſiſts merely of volcanic tufa, in which no vegetation takes place, whence does Nature procure the vegetable alkali, requiſite to the generation of the cryſtallizable alum?

Note. Another inſtance of the like daily production of *native alum* occurs at *Solfatara*, where it is procured, and refined after the manner deſcribed by Prof. *Breiſlak*. From the following paſſage of his: *Eſſais Mineralogiques ſur la Solfatare de Pouzzole*, Naples, 1792, page 157, it appears——*That it is upon the ground of the production of theſe ſaline efflorescences, the abundance and richneſs of which are equally ſurprizing, and, likewiſe, of the exceſſive promptitude of their re-production, that it has been reſolved on to eſtabliſh at Solfatara a manufacture of alum, which of late has been put in activity by Joſeph Brentano Cimaroli.*—In the fuller account of it, given page 231, according to which, the aluminous lixivium, by means of boiling, is brought to ſhoot into cryſtals in no longer time than 24 hours, there is no mention made of any artificial addition of pot-aſh. It is therefore probable, that the alum of *Solfatara*, like the above of *Miſeno*, is already by Nature provided with that portion of pot-aſh, which is neceſſary to the production of perfectly cryſtallized alum.

XXIV.

XXIV.

EXAMINATION

OF THE

NATIVE SALT-PETRE (Nitre),

From Molfetta.

THE difcovery of the native falt-petre-mine, or of the *Pulo*, producing nitre at *Molfetta*, in *Apulia*, made by Abbé *Fortis*, in the year 1783, could not fail to attract the attention of naturalifts, in a degree proportionate to the importance of the fubject.

Various philofophers, who have vifited and examined the *Pulo* fince its difcovery, have already given circumftantial defcriptions of the natural ftate of that remarkable pit, as well as an account of the great quantity of nitre which it affords, and of its incomprehenfible daily re-production. As to thefe defcriptions, I fhall refer the reader chiefly to thofe publifhed by Prof. *Zimmermann* of *Brunfwick* *, and by *de Salis Marschlin* †.

The nitre employed in the following analytical experiments was collected by *John Hawkins*, *Efq*, who has examined that nitre-pit in the *March* of 1788, in company

* *Voyage à la Nitrière Naturelle, qui fe trouve à Molfetta*, par M. *Zimmerman*. Paris, 1789.

† *Reifen in Verschiedene Provinzen des Königreichs Neapel.* 1ft vol. Zuric and Leipzig.

with *Zimmermann* and *Fortis.* In the ſpecimens which I was favoured with, the ſalt-petre inveſted fragments of a yellowiſh-white, compact, lime-ſtone, forming the ſtony matter of the *Pulo.* Theſe fragments, detached from the rock in thin layers, are incruſted with the ſalt, to the thickneſs, for the moſt part, of one ſixth of an inch; when it appears in a finely-grained, cryſtalline form, reſembling white refined, or Canary ſugar. On ſome parts of the lime-ſtone I diſcovered thin incruſtations of a finely-fibrous gypſum, which, in ſome places, ſerved as a baſe for the nitre to reſt on.

a) *One Thouſand* grains of this native ſalt-petre, together with the lime-ſtone and gypſum to which it adhered, were covered with boiling water. The remaining lumps of ſtone having been lixiviated, the clear and colourleſs ſolution, thus obtained, was next prepared for cryſtallizing by gentle evaporation. Each ſhooting of the ſalt was accompanied by tender, needle-ſhaped, ſelenitic cryſtals. No *mother-water* remained: but the whole of the ſolution cryſtallized, to the laſt drop, to a perfect priſmatic nitre. The ſelenite, ſeparated from the ſalt as much as was poſſible, weighed 40 grains; whereas the ſalt gave 446 grains.

b) According to reſearches of Profeſſor *Vairo**, this nitre is ſaid to contain common, or ſea-ſalt, in the proportion of 1 to 6. I therefore expected to obtain, beſides the priſmatic cryſtals of the ſalt-petre, ſome ſea-ſalt alſo, in diſtinct, ſolitary cubes: but no trace of it, viſible to the eye, appeared. For this reaſon, I attempted to diſcover its preſence by another method. With this view, I re-diſſolved, in water, the cryſtals of nitre which I had obtained, and

* *Voyage à la Nitrière Natur. Zimmerman*, page 35.

drop-

dropped diſſolved acetite of barytes into the ſolution. By theſe means I obtained a precipitate, conſiſting of 26 grains of ſulphated barytes; which ſhewed, that 18½ grains of ſelenite were ſtill united with the neutral ſalt. When, after this, I tried the nitrous ſolution with muriated ſilver, no more than 4½ grains of hornſilver (*muriat of ſilver*) would precipitate, ſo that the quantity of common ſalt, indicated by this laſt, can be eſtimated at only two grains. By this, the true quantity of perfectly pure nitre has been reduced to 425½ grains.

However, I think it more probable, that the neutral muriat, which was mixed with the native nitre, was not muriated ſoda, but a *muriat of pot-aſh*, or digeſtive ſalt, as it is called.

c) Upon the ſtony ſubſtances remaining after the lixiviation of the crude nitre, and which exactly conſtituted one half of the firſt weight, viz. 500 grains, I poured muriatic acid. The pieces of lime-ſtone diſſolved with great effervefcence; leaving a reſidue of 196 grains behind, which were white gypſum, of delicate fibres. When the ſulphuric acid had been ſeparated from this laſt, by boiling it in water with carbonated pot-aſh, there remanied ſome carbonat of lime, which diſſolved, without any reſidue, in nitric acid.

The *lime-ſtone*, taken up by the muriatic acid, conſequently amounted to 304 grains; and, being ſubjected to farther trial, it proved to be merely calcareous earth, containing a ſmall portion of iron.

Hence, theſe 1000 grains of *nitre from Miſeno*, here decompoſed, have conſiſted of:

Pure

Pure priſmatic nitre .	*b*) . . .		425½ grains.
Muriated neutral ſalt .	*b*) . . .		. 2
Selenite	*a*)	40	
	b)	18½	254½
	c)	196	
Lime-ſtone	*c*) . . .		304
			986
		Loſs .	14
			1000

By the computation of Prof. *Vairo**, the total maſs of ſalt-petre in the *Pulo* ſhould amount to between 30 and 40 thouſand centners, at 100 lb. each; and the ſecond reproduction of it to more than 50 thouſand centners. As, therefore, the alkaline baſe of priſmatic nitre conſtitutes nearly one half of the whole of that compound, it is obvious, that the queſtion which I have intimated at the cloſe of my laſt eſſay, concerning the origin of the vaſt quantity of vegetable alkali, becomes, in the preſent caſe, far more important and intereſting to the naturaliſt. The conjecture, that Nature poſſeſſes means of producing that alkali beyond the limits of the vegetable kingdom, nay, even without any immediate influence of vegetation, acquires, by this ſingular phenomenon, a very high degree of probability.

* Loco Citato. Page 37.

XXV.

CHEMICAL EXAMINATION OF THE *MINERAL SPRINGS*, at *Carlsbad*.

AMONG the hot mineral ſprings of Germany, that at *Carlsbad*, in *Bohemia*, deſerves the particular attention, not only of the phyſician and the philoſopher, but alſo of every individual that has a due ſenſe of the grand ſcenes in nature.

The baſon of the main-ſpring, that wonderful reſervoir, is, perhaps, the only one of its kind, which Nature herſelf has formed of the conſtituent parts of the ſpring, and, at the ſame time, has covered it by a triple marble-vault, fitted for the collection of the mineral waters produced in the neighbouring ſubterraneous laboratory. The boiling main-ſpring, ruſhing, with vehemence, out of the principal apertures of this water-vault, and filling the atmoſphere with vaporous clouds ;—the inceſſant play of the air-bubbles, forcing their way through the ſmaller rifts and fiſſures, and riſing in the form of pearls through the river Töpel, which flows immediately upon a conſiderable part of that vaulted roof of the ſpring:—all this, at the firſt view, invites the mind to reflection ; at which the ſpectator can hardly avoid falling into the pleaſing illuſion of ſeeing Nature, that uſually likes to operate in a hidden manner, working here cloſe at hand, and, as it were, before his eyes.

I think

I think it needlefs to enter into a topographical and phyfical defcription of *Carlsbad*; becaufe there already exift feveral accounts and defcriptions of it. Among thefe, the *Treatife on Carlsbad*, by Dr. *Becher*, may be confidered as the moft capital work. I fhall, therefore, fuppofe the reader acquainted with its contents; which, alfo, in general, I refer to in this effay.

My principal defign is, to ftate our obfervations, and the conftituent parts of the Carlsbad-water, the decompofition of which we attempted* at the fpot itfelf, in July 1789; as well as to compare them with thofe given by Dr. *Becher*. Befides this, I alfo intend to fay fomething of the manner which Nature, probably, adopts, in elaborating this mineral fpring, by way of a fmall addition to the theories that have been already offered on this head.

In our refearches, we confined our experiments to the three principal fprings: the main-fpring, the *new fpring*, and that in the *caftle*. Upon the whole, thefe, like the other collateral fprings that are lefs made ufe of, agree with each other in their conftituent parts, as well as in the proportion of the more fixed parts, which, in all of them, is much the fame. But they differ confiderably from each other in their fhare of carbonic acid; and this variation is regulated by the temperature, which in one fpring exceeds that of another; the quantity of carbonic acid being in the inverfe ratio of that of the heat. And for this reafon, of the above-mentioned three fprings, main-fpring the hotteft of all, and whofe temperature, upon an average, is of 165° of Farenheit's thermometer, contains the leaft of the acid.

* For I had the pleafure of making thefe experiments in company with *Count Gefsler, Chamberlain and Privy-counfellor to the King of Pruffia.*

 The

The ſpring at the caſtle, on the contrary, the temperature of which is raiſed only to 120° or 125° *Farenh.* contains the greateſt portion of carbonic acid*.

To ſave the trouble of a tedious enumeration of the experiments made, I ſhall give only a ſhort deſcription of our method of proceeding, and mention the reſults in a ſummary way.

The conſtituent parts of the mineral-water of Carlsbad are, in general, *carbonat of ſoda*, *ſulphat of ſoda*, (Glauber-ſalt), and *muriat of ſoda*, or common ſalt; beſides theſe, *carbonated lime*, *ſiliceous earth*, and a ſlight trace of *oxyd of iron*: and, laſtly, a proportionate quantity of free, carbonic acid, or, to characterize it more preciſely, of *carbonic acid gas*, ſolely abſorbed by the water; beſides *free caloric.*

On attempting to ſeparate and to catch or obtain the carbonic acid gas, we proceeded in the following manner:— A glaſs-retort, of 23 cubic inches capacity, was filled with 18 cubic inches of water, taken from the pipe of the ſpring-head; and we lodged it immediately in the ſand-pot of a pneumatic diſtilling apparatus, purpoſely placed near that ſpring. The firſt receiver, into which the neck of the retort was inſerted, and the glaſs-cylinder employed to collect the extricating gas, had been filled with hot-water from the ſpring.

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* When we viſited *Carlsbad* a ſecond time in July 1793, we found the temperature of the

Atmoſphere	20	Degrees, Reaumur.
Spring at the caſtle . .	37½	
New-ſpring	48	
Liebschen-ſpring . .	55	
Main-ſpring	55½	

ſpring. Under theſe circumſtances, we expected that the gas would immediately diſengage itſelf, and paſs over, at the very firſt action of the heat on the retort; this, however, happened only a little before the commencement of actual boiling; which laſt we continued until no more air-bubbles came over.

The air collected in the cylinder amounted to 10¾ cubic inches. When, therefore, the five cubic inches of atmoſpheric air, that remained in the retort before the operation, are ſubtracted, the portion of gas, diſengaged from 18 cubic inches of Carlsbad-water, at the main-ſpring, conſiſts of 5¾ cubic-inches. Theſe were entirely abſorbed by lime-water, and a calcareous precipitate was produced; ſo that nothing remained but the five cubic-inches of atmoſpheric air. By this, and by ſeveral other trials, we were convinced that the gas, diſengaged by that mineral water, conſiſts of pure *carbonic acid*; that the ſulphurated hydrogen gas, which various authors have ſuppoſed to exiſt in it, along with the carbonic acid, is never preſent; and that the preſence of *ſulphureous acid*, together with uncombined ſoda, as ſome others have imagined, is not even ſo much as poſſible.

By the ſame management, and under the ſame circumſtances, an equal quantity of the water of the *new-ſpring* afforded nine cubic inches, and of the *ſpring at the caſtle* 9½ cubic inches, of carbonic acid gas.

I will allow that, by this method of collecting and meaſuring the carbonic acid gas, the higheſt degree of accuracy was not, perhaps, ſo certainly obtained as it would have been by properly employing the pneumatic quickſilver apparatus, which, at that time, was not in our power at Carlsbad. Neverthelefs, I am convinced that this method of conducting and collecting the diſengaged gas, through and by means of the hot water of the main-ſpring, inſtead of employing mercury for that purpoſe, cannot have occaſioned any conſiderable difference in the reſult: for water, in general, when of equal temperature with the natural warmth of the Carlsbad main-ſpring, is not capable of abſorbing a notable portion of carbonic acid. And, beſides, ſuch an abſorption of that acid gas could the leſs have taken place in the preſent inſtance, as that water, being naturally impregnated with as much carbonic acid as it can contain, was incapable of taking up an additional quantity of that acid.

If this proportion of carbonic acid, found in the above-mentioned three ſprings at Carlsbad, be compared with that given by Dr. *Becher*, which, calculated to eighteen cubic inches of water, would amount to ſeven cubic inches in the main-ſpring, to $6\frac{1}{5}$ in the new-ſpring, and to 10 in that at the caſtle, there, indeed, occurs a difference; ſince, in our experiments, the carbonic acid extricated from 18 cubic inches of the main-ſpring water meaſured $1\frac{1}{4}$ cubic inch, and from that at the caſtle $\frac{1}{2}$ inch leſs than Dr. Becher's reſults, whereas that obtained from the water of the new ſpring, meaſured $2\frac{1}{5}$ cubic inches more.

But as Dr. *Becher* had the opportunity of employing a quick-ſilver-apparatus, and as, therefore, I have the leſs reaſon to doubt the exactneſs of his experiments, we are, from thence, the more confirmed in the ſuppoſition, that the proportion of the conſtituent parts of mineral waters is not every year, and, perhaps, not every day and hour exactly the ſame, but rather variable. This fact is alſo proved by other phenomena and arguments.

The water of Carlsbad, likewiſe, contains ſome *iron*, the preſence of which can be aſcertained only at the ſpring itſelf; ſince fince the quantity which actually exifts in that fluid is fo exceedingly fmall as to efcape, in a moft rapid and unexpected manner, the fenfes as well as the efficacy of re-agents. And, for this reafon, many perfons have abfolutely doubted the prefence of diffolved iron in thefe fprings. But that they contain it, Dr. *Becher* has demonftrated by the following experiment. He fufpended, by a thread, one half of a nut-gall in a glafs bottle of a narrow neck, and filled the veffel on the very fpot with water of the main-fpring As foon as the water, in the action of filling, came in contact with the nut-gall, it acquired a reddifh colour; but five minutes after, the colour changed to a bright-red, inclining to the violet.

We, likewife, made the fame experiment. Having previoufly fufpended a flice of a gall, by means of a white filk thread, in a glafs-bottle, of 50 cubic inches capacity, we filled it at the main fpring. The water inftantaneoufly turned of a pale red; but after having ftood at reft, for one hour, a purple-red, extremely light, woolly, flocculent fediment fubfided, which left the fuperincumbent liquor clear and colourlefs.

Another bottle, in which one grain of pulverized pure Pruffian alkali had been placed, when likewife filled at the fpring itfelf, fhewed no change or indication of colour. But fome minutes after, when we inftilled fome drops of nitric acid to faturate the predominant foda, the blue colour appeared by degrees; fo that, at length, the water was uniformly tinged blue by it.

The following experiments convinced us, how neceffary it is to perform thefe trials at the fpring itfelf. We had ordered a jug, recently filled, at the main-fpring, and clofely ftopped, to be brought to our lodgings; where we immediately, and before the temperature of the water had been fenfibly lowered, examined it by means of galls, and tincture of galls. But it remained for a while colourlefs; only, by degrees, it inclined a little to a feeble, turbid olive-green; and when afterwards a few drops of nitric acid had been added, the colour paffed into a fhade of a dilute blueifh-black.

But when the water from the main-fpring had cooled more confiderably, it was no more poffible to produce, by any means, any change of colour, or indication of iron.

The water of the *new fpring* afforded the fame phenomena as that of the main-fpring; that is to fay, when the bottle, into which the re-agents had been previoufly introduced, was filled at the fpring itfelf, the water became coloured, and fhewed its ferruginous contents. But when conveyed to our apartment, in well clofed bottles, it was tinged in fome degree, while its original temperature continued; but as foon as the water began to cool, no trace of colour could then be any longer difcovered.

On the contrary, the water from the *fpring at the caftle*, though likewife taken at the fpring itfelf, and there examined, fuffered no change at all.

It now remained to inveftigate the other *fixed* conftituent parts: for this purpofe, we gradually evaporated, with a gentle heat, *one hundred* cubic inches of water, frefhly taken from each of thofe three fprings, down to fome ounces.

We then feparated, by means of filtration, from thefe refidues, thus reduced by evaporation, the *earthy* parts from the *faline*, that were yet held in folution by the water, and wafhed and dried them. This earthly portion confifted of *carbonated lime*, mixed with *filiceous earth*, and a flight trace

of

of *iron*. By digefting it with muriatic acid, the lime and the iron diffolved, and, on the filter, we obtained the filex alone, in a loofe, flimy ftate. The muriatic folution we treated, at firft, with pruffiat of pot-afh, and there immediately appeared blue flocculent particles: however, it was only after fome days that they formed a folid precipitate. When the fupernatant liquors had again become clear and colourlefs, and the precipitate had been feparated upon the filter, we precipitated the calcareous earth from each of them by carbonated ammoniac, edulcorated, and dried it.

We now proceeded to feparate the falts combined in thofe folutions. Taught by experience, that heterogeneous falts, exifting in one common menftruum, can but feldom be feparated, by cryftallization, with due accuracy, efpecially in fmall experiments, we adopted another more certain method; namely, by faturating, firft, the uncombined foda by an acid, and decompofing afterwards the neutral falts by proper fubftances. At the fame time, by other previous experiments, we had difcovered and afcertained the proportions of the ingredients in falts of the fame nature, to be enabled thereby to calculate thofe refults.

Thefe laft mentioned experiments, ferving as ftandard meafures in the prefent purfuit, were principally as follows.

a) Thoufand grains of foda, recently cryftallized and weighed, after drying on printing-paper, loft, when completely deficcated on the fand-bath, 637 grains of weight. Thoufand parts of foda in the ftate of cryftallization, therefore, are equal to 363 parts of the fame alkali, reduced to a powder by a thorough exficcation effected by means of heat.

b) Hundred grains of the fame foda, deprived by heat of its water of cryftallization, required, for their faturation,

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382 grains of ſulphuric acid, compoſed of a mixture of one part of that acid, rectified, and of 1,850 ſpecific gravity, with three parts of diſtilled water.

c) The ſulphat of ſoda, obtained by this ſaturation, and completely dried, by evaporating in a ſand heat, weighed $132\frac{1}{2}$ grains.

d) One *thouſand* grains of ſulphat of ſoda, recently cryſtallized and dried on printing-paper, when exſiccated to the moſt in a ſand-heat, weighed 420 grains.

e) *Hundred* grainsof the above-mentioned glauber-ſalt, diſſolved in water, and decompoſed by an acetic ſolution of barytes, gave 168 grains of waſhed and dried ſulphat of barytes, or regenerated ponderous ſpar. Thouſand parts of the latter, therefore, contain a portion of *ſulphuric acid* equal to $595\frac{1}{4}$ of ſulphated ſoda, that has been deprived by heat of its water of cryſtallization.

f) One *hundred* grains of common ſalt in cryſtals, dried in the air, diſſolved in water, and decompoſed by a nitric ſolution of ſilver, yielded $233\frac{1}{2}$ grains of edulcorated and dried muriat of ſilver, or precipitated hornſilver, as it is called. Whence the quantity of muriatic acid, contained in 1000 parts of this laſt, is equal to $428\frac{1}{4}$ parts of pure and dry muriat of ſoda.

Aſſiſted by theſe diſcoveries, we could now, with certainty, expect the ſucceſs of our attempt without danger of error, by making a proper uſe of them. Thus we firſt inveſtigated the quantity of free or *carbonated ſoda*, by adding to every one of thoſe ſolutions as much of an accurately weighed quantity of ſulphuric acid, of the ſpecific gravity mentioned, (*b*) as was neceſſary to a complete ſaturation, and

and from the portions of the acid employed in thefe proceffes, we computed the quantity of the alkali contained in each of the folutions.

This done, we combined the muriatic folutions with diffolved acetate of barytes, until all precipitation ceafed. From the weight of the *barytic fulphat* then generated, we calculated the quantity of fulphated foda: having, before, fubtracted that portion of it, which had been produced by the faturation of the uncombined foda, and united with the glauber-falt, naturally contained in the fpring.

At laft, we decompofed the common falt, left in the folutions after the feparation of the barytic fulphat, by means of a nitrated folution of filver; and we computed the quantity of that muriated foda from the hornfilver, obtained by the procefs.

It refulted from thefe experiments, that

A) *Hundred* cubic inches of water from the *main-fpring*, at Carlsbad, contain:

Dry carbonated foda	39 grains.
(or, in cryftalline ftate, 107½ gr.)	
Dry native fulphat of foda	70½
(or, in cryftals, 168 gr.)	
Muriat of foda	34⅝
Carbonat of lime	12
Silex	2½
Oxyd of iron, about	⅛
Total . .	158¾ gr.

Carbonic acid gas, 32 cubic inches.

B)

B) *Hundred* cubic inches of the water, taken from the *new-fpring*, contain:

Dry Carbonat of foda	$38\frac{1}{2}$ grains.
(or, cryftallized, 106 gr.)	
Dry native fulphated foda	$66\frac{3}{4}$
(or, cryftallized, 159 gr.)	
Muriat of foda	$32\frac{1}{2}$
Carbonat of lime	$12\frac{3}{8}$
Siliceous earth	$2\frac{1}{4}$
Oxyd of iron, hardly	$\frac{1}{8}$
Total . .	$152\frac{1}{2}$ grains.

Carbonic acid gas, 50 cubic inches.

C) And laftly, an *hundred* cubic inches of water from the *fpring at the caftle* yielded,

Dry corbonat of foda	$37\frac{1}{2}$ grains.
(or, in cryftals, $103\frac{1}{2}$ gr.)	
Dry fulphated foda	$66\frac{1}{2}$
(or, in cryftals, $158\frac{1}{3}$ gr.)	
Muriat of foda	33
Carbonat of Lime	$12\frac{3}{4}$
Silex	$2\frac{1}{8}$
Oxyd of iron, hardly	$\frac{1}{16}$
Total . .	$151\ \frac{15}{16}$ grains.

Carbonic acid gas, 53 cubic inches.

In order to enable any perfon to reduce thefe conftituent parts to certain weights, or to other liquid meafures of the mineral water, I will mention, that the cubic inch, which, in thefe

thefe experiments, has been made the ftandard, is equivalent to 290 grains of diftilled water, (of the genuine medicinal weight of Nurenberg *). The above 100 cubic inches, therefore, with refpect to their folid capacity, are equal to $60\frac{5}{12}$ ounces of water.

On comparing the fixed conftituent parts, difcovered by Count *Gefsler* and *myfelf*, with thofe given by Dr. *Becher*, I fhall notice merely the water of the main-fpring. The quantity of it, which he employed, in every inftance, was fix pounds medicinal weight. Dr. *Becher* obferves, that he means the old apothecary's weight and meafures, formerly ufed there; which is, to that now introduced, as 12 to 14; but I fuppofe that the above is the fame with the ufual medicinal weight, of 12 ounces, or 5760 grains. Therefore, by calculating, according to thefe data, the dry refidue which we fhould have obtained from 6 lb. medicinal weight, or from $119\frac{5}{29}$ cubic inches of water from the main-fpring, would have amounted to $189\frac{27}{145}$ grains; and this very nearly agrees with the 192 grains obtained by Dr. B.; the difference of $2\frac{118}{145}$ being very unimportant, efpecially as he himfelf has alfo obtained three drachms, or 180 grains lefs of this dry refidue from an equal quantity of the main-fpring water. With regard to the *proportion* of the fixed parts to one another, Dr. *Becher* thinks that the feveral conftituent ingredients, in thofe 192 grains, may be divided in the following manner:

Dry foda	53 grains.
—- *Sulphat of foda* . . .	93
Muriat of foaa	26
Calcareous earth	$20\frac{1}{2}$

* Or $278\frac{3}{4}$ grains, *Englifh Troy*, very nearly. Tranfl.

But,

But, according to the reſult of our experiments, the above-mentioned 192 grains of the reſidue of the water from the main-ſpring would afford,

Dried ſoda	$47\frac{1}{4}$ grains.
—— *Sulphat of ſoda*. . . .	$85\frac{1}{4}$
Muriat of ſoda	42
Calcareous earth	$14\frac{1}{2}$
Siliceous earth	3

To explain theſe variations, beſides firſt repeating the obſervation before mentioned, that in mineral waters the proportion of the ingredients is not, at all times, invariably the ſame, I believe the following remark may be of ſome aſſiſtance in elucidating the difference.

a) Dr. *Becher* procured the *ſoda*, which he uſed in his preparatory experiment, by diſſolving, in water, the calcined reſidue of the deſiccated mother-water; and, having cryſtallized it, he conſidered the ſalt obtained, at the third ſhooting, as pure mineral alkali, and employed it accordingly. This, however, cannot eaſily be preſumed to have been perfectly pure, but was probably ſtill mixed with ſome common ſalt; which ſuppoſition ſeems to be ſtrengthened by the figure of the cryſtals, deſcribed as minute-grained and needle-ſhaped. On every account it would, indeed, have been not ſuperfluous to have tried, before-hand, by experiments, the purity of the ſoda, and the total abſence of all neutral ſaline admixtures. For, in proportion as the ſoda employed in the comparative experiment was ſtill rendered impure, by any foreign ſalt, in the ſame ratio muſt the calculation, founded upon it, have given an exceſs of ſoda above the true quantity which enters into the water of the ſpring.

b) That the portion of *common ſalt* was found to be much leſs by Dr. *Becher*, than by us, ariſes from the uncertain

5 method

method which he has employed to feparate the fulphat and muriat of foda, by mere cryftallization; fince the former, efpecially in the laft fhootings, always attracts to itfelf a portion of the latter, which accompanies it in the lye. Therefore,

c) The proportion of the *neutral fulphat* of the fpring, as determined by calculation, muft, for the fame reafon, have appeared greater than it really is.

d) The *filiceous* ingredient in the water of Carlsbad has entirely efcaped the attention of Dr. *Becher*, as it did other authors, who treat of this fpring. This, however, may be excufed, becaufe filex has been formerly confidered as a fubftance totally infoluble in water, and, therefore, has never been fufpected to be a conftituent part of mineral fprings. But it cannot be allowed that this earth is only cafually admixed with the water, and floats in it as a fine fand; for, that it exifts in it in an actual ftate of folution, is evident, from the fwelled, flimy, and tranfparent ftate in which it remains after the folution of the calcareous earth.

Neverthelefs, this quantity of filiceous earth, in Carlsbad water, whofe folvent power over this earth is aided by its temperature, great as it may appear, with regard to other mineral fprings, is, in fact, but inconfiderable, when compared with the filex, contained in a much larger portion, in other hot-fprings; the *Geyfer*, for inftance, in *Iceland*. But it muft alfo be obferved, that the temperature of this laft fo far exceeds that of Carlsbad, that, according to *Troil's* teftimony, even when this immenfe jet of 19 feet in diameter had rifen, as it often does, to the height of 90 feet, its water is ftill found perfectly boiling hot, when it again comes down to the ground.

I fhall

I ſhall now give an eſtimate of the quantities of the conſtituent parts of the water of Carlsbad, taken by its viſitors. The mean number of cups which are drank is 14 in the day, as the daily allowance is from 10 to 18; the immoderate quantity of 30 or 40 cups, and upwards, which were formerly taken, being now laid aſide: one of theſe cups, upon an average, holds nearly 10 cubic inches of water; and, therefore, will hold 140 cubic inches, which contain:

Cryſtallized carbonated ſoda . .	$150\frac{1}{2}$ grains.
——— *Sulphat of ſoda* . .	228
Muriat of ſoda	48
Calcareous earth	$17\frac{1}{3}$
Siliceous earth	$3\frac{1}{2}$
Oxyd of iron	$\frac{1}{4}$

Carbonic acid gas, 45 cubic inches.

The time uſually ſpent in the medicinal uſe of this ſpring is from three to five weeks. If, therefore, we aſſume, at a mean rate, 26 days for the whole of that time, and calculate by it the quantity of water drank by each patient, it will be found to amount to 364 cups, holding 3640 cubic inches of the mineral water, which contain,

Cryſtallized carbonat of ſoda . .	3913 grains.
——— *ſulphat of ſoda* . .	5928
Muriated ſoda	1248
Calcareous earth	450
Siliceous earth	91
Oxyd of iron	$6\frac{1}{2}$

Carbonic acid gas, 1170 cubic inches.

It is not my province to ſpeak of the medicinal effects of the mineral ſpring at Carlsbad. On this ſubject various cele-

celebrated phyficians and writers, as *Fred. Hoffmann*, *Tralles*, *Springsfeld*, *Zückert*, and in particular Dr. *Becher*, the refpectable author of the above-mentioned *Defcription of Carlsbad*, have given fufficient information and inftruction.

On one point, however, I fhall briefly touch. Many perfons, lefs verfed in chemiftry, are of opinion, that the native glauber-falt of this mineral fpring is effentially different from, and preferable to any other fulphat of foda; upon the ground, that a moderate quantity of the water, for inftance 14 cups, in which that neutral falt, calculated in the cryftalline ftate, amounts only to 228 grains, or 12 grains lefs than half an ounce, is found to poffefs a greater aperient power than any other artificial glauber-falt, though taken in greater proportion. But in this ftatement, which is confirmed by experience, we fhould not forget to have due regard to the influence of the foda; becaufe the alkaline fubftances and earths are converted into neutral or middle falts, in the ftomach and firft paffages, whenever, as is moftly the cafe, any acid there predominates, and they thus acquire the cathartic properties of other purging falts. Nay, it is probable that it is owing to this conftituent part of the Carlsbad water that feveral perfons, whofe humours in the ftomach and firft paffages are, perhaps, more difpofed to *alkalefcence* than *acidity*, often experience, on its internal ufe, effects quite contrary to thofe which they expected from its opening power. Moreover, the filiceous ingredient may be frequently an acceffory caufe of the unpleafant effects on the bowels, which the water produces in thofe perfons in whom the *periftaltic motion* is rather languid.

However, thefe, as well as all other medical remarks, I leave to the phyficians, and will allow to myfelf only fome reflections concerning the fubftances, which Nature employs to impregnate the Carlsbad mineral fpring with the above-

 mentioned

mentioned ingredients, and concerning the manner in which, perhaps, it operates in this proceſs. I ſay, *perhaps*, for the ſearching mind of man is not endowed with the faculty of inſpecting the interior and ſecret receſſes of the laboratory of Nature, without danger of error. All that we are able to do, is to ſuſpect, and to draw probable conjectures from phenomena ſimilar to thoſe, which we have had opportunity of perceiving either in the operations of Nature herſelf, or in our ſmall chemical experiments.

The cauſe which produces the heat in the ſprings at Carlsbad is variouſly ſtated by philoſophers. The opinion of a great fire, ſuppoſed to exiſt in the centre of the globe, to which, formerly, all the great phenomena in the ſubterraneous laboratory of Nature, and hence alſo the generation of hot mineral ſprings, have been aſcribed, has, at preſent, ſcarcely any ſupporter. Others would account for that cauſe by the volcanos, which are ſaid to have once exiſted in that country, and, though burned out on the ſurface, are not yet perfectly extinguiſhed beneath. But this, likewiſe, is an ill-founded hypotheſis; as neither a true crater, nor what might have once been the fire-gulph of a volcano, nor any undoubted lavas and other matters ejected from it, can be found there. In fact, the earthy ſcoriæ, met with in the vicinity of Carlsbad are not of a true volcanic origin; and as little may the baſalts, which are there met with, be conſidered as an additional proof of the volcanic nature of that country.

Thoſe naturaliſts ſeem to come nearer to truth, who trace the efficient cauſe of heat in theſe ſprings from ignited ſulphur-pyrites. With this opinion, likewiſe, the celebrated author of the Treatiſe on Carlsbad Water coincides, when explaining the temperature of its ſprings. And, indeed, it cannot be denied, that pyrites act their part in this caſe.

For

For the ſtratum of pyrites, which is only a few miles diſtant from Carlsbad, and from which the ſulphur and vitriol-works at *Altsattel* are plentifully provided with that crude material; beſides, the ſiliceous ingredient diſſeminated in the ſtony mixture of that ſtratum, under which, according to all indications, that ſubterraneous laboratory lies where Nature prepares the mineral water; and, laſtly, thoſe con-ſtituent parts of theſe mineral ſprings, the origin of which we cannot explain from other ſubſtances beſides from ſul-phur-pyrites: all theſe circumſtances coincide to give weight to that opinion.

Yet, on a maturer conſideration, it will ſoon be evident, that the diſſolved pyrites could not alone afford that quan-tity of caloric, which has heated the ſprings at Carlsbad, for ſeveral centuries paſt to this day, with unabated force; but, on the contrary, that, to the production and preſervation of natural hot ſprings in general, another combuſtible matter is required, from which the ſubterraneous fire receives its food. And thus it will be obvious, that this fuel can be no-thing elſe but mineral coal, that remainder of vegetable fragments of the ancient world, locked up in the boſom of the earth, which provident Nature has wiſely reſerved.

When a ſubterraneous ſtore of mineral coal, ſuch as occur in various places in ſtrata, of an enormous thickneſs, has been once ſet on fire, by ignited pyrites or other cauſes (as may eaſily happen, eſpecially where the ſtratum comes out near to the day) the inflammation will then ſpread throughout the whole remaining maſs, with a quicker or ſlower progreſs. A ſpontaneous extinction and complete refrigeration can certainly not be very ſoon expected in that caſe; for the larger the bulk of a burning body is, the longer will the heat, excited by it, continue. If, beſides, it is conſidered, that this immenſe maſs may poſſibly be incloſed by walls of

 rocks,

rocks, impenetrable, and little capable of conducting heat, at the ſame time that the air finds acceſs to it in but a very ſmall degree; it is then eaſy to conceive, that ages muſt paſs before the caloric diſengaged from ſuch an immenſe maſs can be fixed again, and brought to a ſtate of equilibrium with the whole.

But that a mine of mineral coal had once been burning at Carlsbad is a fact, unqueſtionably proved by the earthy ſcoriæ that have been erroneouſly taken for genuine volcanic lavas, by the porcelain-jaſpers, and by the other ſpecies of ſtones and earths, more or leſs changed by fire, covering the fields at *Hohdorf*, *Leſſa*, and other places, in copious quantity, many of which perfectly reſemble the pſeudo-volcanic products of various countries; ſuch, for inſtance, as the ſtratum of mineral coal even now burning at *Duttweiler*, near *Saarbrück*.

Carlsbad, which is ſituated in a narrow, longiſh valley, is on all ſides ſurrounded by mountains of the middle ſize; which, however, little cohere among themſelves. Theſe moſtly conſiſt of granites, of which that variety is the moſt predominant, which conſiſts of much, large, yellowiſh, white rhomboic fel-ſpar, with ſmall black micaceous ſcales, and a little fine grained quarz.

But, cloſe to the *Hirſchenstein*, the higheſt of thoſe mountains, and ſituated ſouth of the town, there ſtretches from the *Guildhall* to the *Bernhards-rock* another range of low mountains, which cannot properly be conſidered as primitive granite, but rather as a rock of later formation: ſince it exhibits a ſtony maſs, a ſecond time formed of fragments of the primeval rock, and conſiſting of a granitic maſs of ſtones, finely grained and rifty, paſſing into a porphyraceous mixture, with finely interſperſed pyrites. It is the

common

common opinion, which is alſo ſupported by various local circumſtances, that underneath this mountainous range, the laboratory lies, where Nature produces that beneficial ſpring. For, not only does the vaulted roof of the baſon, or reſervoir of the main-ſpring, (the breadth of which extends from the Guildhall, along and under the market-place, as well as under the bed of the river *Töpel*, to the church) proceed from the foot of that low rock, but alſo all the other ſprings iſſue from it; beſides, that the warm mineral water oozes out from ſeveral other of its fiſſures and veins. But, if this ſtony matter is granted to be of ſecondary formation, and not a primitive rock, the poſſibility of a mighty ſtratum of mineral coal, lying under it, can no longer be queſtioned.

Now, concerning the generation and origin of thoſe conſtituent parts, with which this hot water is impregnated, and thereby ennobled to the rank of a medicinal ſpring; theſe depend on the *very ſame laws of nature*, which chemiſtry has learnt by experiments to be ſuch, and by which it is guided in imitating the operations of Nature in the ſmall way. Yet, our knowledge, it muſt be confeſſed, is not always ſufficient to comprehend, accurately and diſtinctly, the method which Nature employs in every particular inſtance. Nature, in her great operations, always proceeds in a ſimple way; whereas, we being but humble imitators of that great miſtreſs of chemiſtry, cannot help reſorting to artificial, and thence imperfect proceſſes, whenever we attempt to obtain the ſame products from the ſame principles.

Firſt, as to the origin of the *carbonic acid* in the water of Carlsbad, the opinion of the author of the *Neue Bemerkungen über das Carlsbad*, who deduces the gas of that ſpring from the ſulphur-pyrites themſelves, cannot ſubſiſt;

for, what is extricated from mouldering pyrites is not the carbonic, but the *ſulphureous acid*, combined, according to circumſtances, with *hydrogen gas*. On the contrary, it admits of no doubt, but that *limeſtone* is the principle, which in all caſes, and hence in this alſo, affords the carbonic acid. From the fact already related, that the rock ſeated upon the laboratory of this ſpring is of a younger date, and later formation; it is certain that limeſtone may be preſent at ſome depth; whether it conſiſt of primitive calcareous rock, or of ſtratified calcareous ſtones; and that it actually and neceſſarily there exiſts, is manifeſt from this very daily generation of ſo great a quantity of carbonic acid. But, whether the developement of this elaſtic acid from the limeſtone is effected merely by the heat, or by means of the ſulphuric acid, diſengaged from the diſſolved pyrites, is a queſtion which cannot be *poſitively* anſwered. It is, however, probable, that it is expelled by heat alone.

With regard to the generation of the *neutral ſulphat*, or the *glauber-ſalt*, it undoubtedly cannot take place, but when veins of common ſalt come into contract with diſſolved ſulphur-pyrites. Part of the muriated ſoda is then decompoſed by the ſulphuric acid, and unites with it to a new neutral ſalt, *viz.* the native glauber-ſalt, or ſulphat of ſoda.

And, as the exiſtence of carbonic acid in the Carlsbad water neceſſarily preſuppoſes the preſence of a calcareous ſtratum; the enquiry into the origin of the calcareous earth, diſſolved in this mineral ſpring, is anſwered of itſelf. It is by the ſpontaneous ſeparation of that earth from the water, that the above-mentioned wonderful ſtone-vault, of the great reſervoir, together with the remaining vaſt quantity of variouſly formed ſtalactites and tufas, have been produced, and are daily augmented. Therefore, it is not neceſſary to ſearch in vain, with Dr. *Becher*, and againſt all

rules,

rules, for the origin of the calcareous earth in the mixture of the pyrites; nor to lay any ftrefs on the fmall quantity, which might be an accidental ingredient in the muriated brine, employed by Nature in the production of the mineral fprings at Carlsbad.

But we cannot judge with equal certainty of the method followed by Nature, in generating the uncombined foda exifting in the Carlsbad water; fince, of all the methods, which we are able to employ for the fame purpofe, there is none of fuch a kind that we could fairly fuppofe to be applied in the operations of Nature, who always accomplifhes her ends by the fhorteft ways. It is probable that a long continued influence of the fubterraneous heat, and humid vapours, are alone fufficient to volatilize part of the muriatic acid of the muriated foda, leaving behind the alkaline principle that had been united with it.

On this predominant portion of free foda alfo depends in part the peculiar tafte of Carlsbad water, which, when drank warm, may be compared to a weak meat-broth.

Sulphur-pyrites, *mineral coal*, *limeftone*, and *brine-fprings of muriated foda*, are, therefore, the raw materials made ufe of by Nature in elaborating thofe hot mineral fprings. How enormous the ftore of them muft be, may be conceived by reflecting upon the quantity of water, and its ingredients, which is afforded by the *main-fpring* alone, in the courfe of one year. By the computations of *Dr. Becher*, there iffue 705 *eimers* in an hour, from the five orifices of that fpring; which makes, for one day, 16,920; and hence, for the year, 6,175,800 *eimers*. And, if the *eimer* be taken to be equal to *one half cubic foot*, that quantity amounts to 3,087,900 cubic feet of water. Thefe contain:

	Pounds avardupoiſe.
Cryſtallizable ſoda	746,884
——— *ſulphat of ſoda* . .	1,132,923
Muriat of ſoda	238,209
Calcareous earth	86,020
Siliceous earth	17,369
Oxyd of iron	1,240

Carbonic acid gas 992,539 cubic feet.

And, ſince the quantity of water yielded by the *new-ſpring*, by that *at the mill*, and by the *other ſtreamlets* iſſuing from the clefts of the rifty rock, taken together, may be eſtimated as equal to that afforded ſolely by the main-ſpring; our aſtoniſhment is juſtly excited, on conſidering the immenſe quantity of products which have been ſent forth by thoſe ſprings at Carlsbad, within a term of 420 years; that is, from 1370, which is the period aſſumed in hiſtory for their diſcovery, to 1790.

Yet, no other uſe is made of the great quantity of ſaline contents with which Nature has enriched the Carlsbad-mineral ſprings; except, that yearly, ſeveral hundred pounds of ſulphated ſoda are obtained in the cryſtallized ſtate, by evaporation, and ſold by the name of *Carlsbad-ſalt*. But it would be an object deſerving the exertions of induſtry, if, at the ſame time, pains were taken to recover and employ one part of mineral alkali, or ſoda; inſtead of ſuffering ſo many thouſand pounds of that natural product, ſo valuable with reſpect to our preſent wants, to be unemployed, and carried away into the river *Töpel*.

Before I conclude, I ſhall ſay a few words on a cold *acidulous ſpring*, which is met with behind the brew-houſe, in a granitic rock. This ſpring collects in a ſmall ſhallow baſon, ſituated on the declivity of the rock, and is richly impreg-

impregnated with carbonic acid, that penetrates through the bottom of the bafon, and covers the fluid in a ftratum from four to fix inches thick. Its tafte is fo exceedingly four, that a doubt has arifen, whether that acidity depends merely on the proportion of the carbonic acid. But experiments have fhewn it to contain no other extraneous acid; and the quantity of carbonic acid gas was found to be equal in volume to that of the water itfelf, where 18 cubic inches of water have yielded 18 cubic inches of the gas. This *acidulous fpring* hardly contains any fixed conftituent ingredients: for, when a confiderable quantity of it has been evaporated by the affiftance of heat, a refidue was indeed left, which proved to be a neutral muriat, but fo fmall, as almoft to efcape obfervation.

This valuable, but, at Carlsbad, little efteemed fpring, methinks, deferves to be protected againft the cafual impurities by which it is now liable to be defiled, by a more fuitable inclofure and careful covering; as well as to be more commonly applied, both for *medicinal* and *economical* purpofes.

XXVI.

CHEMICAL EXAMINATION

OF THE

SALT-SPRINGS AT KÖNIGSBORN,

And their Products *.

THE faline fprings, among others, chiefly belong to thofe objects, with the inveftigation of which the induftry of chemifts has been hitherto but little occupied. This want of a more folid and complete knowledge of the conftituent parts of the faline fprings cannot fail to have occafioned a number of erroneous proceffes in the falt-works; and, the neceffity of abolifhing or correcting them, is in general fuggefted only by the lofs experienced for many years. How many errors would have been avoided in the calculations and eftimates, if, for inftance, inftead of employing the *hydrometer*, that deceitful, empirical fcale, which hitherto has been almoft alone reforted to, and trufted, in afcertaining the proportion of falt contained in any brine, the falt-makers had been able to proceed upon the ground of a more certain knowledge, founded on chemical analyfis, of the true faline portion, as well as of the other foreign fubftances, which are the habitual concomitants of common falt? For this reafon, I believe, that by publifhing the prefent inquiry into the faline fprings, and their various products, of the *falt-works* at *Königsborn*, near *Unna*, in

* *Sammlung der Deutfchen Abhandlungen der Königlichen Academie der Wiffenfchaften.* Berlin, 1794.

in *Weſtphalia*, I am contributing, perhaps, not an unimportant ſhare to a general chemical knowledge of ſaline ſprings.

The ſaliniferous mountain at *Königsborn* conſiſts of a compact, marly limeſtone, ſeparated in ſtrata, and diſintegrable in the air, which ſeem to reſt immediately upon the ſand-ſtone, or red *dead* rock *. They extend in a direction from eaſt to weſt, from *Paderborn*, between the river *Lippe* and *Emſche*, as far as the dukedom of *Cleves*; and they decline, from ſouthweſt to northweſt, into the biſhopric of *Münſter*, where they are covered by ſtrata of ſand and loam. The ſalt-ſprings at *Salzlotten*, *Weſtrinkotte*, *Werle*, *Saſſendorf*, and *Unna*, which have been uſed for many centuries paſt, and ſeveral indications of a weak brine, near *Bochum*, in the *Dortmundt* territory, &c. are likewiſe ſituated on the ſame mountains.

The preſent ſalt-work at *Königsborn* lies about one mile (Engliſh) diſtant from *Unna*, to the north, in a plain; accompanied on both ſides by gentle elevations. Wherever the ground is perforated or dug, at and below Königsborn, towards the north, there are always ſalt-ſprings found; but above Königsborn, ſouthwards, ſprings of ſweet water exiſt, which come forth to the day, and even will riſe in pipes to 10 or 12 feet. On this account, the brine has been procured, for many years paſt, by means of ſuch perfora-

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* By the *dead rock* is underſtood the ſtone, or ſubſtance, which lies between the primary and ſecondary ſtrata, and participates of the nature of both. The Germans call it *todt-liegendes*; *Kirwan* calls it *ſemiprotolite*, and likewiſe *deadlier*. See his *Geological Eſſays*. Lond. 1799. page 225; and his *Elements of Mineralogy*. Lond. 1794. vol. i. page 363.—Tranſl.

tions

tions, of which there have been more than twenty, of a depth from 75 to 280 feet. The brine obtained from theſe, at a depth from 50 to 80 feet, always contains from $1\frac{3}{4}$ to two ounces of ſalt in the pound; that from 80 to 120 feet, contains $2\frac{3}{4}$ ounces; but that from 120 to 200 feet, affords $3\frac{1}{4}$, and even $3\frac{1}{2}$ ounces; and it is pumped up to the height of 12 feet above the ſurface, by means of the above-mentioned wooden pipes, in a quantity amounting to from three to four cubic feet every minute. Experience has ſhewn, that this ſaline ſpring has decreaſed in dry weather, in quantity of water, and richneſs of ſalt; but has increaſed, in both reſpects, in wet weather, or when in the midſt of ſummer it has rained only a few days, after a great drought. However, after the lapſe of four or ſix years, the brine has been ſo much impoveriſhed, at every well, as to yield only $1\frac{1}{2}$ ounce of ſalt; although neither the quantity flowing out had increaſed, nor had the brine been otherwiſe altered. As often, therefore, as this happened, a new perforation has been made, by which means a brine, 3 or $3\frac{1}{4}$ ounces, rich in ſalt, was again obtained for ſome time. From this account it would ſeem, that there exiſt three diſtinct ſalt-ſprings lying upon each other; that the deepeſt are the richeſt; which, therefore, by their riſing, force away the upper and lighter ones; and, that theſe laſt muſt be in conjunction with ſome ſtream, the ſweet water of which waſhes a maſs of ſalt, and thereby becomes impregnated with part of it. Hence may be explained the rapid increaſe of the quantity of the fluid, and of its proportion of ſalt, after rainy weather. In conſequence of this conjecture, ſome years ago, ſhafts were ſunk between the ſeveral borings; the lighter ſprings were ſtopped up, and the richeſt were brought out to the day. However, the event was, that by means of this perforation, at the 111th foot in depth, a copious ſpring was come at, but only one ounce in richneſs; which poured into the well, that was already 60 feet deep,

deep, in ſuch quantities, that at every minute 25 cubic feet were to be overcome. On the very day that this ſpring had been pierced, the ſaline contents in the ſeveral brines augmented in all the wells, from $1\frac{1}{4}$ ounce to $1\frac{1}{2}$, 2, and even $2\frac{1}{4}$ ounces. This weak brine, therefore, ſeems to impoveriſh the richer ones, by penetrating through the fiſſures of the marly rock to the perforated cavities; and either keeping off the deeper ſprings of 3 ounces richneſs in ſalt, or mixing with, and thus lowering them down to 1 and $1\frac{1}{2}$ ounce.

To ſhew what quantity of ſalt may be procured from theſe ſprings, I ſhall ſelect the period of three years; namely, from the 1ſt of June, 1788, to the laſt of May, 1791. During that time were procured:

35,521,534 pounds.

This gives for one year:

$11,850,511\frac{1}{3}$ pounds.

By taking into the calculation the loſs occaſioned by the *boiling*, which has been aſcertained by actual experiment, as well as the loſs ariſing from the *graduation* *; which, by eſtimation, is reckoned at 37 *per cent*, there will be required of the brine, to obtain the above produce in each year:

336,069,731 pounds; or,
$4,972,748\frac{1}{3}$ cubic feet.

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* In other words: from evaporating the brine by means of air, previous to their boilings, in particular buildings, called *graduating-houſes*. Conſult *Gren's Principles of Modern Chemiſtry*. Lond. 1800. vol. i. page 294.—Tranſl.

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In ſpeaking of the chemical examination of thoſe ſprings; to avoid unneceſſary repetitions, I ſhall only in general explain the method in which I have proceeded in this inquiry; and, with reſpect to each particular ſpring, &c. I ſhall merely ſtate the reſult of my experiments:

1.) In order to determine the ſpecific gravity of each brine, I meaſured 50 cubic inches (each equal to 290 grains of diſtilled water); weighed, and compared them with the weight of an equal quantity of diſtilled water.

2.) Theſe 50 cubic inches of brine were then evaporated, in a ſand-heat, to a dry reſidue, and the weight of it noted.

3.) Theſe reſidues were then covered in cylindrical glaſs-veſſels, with alkohol, and extracted by means of it during 24 hours, at a moderate temperature, and with repeated ſtirring.

4.) After the alkohol had been again ſeparated by filtration, it was evaporated to dryneſs. Upon the reſidue left by it, freſh ardent ſpirit was affuſed, in ſuch a quantity as was neceſſary to ſeparate the ſmall portion of common ſalt, which had united with the ſpirituous ſolution, at the firſt extraction. After this, the laſt alkohol was likewiſe evaporated, and the reſidue weighed.

5.) That portion which had been extracted by alkohol conſiſted of *murіat of lime*, mixed with a very trifling portion of *muriated magneſia*; the proportion of which laſt was determined in the following manner:—The reſidue, obtained by the evaporation of the alkohol, was diſſolved in water, the ſolution heated, and the earth precipitated by ſoda. This earth, when waſhed, was combined with ſulphuric acid, added in exceſs. After the mixture had ſtood for

for a while in a warm place, and the predominant acid had been again abſorbed by carbonat of lime, which was added for this purpoſe, the liquor was freed from the ſelenite or gypſum then generated, and evaporated by a gentle heat. When the ſelenite, which ſtill appeared, was again ſeparated, and the liquor ſufficiently reduced, the ſolution was expoſed to ſpontaneous exhalation in the open air, and thus made to cryſtallize. The ſulphat of magneſia, produced by this proceſs, was rediſſolved in water, and decompoſed by ſoda; upon which the magneſia, which ſeparated, was ſaturated with muriatic acid, evaporated to dryneſs; and the weight of this muriated magneſia ſubtracted from the muriated lime.

6.) The deſiccated muriat of ſoda, remaining after the ſeparation of thoſe deliqueſcent ſalts, by means of alkohol, was next diſſolved in water, and filtered.

7.) The remainder on the filter conſiſted of *ſulphat* and *carbonat of lime*; and in ſome, brines of *oxyd of iron.*— When weighed, it was treated with muriatic acid, and the ſelenite ſeparated upon the filter. The filtered ſolution, when it appeared to contain a ſeparable portion of iron, was combined with cauſtic ammoniac; and the oxyd of iron, which fell down as a brown flocculent precipitate, when collected by the filter and ignited, was weighed, and its weight reduced to that of carbonated iron.

8.) I combined the muriatic ſolution of No. 6 with carbonat of ſoda, aſſiſted by heat, when a precipitate enſued, conſiſting of carbonated lime. The ſoda, employed for its precipitation, having thus been again neutralized by the muriatic acid, I treated this muriatic ſolution with muriated barytes. From the ſulphat of barytes, obtained by this management, it was obvious that the calcareous earth precipitated,

precipitated, by the carbonated ſoda, from the diſſolved muriat of ſoda, had been combined with ſulphuric acid in the character of *ſelenite.* In like manner, it followed from the proportion, which the quantity of ſulphuric acid bore to the calcareous earth, obtained in a ſtate of combination with it, that the muriatic ſolution contained ſelenite only, and no glauber-ſalt, nor any other alkaline or earthy ſulphat. The total abſence of theſe laſt was alſo confirmed by this; that the dry ſalt gradually diſſolved in a mixture of two parts of alkohol with one of water, which I affuſed upon it; and, that at laſt nothing but ſelenite remained.

The experiments, performed in the manner here explained, gave the following reſults:

A.

Brine of the Varsthauſer-ſpring.

Its ſpecific gravity was 1039 (diſtilled water being 1000).

Fifty cubic inches, evaporated to dryneſs, afforded a grey-white reſidue, weighing 882 grains.

This reſidue conſiſted of:

Muriat of lime	46 grains.
——— *magneſia* . . .	1
Carbonat of lime	12
Selenite, or ſulphat of lime .	25
Muriat of ſoda . . .	798
	882

B.

B.

Brine of the Glückauf-ſpring.

Its ſpecific gravity was found to be 1029.

Fifty cubic inches left a pale-red reſidue of 585 grains, containing:

Muriat of lime	32 grains.
——— *of magneſia* . . .	1
Carbonat of lime	11
Carbonated oxyd of iron .	1
Selenite	18
Muriat of ſoda, or *common ſalt*	522
	585

C.

Brine of the Frederic-anton-ſpring.

Its ſpecific gravity was 1025.

Fifty cubic inches left, by evaporation, 540 grains, of a light-reddiſh reſidue, conſiſting of:

Muriated lime, including a ſcarcely obſervable trace of *muriated magneſia*	20 grains.
Carbonated lime, or crude calcareous earth	$11\frac{1}{2}$
——— *oxyd of iron*	$\frac{1}{2}$
Selenite, or gypſum	14
Muriated ſoda	494
	540

D.

Brine of the Goldener Sonnen-ſpring.

The ſpecific gravity was 1024.

The dry reſidue, yielded by 50 cubic inches, had a light-grey-white colour, and weighed 521 grains. It was reſolved into:

Muriat of lime	30 grains.
——— *of magneſia* . . .	$\frac{1}{2}$
Carbonat of lime	11
Selenite	15
Muriat of ſoda	$464\frac{1}{2}$
	521

E.

Brine of the Ludwigs-ſprings.

Its ſpecific gravity 1023.

The light-reddiſh reſidue, from 50 cubic inches of the evaporated brine, weighed 508 grains, and contained:

Muriat of lime	20 grains.
Carbonated lime	10
——— *oxyd of iron* . .	$\frac{1}{2}$
Selenite	13
Common ſalt, or muriated ſoda	$464\frac{1}{2}$
	508

The

The brine, which is brought up from the various ſalt-ſprings, is conducted into one common reſervoir, from which it is pumped to the top of the *graduating-houſes*, where it is three times *graduated.*

F.

Brine of the firſt graduation.

Its ſpecific gravity roſe to 1060. The reſidue from the evaporation of 50 cubic inches weighed 1285 grains; and conſiſted of:

Muriated lime	65	grains.
——— *magneſia*	$1\frac{1}{2}$	
Carbonated lime, containing ſome iron	$4\frac{1}{2}$	
Sulphated lime, or ſelenite . . .	44	
Muriated ſoda	1170	
	1285	

G.

Brine of the ſecond graduation.

Specific gravity 1076.

Fifty cubic inches, evaporated, gave a reſidue of 1615 grains. This was decompoſed into:

Muriat of lime	75	grains.
——— *of magneſia*	2	
Carbonat of lime	3	
Selenite	48	
Muriat of ſoda	1487	
	1615	

H.

Brine of the third graduation.

Its ſpecific gravity amounted to 1086.

Fifty cubic inches of it have left, upon evaporation, 1850 grains of a dry reſidue, containing :

Muriat of lime	82 grains.
——— *of magneſia*	3
Carbonat of lime	3
Sulphat of lime (ſelenite)	52
Muriat of ſoda (common ſalt) . .	1710
	1850

The ſalt obtained by boiling from theſe *graduated* brines is of two ſorts, of which the one is deſtined for *foreign*, and the other for *home* conſumption. The *firſt* conſiſts, for the moſt part, of conſiderably large, four-ſided, hollow cryſtals, compoſed, in a funnel-like manner, of ſimple cubes of muriated ſoda. Such cryſtals are always formed on the ſurface of the brine, when they can evaporate without agitation. The *ſecond* ſort is externally diſtinguiſhed from the preceding by ſomewhat ſmaller and leſs regular cryſtals.

I.

Common ſalt for exportation.

One pound of it, that had been completely deſiccated with the aſſiſtance of heat, was pulverized, and then

 ex-

examined by the method above-deſcribed. It conſiſted of:

	Oz.	drach.	gr.
Moiſture, expelled by the drying .	—	3	—
Accidental impurities, and ſand . .	—	—	10
Muriated lime	—	—	25
Selenite	—	1	30
Pure muriat of ſoda	15	2	55
	16 Ounces.		

K.

Common ſalt for home-conſumption.

One pound of it, treated as the laſt, contained:

	Oz.	drach.	gr.
Moiſture	—	4	30
Accidental impurities . . .	—	—	18
Muriated lime	—	—	30
Selenite	—	1	35
Pure muriat of ſoda . . .	15	—	7
	16 Ounces.		

L.

Mother-water.

The mother-brine proved to be of conſiderable ſpecific gravity; namely, 1218.

Fifty cubic inches of it, when evaporated, yielded 5440 grains of dry ſalt, which I divided into two parts, ſubjecting each to a ſeparate examination.

1) 2720 grains, or one half of the falt obtained from the mother-water, and decompofed after the manner fo often mentioned, gave:

Muriated calcareous earth . . .	330 grains.
——— *magnefian earth* . . .	420
Sulphated calcareous earth . . .	50
Common falt	1920
	2720

2) The other half of the falt, afforded by 50 cubic inches of the mother-water, I re-diffolved in water, and evaporated the folution to the point of cryftallization. I obtained from it, at five fucceffive fhootings, 4 ounces and 2 drachms of cryftallized muriated foda, but which was ftill contaminated by the mother-water which adhered. For this reafon, I diffolved it once more in water, and cryftallized it anew; by which treatment I then obtained 3 oz. 7 dr. of pure common falt. By this it was rendered evident, that every cubic foot of that mother-water, if treated in the fimple way of cryftallization, would ftill afford 16 or 17 pounds of pure muriat of foda. The mother-water of both cryftallizations was diluted with water, and its earthy portion, precipitated by foda, weighed 544 grains, when wafhed and ignited. This precipitate confifted of *calcareous* and *magnefian* earth; which I feparated, by faturating the mafs with fulphuric acid. When the fulphat of magnefia had been filtered off from the fulphat of lime which was formed at the fame time, I decompofed it by means of foda. The magnefia, then obtained in a pure ftate, and weighing 290 grains, by treating it with muriatic acid, was converted into muriat of magnefia, which, evaporated to drynefs, amounted to 420 grains; exactly as it did in the foregoing procefs.

 This

This portion of muriated magnefia, contained in the mother-water along with the muriated lime, and exceeding the latter in quantity, deferves particular notice. In both brines, in the *graduated* as well as the rough, the muriated magnefia amounted only to the 30th or 40th part of the muriated lime ; in the mother-water, on the contrary, the quantity of the firft exceeds the latter nearly by one fourth part. The caufe of this feems to lie in the following circumftance :—It is cuftomary, at Königsborn, to preferve the mother-water of 4, 5, or more boilings in the boiler. At any fubfequent boiling, therefore, a ftronger heat is required, to promote the cryftallization of the falt ; and when, in this cafe, a part of the bottom of the boiler becomes dry, a portion of the muriated lime is then decompofed, and its earthy bafis becoming *free*, increafes the calcareous earth in the *fchlot*, or incruftation (*pfannenftein*) of the veffel: but the muriatic acid efcapes in vapours, as may diftinctly be perceived by the fmell.

M.

Incruftation of the boiler.

One Ponnd of it, pulverized and dried in a gentle heat, was boiled with 12 lb. of water. The filtered folution was next evaporated to drynefs, and the falt obtained was treated in the method all along mentioned. When the undiffolved, grey-white, earthy refidue was examined, it proved to be a mingled mafs of fulphat of lime, of *carbonated lime containing a little iron*, and of a fandy *filiceous earth.*

The proportion of thefe conftituent parts to each other was found to be as follows:

	Oz.	drach.	gr.
Moiſture	1	6	—
Muriated lime	—	1	10
——— *magneſia*	—	—	10
Muriat of ſoda, with a ſcarcely perceivable *trace of ſulphated ſoda*,	4	4	40
Carbonat of lime	1	2	30
Sandy ſiliceous earth	—	3	30
Sulphat of lime (ſelenite) . . .	7	6	0
	16 Ounces.		

N.

Dornenſtein.

(That is, the earthy and ſaline incruſtations formed on the bruſh-wood in the *graduating* houſes.---Tranſl.)

The *Dornenſtein* of theſe ſalt-works conſiſts of a dark-brown, compact, indurated, ſtony cruſt, ſimilar to the incruſtations at *Carlsbad.*

1.) Of this I boiled *two ounces*, reduced to powder, with a ſufficient quantity of water. This, however, would diſſolve but little; for, after evaporation, there remained only four grains of common ſalt, mixed with iron and ſelenite.

2.) The powder of the ſtone which remained after boiling was ſaturated with muriatic acid. The ſolution was attended with great effervefcence, and, towards the end, was promoted by heat. When filtered, it left ſelenite behind.

3.) This

3.) This muriatic ſolution, combined with cauſtic ammoniac, depoſited a quantity of iron in a flocculent form; the weight of which, firſt aſcertained when collected and ignited, was afterwards reduced to that of carbonated iron.

4.) The ſolution, now perfectly colourleſs, afforded carbonat of lime, by the addition of ſoda.

The proportion of the ingredients in theſe two ounces, or 960 grains of the mentioned *Dornenſtein*, was :

Impure common ſalt . . .	4 grains
Selenite	25
Carbonated oxyd of iron . .	92
——— *calcareous earth* .	828
Moiſture	11
	960

What corrections, or improvements, might be made in the boiling of ſalt in the *ſalt-works* at *Königsborn*, in conſequence of the analyſis here communicated of the ſalt-brines, or ſprings of that place, and their products, I leave to the judgment of practical *halurgiſts*, or ſalt-makers.

But the advantage which the ſcience may derive from the performance and collection of theſe and ſimilar analyſes, cannot be doubted : thereby, not only the ſum of our obſervations hitherto collected, on the nature and conſtituent parts of ſalt-ſprings in general, will be rendered more complete and certain ; but likewiſe the knowledge of the laws of elective attractions of bodies, in particular, will be in-

increafed and corrected. An inftance of this laft is afforded in the prefent analyfis, by the circumftance that, in thefe falt-brines, no glauber-falt is found, but only felenite; although the latter, fituated in the proportion in which it is contained in the mixture, fhould be decompofed according to the laws of affinities: at the fame time that the foda of the common falt fhould combine with the fulphuric acid of the felenite, to form glauber-falt. But it muft be here confidered, that the agency of the attractive forces in bodies likewife depends on the various degrees of temperature: and this is really the cafe in this inftance: for it is fhewn, by experience, that the generation of fulphat of foda from the muriats of lime and foda, or, in other words, the generation of glauber-falt from felenite and common falt, can take place only at a cold, much below the point of freezing; but to fuch a low temperature the falt-fprings are not expofed in their fubterraneous refervoirs and canals. Whence it alfo happened, that when, with this view, I repeated the experiment with 16 ounces of the mafs which incrufted the boiler *(pfannenftein)*, and which, during the winter, had been expofed to the cold, and had, in part, fallen to pieces, the newly-generated glauber-falt immediately appeared. Its quantity, afcertained by means of muriated barytes, and calculated for the cryftalline ftate, did, however, in general, amounted to no more than 36 grains.

Finally, the *carbonic acid* muft alfo be added to the conftituent ingredients in faline fprings. This acid is extricated, in the ufual form of air-bubbles, during the evaporation of the *rough* brine; and its difengagement caufes the feparation of the calcareous earth, now deprived of its folvent. The fame efcape of this volatile acid, and the fame feparation of the calcareous earth, likewife take place when the brines are *graduated*; in which cafe the carbonated

ated calcareous earth, together with the oxyd of iron, ſettles around the bruſh-wood, through which the brine paſſes, and forms the *dornenſtein*. On this account, the *graduated* brines contain a much ſmaller proportion of calcareous earth; which, at the proceſs of boiling, is fully depoſited, and aſſiſts, in combination with the ſelenite, to form the compound with which the boiler is incruſtated. (*Pfannenſtein*).—What concerns the proportion of *carbonic acid*, contained in ſalt-ſprings, in a ſtate of abſorption, I did not, in particular, attempt to aſcertain; as ſuch enquiries cannot be made with any proſpect of ſucceſs, but with brines recently collected, and employed on the ſpot.

XXVII.

XXVII.

CHEMICAL EXAMINATION

OF

SPINELL.

THE *ſpinell* ſeems to belong to thoſe ſpecies of gems, which the antients underſtood by the name *Hyacinth*; as they do not aſcribe to it the yellowiſh red colour, poſſeſſed by our modern hyacinth, but a light violet-red, and alſo a roſe-red. Pliny *, for example, ſays:—" *Multum ab amethyſto diſtat hyacinthus, tamen e vicino deſcendens. Differentia hæc, quod ille emicans in amethyſto fulgor violaceus, dilutus eſt in Hyacintho.*" *Epiphanius* enumerates five ſpecies of hyacinth, the *third* of which he calls NATIBOS †, ſtated by *Salmaſius* to have been of a colour, *qui inter roſeum eſt, et dilutiorem.* That the ſtone, now called hyacinth, has been miſtaken for the hyacinth of the antients, was probably occaſioned by the following paſſage of *Pliny* ‡:—" *Hyacinthos Æthiopia mittit et chryſolythos aureo colore tranſlucentes.*" But if in conſequence of a ſounder criticiſm the context be read thus:—*Marceſcens celerius nominis ſui flore hyacinthus. Æthiopia mittit et chryſolithos*, &c. it is obvious, that the *aureus colour* is referred to the chryſolite, which, as is well known, is the *topaz* of our days, and that it has nothing to do with the *hyacinthus* of the preceding ſentence. In this way, alſo, another apparent contradiction in Pliny is removed.

* Lib. xxxvii. cap. 9.

† From the Arabic word, *Natif*, a red crayon colour. *See Joan. de Laet de Gemmis et Lapidibus.* Lugd. Batav. 1647.

‡ Loc. cit.

The

The reader likewife knows that the fpinell has been hitherto ranked along with the *ruby* as its fecond fpecies, fo that the firft fpecies of that genus has included the true genuine ruby. But fince *Rome de l'Ifle** has directed the attention to the different form of cryftallization of thofe two ftones: obferving that the cryftals of the genuine ruby of *Pegu* are oblong, double, hexahedral pyramids, modern mineralogifts have, upon this ground, ranked the *ruby* under the fapphire, as a red variety of it, and introduced the *fpinell* as a diftinct genus; which feparation is alfo fuggefted by the difference of its hardnefs and fpecific gravity.

Befides thefe diftinctions, the nature of the fracture alfo might ferve to difcriminate the genus. For the texture of the fpinell is lamellar, in triple tranfverfe laminas; the fapphire, on the contrary, exhibits in every direction only a flat conchoidal fracture †.

Yet the fureft way to decide on this point would be by chemical analyfis; which, however, with refpect to the ruby cryftallized in hexhedral pyramids, or the red fapphire, can be at prefent but little hoped for, as it is fo feldom met with in its rough ftate.

The original figure of fpinell is the octahedron, or double four-fided pyramid. This cryftalline figure is frequently found perfectly regular, but as often fubject to many variations, which have been detailed and defcribed with great diligence, and uncommon accuracy, by Abbé *Estner* ‡.

No lefs variable is the colour of the fpinell; as it paffes through almoft all the fhades of the red. This variation

* *Criftallographie*, tom. i. page 213.

† *Estner*, *Mineralogie*, II. B. I. Abth. S. 96, 97.

‡ *Ibidem*, page 73. feq.

of

of colour has induced jewellers, or dealers in gems, to fubdivide the genus of ruby, befides the *genuine ruby*, into *almandin*, *fpinell*, *ballafs*, *and rubicell*, as they ufually do.

The red colour of this gem is not only very fixed, or permanent in the fire, but its pale variations are even ftill more heightened by means of a careful ignition. This property the inhabitants of Ceylon know how to employ to advantage, according to the teftimony of *Julius Scaliger*;* and, perhaps, on this dexterity of art depends the amazingly high and magnificent colour which we admire in fine, polifhed rubies, but do not perceive in the rough, uncut ftones.

To the more uncommon variations of colour belong: 1. the fpinell, quite *colourlefs*, and as limpid as water, of which Mr. *Macie*, in London, poffeffes a perfect octahedron in his collection of cryftals; 2. the *fapphire-blue* fpinell, in the collection of *Francis Greville*, Efq.; and 3. the *green* fpinell, the property of *J. Hawkins*, Efq. likewife in London, &c. &c. This affords a new example, that, in determining the genera and fpecies of gems, colour is to be confidered as only a fubordinate or *fecondary* character.

The fpecific gravity of fpinell I have found to be, in felected cryftals, from 3,570 to 3,590.

Although feveral years ago I attempted and publifhed a chemical analyfis of the fpinell†, I have found fome circumftances then not completely afcertained, which require ano-

* *Exercitationes*, &c. No. cxviii.

† *Beob. u. Entdeck. a. d. Naturkunde*, vol. iii. Berlin, 1789. page 336.

ther

ther analytical procefs. The refult of this has taught me, that on the firft analyfis of the fpinell, I had thoroughly overlooked one of its conftituent parts, which I did not fufpect in it, and which is *magnefian-earth*. Among the various experiments, inftituted for accurately determining the proportion of this newly difcovered ingredient, I felect that in particular, which led the neareft to fulfilling this object.

a) *One hundred* grains of rough fpinell from Ceylon, in picked cryftals, previoufly pounded to a coarfe powder in the fteel-mortar, were triturated with water to an impalpable powder in the grinding-difh made of flint. After the powder of the ftone, which was again dried, had been gently ignited, it fhewed an increafe of weight of nine grains, originating from the particles abraded from the fubftance of the grinding-veffel.

b) I then ftrongly digefted that powder with two ounces of muriatic acid. When the acid had been evaporated nearly to drynefs, I diluted the mafs with water, threw it upon the filter, and faturated the yellow muriatic folution with cauftic ammoniac. A brown flocculent *oxyd of iron* fell down, which, collected and ignited, weighed $1\frac{1}{4}$ grain.

c) The liquor feparated from that precipitate was concentrated by evaporation, perfectly neutralized with muriatic acid, and, laftly, combined with diffolved oxalat of pot-afh (falt of wood-forrel). In confequence of this, oxalat of lime precipitated; which, when carefully collected, and heated to rednefs in the cavity of a compact piece of charcoal, with the affiftance of the blow-pipe, afforded three fourths of a grain of lime, or pure *calcareous earth*. This laft, diffolved in nitric acid, and treated with the fulphuric, produced felenite, or fulphated lime.

d) Upon

d) Upon the powder of the ftone, extracted by the muriatic acid, was poured ten times its quantity of alkaline lye, one half of which confifted of cauftic alkali; which mixture being firft evaporated to drynefs, in a filver-veffel, upon a fand-heat, was afterwards ignited during the fpace of an hour. When the mafs had been again foftened with hot water, it left on the filtering paper 54 grains of an ifabella-yellow refidue when dried in the air.

e) Thefe 54 grains were a fecond time mixed, and infpiffated with a tenfold quantity of the fame cauftic lixivium, and afterwards ignited. Upon which, the mafs, foftened again with water, depofited a refidue of a fine pulverulent form, weighing 43 grains, when dried in the air.

f) I then neutralized the yellow alkaline folution (*d*) and (*e*) by means of fulphuric acid, and by affufing more acid, made a clear folution of the precipitate, which then formed. Carbonat of pot-afh, added in a boiling ftate, threw down from it a precipitate of a very great bulk, which, after edulcoration, was again diffolved in fulphuric acid. This folution exhibited a flimy toughnefs; but it became perfectly fluid, when expofed to a raifed temperature, and depofited a fubtle white powder, which, after wafhing and deficcation in the air, weighed 95 grains. The fulphuric acid fluid, when feparated from it, was fet afide for a time.

g) The above-mentioned 95 grains were then gently ignited with thrice their quantity of cauftic pot-afh. When again liquefied with water, and filtered, there remained only a flight refidue, which, after wafhing, diffolved in fulphuric acid, with the exception of a few remaining particles.

h) The

h) The portion taken up by the cauftic pot-afh in the alkaline folution (*g*), was precipitated by means of fulphuric acid. But it diffolved again in the acid, when added to excefs, and was afterwards precipitated by boiling with mild, or carbonated alkali. This precipitate, previoufly wafhed, was once more diffolved in fulphuric acid.

i) The whole of the fulphuric folutions, obtained at (*f*, *g*, *h*), was evaporated to a fmaller compafs. The gelatinus confiftence, into which it congealed, fhewed that a feparation of filiceous earth had taken place. It was therefore largely diluted with water, digefted, and the filex collected upon the filter.

k) This done, the fulphuric folution was put in a ftate to cryftallize, by dropping into it a folution of acetite of pot-afh*, and evaporating it flowly. It yielded at firft regular and pure cryftals of alum. But as the folution affumed a green colour towards the end, I combined it with Pruffian alkali. A trifling precipitation enfued, of which the *oxyd of iron* could not be eftimated more than at one fourth of a grain. The folution, being now freed of its ferruginous ingredient, was next decompofed, in a boiling heat, by carbonated pot-afh; and the precipitate, when diffolved anew in fulphuric acid, was brought to a final cryftallization; after which the fulphat of alumine then obtained was added to the foregoing.

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* *Note.* In order to add the vegetable alkali in the juft proportion requifite to promote the cryftallization of the fulphated alumine, I find it at prefent moft convenient to employ that alkali in a ftate of faturation with acetic acid. By this manner I avoid the danger of decompofing a part of the alum juft forming, by the quantity of alkali, that may eafily happen to be added in excefs.

l) I now proceeded to the analyſis of the 43 grains, that were left undiſſolved by the cauſtic alkaline lye (*e*). Theſe readily diſſolved in dilute ſulphuric acid, leaving ſome ſiliceous earth behind. The ſolution, ſeparated from this laſt, was then combined with a ſmall portion of acetated pot-aſh, and expoſed to ſpontaneous cryſtallization by exhalation in the open air. At firſt there yet appeared ſome ſolitary cryſtals of alum; but afterwards it entirely ſhot into *ſulphat of magneſia* (Epſom ſalt).

m) To ſeparate the ſulphated magneſia, thus obtained, from the admixed ſulphat of alumine, it was ſtrongly ignited in a porcelain-veſſel during half an hour, and the ſaline maſs afterwards ſoftened in water, and filtered. The aluminous, or argillaceous earth, ſeparated by this management, was afterwards diſſolved in ſulphuric acid, and in the proper manner cryſtallized into concrete alum.

n) The pure ſolution of the ſulphated magneſia was precipitated in a boiling heat by means of vegetable alkali. The *magneſian earth*, thus obtained in a carbonated ſtate, weighed $20\frac{1}{2}$ grains, when waſhed and dried; but after ſtrong ignition it weighed only $8\frac{1}{4}$ grains.

o) All the waſhings (of which that at (*f*), on precipitating the ſulphuric ſolution by carbonat of pot-aſh, retained the yellow colour of the firſt ſolution) were, together, evaporated to a dry ſaline maſs. When they had been re-diſſolved in water, there ſtill ſeparated a little earth, which, along with the precipitate remaining at (*g*), was ignited with cauſtic pot-aſh, and then by ſulphuric acid reſolved into *aluminous* and *ſiliceous* earths.

p) The whole quantity of alum obtained at (*k*, *l*, *m*, and *o*) amounted to 665 grains. It was now diſſolved in water, and

and in a heat of ebullition decompofed by carbonated alkali prepared from tartar. The *aluminous earth*, thus obtained, when edulcorated with water, and dried in a moderate warmth, weighed 221 grains. But, after being purified by digeftion with diftilled vinegar, and fubfequent faturation with ammoniac, and being again edulcorated, and at laft fubjected for half an hour to an intenfe red heat, it weighed no more than 74½ grains.

q) I then ignited, for half an hour, the whole of the *filiceous earth* collected from (*i*, *l*, *o*). Its weight was 24½ grains. Hence, fubtracting the nine grains which had been abraded from the flint-mortar (*a*), there remain 15½ grains belonging to the fpinell.

From this analyfis it follows, that the conftituent parts of the *fpinell* in the *hundred* are:

Alumine	*p*)	. . . . . .	74,50
Silex	*q*)	. . . . . .	15,50
Magnefia	*n*)	. . . . . .	8,25
Oxyd of iron . . .	*b*) 1,25 *k*) 0,25	. . .	1,50
Lime	*c*)	. . . . . .	0,75
			100,50

The reafon why, in this inftance, there appears in the fum of the weights an excefs of half a grain, rather than a lofs, unavoidable in the ufual courfe of fuch proceffes, is probably, that the ignition was not powerful enough to effect in thofe ingredients that high degree of drynefs, which that ftone poffeffes in its natural, undecompofed ftate.

 With

With regard to another analytical procefs madé with fpinell, and of which it would be fuperfluous to give a detailed defcription, as it only ferved to pave the way to the foregoing, I fhall here merely relate the following phenomenon.—When the cohefion of the parts which conftitute that ftone had been loofened by alternate treatment with cauftic pot-afh and muriatic acid, I introduced the earth, precipitated by ammoniac from the muriatic folution, into cauftic alkaline lye. It diffolved therein for the moft part, but not wholly. The undiffolved remainder was upon this diffolved in muriatic acid; and when the filiceous earth, which then appeared, had been removed, the fluid was again evaporated to a fmaller volume.

After fome days ftanding, there appeared in it a quantity of fmall cryftalline groups, confifting of clear, and feemingly quadrilateral, fomewhat flattened, little columns; the greater number of which were joined by two and two, in the form of an X, but the others in groups of three, and more, in a ftellated manner.

Thefe cryftals readily diffolved in water. The precipitate, thrown down by cauftic ammoniac, was of a light-brown, on account of fome portion of iron, which ftill adhered. It was then diffolved in fulphuric acid, and this new combination was again fet to cryftallize in the floweft manner. At firft there appeared cryftals of alum; but the remainder of the folution gradually fhot into four-fided columnar cryftals of fulphated magnefia.

It is this cryftallization of *magnefia*, mixed with *alumine* in muriatic acid, which I think worth remarking.

XXVIII.

XXVIII.

CHEMICAL EXAMINATION OF THE *EMERALD from Peru.*

THE *emerald* is one of the beſt known gems, and it has been reckoned even in remote antiquity among the moſt eſteemed precious ſtones, on account of its rich green colour, ſo grateful to the eye. *Pliny* enumerates *twelve* ſpecies of it, and conſiders the *Scythian*, *Bactrian*, and *Egyptian*, as the moſt eminent. However, it can hardly be doubted, but that, in thoſe days, various eſſentially different ſpecies of ſtones of a green colour were compriſed under that name; as is frequently done in our days. The acquaintance of Mineralogiſts with the genuine emeralds, which were furniſhed by the parts of the globe the longeſt known, ſeems at preſent to be almoſt entirely obliterated by our familiarity with thoſe which are found, though ſparingly, in the provinces of *South-America*, and *principally* in *Peru*.

a) For the following analyſis I made uſe of the crude, cryſtallized emerald, of a high graſs-green colour, from *Peru**. I pounded it in a ſteel-mortar to a coarſe powder, and triturated *one hundred* grains of that powder very finely

* For the ſpecimen of emerald ſacrificed to this analytical proceſs, I am indebted to the liberal kindneſs of Prince *Dimitri Gallitzin*, whoſe zeal for the ſtudy of Mineralogy is moſt honourably known.

with water, in the flint grinding-diſh. After gentle ignition, I found its weight increaſed by about 1½ grain.

b) The powder of the ſtone was covered, and ſeveral times digeſted in a ſtrong heat, with muriatic acid; which immediately acquired a yellow colour. After having again filtered off the acid, I ſaturated it to exceſs with cauſtic ammoniac; and by this management there ſeparated light, brown flocculi, which, collected and ignited, weighed half a grain, and were *oxyd of iron*. The fluid was next evaporated to a part, and treated with carbonated ammoniac. But it continued clear, and thus ſhewed, that it contained no calcareous earth.

c) *Fourteen* drachms of cauſtic alkaline lye, made of ſeven drachms of the ſalt diſſolved in as many of water, were then affuſed upon the powder of the ſtone extracted by the muriatic acid (*b*); and after the maſs had been previouſly evaporated to dryneſs in a ſilver-crucible, I ſubjected it to a red-heat for half an hour. However, it would not fuſe, but appeared, after ignition, in an intumeſced, friable ſtate, and of a white colour.

d) On being ſoftened with water, and treated with abundance of muriatic acid, it afforded a very limpid ſolution, from which the earthy ingredient was precipitated by carbonated pot-aſh, with the aſſiſtance of heat. The precipitate had a granular form; and when finely ground, the greateſt part ſeemed to diſſolve in muriatic acid, which was poured upon it. But as ſoon as the mixture had been expoſed to a digeſting heat, it coagulated to a tranſparent thick jelly. When diluted, and digeſted with more water, it depoſited ſiliceous earth to the amount of 67 grains, after waſhing and ignition. This earth was then mixed with four parts of carbonated pot-aſh, and ignited to an incipient fuſion,

fusion, in a crucible made of silver. Upon the mass, re-dissolved in water, which afforded a somewhat turbid solution, I poured muriatic acid to an excess of saturation, and digested them together. The *siliceous earth*, which I thus recovered, was now perfectly pure, and weighed 63½ grains, after having sustained a red heat.

e) The muriatic solution, separated from this silex, together with the preceding (*b*), was saturated with an over-proportion of caustic ammoniac. The paste-like precipitate, thence arising, was immediately removed, and the filtered liquor combined with carbonat of ammoniac; which, however, would throw down nothing more. Sulphuric acid quickly dissolved this precipitate. By the addition of a little acetite of pot-ash, the whole of the solution yielded crystallized alum, with the exception of some *silex*, which still separated, and weighed 4½ grains, after ignition.

f) From the above sulphat of alumine (*e*) being re-dissolved in water, I precipitated the argil by carbonated pot-ash. When the earth had been again desiccated, I poured upon it distilled vinegar; put the whole in a warm place; saturated the acetic acid with caustic ammoniac; and, lastly, filtered the mixture. What remained of the fluid suffered no alteration, either by carbonat of ammoniac, or by carbonat of soda. The *aluminous earth*, now obtained in a state of purity, was first dried, then ignited, and found to weigh 31¼ grains.

Therefore, the constituent parts of *one hundred* grains of *Peruvian emerald*, here decomposed, yielded:

Silex	*d*)	. $63\frac{1}{2}$ grains		
	c)	. $4\frac{1}{4}$		
		$67\frac{3}{4}$		
Subtract . . .	*a*)	. $1\frac{1}{2}$		
		$66\frac{1}{4}$	. . .	66,25
Alumine, or argil .	*f*)	. . . . . .		31,25
Oxyd of iron . .	*b*)	. . . . . .		0,50
				98

XXIX.

XXIX.

CHEMICAL EXAMINATION

OF THE

BOHEMIAN GARNET.

THE denomination *garnet* ferved to the elder Mineralogifts as a generic, or *collective-name*, in which they included almoft all roundifh cryftalline forms, encompaffed by defined lateral facets, or all the fpecies of ftones, of, as they were called, a polyhedral cryftallization. At prefent, however, the *generic name*, *garnet*, has been confined within narrower limits; for the *white* garnet, as well as the *black*, have been juftly removed from it, and arranged as diftinct genera: the firft under the name *Leucite*; the fecond under that of *Melanite*.

It may alfo be forefeen, that feveral other foffils now claffed as fpecies, or as varieties of the garnet, befides thofe laft mentioned, will in time receive another place in the fyftematic arrangement of minerals: in confequence of more accurate obfervations concerning the deviation, not only with regard to their external appearance, but likewife with regard to their chemical conftituent parts, by which they are diftinguifhed from the true and ftrictly determined principal genera, to which laft the Bohemian garnet principally belongs.

The *Bohemian garnet*, (whofe occurrence, method of procuring it from the mines, and external characters, are too well known to require any farther illuftration in this place),

place), when weighed in water, loſt 269 parts of 1000 of its abſolute weight; its ſpecific gravity therefore is = 3,718.

It fuſes by itſelf alone in a proportionate intenſity of heat*. The iron which it contains is reduced to the reguline ſtate, when expoſed to the action of fire in the charcoal-crucible. From 100 grains of Bohemian garnet I obtained a button of iron, of $10\frac{1}{8}$ grains weight.

In order to find out its conſtituent parts, I ſubjected it to the following experiments.

a) I ground *two hundred* grains of Bohemian garnet, previouſly pounded in the ſteel-mortar, with water, to a ſubtle powder, in the flint triturating diſh. When dried, and gently ignited, the powder of the ſtone was found increaſed in weight by ſeven grains. I inſpiſſated it with a lixivium, made of 600 grains of cauſtic pot-aſh, in a ſilver-crucible, and ignited it afterwards for half an hour. The ignited maſs was then ſoftened with water, lixiviated, and filtered. The filtered lixivium was of a light graſs-green, but ſoon loſt that colour, and became light-brown. By expoſure to a warm temperature, it depoſited, after 24 hours, an *oxyd of manganeſe*, which, collected in a porcelain-cup, amounted to about half a grain. On fuſing it upon charcoal, with a neutral phoſphat, and covering it with nitrat of pot-aſh, the ſalt exhibited, after detonation, a dark violet-red colour, mingled with green ſpots.

b) The alkaline lye was then ſuper-ſaturated with muriatic acid, and evaporated nearly to dryneſs. After re-diſſolving the ſaline maſs in water, *ſiliceous earth* was depoſited, which weighed 11 grains, after edulcoration and ignition. When

* See Eſſay I. No. 39.

this

this had been feparated, fome *aluminons earth* was thrown down by carbonated foda from the muriated folution. As the remaining liquor ftill appeared of a yellow tinge, it was again evaporated to a dry falt. But this likewife had a citron-yellow colour, and again afforded a yellow folution with water; from which, however, nothing could be farther feparated, by any means whatever.

c) The lixiviated powder of the garnet had the colour of a light-brown iron ochre. To this I added the fmall portion of alúmine (*b*), and treated it with muriatic acid, with which it immediately formed a golden-yellow folution. When this laft had been evaporated, in a fand-heat, to a gelatinous confiftence; it was again largely diluted with water, once more digefted and filtered. The *filiceous earth*, being well lixiviated, and heated to rednefs, weighed 76 grains.

d) Cauftic ammoniac threw down from the muriatic folution a copious brown precipitate; which, after being collected on the filtering paper, was wafhed, and dried in a moderate warmth.

e) The colourlefs fluid, remaining after the precipitation with cauftic ammoniac (*d*), was evaporated in part, and combined with carbonated foda. By this management, carbonat of lime fell down, which, after drying, weighed 12¾ grains, equal to feven grains of *ignited calcareous earth*, or burnt lime.

f) I then divided the brown precipitate, obtained by means of ammoniac (*d*), into two equal parts.

One half of it I expofed to ftrong ignition in a covered crucible, and found, after this, its weight to amount to 55 grains.

g) The

g) The other half I diſſolved again in muriatic acid, diluted the ſolution with a ſufficient quantity of water, and precipitated its portion of iron by Pruſſian alkali. The ſeparation of the dark-blue precipitate being accompliſhed, I precipitated the ſolution, now freed from iron, by means of carbonated ſoda, and in a boiling heat. The quantity of the white, looſe earth thus obtained amounted, after waſhing, drying, and ignition, to 38½ grains.

From this it was manifeſt, that the proportion of *oxyded iron*, ſeparated by pruſſiated pot-aſh, amounted to 16½ grains.

h) The above 38½ grains of ignited earth (*g*), were then diſſolved in ſulphuric acid, and made to cryſtallize, after the addition of a proper quantity of acetated pot-aſh. The firſt ſhootings yielded regular cryſtals of alum. But the laſt ſhewed, by the oblong, four-ſided columnar figure of its cryſtals, that it was ſulphat of magneſia.

i) But as the ſulphat of magneſia could not be ſeparated from the alumine with ſufficient accuracy, I ſubjected the whole of the ſaline maſs to ſtrong ignition for an hour; after which I liquefied the ignited maſs with water, and combined the mixture, at a raiſed temperature, with powder of calcined oyſter-ſhells, added in ſmall portions, until the ſolution no longer reddened paper tinged with litmus. The filtered ſolution taſted now like pure ſulphat of magneſia; and, when ſet to cryſtallize, I obtained from it 69 grains of this neutral ſalt. However, on being re-diſſolved in water, it ſtill depoſited two grains of ſulphated lime: hence its true quantity amounted to 67 grains.

k) To recover from it the earth in a ſeparate ſtate, I precipitated the ſolution, in a boiling heat, by carbonat of ſoda.

ſoda. The *magneſian earth*, waſhed and dried, weighed 23¾ grains; but when heated to incandeſcence in a covered crucible, and kept in that ſtate during half an hour, it weighed but 10 grains.

By ſubtracting theſe 10 grains of magneſia from the above 38½ grains (*g*), there remain 28½ grains for the aluminous earth.

One hundred grains of *Bohemian garnet* conſiſt, therefore, of:

Silex	*b*)	5½	
——	*c*)	38	
		43½	
and deducting .	*a*)	3½	
		40	40,
Alumine . . .	*k*)	. . . .	28,50
Oxyd of iron . .	*g*)	. . . .	16,50
Magneſia . . .	*k*)	. . . .	10,
Lime	*e*)	. . . .	3,50
Oxyd of mangameſe	*a*)	. . . .	0,25
			98,75

XXX.

CHEMICAL EXAMINATION

OF THE

ORIENTAL GARNET.

THE *Oriental*, or *Sirianic Garnet* *, is diſtinguiſhed from the *Bohemian*, both by its violet-red colour, and by its ſpecific gravity; which is = 4,085. This higher weight of it depends on the greater proportion of iron which it contains, and which is ſo conſiderable, that, by mere fuſion in the charcoal-crucible, I obtained from 100 grains of the oriental garnet a fine button of iron, of 23 grains. It likewiſe, when fuſed alone, in a crucible made of clay, runs into an enamel glaſs of a blacker colour than that of the Bohemian garnet †.

a) *Two hundred* grains of oriental garnet, previouſly bruiſed into ſmall pieces, in the ſteel mortar, acquired eight grains additional weight from the ſubſtance of the flint-grinding diſh, in which they were finely levigated with water. The powdered garnet was put in a cauſtic lye, in which the alkaline ingredient conſtituted thrice the weight of the powder; and, with this, it was inſpiſſated to a dry maſs, in a crucible made of ſilver. It was next ſubjected to red-heat during half an hour; and when the ignited maſs

* Rather *Sirianic*, than Sirian garnet: from *Sirian*, a town in *Pegu*, now deſtroyed.

† See Eſſay I. No. 40.

had again been ſoftened with boiling water, the powder of the ſtone, ſeparated from the decanted liquor, was lixiviated and dried.

b) The alkaline lixivium was of a bright graſs-green. But it was ſoon deprived of that colour by expoſure to a warm temperature, at the ſame time that it depoſited an *oxyd of mangane ſe*, impregnated with iron, in a brown flocculent form, and weighing about $\frac{1}{2}$ grain when ignited.

c) The alkaline lye was now devoid of all colour. It was ſaturated with muriatic acid, and evaporated in part. A light flocculent earth then ſeparated, but part of it diſſolved again upon ſuper-ſaturation with muriatic acid. The inſoluble reſidue conſiſted of *ſiliceous earth* of $9\frac{1}{2}$ grains after ignition. That part of the earth, which had been re-diſſolved by the exceſs of acid, was then ſeparated afreſh by carbonat of pot-aſh. After ignition, this earth weighed $4\frac{1}{2}$ grains; and, upon being tried by ſulphuric acid, it proved to be pure alumine, or *aluminous earth.*

d) The edulcorated powder of the ſtone (*a*), which had a cinnamon colour, and a very incoherent form, was moiſtened with water, and treated with muriatic acid, in which it rapidly diſſolved, without leaving any reſidue. The liquor was limpid, and of a golden-yellow. But, on being ſubjected to evaporation, on a ſand-bath, it coagulated into a ſemi-tranſlucid, gelatinous ſubſtance; which had a deep golden-yellow colour, and was again digeſted for a while along with water that was poured upon it, and with repeated ſtirring. When, after this, it had been brought upon the filter, it left *ſiliceous earth* in a ſwelled ſtate; which, being thoroughly edulcorated by a frequent affuſion of hot water, and deſiccated, weighed 104 grains, but only 70 grains when heated to redneſs.

e) To

e) To the muriatic ſolution, diluted with the waſhings of the ſilex (*d*), I added cauſtic ammoniac in exceſs. It gave a copious brown-red, much intumeſced precipitate, the quantity of which, after waſhing and drying, amounted to 190 grains.

f) The colourleſs fluid remaining from this laſt proceſs was firſt combined with as much muriatic acid as was requiſite to ſaturate the predominant portion of ammoniac, and then with carbonated ſoda. But as this produced no turbidneſs, I evaporated the whole of the liquor to a dry ſaline maſs, which being re-diſſolved in a little water, I tried it once more with carbonat of ſoda. The mixture ſtill continuing clear, ſhewed, that it contained no other conſtituent part.

g) Thoſe 190 grains of the brown-red precipitate, obtained at (*c*), were divided into two parts.

One half was ignited, and then found to weigh 61 grains. I poured upon it ſulphuric acid, evaporated it to dryneſs; and after having ſtrongly ignited the ſaline maſs for two hours, in a melting pot, I extracted it with water, and combined the filtered, clear fluid with carbonated ſoda, in a heat of ebullition. There ſeparated, however, ſome ſcarcely perceptible flocculi of aluminous earth only, without any trace either of lime, or of magneſia.

h) The other half of the precipitate was diſſolved in muriatic acid; and, after ſufficient dilution with water, combined with Pruſſian alkali, added ſucceſſively, till all the ferruginous parts were ſeparated. The blue precipitate of iron weighed 185 grains, when waſhed and deſiccated. After being ſtrongly ignited in a covered crucible, there remained 72 grains of iron attractible by the magnet. One part

part of it was aſſayed for manganeſe by fuſion with a phoſphated alkali; but it gave no indication of this metal.

i) The ſolution being now freed from the iron (*h*), it was decompoſed in a boiling heat, by carbonated ſoda, and the precipitated earth lixiviated, and heated to redneſs. It weighed 25 grains; whereby, ſubtracting it from the 61 grains, obtained from the firſt half of the precipitate (*e*, *g*), the portion *of iron*, contained in 100 grains of this garnet, is found to be 36 grains.

k) When the above 25 grains of ignited earth (*i*) had been diſſolved in ſulphuric acid, and, after the addition of acetated pot-aſh in due proportion, was ſet to cryſtallize, they afforded to the end cryſtals of pure *ſulphat of alumine.*

It reſults from this decompoſition, that the conſtituent parts of the *oriental garnet* are in *the hundred:*

Oxyd of iron . . .	*i*)	. . . . .	36
Silex	*c*)	$4\frac{1}{4}$	
——	*d*)	35	
		$39\frac{1}{4}$	
Subtract . .	*a*)	4	
		$35\frac{1}{4}$	35,75
Alumine	*c*)	$2\frac{1}{4}$	
——	*k*)	25	
		$27\frac{1}{4}$	27,25
Oxyd of manganeſe . .	*b*)	. . . .	0,25
			99,25

XXXI.

CHEMICAL EXAMINATION

OF

VESUVIAN.

FIRST SECTION.

Vesuvian, from the Mountain Vesuvius.

AMONG the different sorts of stones, which the Mountain Vesuvius brings up from the bowels of the earth, in their native unaltered state, that crystalline fossil may be reckoned, which the inhabitants of Naples call the *Vesuvian gem*.—Mineralogists had variously classed it with shörl, chrysolite, hyacinth, topaz, &c. and by the adjective, *vesuvian*, or *volcanic*, distinguished it as a variety of the above mentioned gems; till *Werner* established it as a distinct genus of stones, and gave it the name, *Vesuvian*; as, till then, it was found on Mount Vesuvius only.

An oryctognostic description of that fossil is already met with in various elementary treatises on mineralogy. That given by *Estner* * is particularly accurate and complete, for which reason I direct the reader chiefly to it.

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* *Estner, Versuch einer Mineralogie für Anfänger und Liebhaber.* II. Band. Seite 177 seq.

A.

Examination in the dry way.

a) A ſmall piece of veſuvian, if ignited upon charcoal before the blow-pipe, gradually rounds itſelf into a dark-brown, ſhining, opake globe, tranſparent only in ſplinters.

Borax (borat of ſoda) diſſolves it by degrees, to a clear light brown, and ſomewhat bliſtered, or air-bubbled glaſs-button.

It is not, however, completely diſſolved by means of a neutral phoſphat, for this only envelopes the particles of the foſſil, in the form of an amorphous frothy ſcoria.

The habitude of veſuvian is more remarkable, when acted upon by a greater intenſity of heat in the charcoal-crucible, which I have already communicated in the *firſt of theſe eſſays, page* 32, *n.* 103. The regular group of cryſtallization, there deſcribed, of the tender cruſt that ſurrounds the fuſed veſuvian, is a phenomenon according to my experience, the only one of its kind; and repeated experiments have convinced me that it is conſtantly the ſame.

B.

Examination in the humid way.

To decompoſe the veſuvian in the humid way, I picked out the beſt cryſtallized pieces of that variety which had a brown colour, inclining to olive-green. Theſe were coarſely powdered, and, by elutriation, freed from the greeniſh-white and delicate lamellas of chlorite and mica, which ſtill ad-

 hered.

hered. Placed upon the hydroftatic balance, in this purified ftate, its fpecific gravity was 3,420.

a) *Hundred* grains of it were reduced to an impalpable powder, by levigation with water in the flint-triturating difh. After gentle ignition, its weight was found to have encreafed half a grain. Cauftic alkaline lye, containing 300 grains of the falt, was then affufed upon it, in a filver pot; and the mixture being firft deficcated in a fand-heat, was next fubjected to ftrong ignition, during half an hour. Shortly before ignition the mafs acquired a vivid, light, grafs-green colour, but which was afterwards moftly changed into a dirty olive-green.

b) The ignited mafs, while yet warm, was foftened with water, and thrown upon the filter. The filtered lixivium appeared of a pale greenifh hue, but foon grew feebly brown-red. During gentle digeftion, there fubfided loofe, dark-brown, flocculent particles, leaving the lye colourlefs. As it could be forefeen that they would not well feparate from the filtering paper, I collected them in a fmall porcelain-veffel, and dried them, after edulcoration. By this treatment I obtained a dirty-brown powder, confifting of ¼ grain of *oxyd of manganefe*. When conveyed into fufed phofphoric falt, it diffolved in it clearly. The glafs-globule, thus formed, became by turns colourlefs and amethyft-red, accordingly as I directed on it the inner or the outer point of the flame.

c) Upon the pale-brown, loofe vefuvian powder, ignited with cauftic alkali (*a*), edulcorated and dried, I poured muriatic acid; which diffolved it, with a little effervefcence, and left fome *filiceous earth* behind.

d) The

d) The yellowiſh ſolution, together with the waſhings when reduced in bulk by evaporation, formed a clear coagulum of a full golden-yellow. By diluting it again with much water, and digeſting it for ſome time under repeated agitation, the *ſiliceous earth* was rendered diſpoſed to ſeparation; I then collected it on the filter, and having added the foregoing portion (*c*), I ignited them both. They weighed together 36 grains.

e) Having thus freed the muriatic ſolution from all its ſilex, I added to it cauſtic ammoniac in a greater quantity than its ſaturation required, and immediately gathered on the filter the ſwelled precipitate thereby produced; which, upon being perfectly lixiviated, was conveyed into a cauſtic alkaline lye. It ſoon diſſolved in it upon the fire, leaving, however, a looſe, brown-red, muddy ſubſtance behind.

f) Both alkaline lixivia, that of (*e*), and that of (*b*), were then mixed, and over-ſaturated with ſulphuric acid, till the earth, firſt thrown down by the acid, was again diſſolved. Upon this I precipitated the earth by carbonated pot-aſh, edulcorated and re-diſſolved it in freſh ſulphuric acid, adding then a ſmall portion of acetated pot-aſh, and prepared the ſolution for cryſtallization. It yielded cryſtals of alum to the end, which I re-diſſolved in water, and precipitated its earthy portion by pot-aſh. The *aluminous earth* here obtained, when waſhed and ignited, weighed 19¼ grains.

g) That fluid, which remained on the precipitation, effected by cauſtic ammoniac (*e*), was then concentrated by evaporation, and mixed with carbonated ammoniac. Sixty grains of *crude calcareous earth*, or carbonat of lime, fell down; which, in the ignited or pure ſtate, are equal to 33 grains.

 h) The

h) The brown refidue, remaining from the folution of the argillaceous precipitate, in the cauftic lye (*e*), was found to weigh 13 grains upon exficcation. Muriatic acid was poured upon one half of it, and completely diffolved it. Pruffiat of pot-afh, which was next added, produced a quantity of Pruffian blue, of a pure deep colour. Carbonated ammoniac poured into the liquor, feparated from this laft, ftill precipitated fome aluminous earth, weighing 1 grain after ignition. The fecond half of that brown refidue weighed five grains after expofure to red-heat. From this it followed, that for the above-mentioned 13 grains of refidue, we muft reckon $7\frac{1}{2}$ grains of ignited *oxyd of iron*, and $2\frac{1}{2}$ of ignited aluminous earth. Some experiments made with that oxyded iron, to detect whether it contained manganefe, evinced it to be abfolutely free from this ingredient.

Hundred parts of *vefuvian* from Mount *Vefuvius*, therefore, contain:

Silex	*d*) . .	36 grains.	
Subtract .	*a*) . .	$\frac{1}{2}$	
		$35\frac{1}{2}$ . .	35,50
Lime	*g*)		33
Alumine	*f*) . .	$19\frac{3}{4}$	
——— . . .	*h*) . .	$2\frac{1}{2}$	
		$22\frac{1}{4}$ . .	22,25
Oxyd of iron . .	*h*)		7,50
Oxyd of manganefe	*b*)		0,25
			98,50

SECOND SECTION.

Vefuvian from Siberia.

THE foffil, which I here introduce by that name, belongs to the difcoveries, as yet little known, made in Siberia, a country,

country ſo extenſive and abundant in remarkable mineral ſubſtances. It was diſcovered in the year 1790, by *Laxmann*, at the mouth of the river *Achtaragda*, where it falls into the ſtream *Wilui*. The firſt notice of it has been given by *Pallas* *, under the name *Cryſtals of Hyacinth*, together with a delineation of ſome of theſe cryſtals, added to their deſcription.

Their external colour is a dark olive-green, which, in the interior ſurface, paſſes into the brown of *colophony* (the reſidue of diſtilled turpentine). Their form is a rectangular four-ſided column, with truncated edges; yet the facets of the truncations are ſometimes ſo large, that the cryſtals might almoſt be called eight-ſided priſms.

In the entire cryſtals both ends of the column are ſharpened off to a quadrilateral pyramid. The points, however, are more or leſs, and in part, very much truncated.

As to the ſize of theſe cryſtals, the breadth of the column, in the ſpecimens which I poſſeſs, is from $\frac{1}{2}$ to $\frac{3}{4}$ of an inch; and the length, not meaſuring the pointed termination, from $\frac{1}{2}$ to a whole inch.

The external luſtre is but moderate; the internal is brighter, and partaking of the greaſy gloſs. The fracture is of the imperfect, ſmall conchoidal kind, and diſtinctly exhibits, eſpecially the longitudinal one, a foliated texture.

This foſſil is opake in its entire cryſtals; but its fragments are tranſparent, and even ſemi-pellucid.

* Pallas *Neue Nordiſche Beyträge*, vol. v. Petersburg and Leipzig, 1793, page 282.

The gangue confifts of a pale, greenifh-grey, dull ftone, which feems to be of the ferpentine kind; and in which thofe cryftals are fingly imbedded.

Of one of thofe cryftals, whofe abfolute weight was 253 grains, I found the fpecific gravity to be 3,365; that of another, weighing 188 grains, was 3,390.

On fome of thofe cryftals there are obferved fmall, opake, infulated grains, formed like garnets, and of a greenifh or yellowifh-white colour. Some of thefe adhere but loofely; but others are more deeply concreted with the body of the cryftals; yet, notwithftanding this, they may be eafily feparated, though they leave a cavity on the furface fitting their figure and fize. When fufed before the below-pipe, they run into a dark-brown fmooth globule.

It has already been remarked by *Pallas* *, that this foffil highly refembles the vefuvian of Italy; and this agreement has been more determined by *Eftner* †, on the ground of the external characters of both. This oryctognoftic conjecture has been confirmed by the following chemical examination.

A.

Examination in the dry way.

a) The vefuvian from Siberia, either when ignited by itfelf, upon charcoal with the affiftance of the blow-pipe, or when fufed, under the fame circumftances, with *glafs of borax*, or with a *neutral phofphat*, fhews, in every refpect, the fame

* *Loc. cit.*

† *Verfuch einer Mineralogie*, vol. II. page 184.

relations

relations as that from Mount Vefuvius, treated of in the foregoing fection.

b) One piece of it inclofed in the charcoal-crucible, and committed to the fire of the porcelain-furnace, fufed to an afh-grey, denfe, vitreous globe of a grofs-conchoidal fracture, and pellucid in thin fragments, the external furface of which was befet with numerous grains of iron.

But I have not perceived, on this globe, any diftinct trace of that cryftalline cruft, by which the Italic vefuvian, if fufed in the fame manner, is rendered fo peculiarly remarkable.

B.

Examination in the humid way.

a) *One hundred* grains of the above foffil, taken from a perfectly pure cryftal, were finely pulverized with water in the flint-grinding difh. Their weight increafed half a grain. When infpiffated with a folution of 300 grains of cauftic pot-afh, and afterwards ignited for half an hour, a pale-greenifh mafs was produced, inclining here and there to the brownifh, which, lixiviated with water, left a light-grey powder upon the filtering paper.

b) The lye, recently filtered, had a pale, dirty-brownifh colour, but it foon became colourlefs; and, at the fame time, that fome few brownifh flocculi were depofited, which, undoubtedly, were *oxyded manganefe*, but could not well be collected and examined, from their very minute quantity. When that lixivium had been neutralized with muriatic acid, aluminous earth fell down, which a flight excefs of that acid has again entirely diffolved.

c) The undiffolved refidue of the alkaline folution (*a*) was digefted with muriatic acid. There remained fome

filiceous

ſiliceous earth, which I ſeparated. Cauſtic ammoniac was then added in exceſs to the yellow ſolution, which had been mixed with the preceding (*b*), and it threw down a very intumeſced light-brown precipitate, the ſeparation of which was accompliſhed in an inſtant.

d) That precipitate, duly waſhed, and while yet moiſt, I digeſted with cauſtic alkaline lye. It was but ſlowly diſſolved in this menſtruum, and left a reſidue, the great volume and ſlimy appearance of which indicated, that it could not conſiſt merely of oxyded iron, but was ſtill mixed with ſilex. For this reaſon, I digeſted it with dilute muriatic acid, and evaporated it to a thickiſh maſs; which, being again diluted with water, depoſited the *ſiliceous earth* contained in it.

e) Cauſtic ammoniac, added to this ſolution, now free from all ſilex, again produced a brown paſte-like precipitate, that readily diſſolved in cauſtic lye, leaving a brown flocculent *oxyd of iron* behind, weighing $5\frac{1}{2}$ grains when ignited.

f) To the alkaline lixivia of (*d* and *e*) an over-proportion of muriatic acid was added. They were then mixed with the muriatic ſolution (*b*), and together precipitated by carbonated pot-aſh, with the aſſiſtance of heat. The earth, thrown down by this treatment, was re-diſſolved in ſulphuric acid. There ſtill appeared ſome *ſiliceous earth*, after the ſeparation of which, the ſolution, by proper management, cryſtallized into pure alum. This being again diſſolved in water, I precipitated its *aluminous earth*, purified it afterwards by means of acetic acid and ammoniac, and when dried, I heated it to redneſs. It then weighed $16\frac{1}{4}$ grains.

g) What remained of the fluid, after the precipitation by cauſtic ammoniac (*c*), was evaporated to a part, and upon this combined with carbonat of ammoniac. Thus it afforded 62 grains of carbonat of lime, which are equal to 34 grains of pure *calcareous earth.*

h) The feveral portions of *filiceous earth* of (*c*, *d*, and *f*), when ignited and weighed together, amounted to 42½ grains.

It then refults from this analyfis, that the conftituent parts of the *vefuvian from Siberia* are precifely the fame as thofe of the Italian. Only fome variation takes place in their proportions, which, however, is no argument againft placing them in the mineralogical fyftem as *two fpecies*, or even merely as *varieties* of one *fpecies.* For an *hundred* parts of the *Siberian* foffil yielded:

Silex	*h*) . .	42½ grains.	
minus . .	*a*) . .	½	
		42 . .	42
Lime	*g*)		34
Alumine . . .	*f*)		16,25
Oxyd of iron . .	*e*)		5,50
Oxyd of manganefe	*b*) a trace only.		
			97,75

XXXII.

XXXII.

CHEMICAL EXAMINATION OF *LEUCITE*.

FIRST SECTION.

THOUGH the foffil at prefent known by the name *Leucite* or *Leucolite*, according to others, often occurs in *Italy*, (where it conftitutes one of the ingredients not only in the lavas, the crude as well as thofe that have been converted by volvanic fires into *tufas* and flag-fand, or *volcanic afhes*, but alfo of other mingled maffes of rocks) yet there are but very fcarce and uncertain indications of its exiftence in other regions *. The *leucite* is remarkable by its very determinate fpecific figure, which confifts of low, double octahedral pyramids, flatly fharpened off to four terminating furfaces; fo that it forms a roundifh cryftal, inclofed in 24 trapeziums.

Still lefs does that leucite feem to be known, which occurs in the rocks of Vefuvius, either in maffes or in an indefinite form, varioufly mingled with black mica, black acicular fhörl, hornblende, cryftals of vefuvian, &c. and which hitherto has been moftly confidered as glaffy felfpar, or granular quarz.

* Of the foffils foreign to Italy, and taken for leucite, that in particular will moft probably be confirmed as fuch on chemical examination, which Dr. *Reufs*, fo deferving in the mineralogical hiftory of his country, has found in Bohemia, and defcribed. See his *Mineralogifche Geographie von Böhmen.* Drefden, 1797, vol. II. page 311—404.

The

The former denomination of this foffil, *white garnet*, *Vefuvian garnet*, *garnet-fhaped fhörl*, is no longer to be retained, fince the improvements made in *Oryctology*. On the other hand, *Werner* has affigned to it a peculiar place in the mineralogical fyftem, as a diftinct fpecies.

For the following analyfes I have felected only fuch cryftals of leucite ejected by Vefuvius, as, by their external appearance and internal luftre, together with the yet unchanged ftate of their ftony matrix, (which is a black-grey corneous mafs of bafalt), have convinced me, that they had fuffered no alteration either by volcanic fire, or by any fubfequent decay. Moft of them were of the fize of a nutmeg and upwards. Before they were employed, they were freed as much as poffible from the ftony matrix adhering to their outfide, and likewife from the particles of hornblende ufually contained in their middle. In this purified ftate their fpecific gravity was 2,455.

A.

Examination in the dry way.

a) The leucite is completely infufible, if ignited alone upon charcoal. It then undergoes no manner of fenfible alteration, and its fplinters lofe nothing of their luftre.

b) If a fmall fragment of it be put into fufed borax, it is for a long time moved about in it before it diffolves, which it does by degrees. The glafs-globule, arifing from thence, is clear and light-brown

c) By fufion with a neutral phofphat, the folution is ftill flower, and a colourlefs rifty glafs-pearl is produced.

d) One

d) One *hundred* grains of coarſely pounded leucite were expoſed for an hour to a ſtrong red-heat, in a ſmall porcelain-pot. The loſs of weight cauſed by this was only one-eighth of a grain.

e) Even the violent heat of the porcelain-furnace produced in the leucite only an inconſiderable change *.

B.

Examination in the humid way.

(1.)

a) *Hundred* grains of leucite, reduced to an impalpable powder, were ſeveral times digeſted in muriatic acid, which diſſolved a conſiderable part. There remained a *ſiliceous* reſidue, of 54 grains, after ignition.

b) This ſiliceous earth was then ignited with twice its weight of cauſtic alkali, ſoftened again with water, covered with muriatic acid, added to exceſs of ſaturation, and, after ſufficient digeſtion with this laſt, collected on the filter, and heated to redneſs. It was found to have ſuſtained, by this, a trifling decreaſe of weight.

c) On adding pruſſiat of pot-aſh to the muriatic ſolution, a precipitate enſued of ſo ſmall a quantity, as hardly to indicate one-eighth of a grain of *oxyded iron*. As, beſides, this ſlight portion of iron, probably, does not originate from the leucite itſelf, but from ſome particles of hornblende not perfectly ſeparable, I ſhall not conſider it among the conſtituent parts of that mineral.

* See Eſſay I. No. 55.

d) Upon

d) Upon this I decompofed the folution by cauftic ammoniac; and, after having feparated the precipitate thus obtained, I tried the remaining liquor with carbonated foda, but no farther change was effected by it.

e) The precipitate produced by means of pure ammoniac (*d*) was firft dried. It was next purified by digefting it with diftilled vinegar, and afterwards neutralizing this acid by ammoniac. It weighed $24\frac{1}{2}$ grains, when edulcorated and ignited. Dilute fulphuric acid completely diffolved it to a limpid liquor, and when properly treated, the folution yielded only *alum*.

f) To obtain the earth, which poffibly might have remained latent in the feveral wafhings, I evaporated thefe to drynefs. After having re-diffolved the faline mafs in water, I collected the portion of earth which ftill appeared. However, it amounted only to half a grain, and was *filiceous earth*.

Therefore I obtained:

Silex	*a*)	54	
——	*f*)	$\frac{1}{2}$	
		$54\frac{1}{2}$	54,50
Alumine	*e*)		24,50
			79
		Lofs	21
			100

(2.)

This confiderable lofs, in the fum of the weights of the feparated conftituent parts of the leucite, during this analyfis, lyſis, has induced me to repeat the experiment with ſome variation in the proceſs.

a) One *hundred* grains of leucite were finely ground, and ignited during half an hour, with twice their weight of cauſtic pot-aſh. To the maſs, again ſoftened with water, muriatic acid was added, to juſt the quantity neceſſary for ſaturation. When the mixture had been filtered, I edulcorated and dried the remaining undiſſolved powder of the ſtone.

b) The leucite, thus prepared for decompoſition, was then extracted, in a boiling heat, by means of muriatic acid. There ſeparated ſome *ſiliceous earth*, which weighed 54¼ grains after having ſuſtained a red-heat.

c) The muriatic ſolution was concentrated by evaporation, and tried by oxalat of pot-aſh; but no precipitation nor turbidneſs enſued. After this I recovered the *aluminous earth* in its pure and ſeparate ſtate, by the ſame means as employed in the preceding experiment. Its weight, after ignition, likewiſe correſponded, to within a trifle, with that of the firſt analyſis. It alſo ſhewed, upon farther trial, by re-agents, that, except an unimportant trace of oxyded iron, it was not in the leaſt mixed with any other earth, of whatever kind.

d) In the ſame manner, nothing more, of an earthy nature, could be obtained from the edulcorating waters by evaporation.

SECOND SECTION.

This agreement of the reſults of theſe two analytical reſearches increaſed my uncertainty where to look for the cauſe caufe of that lofs of weight. At the fame time it gave additional ftrength to the conjecture, long fince entertained by me, that in the mixture of foffils, befides the conftituent parts, found by analyfis, there might be prefent other component principles, which have hitherto efcaped difcovery. That chemical decompofitions of bodies, even when inftituted with all poffible care, are attended by fome lofs, is founded on the nature of the fubject itfelf. However, the above lofs was too great to be included in that which is abfolutely unavoidable. It is, indeed, the fhorteft way to get over the difficulty, if the lofs in the fum of the weight of the ingredients, although of fome importance, is accounted for fimply by the air and particles of water expelled. But fuch an explanation would by no means be capable of fatiffying me in the prefent cafe.

I was fully convinced, that, in thofe proceffes, at leaft no earthy, or any other component part, foluble in water, had been loft. It was likewife evident, from the experiments related in the beginning of this effay, that neither *water* nor *carbonic acid* was to be fought for in leucite. For thefe reafons, I proceeded to other experiments, which tended to try that foffil, for the *phofphoric*, *fluoric*, and *boracic* acids; but of none of thefe I could difcover any fign.

On the contrary, I was furprifed in an unexpected manner, by difcovering in it another conftituent part, confifting of a fubftance, the exiftence of which, certainly, no one perfon would have conjectured within the limits of the mineral kingdom, and, leaft of all, in the natural mixture of a folid foffil, which, in a *mineralogical fenfe*, is fimple or unmixed.

This conftituent part of leucite, which now appears in the character of an oryctognoftic or mineral fubftance, is no other than *pot-afh*, which, hitherto, has been thought *ex-*

clufively to belong to the *vegetable kingdom*, and has, on this account, been called VEGETABLE ALKALI.—This difcovery, which I think of great importance, cannot fail to occafion confiderable changes in the fyftems of natural hiftory, till now eftablifhed, and will ferve to illuftrate various phenomena in the mineral as well as in the vegetable kingdom.

The following experiments will fhew the particulars.

(I.)

a) *Two hundred* grains of finely triturated leucite were extracted, by repeated digeftion with muriatic acid. The filiceous earth, collected on the filter, and lixiviated, weighed 109 grains after ignition.

b) The muriatic folution had a yellowifh colour. When evaporated in a fand-heat, to the confiftence of honey, I obferved its furface covered with a pretty ftrong faline cruft. After complete cooling, the mafs appeared like a thick, golden-yellow, clear oil, full of cryftals, partly of a cubical, partly of a tabular form. I gently poured off the yellow fluid, and rinfed the falt with fmall portions of alkohol. The folution, diluted with alkohol, was then evaporated afrefh, and the fmall quantity of falt, which it afforded, again wafhed with ardent fpirit, and added to the firft. The falt thus obtained, and highly deficcated, weighed 70 grains. This I diffolved in water, adding fome drops of ammoniac, which ftill feparated fome particles of aluminous earth. The folution was then again made to cryftallize in a warm place, and it afforded only cubical cryftals, fome of which were lengthened to quadrilateral columns.

c) That portion of the muriatic folution, which would not fhoot into cryftals, was diluted with water, and decompofed in a boiling heat by carbonated ſoda. The precipitate conſiſted of aluminous earth, weighing 47¾ grains, when depurated, waſhed, dried, and ignited. Upon this I poured three times its weight of concentrated ſulphuric acid, and evaporated the mixture to a moderate dryneſs. The maſs re-diſſolved in water, then combined with a ſolution of acetated pot-aſh, and ſet to cryſtallize, ſhot entirely into alum.

d) I mixed the ſiliceous earth, obtained at (*a*), with double its weight of pot-aſh, and kept it in a ſtrong red-heat for the length of one hour. The maſs, which had but moderately coaleſced, was ground, diluted with water, ſuperſaturated with muriatic acid, and digeſted. By ſaturation with mineral alkali or ſoda, the filtered muriatic ſolution ſtill afforded 1½ grain of *aluminous earth*; which being ſubtracted from the firſt weight of the *ſiliceous earth* (*a*), there remainded, for this laſt, 107½ grains.

From thoſe decompoſed 200 grains of leucite have, conſequently, been obtained:

Silex :	*d*)		107,50
Alumine	*c*)	47¾	
———	*d*)	1½	
		49¼ . . .	49,25
			156,75

Hence there were ſtill wanting . . . . . 43,25 grs.
To account for which, I was to direct my attention to the 70 grains of ſalt mentioned at (*b*).

With a view of diſcovering its baſis, I ſubjected it to the following trials:

1.) Its tafte and the figure of its cryftals were found to be precifely the fame with thofe of muriated pot-afh, or digeftive falt, as it is termed.

2.) No change was effected either in the blue, or in the reddened litmus paper, by its folution.

3.) It made a crackling noife, when heated to rednefs, and remained behind as a body fixed in the fire.

4.) Its folution was not rendered turbid, either by carbonated foda, or by cauftic ammoniac.

5.) Having poured *two* parts of ftrong fulphuric acid upon *three* of that falt, I caufed the muriatic acid to evaporate, by means of heat, re-diffolved the mafs in water, and obtained fulphat of pot-afh (vitriolated tartar) in its ufual cryftals.

6.) The portion of falt which yet remained I diffolved in a little water, and treated it with a concentrated aqueous folution of pure cryftallized acid of tartar. *Cream of tartar*, or acidulous tartarite of pot-afh, was, by this management, immediately produced, which fell to the bottom in the form of fand. This was wafhed, dried, and burnt in a filver crucible; and when the coal which it produced was lixiviated, and the clear lixivium evaporated to a dry falt, it proved by every teft that was applied to be a *carbonat of pot-afh*. By faturation with nitric acid, it fhot into prifmatic nitre, (nitrat of potafh).

Therefore, the bafis of thofe 70 grains of falt confifted folely of pure vegetable alkali, which had been neutralized by a proportionate part of the muriatic acid employed in the compofition of the foffil. If now, as *Bergmann* afferts, aſſerts, the alkaline baſis of muriated pot-aſh amounts to 61 parts in an hundred of the compound, the above mentioned 70 grains (*a*) contained 42,7 grains of pot-aſh. And thus the 43,25 grains, before wanted to make up the 200 grains of leucite analyſed, are accounted for to within a trifling deficiency.

Conſequently by the reſults of this analyſis, accompliſhed by muriatic acid, *hundred* parts of leucite conſiſt of:

Silex	53,750
Alumine	24,625
Pot-aſh	21,350
	99,725

(2.)

a) *Three hundred* grains of leucite, reduced to a moſt ſubtle powder, were repeatedly digeſted, by boiling with four ounces of nitric acid. The *ſiliceous earth*, when ſeparated by filtration, and ignited, weighed 162½ grains.

b) This nitric ſolution was next evaporated. At firſt it continued colourleſs; but towards the end it turned a little yellowiſh, and after refrigeration it appeared like clear, tenacious turpentine. When diluted with water, and evaporated to but a moderate degree, it congealed into a greaſy ſaline maſs, conſiſting of ſmall priſmatic cryſtals. It was then ſucceſſively treated and waſhed with alkohol, until the ſalt remained in a purified ſtate. To the ſolution of this ſalt in water a few drops of ammoniac were added; to free it from a ſlight portion of earth which ſtill adhered,

 and

and which was thus thrown down, and afterwards collected on the filter. After this, the whole of the faline folution, which was now as limpid as water, by flow exhalation has fhot into prifmatic hexahedral cryftals, weighing 123 grains, after thorough deficcation.

c) That portion of the above nitric folution, which remained mixed with the fpirit of wine, and refufed to cryftallize, was diluted with water, and, in a boiling ftate precipitated, by the addition of carbonated foda. The earthy ingredient fell down in a flimy, fwelled form.—This, when previoufly wafhed and dificcated, together with the foregoing flight portion of earth (*b*), was treated with diftilled vinegar, and kept for a while in a warm place. The acetic acid was then neutralized by cauftic ammoniac; and the earth, precipitated afrefh, collected on the filter, again wafhed, dried, and ignited; in which ftate it weighed 70¼ grains. It now prefented itfelf in the character of the moft pure *aluminous earth*; for, when diffolved by fulphuric acid, combined with acetite of pot-afh, and cryftallized, it yielded nothing but fulphat of alumine.

d) Having collected the edulcorating water, I concentrated it by evaporation, and treated it, while boiling, with mild foda. But no further precipitation took place.

e) The above mentioned 162½ grains of filex were mixed with twice their weight of efflorefced foda, and along with it ignited for two hours in a filver pot. Upon the mafs, when foftened with a little water, an over-proportion of muriatic acid was added, and the whole, after fome digeftion, diluted with water, and thrown upon the filter. On faturating the muriatic fluid with foda, a yellowifh white precipitate arofe, which, after heating to rednefs,

rednefs, weighed two grains, and was *alumine*, coloured by iron. As thefe fhould be fubtracted, there are only 160½ grains to be put in the account for the *filiceous earth.*

It then appears, that in this analytical procefs, the alkaline-faline conftituent ingredient in the leucite was neutralized with the requifite quantity of nitric acid, and generated true nitre. But that the above conftituent part is really and undoubtedly of the very fame quality and nature with the vegetable alkali, has been evinced by the following examinations.

1.) The tafte and cryftalline figure of this falt perfectly agree with thofe of common nitre.

2.) When its folution had been combined with a folution of nitrated filver, or with that of acetated barytes, it continued bright and clear. This fact fhews, that in the natural mixture of leucite, this alkaline-faline conftituent part is contained, not accidentally and merely by the affiftance of carbonic or fulphuric acid, by which it may be neutralized, but rather in a perfectly pure ftate.

3.) Upon a part of that falt I affufed half its quantity of ftrong fulphuric acid, and carried on its evaporation until the nitric acid had been totally expelled. And when, after this, the refidue had been re-diffolved in water, and cryftallized, it produced fulphat of pot-afh in its ufual cryftalline form.

4.) The portion that remained I introduced into a fmall porcelain-veffel, and heated it to fufion, adding by degrees powdered charcoal in fmall portions, as long as any detonation took place.—The faline mafs remaining confifted of *carbonated pot-afh*: and upon faturating it anew with ni-

 tric

tric acid, it formed again prifmatic *nitrat of pot-afh* ; in the fame manner, as *vitrialated tartar* was produced from it by means of fulphuric acid, and *digeftive falt* by means of the muriatic.

Concerning the alkaline bafis of nitre, I fhall take for a ftandard the proportion ftated by *Bergmann*, according to which 100 parts of prifmatic nitre contain 49 of vegetable alkali. With this, likewife, *Wenzel* very nearly agrees, as he reckons 48⅛ of pot-afh in 100 of nitre, and this fmall difference probably depends on this circumftance, that the latter weighed his nitre in the ignited ftate. As, therefore, upon this ground of calculation, the above mentioned 123 grains of nitre (*b*) contain 60,27 grains of vegetable alkali, the proportion of the conftituent parts in 300 grains of decompofed leucite are as follow :

Silex	*e*)		160,50
Alumine	*c*) . . .	70¼	
———	*e*) . . .	2	
		72¼ . . .	72,75
Pot-afh			60,27
			293,52

Or in *one hundred* :

Silex	53,50
Alumine	24,25
Pot-afh	20, 9
	97,84

(3.)

I attempted alſo the reſolution of leucite into its principles, by means of *ſulphuric acid.*

a) *Two hundred* grains of finely pulverized leucite were evaporated nearly to dryneſs, in a mixture of 200 grains of concentrated ſulphuric acid with double its quantity of water. From the maſs, again liquefied with water, the *ſiliceous earth* was ſeparated by filtering. It weighed 59 grains, and ſhewed by this, that it ſtill contained ſome grains of undecompoſed leucite.

b) The colourleſs ſolution afforded, by evaporation, a clear, tenacious maſs; which, when again diſſolved in water, preſently ſhot, without any further addition, into regular ſulphat of alumine, weighing 128 grains.

c) This alum I expoſed to a red-heat, and boiled the reſidue, previouſly powdered, with water; ſubtracting at the ſame time the predominant part of the acid, by ſaturation with powdered oyſter-ſhells. The filtered and clear ſolution, being upon this evaporated, ſo as to cryſtallize, gave *ſulphat of pot-aſh.*

d) The remainder of the ſulphuric ſolution (*b*) has congealed, on farther evaporation, into a greaſy, finely radiated maſs.

THIRD SECTION.

In all the preceding experiments the leucite from *Veſuvius* alone was employed. But as leucites are found in various other parts of *Italy*, it was an intereſting point for me to learn, whether, and how far, the conftituent parts of thefe laft agree with thofe of the foregoing.

With this view, I felected the leucite of *Albano*, near *Rome*.* The fpecimens I have obtained of it confift of folitary grains, of the fize of green or fweet peafe, and larger. Their exterior colour is a yellowifh-white, and their cryftalline figure is for the moft part indiftinct, owing to the edges and angles being worn off by friction; whereas the Vefuvian leucite is externally dull, and of an afh-grey, and commonly occurs with uninjured angles and edges.—The leucite from *Albano*, on the contrary, is clearer, more tranflucid, and more free from hornblende, in its interior mafs, than that from Mount Vefuvius.

I found its fpecific gravity to be 2,490.

a) An *hundred* grains of leucite from *Albano*, in a fine pulverulent ftate, were boiled with muriatic acid, and left behind them undiffolved *filiceous earth*, which, after ignition, amounted to 54 grains.

b) The muriatic folution was next evaporated to drynefs on a fand-heat, and the yellowifh-white refidue, covered with alkohol, was expofed to a warm temperature, in a high cylindrical glafs. After it had cooled, I decanted the fpirituous folution of the muriated alumine from the muriat of pot-afh, which lay at the bottom as a white cryftalline powder;

*) I acknowledge my thanks for the communication of this, and a great part of the foregoing leucite to *Count Lepel*, and Dr. *Thompfon*, of Naples. It was by this augmentation of my little ftock of this foffil that I was enabled to carry my analytical proceffes to complete evidence.

powder; and when the alkohol had evaporated in a warm temperature, I diſſolved again the reſidue in ardent ſpirit, and added the ſmall portion of muriated pot-aſh, which ſtill ſubſided, to the preceding. The whole quantity of it obtained was 36 grains; of which, according to what has been ſaid before (page 357), 22 grains are *vegetable alkali*, conſtituting its baſis. By ſolution in water, and perfect purification by means of a few drops of ammoniac, and ſubſequent evaporation at a raiſed temperature, it ſeparated in pure cubic cryſtals. Theſe being re-diſſolved, and combined with acid of tartar, produced cream of tartar; which, after ignition and lixiviation, afforded *carbonated pot-aſh*.

c) The muriat of alumine, that was held in ſolution by the alkohol (*b*), was diluted with water, and decompoſed by ammoniac. The *aluminous earth*, thus precipitated, amounted to about 23 grains, when waſhed, dried, and ignited.

Theſe hundred grains of leucite from *Albano* were therefore reſolved into:

Silex . . .	*a*) . . .	54
Alumine . . .	*c*) . . .	23
Pot-aſh . . .	*b*) . . .	22
		99

FOURTH SECTION.

The inferences reſulting from the above experiments might be in ſome degree queſtioned by thoſe philoſophers, who conſider the baſaltic matrix of leucite, as well as all baſalts in general, as lavas, and hence would think themſelves entitled to doubt the primitive origin of leucite, and the originality of its alkaline conſtituent ftituent part now difcovered. Therefore, in order at once to obviate every poffible objection, I refolved to inveftigate whether a leucite, the mixture of which muft be acknowledged as not volcanized, even by the moft obftinate Volcanifts, would contain pot-afh in its natural mixture as a conftituent part, though hitherto this alkali has been confidered as belonging only to the vegetable kingdom. For this purpofe, I felected that *irregularly fhaped*, finely-grained, foliated *leucite*, mentioned at the beginning of this Effay, which either accompanies the ftony maffes, compounded of mica, fhörl, vefuvian, calcareous fpar, &c. that are ejected by Vefuvius in their original rough ftate; or which is concreted with them. Of thefe fpecimens, I feparated for this inquiry a fufficient quantity of *leucite* in a lump or *mafs*, and performed its analyfis according to the method before defcribed.

By the procefs I obtained, befides *filex* and *alumine*, a cubically cryftallized muriated neutral falt, whofe alkaline bafis fhewed itfelf to be vegetable alkali, from the circumftance of its producing cream of tartar, by combination with tartareous acid.

This enquiry into the conftituent parts of that variety of leucite was fatisfactory; though the determination of their *proportions* could not be accomplifhed with due accuracy, on account of the black needles of fhörl, fmall wax-yellow grains of vefuvian, and the like, with which it was too abundantly mixed.

FIFTH SECTION.

(1.)

As the preceding analyfes were all performed with thofe fpecies of leucite, which remained in their unaltered original

ginal ſtate, it remained to complete the ſubject by the examination of a leucite, which had ſuſtained the action of a *volcanic fire.*

The ſpecimen of leucite ſubjected to this experiment was picked up at *Pompeji*, and belongs to the moſt common varieties. It conſiſts of detached grains, for the moſt part of the ſize of a pepper-corn. Its interior ſurface, like the exterior, is aſh-grey, of an earthy appearance, and wholly opake; and it may be eaſily comminuted to a ſandy powder.

Hundred grains of it, decompoſed by muriatic acid, exactly in the ſame manner as the leucite from *Albano* in the third ſection, and the muriat of pot-aſh thereby obtained, calculated for its baſis of vegetable alkali, have afforded:

Silex	54,50
Alumine	23,50
Pot-aſh	19,50
	97,50

It remains for repeated experiments to decide, whether it is merely accidental, that the proportion of the alkaline ingredient, in this inſtance, is leſs than uſual; or whether this diminution takes place regularly in every leucite, altered by volcanic fire.

(2.)

In this place I ſhall, moreover, briefly notice a particular variety of leucite, which occurs at *Ronciglione*. It is found

found of middle-fized, infulated grains, prefenting fometimes traces of their original cryftalline form. Thofe grains are whitifh, inclining to the ifabella-yellow; they are entirely opake, of an earthy look, and very eafily friable. When thus comminuted, they do not yield fuch a harfh fandy powder, as is obtained from grains of volcanized leucite, but a foft powder refembling argillaceous earth.—It feems, therefore, that they have not fuffered any change by the fire; but have rather undergone a high degree of decay, caufed by the joint action of water and air; and finally, that, by this alteration, they have been brought near to their complete fpontaneous decompofition, or refolution into their component principles.

The ftock which I had of them was too fmall to admit of a complete examination; which, however, I think they deferve, for the purpofe of difcovering, whether in this ftate of great decay, they had fuffered any lofs of that alkaline ingredient, which was before unknown in the mineral kingdom.

I now flatter myfelf with the hope, that, by the experiments here communicated, and feveral times repeated, I have fully demonftrated the exiftence of pot-afh in the leucite, as one of its chemical conftituent parts. Neverthelefs, I am contented to defer the general reception of this new difcovery till feveral other chemical naturalifts have re-examined and confirmed it. This trial may be the fooner expected, fince my method of proceeding in the main object of this inveftigation is attended neither with laborious operations, nor with much lofs of time.

But if that alkali, as foon as it can no longer be confidered as a fubftance, produced only in the juices of plants during their

their vegetation, be required to occupy a more ſuitable place among the original, ſimple mineral ſubſtances, it will then likewiſe be neceſſary to give it a more appropriate name.

The term *Pot-aſh*, which, in the new chemical nomenclature, is raiſed to a *generic* name, cannot among us *Germans* claim a general acceptation; as its origin depends on a trivial *etymological* ground, and has been introduced into uſe merely from this circumſtance, that formerly, inſtead of calcining furnaces, iron *pots* were employed to ignite the inſpiſſated lyes procured from wood-aſhes.

I ſhould wiſh to recommend, that the denominations hitherto uſed, of *vegetable alkali*, *lixiviated vegetable ſalt*, *pot-aſh*, &c. be diſcarded, and the name KALI* be employed in their ſtead. In like manner ſhould the appellations, *mineral alkali*, *ſoda*, &c. denoting the alkaline baſis of common ſalt, give place to its ancient name,—NATRON.

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*) This has been done by the London Royal College of Phyſicians in the year 1787. They have introduced in their *Pharmacopœia* both theſe names, *kali* and *natron*, here recommended by *Klaproth*. The *Edinburgh Diſpenſatory*, on the other hand, calls the firſt *lixiva*, and the ſecond *ſoda*.—However, the terms, *pot-aſh* and *ſoda*, being at preſent more familiar to modern Engliſh chemiſts, the Tranſlator has, for the moſt part, given them the preference.—Tranſl.

XXXIII.

CHEMICAL EXAMINATION OF *PUMICE-STONE.*

THE *Pumice-ſtone* belongs to thoſe mineral bodies, on the origin and formation of which the opinions of philoſophers are yet divided. Various paſſages in the works of *Theophraſtus*, *Dioſcorides*, *Pliny*, and *Galen*, concerning this ſubſtance, ſhew ſufficiently, that, even in remoter ages, Naturaliſts have thought it worth their conſideration. One of the principal foundations abſolutely neceſſary to be laid down by the inquiring *Geogoliſt*, if he wiſhes to raiſe with ſucceſs the edifice of his theories, undoubtedly conſiſts in a juſt and accurate chemical knowledge of his object. This knowledge has, however, been hitherto wanting, with regard to pumice-ſtone. For, although various analyſes of it have been publiſhed, there ſtill occurs a very important difference in the enumerations of its conſtituent parts : ſo much ſo, that the Mineralogiſt is at a loſs to know, which of them he is to follow in the arrangement of foſſils.

Many of thoſe who have analyſed the pumice ſtone, cnoſider it, with *Bergmann*,* as an *asbeſt* changed in its mixture by a volcanic fire. This opinion ſeemed to be juſtified, partly by its fibrous texture, partly, and eſpecially,

* *Bergmann* Opuſc. Phyſ. et Chemic. vol. III. p. 197.

by

by the portion of magneſia, that has been ſuppoſed to exiſt in it. But, notwithſtanding that *Bergmann*, *Cartheuſer**, and but very lately *Spallanzani*†, have mentioned the magneſian earth, in their analyſes of pumice-ſtone, as a conſtituent part,—I am convinced, by my own experience, that it does not, in the leaſt, enter into this foſſil. The ſuppoſed origin of pumice-ſtone from asbeſt is, therefore, unfounded; and, along with this falſe derivation, likewiſe, another difficulty of ſome weight is removed, which ſeemed to oppoſe the inſtructive theory of the *matrices of pumice-ſtone* given by *Noſe* ‡.

a) Common, grey-white, fibrous pumice-ſtone, ſwiming on water, and procured from *Lipari*, was ground, and boiled with water. The water boiled with it was found to have extracted nothing; only, by treatment with nitrated ſilver, it gave a ſlight indication of muriatic acid.

Hundred grains of this pumice-ſtone, gently ignited, and finely pulverized after decoction, were expoſed to a red-heat, with twice their weight of cauſtic alkali, during half an hour. The maſs returned from the fire of a bright graſs-green colour; by which it was found to contain a ſmall portion of *manganeſe*. After having been ſoftened with water, this colour changed to a foul light-brown. It was then digeſted with dilute muriatic acid. *Siliceous earth* ſeparated in this proceſs; which, collected on the filter, and finally heated to redneſs, weighed 77½ grains.

b) What had been diſſolved by the acid was next precipitated by cauſtic ammoniac, and the browniſh precipi-

* *Cartheuſer*, Mineralogiſche Abhandlungen, Th. II. p. 136.

† *Spallanzani*'s Travels into both *Sicilies*, vol. II.

‡ *Orographiſche Briefe*, vol. II. page 185 and others. Alſo *Sammlung einiger Schriften über Vulkanische Gegenstände a. d. Baſalt*, page 271.

tate collected on the filter. The fluid ſeparated from it, contained no extraneous matter.

c) Hot cauſtic lye directly diſſolved that precipitate, leaving an *oxyd of iron* behind it, the quantity of which, after ignition, was 1¾ grains.

d) The alkaline ſolution, previouſly ſuper-ſaturated with muriatic acid, was combined with carbonated alkali. Thus, the earth which it held diſſolved was precipitated. When edulcorated, and heated to redneſs, it weighed 17½ grains. It proved to be pure *aluminous earth*; for, on being re-diſſolved in ſulphuric acid, and combined with an adequate portion of liquid acetated pot-aſh, it afforded nothing but alum.

In conſequence of this, the conſtituent parts, diſcovered in the common *pumice-ſtone from Lipari*, are:

Silex	*a*) . . .	77,50
Alumine	*d*) . . .	17,50
Oxyd of iron	*c*) . . .	1,75
Beſides a trace of *manganeſe*	*a*)	
		96,75

It is worth remarking the ſmall degree of ſolvent power which acids exert on rough pumice-ſtone. Although I had digeſted 100 grains of finely-ground pumice-ſtone with twelve times its quantity of muriatic acid, aſſiſted by a boiling heat, yet it was hardly attacked. The acid, indeed, was tinged of a faint yellow; however, at moſt, there appeared only a few looſe, browniſh flocculi, which, when moſt carefully collected, ſcarcely amounted to ⅛ of a grain, and conſiſted, for the greateſt part, of oxyd of manganeſe. The ſulphuric acid proved to be as little capable of affecting rough pumice-ſtone as the muriatic.

XXXIV.

CHEMICAL EXAMINATION

OF THE

TERRA AUSTRALIS (Sidney-earth).

A few years fince, the public has become acquainted with an arenaceous, or fandy foffil, under the name *Auftral-fand*, which has been found near *Sidney-cove*, in *New South-Wales*, and was brought from thence to England. This foffil has been afferted to contain a new, diftinct, peculiar earth, denominated *Auftral-earth (Sidneia, Cambria)*, upon the ground of its analyfis made and publifhed by *Jos. Wedgwood* *; of which the following are the principal particulars. The principal character of that earth is faid to be, that it refifts all acid and alkaline menftrua, ftrong muriatic acid only excepted, which alone, by means of repeated digeftion, takes up this earth from that arenaceous foffil. It is alfo faid to be again precipitated from its muriatic folution, merely by dilution with water; and to be, after this, abfolutely infoluble in any other folvent but the muriatic acid, with the affiftance of heat.

My defire of acquiring information on this fubject by my own experience has continued till now unaccomplifhed. It is only of late that I was fortunate enough to receive a quantity of auftral-fand; little, indeed, yet fufficient for an examination fparingly managed. The fpecimens obtained

* *Philofophical Tranfactions*, vol. lxxx. 1790.

were of two ſorts. One of them was mixed with a greater proportion of thoſe black, ſhining lamellæ, that are taken for graphite, but, to my conjecture, are rather flakes, or ſcales, of ferruginous mica. The other ſort was purer, and had leſs of the ſubſtance juſt mentioned. For this reaſon I employed only this in the preſent inquiry.

a) I triturated *thirty* grains of it to a moſt impalpable powder. The original grey-whitiſh colour of that foſſil changed thereby to a blueiſh, owing to a more minute diviſion of the particles of ferruginous mica. Strong muriatic acid was then affuſed upon the powder, and digeſted with it for a conſiderable time, in a heat of ebullition. After cooling, the acid was decanted from the ſediment, and this laſt digeſted with a freſh quantity of the ſame acid. This operation was reiterated a third time.

b) When the acid had been filtered clear, through a double-folded printing-paper, I diluted it gradually with a large quantity of water; but not the leaſt turbidneſs nor precipitation enſued. I expoſed the mixture to a warm temperature; yet ſtill it remained clear and limpid, like water.

c) The muriatic liquor was then ſaturated with carbonat of pot-aſh. This threw down a few light particles, which, collected on the filter, waſhed, and dried, weighed $3\frac{1}{4}$ grains. They alſo diſſolved in dilute ſulphuric acid, but left behind a ſlight portion of ſilex, and formed with that acid cryſtals of alum.

d) The reſidue left on the extraction with muriatic acid was ignited with three parts of carbonated pot-aſh, then again treated with muriatic acid, and its inſoluble ſlimy portion ſeparated by filtration. This laſt conſiſted of ſilex, weighing $19\frac{1}{2}$ grains, when edulcorated and ignited.

e) The

e) The muriatic ſolution was then tried with pruſſiated pot-aſh. The blue precipitate hereby produced indicated about $\frac{1}{4}$ grain of iron.

f) By combining afterwards the ſolution with carbonated pot-aſh, aluminous earth was precipitated; which, after ignition, weighed $8\frac{1}{2}$ grains, and, upon ſolution in ſulphuric acid, entirely cryſtallized into ſulphat of alumine.

Silex, *alumine*, and a little *iron*, therefore, were all the principles I was able to diſcover in the auſtral-ſand here examined; and no trace of any other conſtituent ingredient appeared.

Although in this inquiry I have been obliged to confine myſelf to the ſmall quantity of 30 grains, without being able to repeat it for want of a greater ſtock of this mineral, yet its reſult is ſufficient to excite a very reaſonable doubt of the *real exiſtence* of ſuch a new earth as is pretended to be met with in auſtral-ſand. Time will ſhew whether this doubt may be removed, or confirmed, by repeated and more accurate analyſes. If the laſt ſhould be the caſe, the illuſion which led to that erroneous ſuppoſition may, perhaps, be explained in the following manner:—

Mr. *Wedgwood* does not tell whether he had filtered, to perfect clearneſs, the muriatic acid employed for the extraction of the foſſil, and *previouſly* to its being mixed with water. The contrary ſeems rather to have taken place; for he ſays that the fluid turned white when he added water to the acid, for the purpoſe of diluting the acid, and edulcorating its remaining part. It is therefore probable that the earth, let fall by the acid on the admixture of water, was nothing elſe but alumine ſtill chemically combined with ſilex, which, during the long and hot digeſtion, had been

 taken

taken up by the muriatic acid, and was now depofited in the water.

Finally, that the foffil here examined was *genuine auftral-fand*, is warranted by the hand from which I received it. It was Mr. *Haidinger*, from *Vienna*, who kindly gave it me on his return from London, where he obtained it from the Right Hon. Sir *Jofeph Banks*, Bart.*

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* Since that time *Charles Hatchett*, Efq. F. R. S. of London, has likewife analyfed the *terra auftralis*, and found it to contain *no new earth*, but to be a compound of filex, *alumine*, *oxyd of iron, and plumbago*. His paper is printed in the *Philofophical Tranfactions* for the year 1798.---Tranfl.

XXXV.

XXXV.

CHEMICAL EXAMINATION

OF THE

GRANULAR SULPHATED BARYTES,

From Peggau.

THE *granular* barofelenite, or *fulphat of barytes*, is one of the rarer fpecies of this genus of ponderous earth. That of *Peggau*, in *Stiria*, which is the fubject of this effay, occurs of a beautiful milk-white colour, is maffive, refplendent, finely-grained, femi-indurated, and brittle. It bears a very ftrong refemblance to the white, fine-grained Carara-marble; to fuch a degree, that, by its mere appearance, it might eafily be miftaken for it, were it not for its greater fpecific gravity, which is 4,380, and by which it is readily diftinguifhed.

A.

a) It lofes nothing of its weight by ignition.

b) When pulverized, and boiled with a large quantity of water, it imparts to this laft nothing obfervable by the fight, tafte, or fmell. Of all the re-agents, only the folution of filver in nitric acid rendered the water boiled with it in a flight degree opalefcent.

c) In like manner, nothing of it was diffolved by digeftion with muriatic acid. The only exception from this is an unimportant trace of iron, which was detected by Pruffian alkali.

B.

a) *Two hundred* grains of this foffil, mixed with 500 grains of carbonated pot-afh, were fubjected, for two

 hours,

hours, to a moderately ſtrong red-heat. The maſs, which only conglutinated, was then pulverized, boiled with water, and the remaining earth collected upon the filter.

b) The alkaline fluid contained ſome ſiliceous earth, beſides the *ſulphuric acid of the barytes*. To ſeparate that earth, the fluid was fully neutralized by muriatic acid, and evaporated to dryneſs. The *ſilex* remaining, after the reſolution of the ſaline maſs in water, weighed 18 grains upon ignition.

c) The barytic earth freed from the ſulphuric acid (*b*) was covered with water, and combined with muriatic acid. After ſome digeſtion, the whole was found diſſolved, except a remainder of *ſiliceous earth*, of two grains weight, when ignited. When this laſt had been ſeparated, I cauſed the filtered ſolution to cryſtallize, by the uſual management; and it afforded, to the end, only muriat of barytes, partly in rhomboidal, partly in oblong ſix-ſided tables.

d) All theſe cryſtals I diſſolved again in water, and dropped ſulphuric acid into the ſolution only as long as it produced any precipitate. The regenerated *ſulphat of barytes*, when collected, waſhed, and dried, weighed 185 grains; but, when heated to redneſs, no more than 180 grains.

The mixture of this foſſil, in *one hundred parts*, therefore, conſiſts of:

Pure ſulphat of barytes	*d*)		90
Silex	*b*)	9	10
——	*c*)	1	
			100

Or,

Or, because in the ignited ponderous spar, or sulphat of barytes, the *earth* is to the acid very nearly in the proportion of 2 to 1, the above fossil consists of:

Barytes	60
Sulphuric acid (free from water)	30
Silex	10
	100

XXXVI.

CHEMICAL EXAMINATION

OF THE

TESTACEOUS SULPHAT OF BARYTES,

From Freiberg.*

IT was, undoubtedly, the powerful attraction which the barytic earth has for fulphuric acid, exceeding even that of the pure fixed alkalis, that induced the deferving *Scheele*, who firft difcovered it as a diftinct earth, to think that an alkaline falt is incapable of refolving the natural mixture of barofelenite into its feparate principles. On this account, when attempting to expel its fulphuric acid, he reforted to the imperfect and tedious procefs of repeatedly working the ftone to a pafte, with honey or oil, of calcining that mafs by means of the muriatic or nitric acids, and, at laft, of extracting fuch a part of it as had been difengaged from the fulphuric.

Yet there are feveral inftances where the unaffifted force of attraction of pure alkali has been too weak to feparate

* Chemifch. Annal. 1796. I. B. S. 387. It is, properly, a variety of common *ponderous fpar*. *Kirwan* calls it *Barofelenite*. The *author*, with the reft of the *Germans*, and fome *French*, calls it *(fchalig) teftaceous*, from its form, pretty equally fpreading in length and breadth, but, comparatively, of inconfiderable thicknefs. *Emmerling* has given a mafterly detailed defcription of its figure and varieties. See his *Lehrbuch der Mineralogie*, Gieffen 1793. Vol. I. page 557. feq.—Tranfl.

the

the component principles of mixed bodies; while, on the contrary, when they have been employed in the carbonated, or otherwiſe neutralized ſtate, the deſired object has been attained by this new increaſe of attractive force.

This is the very caſe with ponderous ſpar, and is founded on the method learnt of *Wiegleb* : which is, to decompoſe it in a ſhorter, cleanlier, and more complete manner, by igniting it with carbonat of pot-aſh. This method, as to the moſt eſſential part, has ſince been univerſally approved and adopted.

It ſeems, however, to be the common opinion, that this decompoſition obtains, in the *dry way* only, and that the ſeparation of ſulphuric acid from barytes abſolutely wants the ſupport of red-heat; as, to my knowledge, no one has yet attempted the *humid way*, to effect it.

A.

a) *A thouſand* grains of *common*, *white*, *thick*, *teſtaceous baroſelenite**, in the pureſt ſelected pieces from the mine *Kurprinz Frederick Auguſt*, near *Freiberg* (in Saxony), were triturated with water to the fineſt powder, and then boiled for one hour, in a ſilver pan, with twice their weight of carbonated pot-aſh, and five of water, ſtirring them occaſionally, and ſupplying the loſs of water as it evoporated; which being done, more water was added, and the whole filtered. The reſidue weighed 910 grains, after waſhing and exſiccation. Muriatic acid was affuſed upon it ſucceſſively, until all effervefcence ceaſed. After gentle di-

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* Thick-teſtaceous *(Dickschalig)*, when from ¼ to ½ an inch thick.—Tranſl

geſtion,

geſtion, the muriatic acid was filtered off from the ſtill undecompoſed barytic ſulphat, which, upon waſhing and drying, weighed 426 grains.

b) With this remainder of ſulphated barytes, the ſame proceſs of coction with double its quantity of carbonated pot-aſh, and five times that of water, was repeated.—The edulcorated powder amounted to 387 grains; of which, after extraction of the ſoluble part of earth by muriatic acid, there remained 198 grains ſtill undecompounded.

c) Theſe 198 grains, treated in the ſame manner with alkali and water, gave then 183 grains. Of theſe, the muriatic acid left again 128 grains of undecompoſed ſulphat of barytes.

d) When theſe had been boiled with pot-aſh and water, in the manner mentioned before, there remained 122 grains; which muriatic acid diſſolved, excepting a remainder of 96 grains.

e) After a new ſubſequent decoction with twice the quantity of alkali and water, there remained 90 grains; of which, upon extraction performed with muriatic acid, there appeared a reſidue of 72 grains; which,

f) Upon repeating the boiling with carbonic pot-aſh, left 69 grains of powder, and, after extraction by muriatic acid, 61 grains.

g) As I thus obſerved that the ſucceſs of the decompoſition of ponderous ſpar decreaſes in the proportion of its diminiſhed quantity, I had recourſe to the *dry way* for the final analyſis of that reſidue. For this purpoſe I mixed it with three times its weight of mild alkali, or carbonated pot-

pot-aſh, calcining the mixture in a ſilver-veſſel during the ſpace of half an hour. After ſoftening the maſs, there remained 50 grains of edulcorated reſidue; which now totally diſſolved in muriatic acid, only five grains of unattacked *ſilex* excepted.

The alkaline lixivium, obtained from that ignited maſs, and ſomewhat reduced by evaporating, then afforded three grains of *ſiliceous earth.*

h) I then evaporated, together, all the muriatic ſolutions mentioned before, to the point of cryſtallization; and they yielded, at the firſt two ſhootings, the muriated barytes in a perfectly pure ſtate.

i) The remaining ſolution ſeemed to exhibit ſigns of the preſence of ſome iron. It was therefore ſaturated with cauſtic ammoniac, and filtered. There collected on the paper a browniſh earth, which, when highly dried, weighed $1\frac{1}{2}$ grain. Yet, notwithſtanding this ſmall quantity, it was not mere oxyd of iron; for, when diſſolved in muriatic acid, and treated by Pruſſian alkali, the fluid remaining, after the ſeparation of the blue precipitate, yielded half a grain of *alumine*, by combination with ammoniac. The portion of iron, therefore, amounted only to one grain.

k) The remainder of the ſolution of muriated barytes, being thus freed from thoſe foreign ingredients, was decompoſed by means of mild ammoniac. I then re-diſſolved the precipitated earth in muriatic acid, and put it in a gentle temperature for farther cryſtallization. Pure muriat of barytes cryſtallized, as long as the ſolution contained one drachm of it; upon which I committed it to ſpontaneous exhalation in the open air. It cryſtallized entirely, without leaving any drop of liquor, to regular cryſtals; of which

which the firſt ſhooting ſtill conſiſted of ſome tables of muriated barytes, but the ſubſequent ones afforded needle-ſhaped cryſtals of muriated ſtrontian-earth.

l) Upon this, I carefully collected the cryſtallized muriat of ſtrontian, diſſolved it again in water, and re-produced it again in its former ſtate of *ſulphated ſtrontian-earth*, by dropping ſulphuric acid into the ſolution. The ſulphat, waſhed and dried, weighed 8½ grains.

m) The whole of the cryſtallized muriat of barytes, which was collected, amounted to 18 drachms.

n) Another portion of *a thouſand* grains of ſulphated barytes, ground to a moderately fine powder, and ſubjected to intenſe red-heat for half an hour in a porcelain-crucible, loſt no more than ſeven grains of their weight; which loſs may probably have conſiſted only of the *aqueous particles* driven out in the proceſs.

It reſults from theſe experiments, that the *white*, *teſtaceous ſulphat of barytes*, in pieces ſelected of the utmoſt purity, and from the mine mentioned above, reckoning with *a thouſand* parts, is compoſed of:

Sulphated barytes	975
——— *Strontian-earth* . . .	8,5
Silex	8
Oxyd of iron	1
Alumine	0,5
Water	7
	1000

B.

B.

The refult of this analyfis, therefore, demonftrates, that the *humid way* is likewife applicable in the decompofition of ponderous fpar, by means of alternate boiling with a concentrated aqueous folution of carbonated pot-afh, and fubfequent folution in any fuitable acid.

This management affords, efpecially in operations performed with great quantities, a double advantage. The *firft* is, the faving of crucibles, which would be otherwife deftroyed; the *fecond* is this, that the remaining alkali, which ought to be recovered after the feparation of the newly-formed neutral fulphat, is not liable to be contaminated in this method.

When ponderous fpar is ignited or fufed with pot-afh, that part of the alkali which is not neutralized, during the procefs, by the fulphuric acid of the foffil, will attack not only the filiceous and argillaceous earth, which are ufually contained in the ponderous fpar, but alfo that which enters into the fubftance of the crucible. It will alfo retain a great part of thofe earths, in a diffolved ftate, in proportion as the alkali, during ignition, gives out its carbonic acid, and becomes more or lefs cauftic. On the contrary, if the procefs of boiling be employed, no tranfition takes place in the alkali, from the mild or carbonated, into the cauftic or pure ftate; hence alfo no contamination of it with filex and alumine will arife.

XXXVII.

XXXVII.

CHEMICAL EXAMINATION

OF THE

CROSS-STONE (Staurolite.)

THE chemical analyfis of that foffil, which is found at *Andreasberg*, on the *Harz*, and has the name of *crofs-ftone*, *crofs-cryftal* (*ftaurolithus*), and confifts of double cryftals, concreted in the form of a crofs, has already been inftituted by two eminent chemifts, *Heyer* and *Weftrumb*. Both have long ago publifhed their analyfes. It might therefore be deemed needlefs to add mine, if the following reafons did not excufe it.

It is well known, that both thefe chemifts have found *barytes*, befides *filex* and *alumine*, among the conftituent parts of that foffil. To fuppofe the prefence of barytes, in this inftance, *Weftrumb* was fatisfied with the obfervation, that, by combination with fulphuric acid, this earth forms a precipitate of difficult folution in water. From the ftate of chemical knowledge of the fimple earths at that time, it was indeed allowable, to confider fuch a precipitate, directly and without trial, as fulphated barytes.

But fince we have become acquainted with ftrontian-earth, which likewife combines with fulphuric acid to a difficultly foluble precipitate, that phenomenon alone is not fufficient to determine, whether a certain earth, met with in any procefs, be the barytic.

Heyer,

Heyer, on the contrary, when examining the ſtaurolite, found this conſtituent part of it to cryſtallize both in the nitric and muriatic acids; from which he could, with greater confidence, ſuppoſe it to be of a barytic nature. But, as he has given no particular account of the figure of its cryſtals, eſpecially of thoſe formed with the muriatic acid, I thought that a freſh examination of this foſſil might be a means to aſcertain, whether the earth mentioned was really the barytic, or whether the ſtrontian.

a) *One hundred* grains of white cryſtals of the croſs-ſtone, carefully freed by diſtilled vinegar from all adhering calcareous earth, were finely pulverized, and ſubjected to a low red-heat for half an hour, with a double quantity of carbonated pot-aſh. The maſs, which was then eaſy of trituration, was lixiviated with water, and left 109 grains behind.

b) To this reſiduum was added the ſmall portion of earth, which was ſtill obtained from the alkaline lye, by ſaturating it with an acid, and evaporation. I then gently digeſted it with muriatic acid, with which it effervеſced, and depoſited *ſiliceous earth*, in a fine, ſandy form, weighing 32 grains, after previous ſeparation by the filter, and ignition.

c) The muriatic ſolution, ſuper-ſaturated with cauſtic ammoniac, gave a tranſparent, paſte-like precipitate, which, upon edulcoration, drying, and ignition, weighed 33 grains. It conſiſted of alumine, but ſtill mixed ſilex. For this reaſon, I combined it with ſulphuric acid, and evaporated it to a moderately dry ſaline maſs, which, again diluted with water, depoſited *ſiliceous earth*, amounting to 17 grains, when heated to redneſs. The true quantity of aluminous earth, therefore, amounted to 16 grains.

 d) The

d) The remaining ſolution was evaporated to a ſmaller volume, and the earth, which it ſtill contained, was precipitated by means of carbonated pot-aſh. This earth weighed 23 grains, when waſhed and dried. But when re-diſſolved in muriatic acid, it ſhot, to the laſt drop, into tabular cryſtals of muriated barytes: proving, by this, to be *true barytic earth.*

e) Since, in conſequence of other experiments, thoſe 23 grains of carbonated barytes are equal to 18 grains of *pure barytes*; ſince, moreover, the ſtaurolite loſt 15 per cent of the whole, on ignition, and, as this loſs was probably mere water, the proportion of its conſtituent parts is as follows:

Silex	*b*)	32	49 grs.
	c)	17	
Barytes	*e*)		18
Alumine	*c*)		16
Water	*e*)		15
			98 grs.

XXXVIII.

XXXVIII.

SOME FARTHER RESEARCHES

CONCERNING

WITHERITE and STRONTIANITE.

FIRST SECTION.

A.

IT is needlefs to prove, that chemical analyfes give more accurate refults, the greater the quantity is of the fubftance fubjected to decompofition. But, at the fame time, it is not lefs evident, that the expence of the procefs increafes in the fame proportion. The chemift, therefore, who, befides time, trouble, and patience, frequently facrifices a confiderable fum to his love for the fcience, fhould not be cenfured for parfimony, if he can but feldom perform his analytical experiments with ounces and pounds, but muft commonly reftrain himfelf to fmaller quantities.

The following refearches on *witherite* may afford an inftance of what juft now has been faid.

a) *Twelve ounces* of *witherite* from *Anglezark*, (near *Chorley*, in Lancafhire) coarfely powdered, were gradually diffolved in *fifty ounces* of a mixture, compofed of one part of muriatic acid and three of water. Except a few grains of fand, no refidue was left. The filtered folution, when fet to cryftallize, gradually afforded 14 ounces $5\frac{1}{2}$ drachms of *muriated barytes.*

 b) The

b) The mother-water, remaining from that ſolution, had acquired a greeniſh colour; and, as likewiſe the cryſtals which laſt formed, ſeemed to tend a little to the green, I deſiccated them in a high heat, waſhed them with alkohol, and added the waſhings to the remaining fluid; which I then treated with cauſtic ammoniac, added to exceſs of ſaturation. By this management, the ſolution was rendered ſky-blue, and, at the ſame time, turbid, by a ſlight portion of earth which then ſeparated. This laſt, collected, and dried in the air, weighed $2\frac{1}{2}$ grains; had a yellowiſh-white colour, and was *aluminous earth, mixed with iron*.

c) On ſuper-ſaturating the filtered fluid with muriatic acid, the blue colour diſappeared. I then treated it with pruſſiat of pot-aſh of the utmoſt purity. This produced a brown-red, tender precipitate, which I carefully gathered, waſhed, and deſiccated. But this, beſides that it was of ſo ſmall a quantity, had ſo firmly adhered to the filtering paper, that it could not be accurately ſeparated from it. It was, therefore, together with the paper, ſubjected to low-red heat, and the aſhes were extracted by liquid carbonat of ammoniac, until the portions of this, ſucceſſively employed, ceaſed to be tinged blue. When upon this, the volatile-alkaline tincture had been evaporated, there remained in the evaporating pan a bright-green, carbonated *oxyd of copper*, weighing half a grain; which diſſolved in a few drops of dilute ſulphuric acid, and immediately precipitated, in the reguline ſtate, on a poliſhed piece of iron, upon which it was dropped.

d) The mother-water of the ſolution of the witherite (*b*), previouſly purified with cauſtic ammoniac and Pruſſian alkali, was next combined with mild alkali prepared from tartar; and the precipitate, that appeared of a dazzling white, being diſſolved in muriatic acid, was left to ſpontaneous

neous exhalation. Thus the ſolution conſtantly afforded muriat of ſtrontian-earth, in ſmall hexahedral cryſtals; which, re-diſſolved in water, and precipitated by carbonat of ammoniac, yielded 98 grains of *carbonated ſtrontian-earth.*

Theſe 12 *ounces of witherite*, which are equal to 5760 grains, conſiſted, therefore, of:

Carbonated barytes	5659 grs.
———— *Strontian-earth*	98
Carbonated oxyd of copper	0,50
Alumine, contaminated with iron, and dried in the air	2,50
	5760 grs.

The foregoing analytical proceſs ſerves to confirm the exiſtence of a ſlight trace of copper in the Engliſh witherite, which has been already obſerved by *Weſtrumb**, as well as the preſence of ſtrontian-earth, both in the Engliſh and Siberian witherite, noticed by *Lowitz*†.

B.

Hitherto, the only places where carbonated barytes is found native, are *Anglezark*, in England, and the *Schlangenberg*, in Siberia; for, the report of its occurrence in the metalliferous mountains of Saxony has not yet been confirmed. However, this foſſil has of late alſo been diſcovered in a third place, which is the pit *Steinbauer*, near

* *Chemiſche Abhandlungen, von Weſtrumb*, Hanover, 1793, vol. I. page 266.

† *Chemiſche Annalen*, 1795. I. Band. Seite 110.

Neuberg, in Upper-Stiria. It is found there in a ftratum of fpatofe iron-ftone, partly maffive, or in confiderable lumps, and in part coarfely diffeminated in brown iron-ochre.

One hundred grains of this *Stirian witherite* diffolved completely, and with effervefcence, in dilute muriatic acid. The whole of that folution fhot into muriat of barytes, in tabular cryftals; the aqueous folution of which was precipitated in the ftate of fulphated barytes, by means of fulphuric acid.

SECOND SECTION.

A.

THE attemps made to free *witherite* from its portion of carbonic acid, fimply by ignition, and to bring it thus to the perfectly cauftic ftate, have hitherto mifcarried, owing to its vitrifying with the mafs of the clay-crucibles; and, on the other hand, its confuming, and, as it were, diffolving, thofe made of charcoal. On this account, I refolved to repeat the experiment with a veffel made of platina.

A piece of witherite, weighing 200 grains, was put in a platina crucible, previoufly weighed, and this laft, when introduced into a faggar (*caffette*) made of clay, was conveyed into the middle chamber, or fire-place, of the porcelain-furnace; where the intenfity of heat is at 136 degrees of *Wedgwood's pyrometer*. When the veffel had returned from the fire, I found the weight of its contents diminifhed 23½ grains. The calcined witherite appeared as a dirty-brownifh, coarfe powder; which fo firmly adhered to the bottom of the crucible, that it could not be detached without injuring the latter. I, therefore, tried whether I could foften the calcined witherite with water. But, although

though the water affufed upon it became intenfely heated, the feparation of the ftone proved fo difficult, as to oblige me to affift it by a boiling heat. The calcined witherite left at the bottom of the platina crucible fome flofculous impreffions; and, in general, its internal polifh fuffered much, though the external remained unimpaired.

The lofs of weight, amounting to $11\frac{3}{4}$ *per cent*, indicated that the witherite had not loft much above one half of its carbonic acid. It was owing to this, that it would not entirely diffolve in boiling water, and that the refidue ftill confiderably effervefced with acids.

In the filtered aqueous and clear folution of the calcined witherite, which had been directly preferved in a well-ftopped bottle, I obferved, after fome days, that the barytic earth had cryftallized in feveral fmall groups, between which various infulated cryftals formed diftinct octahedrons. In order to obtain a greater quantity of them, I reduced, by boiling, all the water impregnated with the ignited barytes to one fourth part; feparated by filtration the pellicle of carbonated barytes, which formed on the furface of the fluid during the procefs; and transferred the liquor, while yet hot, into a glafs provided with a ftopper. Before the water had thoroughly cooled, fimilar cryftals were formed, which I found confiderably increafed on the following day. Thus I faw with pleafure confirmed by my own experiments the fact, that calcined barytes is cryftallizable in water; which property *Vauquelin* and *Pelletier* have of late, each in a different way, difcovered at Paris.

B.

Since, therefore, according to this laft experiment, the barytic earth agrees in this point with the ftrontian, it follows, that this property of any calcined earth to cryſtallize in mere water can no longer be conſidered as an excluſive character of ſtrontian-earth. But from this we can by no means conclude, that both theſe earths are *identically* the ſame. Their eſſential difference, beſides the other diſcriminating properties already known, principally depends on the ſpecifically different degrees of affinity, or chemical attraction, ſhewn by each of them for the various acids. Of this, the following experiment furniſhes a proof.

I mixed an aqueous ſolution of acicularly cryſtallized muriated *ſtrontian-earth* with a ſolution of *acetated barytes*; evaporated the mixture to dryneſs; expoſed the obtained ſaline maſs to a ſtrong red-heat in a crucible; re-diſſolved that ignited reſidue in water; promoted the cryſtallization of the filtered ſolution by the uſual means, and obtained only *muriated barytes*, cryſtallized in quadrangular tables.

The muriatic acid, therefore, quitted the ſtrontian-earth, and combined with barytes, with which it had a ſtronger affinity.—By this new demonſtration of the eſſential difference of theſe two earths, deduced from the different degrees of their attractions for acids, it may be hoped, that chemiſts will no longer entertain any doubts concerning the exiſtence of the ſtrontian as a diſtinct earth.

C.

Before I conclude, I ſhall yet notice, in a few words, the relations of barytes to pruſſiat of pot-aſh. The precipitation, effected by this laſt, of barytic earth from thoſe acids with which it forms ſoluble middle ſalts, has ſeveral times occaſioned erroneous concluſions. It was upon this, that *Bergmann* and others have founded their hypotheſis, aſcribing a metallic nature to that earth, already refuted by more accurate

rate examinations. With no better reafon, has even lately one of the principal French chemifts* reckoned the precipitation of barytes by Pruffian alkali among the characters which diftinguifh it from ftrontian earth.—However, this precipitation does not take place, except when the pruffiated pot-afh employed is not entirely free from the neutral fulphat, which ufually contaminates it; for, if the pruffiat is perfectly pure, it is as little capable of precipitating barytes as any other of the fimple earths. On this account, whenever I prepare Pruffian alkali, to be ufed in accurate chemical experiments, I always repeat the proceffes of its purification, until the folution of nitrated barytes is no longer, even in the leaft degree, rendered turbid by it.

* Journal des Mines, N. xxi. Prairial, p. 45. feq.

XXXIX.

XXXIX.

CHEMICAL EXAMINATION

OF THE

SULPHATED STRONTIANITE

*from Penſylvania**.

AFTER the ſtrontian-earth had been eſtabliſhed as a peculiar, chemically-ſimple earth, it was to be expected, that it might likewiſe occur combined with *ſulphuric acid*, inſtead of the *carbonic*, as is the *ſtrontianite* from Scotland. This conjecture was already in part verified; as it has been found, that moſt of the ponderous ſpars contain ſulphated ſtrontian-earth in their mixture, though in only a ſmall proportion, not amounting in the baroſelenites, hitherto examined with this view, to more than from one to two *per cent.*

But the preſent analyſis will fully prove the exiſtence of a perfect *natural ſulphat of ſtrontian-earth*, without any portion of barytic ingredient.

The foſſil, in which I diſcovered this combination, has been known but a few years. It was at firſt called, *blue, fibrous gypſum, from Frankstown*, in *Penſylvania.* The following are its diſtinctive characters.

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* Sulphat of ſtrontian-earth *(ſtrontites)* has alſo been diſcovered lately in the beach at *Auſt-paſſage*, near *Briſtol*, in Glouceſterſhire, in ſeveral veins. This foſſil has been analyſed by *William Clayfield.* See *Contributions to Phyſical and Medical Knowledge*, &c. collected by Dr. *Beddoes.*—Tranſl.

Its

Its colour is a pale ſky-blue. It occurs in flat layers, or ſtrata, from $\frac{1}{4}$, $\frac{1}{2}$, to $\frac{5}{8}$ of an inch thick, included between two even ſides; which laſt partly appear to be real ſeams, or joints (*ſaalbänder*), and, partly, are mere ſeparating ſurfaces, formed by ſmall clefts of the rock, filled with clay. On theſe exterior ſides the foſſil has a dull appearance; but, internally, it is poſſeſſed of the ordinary luſtre. It is eaſily comminuted, and conſiſts throughout of coarſe, parallel, brittle fibres, which form needle-ſhaped fragments.

The ſpecific gravity of this foſſil I found to be 3,830. This conſiderable weight naturally ſuggeſted a doubt of its belonging to the ſpecies of gypſum. For this reaſon, it has been conſidered as a variety of ponderous ſpar, and placed in the mineralogical ſyſtem in the character of *fibrous ſulphat of barytes.* This, however, is not more its proper place, than that of gypſum, or ſulphat of lime.

A

a) *Hundred* grains of the foſſil, finely pulverized, were boiled in one pound of diſtilled water; whereby it loſt three grains. The water of the decoction was rendered turbid by mild alkalis, by oxalat of pot-aſh, by the nitrated ſolution of ſilver; but, moſt of all, by muriated barytes.

b) The powder, when again dried, was treated with muriatic acid; which, a trace of iron excepted, extracted nothing that was obſervable.

B.

a) I ignited *two hundred* grains of ſuch pieces of the foſſil as were pure, and free from the grey argillaceous matter,

matter, that croffes it in thin fiffures. It loft by this about one grain in weight; and the blueifh colour paffed into the light ifabella-yellow. It was next triturated, then mixed with 500 grains of carbonated pot-afh, and the mixture expofed in a filver pot to a moderate red-heat, during the fpace of three hours. The mafs became grey, ftrongly coalefced, and nearly entered into fufion. Upon this, I pulverized it, boiled it with water, and collected the earth upon the filter.

b) The alkaline lixivium was fuper-faturated with muriatic acid, evaporated to drynefs, and the faline mafs foftened again with water, and neutralized with alkali. As by this treatment no feparation of earth was obfervable, I faturated again the lixivium to excefs with muriatic acid, and combined it with muriated barytes. In this way I obtained 254 grains of *barytic fulphat*, which, upon ignition, weighed 250 grains.

c) That earth, which remained after the decoction of the faline mafs that had been fufed with the alkali (*a*), was combined with dilute muriatic acid, which readily attacked, and diffolved it entirely, with effervefcence. Cauftic ammoniac, added to the colourlefs folution, clarified by filtering, threw down the fmall portion of iron which it contained in fcarcely perceptible brownifh flocculi. The folution being thus freed from iron, I precipitated its earthy portion by carbonated ammoniac, affifted by heat.

d) The earth hereby obtained was very white, tender, of a moderate gravity, and weighed 164 grains in its dry ftate. It was again diffolved in muriatic acid, and the folution made to cryftallize by gentle evaporation. It gradually, and entirely, fhot into long needled cryftals of fix unequal furfaces; which middle, or earthy falt, proved, upon trial, to be mere *muriat of ftrontian-earth*. A little of this

falt,

ſalt, brought into contact with the wick of a burning candle, gave to the outer flame a highly beautiful carmine-red; and a ſolution of it in moderately ſtrong ſpirit of wine burned with the ſame colour, when cotton, or printing paper, dipped into it, was ſet on fire.

Hence it appears, from this analyſis, that the above foſſil, with the exception of its trifling portion of iron, conſiſts ſolely of *ſulphated ſtrontian-earth.*

C.

I repeated this analyſis in a ſhorter way: by boiling with alkaline lye, without previous ignition.

a) *One hundred* grains of the foſſil, ground to a moſt ſubtle powder, were mixed with a triple quantity of carbonated pot-aſh, covered with ſix ounces of water, made to boil, and kept in that ſtate during half an hour.

b) The lixivium, filtered off from the remaining earth, was ſaturated to exceſs with muriatic acid, in which ſtate it continued clear; and was then combined with ſucceſſive portions of muriated barytes, till no more precipitate enſued. The *ſulphat of barytes*, thus produced, weighed 126 grains after waſhing and drying, and 124 after ignition.

c) The earthy part of the foſſil, which had been diſengaged from the ſulphuric acid by boiling with alkali, and had in its ſtead taken up carbonic acid, weighed 82 grains. Muriatic acid diſſolved it entirely, and with rapidity, leaving only a few brown particles behind. The filtered ſolution was firſt treated with an over-proportion of cauſtic ammoniac, and, when no longer rendered turbid by it, was precipitated by mild, or carbonated pot-aſh.——It gave again

again its former weight of *carbonated ſtrontian-earth*; namely, 82 grains, when dried in the air. When heated to redneſs, it formed a moderately conglutinated maſs, and occupied only one half of its former volume; yet it did not loſe an entire grain in weight. After trituration, though previouſly ignited, it diſſolved rapidly, and with efferveſcence, in muriatic acid; and gave, by this combination, *muriated ſtrontian-earth*, in long, thin columns, of ſix unequal lateral ſurfaces.

Hence, the reſult of this decompoſition in the *humid way*, accompliſhed ſo completely, and with ſo much eaſe, moſt exactly correſponded with that of the preceding.

Now, ſince previous experiments have ſhewn, that 126 parts of *barytic ſulphat* contain 42 of *real ſulphuric acid*, or *without water*; and ſince 82 parts of carbonated ſtrontian-earth contain 58 of *pure ſtrontian-earth*, the proportion of the ingredients conſtituting the Penſylvanian, blue, fibrous, *ſulphated ſtrontianite* is accordingly:

Strontian-earth	58
Real *ſulphuric acid*	42
Oxyded iron, a ſlight trace	
	100

By theſe analytical experiments it is fully proved, that I was not miſtaken, when I ſuſpected this foſſil to be a ſulphat of ſtrontian-earth. In forming that conjecture, I was chiefly determined by its ſpecific gravity, which is conſiderably leſs than that of ponderous ſpar; and, likewiſe, by its fibrous texture: for, even the artificial combination of ſtrontian-earth with ſulphuric acid, effected by diſſolving that earth in this acid, cryſtallizes into needles, reſembling the fibres of the foſſil, though ſmaller and more delicate.

XL.

XL.

CHEMICAL EXAMINATION OF THE *WATER OF THE BOILING SPRING,* *at* RYKUM, *in Iceland**.

CONSIDERING the ſlowneſs, with which the knowledge of the chemical properties of even the moſt common natural bodies uſually advances, it is not ſurprizing, that even thoſe of *ſiliceous earth* have ſo long remained but partially inveſtigated. This earth has always been conſidered as a ſubſtance, by itſelf, abſolutely inſoluble in water. It was, therefore, totally neglected in *hydrologico-chemical* inquiries, or reſearches into mineral waters, until *Bergmann* directed the attention of chemiſts to its ſolubility in ſimple water, and demonſtrated that it exiſts in a ſtate of ſolution in the Geyſer, and other boiling ſprings of Iceland.

But although, in this inſtance, this celebrated philoſopher juſtly conſiders the heat, which the water of thoſe ſprings poſſeſſes when it riſes into day, (and which even then is higher than that of ordinary boiling), as a means of promoting the ſolution, yet experience has ſhewn, that an actual ſolution of ſilex in water takes place, not only in ſprings, the natural temperature of which is much inferior to the ebullient heat of thoſe in Iceland, but alſo in ſeveral other mineral waters: and even that ſome common ſweet-water ſprings contain diſſolved ſiliceous earth.

Thus, when I was attentive to this point, whilſt analyſing the mineral waters of *Carlsbad**, I found that 1000 cubic inches of the main ſpring contain 25 grains of *ſilex*, actually diſſolved.

* Read in the *Royal Academy of Sciences at Berlin*, Auguſt 28, 1794.

That,

That this is not the greateſt quantity of ſiliceous earth ſoluble in water, and that, eſpecially, the hot ſprings in Iceland might poſſily contain a much larger proportion of it, I was led to conjecture from the *ſiliceous tufas* which they depoſit in conſiderable quantities. At that time, however, a proof of this opinion, ſupported by chemical inveſtigation, was ſtill wanting. It gave me, therefore, the greateſt pleaſure, when I received a ſufficient quantity of water of one of the principal Icelandic ſprings, which enabled me to perform this inquiry, and to compare its reſult with that of the analyſis of Carlsbad water.

In modern times, *Uno von Troil*, and after him, *Banks* and *Solander*, have particularly deſerved well of the Natural Hiſtory of Iceland, ſo remarkable in ſeveral of its individual ſubjects, ſome of which are *unique* in their kind. The lateſt voyage to that iſland, undertaken for the purpoſes of Natural Hiſtory, is that of *Stanley*, in the year 1789. This learned traveller, (who has given in the papers of the Royal Society of *Edinburgh* a circumſtantial deſcription of the ſpring at the Geyſer), when collecting the natural products of that ſpot, had likewiſe providently brought back with him a number of bottles filled with the water of thoſe ebullient ſprings.—Two of theſe, that came to my hands, ſerved for the following analyſis.

The water contained in both bottles is from the ſpring at *Rykum*. From this ſpring, 24 Engliſh miles diſtant from *Hafniſiord*, the water ruſhed formerly out to the height of 60 or 70 feet. But ſince the orifice of the ſpring has been covered, for the greateſt part, by an overthrow of the rock, the ſtream of water, at preſent, ſpouts off ſideways, from 50 to 60 feet. The heat of this ſpring, even after the jet,

* See p. 274 of this work.

is ftill fo intenfe, that Fahrenheit's thermometer rifes to 212°. Therefore, as it is beyond a doubt, that part of the heat is loft during the fpouting, and, confequently, that the water muft have been fome degrees hotter in its fubterraneous refervoirs ; Nature affords us here an inftance, in the large way, of what Art performs in the fmall, by Papin's digefter: namely, that confined water, even while in its unelaftic, denfe, liquid ftate, is capable of acquiring a degree of heat, furpaffing that of its boiling point.

The water, in both bottles, was clear, bright, without fediment, and without tafte. Yet, at the fpring itfelf, it fhewed fome fulphureous ingredient, according to *Stanley*. For, when employed frefh from the fpring, it gave to the infufion of tea prepared with it, as well as to the meat boiled in it, a naufeous tafte ; whereas, the water from the fpring at the Geyfer, ufed in the fame manner, gave no fign of it. But as, in the water which I examined, I could not difcover any fulphur, either by the tafte, by the fmell, or by re-agents, it remains undecided: whether this effect proceeded from a portion of highly volatile, fulphurated, hydrogen gas, only obfervable at the fpring itfelf, or whether, perhaps, the fmell produced by putrefcent, organic fubftances has not been miftaken for it; which laft is not feldom the cafe, with various waters, fuppofed to be hepatic.

On employing other re-agents, it appeared, that this water from *Rykum* contains neither free carbonic acid, nor iron, nor lime, nor magnefia ; and that *carbonated*, *muriated*, and *fulphated foda*, are to be expected.

Guided by thefe previous indications of the conftituent parts of this water, I performed its analyfis in the following manner.

I evaporated *a hundred cubic inches* of it in a gentle fand-heat. When this quantity had been reduced to a remainder of about fix cubic inches, I found it coagulated to a pale-brownifh, ftiff, fomewhat turbid jelly. This evidently fhewed, that this water had contained a confiderable portion of diffolved filiceous earth, which now appeared in its ufual gelatinous form. After the evaporation had been carried on to perfect drynefs, the powder which was left weighed 25½ grains.

To feparate the *filiceous earth* from this refidue, previoufly to the fubfequent operations, I poured water upon it, and when foftened, I threw it upon the filter, wafhed the feparated earth, and expofed it to a moderate temperature, to dry. It appeared in a delicate, loofe, pulverulent ftate, and weighed nine grains. To difcover whether it was pure, or mixed with any other foluble earth, I digefted it with muriatic acid; but when this was again filtered off, it contained nothing extraneous, except a trace of *aluminous earth*, hardly worth noticing.

Hence, the falts ftill held in folution, deducting the nine grains of filex, amounted to 16½ grains. Concentrated acetic acid was then dropped into the liquor to the over-faturation of the foda; and when the mixture had been evaporated to drynefs, I feparated, by highly rectified alkohol, the acetite of foda thus produced, and found the weight of the refidue, again deficcated, to be 13½ grains. From this it followed, that the ingredient, *carbonat of foda*, reckoned in its dry ftate, amounted to three grains; which are equal to eight grains of cryftallized mild foda.

Thofe 13½ grains, which yet remained, were liquefied in a little water, and the folution left to fpontaneous evaporation. It gave cryftals of *muriated* and *fulphated* foda. To find the proportion of thefe two falts to each other, I

re-diffolved

re-diſſolved the mixture in water, and decompoſed it: firſt by acetated barytes, and then by nitrated ſilver. Calculating afterwards the quantities of the precipitated ſulphat of barytes, and muriat of ſilver, upon the baſis of other comparative experiments, I found, that in thoſe 13½ grains were contained 8½ grains of *common ſalt*, and five grains of *Glauber's ſalt*, reckoned in its dry ſtate, or 12 grains, if cryſtallized.

According to this, the above 25½ grains of ſalt, afforded by 100 cubic inches of water from the boiling ſpring at Rykum, when deprived of their water of cryſtallization, or in the deſiccated ſtate, conſiſt of:

Carbonat of ſoda (natron) . . .	3 grs.
Sulphat of ſoda (Glauber's ſalt) . .	5
Muriat of ſoda (common ſalt) . . .	8,50
Siliceous earth	9
	25,50

Shortly after the concluſion of the foregoing analyſis, I found in the *Annales de Chimie*, *Paris*, 1793, that a ſimilar examination had been made of the Icelandic hot ſprings, by Dr. *Black* of *Edinburgh*, together with a full detail of the method he purſued. In this inquiry, he likewiſe was ſupplied with the water by Mr. *Stanley*.

In order to compare the reſults of the analyſis of the ſpring-water at *Rykum*, made by Dr. *Black*, with mine, I reduced the conſtituent parts, enumerated by him, to the proportion of 100 cubic inches, equal to 29,000 grains of water. Hence, omitting unimportant fractions, they ſtand in the following proportion:

Carbonated free ſoda . . .	1,50	grains
Silex	10,80	
Muriat of ſoda	8,40	
Dry *ſulphat of ſoda* . . .	3,70	
	24,40	

When the numerous, and partly unavoidable cauſes are conſidered, which occaſion ſmall differences in the proportion of the conſtituent parts diſcovered, theſe two analyſes may be conſidered, upon the whole, as reciprocally confirming each other. The quantity of *alumine*, which, being very trifling, I have not determined, ſhould, according to Dr. *Black's* analyſis, be eſtimated at $\frac{1}{7}$ of a grain in 100 cubic inches of water.

What in particular has attracted the attention of Dr. *Black* is the *ſiliceous earth* he diſcovered, and its ſolution in water. For this reaſon he ſays, that in the courſe of that inquiry he had detected in ſilex ſuch properties as have never before been ſuſpected in it, or never been accurately deſcribed. He here principally alludes to the fact, that ſiliceous earth diſſolved by fixed alkalis will not ſeparate from them, even when neutralized by alkalis, as long as a ſufficient quantity of water required to that effect is preſent *.

Dr. *Black* aſks; " How and by what means is the ſili-
" ceous earth diſſolved in water?—Is the hot water, of its
" own accord, poſſeſſed of the power of diſſolving this

* Without inculpating the ingenious Dr. *Black* for this little deficiency in his acquaintance with the experiments made by the German Chemiſts, I cannot avoid remarking, that I have, at an earlier period, known and deſcribed that property of ſiliceous earth. See my *Chemiſche Unterſuchung des Elaſtiſchen Steins aus Braſilien*, im. 6. B. der *Schrift. d. Berl. Geſellſchaft Naturforſch. Freunde.* 1785.

" earth;

" earth ; or can this be effected only by the means of the " intervening alkali ?"—In anfwering thefe queftions, he does not approve of *Bergmann's* opinion, that the folvent power of water, affifted by heat, is alone fufficient for this effect. He rather thinks, that the alkali is the efficient caufe of this folution, and the heat merely a means of promoting it. In his opinion, a chemical combination of the filex with alkali is always prefent, when water exerts a diffolving power on the earth, and this idea he fupports by the example of the agency of hot aqueous vapours upon glafs. The doubt, which might be raifed againft it, from the difproportion of thefe two fubftances to each other in the Iceandic hot fprings, he wifhes to obviate by ftating, that the filex had originally been united in them with a much larger portion of alkali ; but that, fubfequently to the folution of this compound in water, part of the alkali had again been neutralized by acids, or acid vapours, that combined with the fluid. But there is no neceffity for this mode of explanation ; as it is manifeft by feveral facts, that filiceous earth alone, if under favourable circumftances, is foluble in water, without the concomitant aid of alkaline falt.

Moreover, this opinion, that the filex exifts in the above mentioned fprings in a ftate of chemical folution by foda, feems likewife to have led Dr. *Black* to prefuppofe this alkali in thofe waters in the *cauftic* or *pure ftate*, that is, *free from carbonic acid*; becaufe it is allowed on all hands, that, in this ftate only, is it capble of effecting this folution. Yet, not to mention that no proof is given of this hyphothefis, there occurs no inftance in nature, upon which to eftablifh its probability. The very effervefcence, that enfued on faturating with acetic acid the faline refidue left by the evaporated water, would prove the contrary ; unlefs, indeed, it be objected to this argument, that the alkali had attracted the carbonic acid, during the evaporation of the water.

XLI.

XLI.

CHEMICAL EXAMINATION

OF THE

SILICEOUS TUFA, (Kiefeltuff.)

From the Geyfer.

IN the fame manner, as mineral waters impregnated with lime depofit the *calcareous* tufa in various forms, do the hot fprings in Iceland depofit their *filiceous* ingredient in the form of tufa. It is likewife of this *filiceous* tufa that the wonderful pipe and bafon confift, which the *Geyfer*, the largeft of the fprings in Iceland, has formed for itfelf. *Von Troil* found, in the year 1772, the circular orifice of that pipe, whofe depth is unknown, and which the ignorant Icelander confiders as the gate of hell, to be 19 feet in diameter. On the upper part, the aperture widens in the form of, a large bafon of 60 feet in diameter, and whofe exterior border is 9 feet higher than the pipe itfelf. From this pipe the water fpouts out feveral times in the day, by gufhes, at unequal intervals of time, with powerful force, and fometimes to the height of above 100 feet. What a grand fight muft it afford, to fee a column of boiling water, 19 feet in diameter, rufh up to fuch a height! To form an idea of that column of water, let it be compared with the moft celebrated artificial fountains, for example, that on the *Carlsberg* near *Caffel* in *Heffia*, which is only 14 inches in diameter, and hence is more than 16 times fmaller than the Geyfer.

As

As the ſiliceous tufa produced by this ſpring is to be met with only in few collections; and as,—beſides the ſhort account given by *Bergmann*, in his treatiſe *De Productis Volcanicis*,—no other characteriſtic deſcription of it exiſts, I here inſert that, which *Karſten* has drawn from the ſpecimens in my poſſeſſion.

SILICEOUS TUFA.

"Its *colour* is partly *reddiſh-white*, and externally ſpeckled with *cochineal-red*; partly *greyiſh-white*, with yellowiſh-grey ſtripes.

"It occurs in *maſſive* lumps, and alſo *denticulated*, *coroded*, and moſt finely *botryoidal*.

"Its exterior ſurface *perfectly-dull*.

"But internally partly *dull*, in part highly *glittering*, and then of a *ſilky luſtre*; here and there a little *reſplendent*.

"Its fracture partly *compact*, and totally *flat conchoidal*, or *uneven*; partly *fibrous*.

"It breaks into indeterminate angular, not very ſharp fragments.

"It conſiſts, when conchoidal, of *finely grained* inſulated pieces; when of uneven fracture, it then is found in ſeparate *thin* and *curved teſtaceous* pieces; and its fibrous varieties preſent no detached pieces.

"It is alſo, more or leſs, *ſtrongly tranſparent on the edges*.

 "*Semi-indurated,*

" *Semi-indurated*; may be ſplit in pieces without any " great difficulty; is very *brittle*, and of little *weight*."

Note. The *fibrous* variety has always the luſtre of ſilk, and the fibres croſs each other in ſuch a manner, that its inſide has a *cellular* appearance.

For the following analyſis of the *ſiliceous tufa from Iceland*, I have choſen the *fibrous* variety, whoſe ſpecific gravity is = 1,807.

One hundred grains of it were finely triturated, and ignited for two hours, in a ſilver crucible, with four times its weight of mild pot-aſh. When the concreted maſs had cooled, I poured water upon it, ſaturated it to exceſs with muriatic acid, and filtered it after ſome digeſtion; upon which the *ſiliceous earth* remained behind in its uſual ſlimy form.

The acid fluid, being afterwards ſaturated with mild, or carbonated pot-aſh, was rendered turbid by it; and depoſited a ſlight looſe precipitate; which, collected, waſhed, and deſiccated, weighed 3 grains; but when re-diſſolved afreſh in muriatic acid, it ſtill left 1 grain of *ſilex*.

The ſolution ſtill contained 2 grains of diſſolved matter: namely, ½ grain of *oxyded iron*, and 1½ grain of *aluminous earth*. Theſe, likewiſe, were ſeparated.

Hence the ingredients, found in the above 100 grains of analyſed *fibrous ſiliceous tufa*, from the *Geyſer*, conſiſted of:

Silex	98
Alumine	1,50
Oxyd of iron	0,50
	100

 XLII.

XLII.

CHEMICAL EXAMINATION

OF THE

*ELASTIC QUARZ**,

(Sand-ſhiefer, flexible Sand-ſtone)

From Braſil.

THE ſingular elaſtic flexibility ſo ſeldom occurring in the mineral kingdom, in which this foſſil, in its form and appearance, reſembles novaculite (Turkey-hone), has attracted the attention of Naturaliſts, but at the ſame time has led many perſons to doubt its exiſtence as a natural ſubſtance, and to ſuſpect, that this may probably be a product of art. It comes from Braſil, near *Villa-rica*, the principal town of the province of *Minas Geraës*, which fact was, for a while, kept a ſecret. There it occurs in not very thick ſtrata, whoſe *hanging* and *ſhading ſides* are caſed over by a grey cruſt of ¼ inch thick; and from thence it was brought

* Schriften der Berliner Geſellſchaft Naturforſchender Freunde. 6. B. 1785, pag. 322.—The miners indicate by theſe expreſſions the greater or leſs ſlope in the ſtrata, though chiefly with reference to *rake-veins*, not fully perpendicular. The hanging ſide is that towards the day, and is alſo called *hanger*; and the hading ſide, which likewiſe goes by the name *ledger*, is the under one next to the bed of the ſtratum. See *Williams's Natural Hiſtory of the Mineral Kingdom*, 8vo. Edinb. 1789. vol. I. page 269.—Tranſl.

to Portugal the firſt time, in the year 1780, by the *Marquis de Lavradio*, Viceroy at *Rio de Janeiro*. Among the ſpecimens I have ſeen, that of the Imperial Cabinet at Vienna, ſo remarkable for its precious foſſils, is by far the greateſt; it being 26 Vienna inches long, 16 inches broad, and 1 inch thick. It is, however, probable that this ſtone, together with its remarkable phyſical property mentioned before, was already known in the ſixteenth century; and that it is the ſame with that deſcribed by *Gaſſendi in Vita Peireſkii** in the character of a *flexible wetſtone* (novaculite); as ſuggeſted by the authors of the *Göttingiſche Gelehrte Anzeigen*, when this ſtone has again been brought into notice †.

A.

On inſpecting with a microſcope the homogeneous or integrant parts of which this elaſtic ſtone is aggregated, and which may be eaſily ſeparated by compreſſure or levigation, I found them all alike: that is, they were all flat, longiſh plates or ſcales, perfectly clear and pellucid. All their difference conſiſted in the variety of their outlines; ſome truncated more ſharply; others more obtuſely; others longer, but very thin; while others were broader and ſhorter; but moſt of them I perceived on one or both ſides notably ſinuated. I am inclined to think, that the elaſticity of this foſſil originates ſolely from the form of its aggregation. For, as may be diſtinctly ſeen at the firſt glance in the entire ſtone, all thoſe longiſh lamellæ are interwoven

* Libr. IV. ad annum 1630. pag. 254. Edit. 1706.

† Of the year 1784. Number 211.

in

in *one single* direction, and implicated in such a manner, that each junction resembles a vertebra, or hinge. With this idea also corresponds the particular kind of the flexibility of the stone, which is not tough or coriaceous. For, if the stone be held upright and shaken, it vibrates with some noise to and fro; but as soon as its agitation is discontinued, its parts conjoin again firmly by a force like a spring.

B.

I now proceed to its chemical analysis.

a) As, on triturating, I found the particles of the stone extremely hard, which was indeed previously ascertained by its faculty of cutting glass with ease, and of striking fire with steel, I endeavoured to facilitate its decomposition by previous mechanical comminution.

To effect this, I subjected *one hundred* grains to red-heat, and quenched them in cold water; but I observed, that by this neither their weight nor their hardness had decreased. They were then reduced to an impalpable powder in an agate mortar, mixed with four parts of dried carbonated soda, and ignited under the muffle in a porcelain-saucer, during six hours, in a moderate degree of heat; by which the mixture only conglutinated, without actual fusion. The ignited mass was pulverized with water, super-saturated with muriatic acid, digested and filtered. A quantity of very loose *siliceous earth*, to the weight of 96½ grains, remained on the filter.

b) The separated muriatic fluid was treated with Prussian alkali; and the blue precipitate, thence arising, ignited.

 It

It weighed one grain; of which, however, only $\frac{1}{2}$ grain can be reckoned as *oxyd of* iron, entering into the 100 grains of the decompoſed foſſil.

c) At laſt, by ſaturating the ſolution with carbonated potaſh, a tender earth was thrown down; which, after waſhing, drying, and ignition, weighed $2\frac{1}{2}$ grains; and, examined by means of ſulphuric acid, was found to be *aluminous earth*.

Conſequently, *hundred* parts of *elaſtic quarz* from *Braſil* have yielded:

Silex	96,50
Alumine	2,50
Oxyd of iron . . .	0,50
	99,50

There are ſometimes very ſmall blackiſh grains, like points, mingled with this ſtone. As theſe probably are garnets, or cryſtals of horn-blende, it ſeems that the portion of iron and alumine diſcovered in the foſſil chiefly proceeds from them.

XLIII.

CHEMICAL EXAMINATION

OF THE

GLASS-STONE (Hyalite),

From Dauphiny.*

As the term *Shörl* was formerly ufed in too vague a fenfe; to remedy this uncertainty, it has been found necef-fary to confine its mineralogical fignification within narrower limits. On this confideration, the foffil here treated of, which *Romé de l'Ifle* has firft introduced into public notice, by the name, *Schörl tranfparent*, *lenticulaire*, but which has fince become more known by that of *Violet-Schörl*, could no longer be ranked under that head. *Werner*, therefore, has claffed it as a diftinct fpecies, and given it the name, *Thumerftone.* But it alfo has got other names, fuch as, *Glafs-ftone*, or *Haylite*, *Pfeudo-fhörl*, *Glafs-fhörl*, *Oifannite.*

It was, for the firft time, difcovered in *Dauphiny*, chiefly at *Bourg d' Oifans* near *Allemont*; partly upon a blackifh-grey horn-blende-ftate, partly in the clefts of a greenifh-grey gneifs, already fomewhat foftened by decay, where it is accompanied by quarz, amianth, and cryftallized actino-lite. Moft of its cryftals are upright, and their leading figure is very compreffed rhomboidal parallelopipedons or

* See Magazin für Die Naturkunde Helvetiens. I. B. 1787 pag. 180.

flat

flat rhomboidal tables, ſharply truncated, and of a fine ſtriated ſurface. The colour of the purer tranſlucid cryſtals is a faint amethyſtine-red, which in the leſs bright cryſtals changes to the white-grey.†

Glaſs-ſtone, or *hyalite*, is alſo found in the Pyrenees at *Barèges*, and other places; but not in ſuch clear and large cryſtals as that of Dauphiny.

The third place where this foſſil occurs is the mine *Niklas*, at *Thum*, near *Ehrenfriesderdorf* in Saxony; where it is rarely met with in a cryſtallized ſtate, but moſtly in ſeparate, maſſive, teſtaceous pieces.

Beſides theſe, I have likewiſe found it in a ſpecimen of native ſilver, from *Kongsberg*, preſerved in the inſtructive collection of Mr. *Siegfried* at Berlin.

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a) Glaſs-ſtone, treated upon charcoal before the blow-pipe, foams much as ſoon as it becomes red-hot, and readily melts into a black, ſhining, opake bead. This phenomenon, along with the great difference of its external characters, affords a ſufficient ground to ſeparate the *hyalite* from *ſhörls*, with which it has been confounded. The true *ſhörls*, indeed, likewiſe fuſe upon charcoal; however, *firſt*, their fuſion is not accompanied by a briſk effervefcence, but rather by a languid ſwelling; *ſecondly*, a much ſtronger and more laſting heat is required, to make pure ſhörls run into a globule equally fuſed in all its parts; and, *thirdly*,

† Fuller deſcriptions of its external characters are found in the later mineralogical elementary books, among which deſcriptions, that given by *Eſtner* is the moſt complete. See his *Mineralogy.* II. B. I. Abth. S. 258.

moſt

moſt ſpecies of ſhörls, if not all, loſe their colour by the fire; whereas the cleareſt and leaſt coloured fragments of that foſſil yield a completely black vitreous bead. In this reſpect, hyalite agrees more with horn-blende *.

b) To diſcover the conſtituent parts of hyalite, I choſe that from Dauphiny, firſt mentioned. *One hundred and ſixty* grains of the pureſt cryſtals, broken off from ſeveral *druſes* (regular cryſtalline groupes), were ignited for one hour in a porcelain-pot, at a degree of heat not intenſe enough to fuſe them. Their weight, colour, figure, and hardneſs, continued unimpaired. Only three grains were loſt during trituration.

c) Theſe 157 grains of the pulverized ſtone, mixed with three times their weight of exſiccated ſoda, were expoſed for three hours to a gentle red-heat, in a procelain pot. After cooling, they were found conglutinated into a blueiſh-grey, compact, hard, finely porous maſs, readily ſeparable from the ſides of the veſſel. When finely ground, covered with water, and ſuper-ſaturated with muriatic acid, the mixture acquired a gelatinous conſiſtence, and a dirty brown colour. On diluting it with more water, and digeſting it, oxygenated muriatic acid gas was extricated, and the brown colour diſappeared; the fluid, ſuperincumbent on the undiſſolved, white, ſlimy earth, being clear and of a gold-yellow. This earth, after decanting the liquor, was digeſted anew with muriatic acid; then ſeparated by filtration, waſhed, and ſtrongly ignited. It weighed 79 grains, and was *ſiliceous earth.*

d) To obtain firſt of all the metallic part of the ſolution, I gradually dropped Pruſſian alkali into it, as long as any

* On the habitudes of this foſſil in porcelain-fire, ſee Eſſay I. No. 36.

precipitation

precipitation would enfue. The deep-blue precipitate, thus procured, weighed 61½ grains, upon wafhing and drying; but, when ftrongly ignited, there remained only 28 grains, which confifted of *black oxyd of iron*, obeying the magnet. From thefe muft be fubtracted the portion of iron retained by the falt employed; and hence, (from the refult of another effay, made on purpofe with a portion of Pruffian alkali of the fame preparation) only 15 grains of that metal are left to be put in the account as a conftituent part of the foffil.

e) The amethyftine red colour of the rough cryftals, and the blueifh colour of the mafs fufed with foda, but ftill more the vapours of oxygenated muriatic acid emitted during the folution, fhewed that *manganefe*, as well as iron, was prefent in this inftance. For this reafon, I ignited thofe 28 grains of oxyded iron (*d*), adding 10 drachms of nitre; and when this laft had been for a while in red fufion, I poured it off from the iron that lay at the bottom of the crucible upon a marble flab. When fixed again, the nitre appeared of an emerald-green. Thrown into water, it foon diffolved, tinging the liquid of an amethyftine-red; and, when this colour had vanifhed, *manganefe* fell down in light-brown, loofe flakes, weighing 1¼ grain. But, on being farther tried, it was found to be ftill mixed with iron.

f) I next began to examine the diffolved earths.—By the perfect and ready fufion of hyalite alone, and without addition, I was induced to fufpect in it a confiderable proportion of calcareous earth; but neither oxalic acid alone, nor oxalat of pot-afh, produced any turbidnefs or precipitate. However, as the fequel has fhewn, lime was, neverthelefs, prefent. This fact may ferve as a caution, that even the very beft re-agents ought not to be always trufted to with unlimited confidence.

Carbonated

Carbonated pot-aſh was now employed to precipitate the earth contained in the ſolution. It fell down, white, and of a looſe form; and weighed 91 grains after waſhing and deſiccation in a low heat. The fluid filtered off, together with the waſhings, were entirely evaporated, and the remaining dry ſaline maſs re-diſſolved with a little water. By this management 1½ grain of a granular earth was ſtill left, which I added to the preceding 91.

g) Upon theſe 92½ grains of earth I affuſed one ounce and a half of diſtilled vinegar, concentrated by freezing, leaving the whole ſtanding for 12 hours. A feeble, but laſting effervefcence took place. The acetic ſolution being decanted, another freſh ounce of acetic acid was affuſed upon the ſediment; and, after 12 hours, it was expoſed to a moderate temperature. When, after 48 hours, the ſubtle earth, which gave the ſolution an opaline appearance, had ſubſided, I collected it upon the filter; waſhed, dried, and ignited it. It weighed then 41½ grains. At this time the acetic ſolution yielded a white precipitate, by uncombined as well as by neutralized oxalic acid. But, as from this alone no certain concluſion could be made as to the preſence of lime, I added to that fluid ſucceſſive portions of ſulphuric acid, till the white granular precipitate ceaſed to fall down. The mixture, a little evaporated and filtered, left ſulphat of lime behind, which, after ignition, weighed 38 grains.

h) The liquor, filtered off from this laſt, was combined with cauſtic ammoniac. *Aluminous earth* fell down, weighing 2½ grains when ignited. The remainder of the ſolution afforded ſtill ſome ſelenite, on evaporation to dryneſs; which, ignited, left two grains, and was added to the preceding 38 grains (*g*).

 i) In

i) In order to decompofe the felenite, I boiled it during a quarter of an hour with a folution of carbonated pot-afh, in fuch a proportion as made the alkali predominate. The earth left behind weighed 26½ grains, after wafhing and torrefaction; and proved, upon trial, to be a highly pure carbonat of lime. Therefore, fince nine parts of crude calcareous earth afford by ignition five parts of burnt or quick-lime, the above-mentioned 26½ grains are equal to 14¾ grains of *calcareous earth*, freed from water and carbonic acid.

k) Thofe 41½ grains of earth (*g*), together with the 2½ grains (*h*), which I took for *alumine*, were combined with three drachms of concentrated fulphuric acid, and then diluted with fome water. The mixture exhibited a pleafing rofe-colour; but which, on infpiffating the fluid almoft to drynefs, paffed into a light blue: fhewing thus the prefence of a fmall trace of *manganefe*. On being re-diffolved in water, it yet depofited fome *filiceous earth*, weighing 3¾ grains, after ignition. By fubtracting thefe from the foregoing 44 grains, that were held in folution by the fulphuric acid here employed, the quantity of *aluminous earth* found in the foffil is reduced to 40¼ grains.

l) To be affured that this ingredient is pure alumine, unaccompanied by magnefia, I heated the folution to the degree of boiling, and gradually faturated it with elutriated chalk, until it effervefced no more, and no acid could be obferved to predominate. After gentle boiling for half an hour, I filtered the fluid, reduced its quantity by evaporation, and feparated the felenite which yet appeared. However, no fign of fulphated magnefia could be perceived in the folution, either by the tafte or by re-agents.

Thus

Thus the decompofed 157 grains of *hyalite*, from Dauphiny, have yielded :

Silex	c) . . . 79	} .	82,75
——	k) . . $3\frac{3}{4}$		
Alumine	k)		40,25
Lime	i)		14,75
Oxyd of iron, including that of *manganefe*	d)		15
			152,75
		Lofs	4,25
			157

Wherefore, an hundred parts contain :

Silex	52,7
Alumine	25,6
Lime . . . , . . . : . .	9,4
Oxyd of iron and *manganefe* .	9,6
	97,3

XLIV.

CHEMICAL EXAMINATION

OF

CHRYSOPRASE,

And its concomitant Green Earth *.

CHRYSOPRASE is a natural product, hitherto exclusively of Silesia, chiefly found near the village *Kosemütz*, in the Principality of *Münsterberg*; where it occurs in the clefts and disjunctions of a soft serpentine rock, together with quarz, hornstone, chalcedony, opal, asbest, talc, *(magnesia)* and various other species of earths †.

Authors are not agreed in stating the constituent parts of chrysoprase. Their opinions chiefly differ with respect to the principle that produces the green colour of this stone: some ascribing it to iron, others to cobalt, and some again to copper.

FIRST SECTION.

Analysis of Chrysoprase.

a) Some selected, pure pieces of chrysoprase were heated to redness, and quenched in water. Their colour was

* See *Beob. u. Entd. a. d. Naturkunde*. 2 B. 2 St. Berlin. 1788. p. 17.

† A more circumstantial account of the natural history and bed of chrysoprase, and the stones that accompany it, is given in *Lehmann's Physisch-chemischen Schriften*—and *Gerhard's* Beyträgen zur Chemie, *and Geschichte des Mineralreichs*; as also in his *Grundriss des Mineralsystems*.

hereby

hereby changed to a blueiſh-grey; and, by a ſecond torrefaction and quenching, into a blueiſh-white. The ſtone loſt 1½ *per cent.* by the ignition, and became ſo ſoft, that it admitted of being eaſily ground to a very ſubtle powder.

Three hundred grains of this powder, mixed with twice their weight of dry carbonated ſoda, were ſubjected to a low red-heat for ſome hours, in a veſſel made of porcelain-clay. The maſs was then powdered while yet warm, and digeſted with water. The ſolution acquired a dirty browniſh colour, and left, upon filtration, a grey-yellow reſidue of 44 grains when edulcorated and dried. It paſſed colourleſs through the filter, and by ſaturation with muriatic acid, it yielded a copious precipitate; which, collected, waſhed, dried, and ignited, conſiſted of 268¼ grains of *ſiliceous earth*.

b) Upon the 44 grains of reſidue, that were ſeparated on diſſolving the ignited maſs in water (*a*), introduced into a retort, I poured *eight* times their weight of nitro-muriatic acid, and digeſted them together. This done, I abſtracted the greateſt part of the acid, and what had diſtilled over I returned upon the contents of the retort; digeſted it once more, and then filtered the whole. There remained on the paper a white, looſe *ſiliceous earth*, weighing 20¼ grains upon ignition.

c) To the filtered ſolution I added cauſtic ammoniac in exceſs. Its colour, which before was of a dilute green, turned blueiſh; and a little browniſh matter fell down in the form of ſlime. Upon this precipitate nitric acid was affuſed in a ſmall retort, and again diſtilled off from it. This affuſion and abſtraction were repeated twice more; and, at laſt, the retort was ſtrongly heated to redneſs upon charcoal. The reſidue I then diſſolved in weakened nitric acid. A brown *oxyd of iron* remained, amounting to ¼

 grain,

grain, which, diſſolved in muriatic acid, afforded, with Pruſſian alkali, a deep blue; and, with tincture of galls, an ink-black precipitate. Whence this portion of iron, as it is ſo ſmall, can have no ſhare in producing the green colour of chryſopraſe.

From the nitric ſolution, cleared from iron, carbonated ammoniac precipitated ½ grain of looſe *aluminous earth*, weighed in the dry ſtate; but for which, in the ignited ſtate, only ¼ grain can be reckoned.

No trace appeared of *magneſian earth*.

d) The ſolution, ſuper-ſatuated with cauſtic ammoniac (*c*), was tried for lime; and with this view combined with carbonated ſoda. The precipitate produced was carbonat of lime. Upon deſiccation, it weighed 4¾ grains, which denote 2½ grains of *calcareous earth*, in the ignited ſtate.

e) The fluid, from which this lime had been ſeparated, ſtill preſerved its blueiſh colour (*c*), and yielded no precipitate, either with acids or with alkalis. For this reaſon, it was diſtilled to dryneſs. There remained in the retort a yellowiſh ſaline maſs, which again made a green ſolution with water. When this ſolution had been combined with mild pot-aſh, it depoſited only a ſlight portion of a white-greeniſh earth; the remainder would not precipitate, notwithſtanding all my endeavours: therefore, I dropped into the mixture as much nitric acid as was neceſſary to re-diſſolve the precipitate, and treated it with pruſſiat of pot-aſh, until the whole was ſeparated. The collected, waſhed, and dried precipitate had a ſea-green colour, and weighed 17 grains.

f) In this precipitate, therefore, that conſtituent part of chryſopraſe was contained, on which its green colour depends.

pends.—What then is this conftituent part? Certainly not *iron*; for this, by its nature, will never diffolve in cauftic ammoniac, nor ever produce with it a blue colour. Befides, it would have been precipitated of a deep blue, by the Pruffian alkali, with which it was tried (*c*); and, laftly, the oxyd of iron, of which there exifts only a very flight portion in the chryfoprafe, had already before been feparated (*c*). Neither can it be faid, that *copper* forms any part of that precipitate. This metal does indeed diffolve of a blue colour, in ammoniac, as does the above-mentioned precipitate; but as this property does not exclufively belong to copper alone, no decifive conclufion can be deduced merely from this circumftance. Moreover, the bright aqua-marine colour of this precipitate, produced by means of pruffiated pot-afh, has abfolutely nothing in common with the red-brown colour, with which copper always prefents itfelf, when thrown down from any folvent by that precipitant.

But the moft convincing proof of the total abfence of copper in this inftance was afforded by the following experiment: I expofed the 17 grains of the greenifh precipitate (*e*) to red-heat, in a crucible, and fubjected the black-brown refidue, which weighed feven grains, to vigorous digeftion in nitric acid. By this treatment, a flight quantity of iron, originating from the Pruffian alkali employed for the precipitation, was depofited; and all the remainder afforded a green folution with nitric acid. This I diftributed into two phials; putting into the one a piece of polifhed iron, and into the other a ftick of zinc. But in neither of them, both in the cold or heated, could the leaft indication of copper be obferved.

g) After I was thus fully certain that no copper was prefent, I could not account for this conftituent part of chryfoprafe, otherwife than by taking it for *oxyded nickel*.

 This

This concluſion was corroborated by all the phenomena above-mentioned, which wholly reſembled thoſe of other experiments which I made, by way of trial, with an oxyd, prepared from the utmoſt pure reguline nickel.

Being accuſtomed to repeat thoſe experiments, which lead to new diſcoveries, in order to ſecure myſelf, by the agreement of the reſults, againſt accidental miſtakes, I ſubjected another quantity of chryſopraſe to analyſis.

The blue ſolution of oxyd of nickel in ammoniac, which I then obtained, I diſtilled to dryneſs from a retort; after which, I roaſted the reſidue with wax, in a gentle heat, and tried to reduce it to the reguline ſtate upon charcoal, by means of borax and fuſible phoſphoric ſalt. The reduction ſucceeded with either flux; but it required to be ſtrongly aſſiſted by the blow-pipe. While reducing with borax, the metal would not eaſily run into a button; but, with the phoſphoric ſalt, it proved ſomewhat more fuſible, and yielded a white-grey bead, that exhibited a ſhining polyhedral ſurface, and a finely grained fracture.

Theſe metallic buttons were too few to admit of a farther examination. For this reaſon, I endeavoured to procure more of them, which I effected by decompoſing the green earth of chryſopraſe, deſcribed in the following ſection; and the third ſection will ſhew, that thoſe ſeven grains of the precipitate obtained by Pruſſian alkali, and ignited *(f)*, denote $2\frac{1}{2}$ grains of metallic nickel; or three grains of pure *oxyd of nickel,* when heated to redneſs.

Whence the conſtituent parts, produced from the 300 grains of *chryſopraſe* decompoſed, are:

Silex

Silex	*a*) . . $268\frac{1}{4}$	}	288,50 grs.
——	*b*) . . $20\frac{1}{4}$		
Alumine . . .	*c*)		0,25
Lime	*d*)		2,50
Oxyd of iron . .	*e*)		0,25
Oxyd of nickel .	*g*)		3
			294,50
Lofs, which the chryfoprafe fuffers by ignition, and chiefly confifts of particles of water	. . . . *a*)		5,50
			300

With this proportion of the conftituent parts of chryfoprafe, the refults of feveral of my experiments agree pretty well. Yet I readily admit, that, on repeating fuch experiments, fome fmall differences may take place, efpecially in the portions of iron and nickel, fince the green colour of this foffil fo often varies. In like manner, I have fometimes difcovered more fenfible indications of magnefian earth, though never amounting to more than $\frac{1}{8}$ *per cent.*

SECOND SECTION.

Analyfis of the Green Earth of Chryfoprafe.

a) Among the varieties of the glittering, fattifh, green earth, that fometimes accompanies chryfoprafe, I felected that for the prefent enquiry, which by its uniform apple-green colour is diftinguifhed from the others, as the moft pure and leaft contaminated with heterogeneous matters. Upon *three hundred* grains of this, put in a retort, I poured four times their weight of an *aqua regia*, compofed of three parts of muriatic, and one of nitric acid, and at firft digefted geſted them for a while. The action of the acid upon the earth was attended with an extrication of yellowiſh vapours. That portion of the acid which paſſed over was poured back into the retort, with the addition of one part of freſh nitric acid; and, after a ſecond digeſtion, diſtilled off to moderate dryneſs. The remaining maſs, whoſe green colour was now changed into a yellow, was again digeſted with the acid that had been abſtracted, and next ſeparated by filtering from the indiſſolvable reſidue.

b) This reſidue, which reſiſted the attack of the digeſting acid, conſiſted of a very tender, looſe, dazzling-white, and glittering *ſiliceous earth*, that weighed 105 grains after deſiccation in a red-heat. I mingled and ignited it with 210 grains of carbonated pot-aſh; upon which I triturated the maſs with water, ſuper-ſaturated it with nitric acid, digeſted and filtered it. In the fluid that paſſed through the paper nothing could be found, except *one grain* of ſilex.

c) The ſolution, ſeparated from the ſilex (*a*), had a green colour. It was combined with carbonat of pot-aſh, and the precipitate produced was edulcorated and dried in the air. This precipitate had a pale green colour, like the crude earth, and weighed 280 grains. By way of previous examination, I diſſolved *one fifth part* of it in muriatic acid, and tried the ſolution, which again exhibited its original green colour, in the following manner:

α) *Ammoniac* threw down a white green precipitate, which, on adding more ammoniac, in part re-diſſolved, and produced a blue tincture.

β) By means of *pruſſiated pot-aſh*, a copious ſea-green precipitate, inclining to blue, fell down.

γ) *Tincture*

γ) *Tincture of nut-galls* produced a faint ink-colour.

δ) With *alkaline fulphuret* there arofe a blackifh precipitate.

ε) In the remainder of that fifth part of the muriatic folution I immerfed a *polifhed iron*, which became tarnifhed, of a grey colour; but no fign of copper, either in a cold or a warm temperature, appeared.

d) The other four-fifth parts of the green precipitate (*c*), which now contained one half ounce of rough earth of chryfoprafe, cleared from filex, were diffolved in nitric acid, and treated with an over-proportion of carbonated ammoniac, fhaking it feveral times. The fupernatant blue folution was decanted on the next day from the refidue; and to this laft frefh portions of ammoniac were repeatedly added, till it ceafed to afford a blue tincture, that could be obferved.

e) The refidue, left after the extraction by ammoniac, was a loofe white-grey earth, weighing 85 grains when dried in the air. It was diffolved by digeftion in nitro-muriatic acid, and treated with cauftic ammoniac, until nothing more fell down. The light-brown precipitate then obtained was heated to rednefs; after which it weighed 26 grains. Nitric acid was next affufed upon it in a retort, and again abftracted by diftillation; and this abftraction and digeftion were repeated twice more. I then urged the fire of the coals fo as to redden the retort, powdered the calcined refidue, diffolved it in dilute nitric acid, and threw it upon the filter. There remained a red *oxyd of iron*, which, dried and deflagrated with wax, was attracted by the magnet, and weighed eleven grains.

f) The

f) The 15 grains which yet remained in the ſolution after the ſeparation of theſe 11 grains of iron (*e*), were precipitated by mild ſoda, deſiccated in the air, and extracted in the cold by diſtilled vinegar. This attacked it with effervefcence; but, when again filtered off, and treated with carbonated ſoda, it depoſited, without any effervefcence, a looſe earth, which after ignition weighed three grains; and, being tried with ſulphuric acid, proved to be *magneſia.* The remaining earth, now reduced to 12 grains, when calculated the ignited ſtate, was *alumine.*

g) There ſtill remained that fluid (*e*), from which the iron, and the magneſian and aluminous earths were precipitated by cauſtic ammoniac. It was warmed, and combined with carbonat of ſoda, which precipitated $1\frac{1}{2}$ grain of crude *calcareous earth*, for which, to avoid ſmall fractional parts, I put one grain of burnt *lime* in the account.

h) I now return to the blue extraction, prepared with carbonated ammoniac (*d*). I diſtilled it, together with the water employed for lixiviating the reſidue, from a retort, almoſt to dryneſs. The reſidue I ſoftened with water, and found, that, upon filtration, it left ſeven grains of a pulverulent iſabella-coloured earth; which, by ignition, loſt one half of its weight, yet continued unchanged in colour.—When previouſly diſſolved in nitric acid, it was thrown down of a white-yellow by alkalis, of a pale olive by pruſſiated pot-aſh, and of a light-brown by arſenical alkaline ſulphuret; but by the tincture of galls it would not at all precipitate. On this account I conſidered it as an impure *oxyd of nickel.*

i) As no ammoniac any longer predominated in the fluid which had been filtered off from the iſabella-coloured earth (*h*), it had again a bright graſs-green colour. I now endeavoured

endeavoured to ſeparate the ſubſtance which it held in ſolution, by adding alkaline ſalts.—Yet I could not completely ſucceed; and, notwithſtanding that I watched the moſt exact point of ſaturation, this middle (or earthy) ſaline liquor ſtill retained part of that ſubſtance in a diſſolved ſtate. The greateſt portion of the precipitate I firſt obtained by means of mild ammoniac; and when this had been ſeparated, mild pot-aſh threw down another portion. The precipitate, collected, waſhed, and dried in the air, had a pale, whitiſh-green colour, and weighed 50 grains.

k) *Thirty* grains of this precipitate were ignited for ½ an hour; whereby its whitiſh green was altered to a grey-green: and it loſt half of its weight. Thoſe 50 grains, therefore, muſt be eſtimated at 25 grains of ignited *oxyd of nickel*. In this inſtance I did not perceive that ſort of excreſcence which uſually takes place when oxyds of nickel, procured from ores of that metal, are expoſed to fire; perhaps, becauſe no portion of arſenic, by the eſcape of which thoſe delicate ramifications are probably produced, was here preſent.

l) Since neither acids nor alkalis would precipitate any thing from the remainder of the fluid above mentioned (*i*), it now only remained to apply pruſſiat of pot-aſh. This ſtill precipitated a conſiderable quantity of a pale ſea-green earth; which, upon waſhing and ignition, became granular, aſſumed a brown colour, and weighed 21 grains. This quantity, calculated after the manner to be explained in the third ſection, indicates 9 grains of ignited, pure *oxyd of nickel*.

Therefore, the conſtituent parts contained in *half an ounce* of that variety of the *green-earth of chryſopraſe*, which had

had been employed for this inveftigation, are the following:

Silex (fince 105 grains were obtained from 300 grains of that earth)	*b*)			84 grains
Alumine	*f*)			12
Magnefia	*f*)			3
Lime	*g*)			1
Oxyd of iron	*e*)			11
Oxyd of nickel	*h*)	$3\frac{1}{2}$		
———	*k*)	25		37,50
———	*l*)	9		
				148,50
Lofs, very nearly approaching that which the rough earth of chryfoprafe fuffers by red-heat				91,50
				240

THIRD SECTION.

Clofer Examination of the Portion of Nickel contained in Chryfoprafe, and its concomitant Green-earth.

In order to examine more accurately the whitifh-green metallic oxyd that enters into chryfoprafe, as well as its concomitant green-earth, I procured another quantity of it, by repeated decompofitions of thofe two fubftances, performed in the manner before defcribed. This I fubjected to the following experiments.

a) Treated with *ammoniac*, it foon diffolved, and yielded a pure blue tincture, though lefs faturated than that which is af-

afforded by the ſolution of copper in ammoniac, made with the ſame proportion of theſe reſpective ingredients. If nitric acid be affuſed in a quantity a little beyond what is neceſſary to ſaturate the ammoniac, the ſolution appears of a light graſs green.

b) It entirely diſſolved, and with effervеſcence, in *ſulphuric acid.* It likewiſe gave with this a green ſolution; from which

α) *Carbonated pot-aſh* precipitated that oxyd of a whitiſh-green.

β) *Pruſſian alkali* of the ſame, but ſomewhat darker colour.

γ) *Tincture of galls* produced no change nor turbidneſs in the ſolution.

δ) *Arſeniated alkaline ſulphuret* threw down a great quantity of a black-brown precipitate; but of which

ε) Neither on *poliſhed iron*, nor on *zinc*, any thing of a metallic nature would depoſit; the ſolution producing only ſome weak, grey ſpots on theſe metals.

ζ) By expoſure to open air, this ſolution ſhot into clear, emerald-green, rhomboidal cryſtals of *ſulphated nickel*, which, by roaſting, crumbled into a white-greeniſh powder.

c) The green oxyd of nickel, tried upon charcoal, with a blow pipe, ſhewed the following appearances:—

α) Ignited by itſelf, it became *violet*; but ſhewed no diſpoſition to fuſe.

β) With *borax*, aſſiſted by a continued ſtream of air from the blow-pipe, it fuſed, and was partially reduced to a white-grey metallic maſs; but which would not run into one ſingle button.

γ) *Phoſphated alkali* likewiſe reduced it to the reguline ſtate, at the ſame time that it more readily united into one bead. The glaſs globule exhibited, during the action of heat, a garnet-red, but, after refrigeration, a hyacinthine colour.

d) I now attempted its reduction in the *crucible*. With this deſign, I introduced the 15 grains of metallic oxyd, remaining after ignition from thoſe 30 grains mentioned (2 Sect. *k*), into a crucible, previouſly mixed with the ſame quantity of reſin, and three times that of calcined borax, and covered the whole with common ſalt. The veſſel was then conveyed to the melting-furnace, and the fire managed in about the ſame manner as on aſſaying copper. After cooling, the inſide of the crucible was found lined with a thin glazing, on ſome places of the upper part, of a green, but on the lower one, of a bright hyacinthine colour. The maſs itſelf fuſed well; and, on breaking the veſſel, there was found, under the colourleſs ſaline cover, a tranſparent light-brown glaſs, and, between this, a metallic button. This, however, being refractory, had not run into a compact maſs, but was only conglutinated, conſiſting of ſeparate, ſmall, looſely-coherent globules.

This metal had a perfect metallic luſtre, and a grey colour, verging to the red When freed by elutriation from the adhering ſcoria, it weighed 9¼ grains. But as here and there ſome minute grains were ſticking to the fragments of the crucible, not eaſily ſeparable, I may properly

perly eſtimate them at $\frac{1}{4}$ grain; wherefore the weight of the *metallic nickel* is determined at 10 grains.

α) The *magnet* has attracted theſe metallic grains with ſuch rapidity, that, on its approach, the whole quantity adhered to it in an inſtant; and not one ſingle globule remained behind.

β) One grain of them by weight afforded, with *ſulphuric acid*, aſſiſted by heat, a graſs-green ſolution; from which

γ) *Ammoniac* again precipitated the metallic part, of a bright whitiſh-green; but, on being affuſed in greater quantity, it ſoon re-diſſolved it clearly, and of a ſky-blue colour.

δ) *Five* grains of this reduced nickel, diſſolved in *nitric acid*, and thrown down by *Pruſſian alkali*, then edulcorated and dried, gave a ſea-green precipitate; which, expoſed to red-heat, left 15 grains of a granular reſidue, wholly attractible by the magnet.

ε) Thoſe metallic grains urged by the flame upon charcoal, before the blow-pipe, exhibited no diſpoſition to melt, or fuſe, but turned to a greeniſh oxyd.

ζ) When fuſed with *borax*, they likewiſe would not readily enter into fuſion. The glaſs of borax turned aſh-grey and opake; and the metal remained in it in a divided ſtate.

η) But with fuſible *phoſphoric ſalt* they melted pretty ſoon into one ſingle bead, of a polyhedral ſurface. The glaſs globule, which, during the action of heat,

 was

was of a deep garnet-red, became tranfparent after cooling, and affumed a fine hyacinth colour.

e)Notwithftanding that all thefe facts, taken together, fufficiently demonftrate that the conftituent part of chryfoprafe, from which its peculiar green colour arifes, is a *true oxyd of nickel*; yet I have, for the fake of fuperabundant evidence, made other experiments with an oxyd of nickel, which I prepared by the following method.

A portion of *ore of nickel*, from the pit *König David*, on the *Sauberg*, at *Annaberg*, was coarfely pounded, the pureft pieces felected, converted into a grofs powder, and roafted in fhallow pots, as long as any arfenical vapour exhaled. The powdered ore acquired, by this, a dirty green colour, and vegetated, in part, into ramified figures. This oxyd of nickel I reduced with black flux, and obtained a yellowifh-white, brittle, metallic button, of eafy fufion. This, being once more calcined, was digefted in a retort, with an equal quantity of ftrong fulphuric acid; after which the acid was again diftilled over to drynefs, and the refidue re-diffolved in water, and filtered. At the beginning, the folution depofited fmall cryftals of arfenic; and when thefe had been removed, the fulphated nickel fhot into beautiful, deep-green, rhomboidal cryftals. This vitriol of nickel I again diffolved in water, and precipitated it by means of carbonated pot-afh. Upon the oxyd of nickel thus obtained, when wafhed, dried, and pulverized, ammoniac was affufed. This laft foon extracted a fine blue tincture, which, filtered off from the refidue, was faturated with nitric acid; and, by means of mild pot-afh, all the whitifh-green earth which it would yield was precipitated from it.

With this oxyd of nickel, extracted in this way from its ore, I have inftituted various experiments, for the fake of trial;

trial; which, to avoid prolixity, I ſhall not particularly enumerate. I will, therefore, only ſtate, that this oxyd, as to the eſſential phenomena, has perfectly agreed with that extracted from chryſopraſe.

f) Thoſe who deſire information reſpecting the habitudes of nickel in general, I refer to the valuable treatiſe of *Bergmann* * on that metal; where he relates his experiments, made with unwearied patience, for the purpoſe of extracting the regulus of nickel, in a ſtate of purity, from its ores, in which it is conſtantly accompanied by foreign metallic ſubſtances. The difficulties which take place in thoſe proceſſes, I have found confirmed by my own experiments: but I think the beſt method of obtaining the reguline part of nickel is that deſcribed above; namely, by means of ammoniac: yet the product becomes ſomewhat expenſive.

In the chryſopraſe, on the contrary, the oxyd of nickel is not mixed with other metallic matters, a very ſlight portion of iron excepted; and ſince the proceſs which I have there given likewiſe ſerves to ſeparate this inconſiderable ferruginous ingredient, we may ſafely conſider the *metallic nickel*, produced from chryſopraſe, or its accompanying green earth, to exiſt in the ſtate of the *utmoſt poſſible purity*.

g) To this aſſertion, however, it may, perhaps, be objected, that the nickel obtained in that way ſtill obeys the magnet, and, therefore, yet contains ſome iron. But has it as yet been unqueſtionably proved, that iron alone is ſubjected to the law of magnetic attraction?—Have the arguments which various philoſophers have brought forward

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* *Torb. Bergmann* Opuſc. Phys. et Chim. vol. II. page 231. *De Niccolo.*

againft this fuppofition, been completely refuted?—When the chemift no longer finds any trace of iron in pure cobalt, or in pure nickel, and, neverthelefs, obferves the magnet to act upon it—can his doubt, whether the attractive force of the magnet be confined only to iron, as has been hitherto believed, be fairly rejected without any farther inveftigation?

h) I muft yet mention fome *experiments relative to vitrification*, for which I have ufed the rough chryfoprafe, as well as the oxyd of nickel extracted from it, in combination with various other vitrifying media.

α) *Rough chryfoprafe*, finely powdered and elutriated, ...	1 part,
Carbonated pot-afh, ...	2 parts,

mixed and fufed in a crucible, afforded a violet-blue glafs, which deliquefced in the air to a brownifh fluid.

β) *Rough chryfoprafe* . . .	5 parts,
Carbonated pot-afh . . .	4 parts,

gave, after a fufion continued for two hours, a beautiful hard glafs, of a violet-blue.

γ) *Rough chryfoprafe* . .	equal parts of each
Dry *carbonated foda* . . .	

yielded a tourmaline-brown glafs, tranflucid only in thin fplinters. Its furface had fome delicate veins of reticular delineations; produced by extremely fmall grains of reduced nickel, lying clofe to each other in a linear range.

This reduction, which takes place without the addition of any combuftible matter, is remarkable. *Lehmann* has before

 men-

mentioned a bead of reduced nickel, obtained from chryſo-praſe by reducing fluxes; but he miſtook its nature, erroneouſly conſidering it as iron.

δ) *Rough chryſopraſe*, and
Calcined borax, in equal quantities,

gave a brown tranſparent glaſs, reſembling rock-cryſtal of that colour. *(Rauch-topas).*

ε) Prepared *ſiliceous earth* . .	80 grains,
Carbonated pot-aſh . . .	60
Oxyd of nickel, from chryſopraſe	3

yielded a clear, violet-blue glaſs.

ζ) Prepared *ſiliceous earth* . .	80 grains,
Carbonated pot-aſh . . .	60
Oxyd of nickel, from the ore of that metal of *Annaberg*, obtained by the proceſs mentioned at *(e)* . . .	3

By this experiment I obtained a glaſs of a violet-blue colour, perfectly reſembling the laſt.

η) Prepared *ſiliceous earth*,	
Burnt *borax*; of each . . .	60 grains of each
Oxyd of nickel from *chryſopraſe*	3

produced a clear, light-brown glaſs.

θ) Prepared *ſiliceous earth*	
Vitrified *phoſphoric acid*, prepared from bones,	60 grains of each
Oxyd of nickel from *chryſopraſe*	3 grains,

 have

have afforded a honey-yellow glafs; but which did not become entirely clear.

i) Of the various inferences that may be drawn from the preceding facts, I will felect only a few.

Lehmann, to my knowledge, was the firft, who obferved that chryfoprafe affords a *blue glafs* by fufion with carbonat of pot-afh. This obfervation is confirmed by the experiments of *Achard*, made on the fubject of the fufibility of various fubftances. The foregoing experiment (ϵ) fhews, that this blue colour folely depends on the portion of nickel contained in chryfoprafe; and it is proved, by the experiment (ζ), that the oxyd of nickel, if freed, as much as is practicable, from extraneous admixtures, poffeffes the property of tinging glafs-frits, mixed with mild pot-afh, of a *blue* colour, on their vitrification. But what can be the reafon, that this blue colour is not produced by means of mild foda employed in the fame manner? To what caufe is that difference to be afcribed?

The fame experiments alfo prove that *Le Sage* * was in the wrong, when he afferted that the metallic ingredient in chryfoprafe is cobalt. Befides cobalt, we now know feveral metallic fubftances capable of producing a blue glafs, under certain conditions, with which the chemift fhould be thoroughly acquainted, before he infers from this the nature of any metallic fubftance. Thus, *cobalt* covers all fluxes, (enamels, glafs-paftes) blue; while *oxyd of wolfram* (tungften) imparts a blue colour to fuch frits only as are mixed with phofphoric falts, leaving, on the contrary, thofe

* See *Analyfe Chimique et Concordance des Trois Règnes*, par Mr. *Sage*, tom. II, Paris, 1786, page 73.

co-

colourlefs that are combined with borax. In like manner, the *oxyd of nickel* tinges blue the frits prepared with carbonat of pot-afh; but brown, thofe into which carbonat of foda, or borax, enters; and, laftly, it produces a *honey-yellow* in fuch as are mixed with a neutral phofphat.

Since, therefore, chryfoprafe does not afford a blue, but a *brown* glafs, when melted with borax; this fact, together with the knowledge that no trace of any green fympathetic ink is difcovered in its muriatic folution, is alone a fufficient evidence of the abfence of any portion of cobalt from that foffil. *Le Sage* tells us, indeed, he has produced a blue glafs from chryfoprafe and borax; but again this affertion of his does not correfpond with experience.

XLV.

CHEMICAL EXAMINATION

OF THE

NOBLE OPAL,

From Cscherwenitza, in Upper-Hungary.

IF the *Noble Opal*, effulgent with variegated colours (*chatoyant*) be contrafted with the colourlefs *rock-cryftal* and the dull, dark coloured *flint*, it would hardly be poffible, were it not for the conviction afforded by chemical experience, to be perfuaded that the chief conftituent part of thofe three fpecies of ftones, fo diffimilar in their external appearance, is the fame fimple, pure, filiceous earth, or, at leaft, only in exceedingly fmall proportions, mingled with foreign ingredients; and that it is only the difference in the ftate of aggregation which modifies the one to opal, the other to rock-cryftal, and the third to flint.

But that the *noble opal* * really belongs to the pureft forts of filex, is demonftrated by the following analyfis.

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* *Eftner* has publifhed in his *Mineralogy*, vol. II. page 402 feq. an ample defcription of this beautiful ftone; taken principally from the valuable opals in the Imperial Cabinet at Vienna, fo diftinguifhed by their beauty and magnitude; and, befides, from thofe in the collection of opals of Abbé *Neumann*, Director of the Imperial Cabinet of Medals, which, perhaps, is the moft complete in its kind. Of the accurate agreement of thofe defcriptions with the originals, I had the pleafure of convincing myfelf by my own infpection, at Vienna.

A.

A piece of rough, or unwrought noble opal, weighing $76\frac{1}{2}$ grains, was expofed to fire, in a well-covered porcelain-veffel. It crackled at the very firft degree of heating, When the noife caufed by this had ceafed, it was kept in ignition for half an hour longer. After cooling, it was found burft into fmall flaty fplinters, of a pure milk-white, and a furface partly glittering, partly of an enamel-luftre. The yellowifh ferruginous covering, which is perceivable even in the rough ftone, and penetrates its extremely minutes fiffures, was changed, by the ignition, to a *high-yellow-red*, and, in part, *iridefcent*, or exhibiting changes of rainbow colours. It experienced a lofs of weight of $7\frac{1}{2}$ grains, or about 10 per cent.

B.

a) *Hundred grains* of rough, noble opal, finely-pulverized in the flint mortar with water, were mixed, after exficcation, with 200 grains of dry carbonated foda, and fubjected to moderate red-heat for two hours, in a filver-crucible.

The mafs, which but loofely coalefced, was then triturated, foftened with water, fuper-faturated with muriatic acid, and brifkly digefted. The fluid formed a gelatinous coagulum as it cooled. When diluted with more water, and again digefted, it was filtered, and the *filiceous earth* remaining on the paper thoroughly lixiviated, and ignited, after previous drying. It then weighed 90 grains.

c) The muriatic liquor was reduced to a fmall bulk by evaporation, and treated with cauftic ammoniac, added in ex-

excefs. But only a very fmall quantity of brownifh flocculi feparated, confifting merely of iron, and amounting to $\frac{1}{10}$ of a grain, when collected and ignited.

But, fince the very pure white colour of the ignited opal evidently proved, that this flight portion of iron does not effentially belong to its mixture; and fince, befides, not the leaft perceptible trace of alumine appeared, I can only reckon as real conftituent parts, in the opal here examined, the following:

Silex	90
Water	10
	100

XLVI.

XLVI.

CHEMICAL EXAMINATION

OF THE

*SAXON HYDROPHANES**.

AMONG thofe varieties of opal, which are known by the names, *hydrophanes*, *changeable opal*, *oculus mundi*, and poffefs the remarkable property of becoming tranfparent in water or other fluids, thofe from *Saxony* are, befides, particularly diftinguifhed by the beautiful opalefcent play or change of colours, which they exhibit in that fituation, of which fome exhibit fenfible indications, even in their natural dry ftate.

Yet, although hydrophanes has been analyfed by various perfons, the proportions of its conftituent parts are ftated very differently.—From this difagreement, *Wiegleb* was induced to inftitute a new examination of this ftone, which made it appear, that the argillaceous ingredient, to which that peculiar phyfical property of hydrophanes has been erroneoufly attributed, is a much fmaller conftituent part than has been afferted by various authors.

This inveftigation, made by *Wiegleb*, does not thoroughly agree with the refult of that which I performed with various hydrophanes, kindly given me by Baron *Racknitz*, of *Drefden*, and found at *Selitz*, near *Hubertsburg*. This learned connoiffeur and refpectable promoter of mineralogical fcience likewife confirms the circumftance related by *Wiegleb*, that hydrophanes, while in the mine, is foft; and, in

* *Chemifche Annalen*, 1790, part I. page 61. *Chemifche Annalen*, 1789, part I. page 402.

in this ftate, fufceptible of receiving impreffions from hard bodies.

a) *One hundred* grains of this Saxon hydrophanes were coarfely divided or bruifed, and ignited upon red-hot coals, in a fmall glafs retort. At the end of this procefs there appeared, in the receiver, an empyreumatic water, covered with a thin greafy pellicle. The lofs of weight arifing from this was $5\frac{1}{4}$ grains.

b) The ignited hydrophanes was then triturated to a fubtle powder, mixed with twice its weight of carbonated foda, and kept in a moderate heat for two hours. When the mafs had cooled, it was powdered, fuper-faturated, and digefted with dilute muriatic acid. This done, the muriatic fluid filtered off from the *filiceous earth*, that had much fwelled, together with the lixiviating water, was concentrated by evaporation, and faturated with cauftic ammoniac; by which, however, only a fmall precipitate was produced, confifting of pure *alumine*, unmixed with iron, and weighing $1\frac{5}{8}$ grains after ignition. Nothing farther was found in the remaining liquor.

Hundred parts of this *hydrophanes*, from *Saxony*, therefore contain:

Silex	93,125
Alumine	1,625
Volatile inflammable parts, and *water*	5,250
	100

If this hydrophanes, after complete expulfion of its aqueous moifture, be fteeped in melted wax or fpermaceti, in which ftate of artificial preparation it is called *pyrophanes*; it acquires the property of being quite tranflucid, and of a brown yellow or grey colour, when heated in a fpoon upon a charcoal fire.

XLVII.

XLVII.

CHEMICAL EXAMINATION

OF THE

WHITE AND GREEN OPAL

From Kofemütz *.

AMONG the different ftones that accompany the chryfoprafe in its veins, on the mountainous diftrict of *Kofemütz*, there alfo occur various forts of opal, which ought to be claffed partly with the *common* (dull) *opal*, partly with the *femi-opal*. They are there found chiefly of four colours, viz. green, reddifh, yellow, and milk-white; of which the three laft varieties belong to the *common-opal*, and moftly lie on a grey and brownifh hornftone.

The fubject of this enquiry was the *milk-white*, *inclining to the blueifh and tranfparent* variety of that *common-opal*.

a) *Half an ounce* of this foffil, moft finely levigated, and intimately mingled with one ounce of deficcated foda, was moderately ignited for two hours. The mafs, obtained and ground to powder, was faturated to excefs with dilute muriatic acid; then evaporated nearly to drynefs, again diluted with water, and finally thrown upon the filter The refidue, lixiviated, dried, and ignited, gave 237 grains of *filiceous earth*.

b) The fluid, diminifhed by evaporation, and combined with cauftic ammoniac, afforded a flight quantity of a brownifh

* *Beobachtungen und Entdeckungen aus der Naturkunde*. Berlin, 1788. vol. II. page 45.

precipitate.

precipitate. As the remaining liquor continued unaltered, on being combined with carbonat of foda, it fhewed, by this, that it held no other fubftance in folution.

c) When the precipitate, obtained by means of cauftic ammoniac, had been rediffolved in muriatic acid, and treated with pruffiat of pot-afh, it afforded fome Pruffian blue, of which the *oxyd of iron*, that enters as a conftituent part into this opal, was, at moft, one-quarter of a grain. After its feparation, carbonat of foda ftill precipitated half a grain of *aluminous earth*, which, upon ignition, could not be eftimated at more than one-quarter of a grain.

This *common opal*, therefore, chiefly confifts of mere filiceous earth; for *one half* ounce of it yielded:

Silex	237 grains.
Alumine	0,25
Oxyd of iron	0,25
	237,50
Lofs . .	2,50
	240 grs. or ½ oz.

The *apple-green* variety of thofe opals from *Kofemütz*, which it will be more proper to rank under the *femi-opal*, penetrates like the chryfoprafe, in clefts or veins, of from one-half to one full inch thicknefs, thofe maffes of earths and ftones, which lie promifcuoufly in irregular ftrata in the mountains which afford chryfoprafe. The conftituent parts of this green femi-opal are likewife thofe of the foregoing common white opal, only that it contains about *one per cent.* of *oxyded nickel*, from which, likewife, its green colour, like that of chryfoprafe, originates.

XLVIII.

XLVIII.

CHEMICAL EXAMINATION

OF THE

YELLOW OPAL from Telkebanya.

FOR the analyſis of this ſpecies of opal, expreſſed by the name *pitch-opal, telkebanya-ſtone*, I ſelected that clear greeniſh-yellow variety, which in groſs ſplinters reſembles the *bright-yellow* common *amber* (electrum, ſuccinum).

a) *Hundred* grains of it, broken into coarſe fragments, were ſubjected to red-heat for half an hour in a covered crucible. The ſtone flew in pieces, with a moderate decrepitation or crackling noiſe. It was ſlightly tranſparent, after this ignition, but only on the edges; its colour alſo changed into a pale brown-yellow, and the loſs of weight, which it ſuſtained, amounted to five grains. At the ſame time it became very ſoft, and allowed of being eaſily ground to a ſubtle iſabella-yellow powder.

A ſtronger heat renders this opal greyiſh-white. The ſlight portion of iron which it contains, and from which it derived its colour, is reduced, in this proceſs, to the reguline ſtate; and, by means of a good magnifying lens, extremely fine grains of iron, that have tranſuded, may then be diſcovered *.

b) The above-mentioned 95 grains of ignited and pulverized opal were mixed with 200 grains of effloreſced mild

* See Eſſay I. No. 66.

ſoda,

foda, or fuch as had loft its water of cryftallization in the air; and in that fituation expofed to, and maintained in, a moderate red-heat during the fpace of one hour. The mixture came out of the fire quite white, and but loofely conglutinated. It was next foftened with water; fuperfaturated with muriatic acid; concentrated by evaporation to a jelly; once more diluted with water; and, laftly, thrown upon the filter. The *filiceous earth*, which, by this management, remained behind on the paper, weighed $93\frac{1}{2}$ grains, when ignited.

c) I then treated the colourlefs muriatic fluid with cauftic ammoniac, added in an over proportion. But only a few brown flakes feparated, which, when collected and ignited, afforded one grain of oxyd of iron. The remainder of the fluid contained no other ingredient.

Accordingly, *hundred* grains of this *yellow opal*, from *Telkebanya*, confift of:

Silex	93,50
Oxyd of iron . . .	1
Water	5
	99,50

XLIX

XLIX.

CHEMICAL EXAMINATION

OF THE

BROWN-RED SEMI-OPAL

From Telkebanya.

THIS foffil, which occurs but feldom in the Telkebanya-mountains, and by fome has been erroneoufly confidered as a red pitch-ftone, poffeffes a brown-red colour; is maffive, and of moderate brilliance. Its fracture is flat conchoidal, and its texture compact and fmooth. It is opake, brittle, and burfts eafily. By reduction to a fine pulverulent ftate, it acquires a fully faturated deep-red colour, fimilar to that of powdered refin, called dragon's-blood. Its fpecific gravity I found to be 2,540.

a) When entire pieces of it were ftrongly ignited for half an hour, in a covered crucible, it neither flew in pieces, nor experienced any change of colour; but it loft $7\frac{1}{2}$ *per cent.* of weight.

But when expofed to the more intenfe heat of the porcelain furnace, the phenomena take place, which have been mentioned in Effay I. No. 65. For, if ignited in the *charcoal crucible*, a great number of grains of iron tranfude, and the fracture of the ftone becomes grey, dull, earthy, very rough and porous, like fpunge. If ignited in the *clay-crucible*, its whole furface is covered by a fine-fcaly ferruginous cruft, of a metallic luftre, and attractible by the load-ftone. It is, indeed, an unexpected phenomenon, and hence the more remarkable, that iron, fo ftrongly oxyded as it is when contained in this foffil, has, in the latter inftance, been re-

 duced

duced to the reguline ftate, fo as to obey the magnet; and this, without any admixture of charcoal, or any other fubftance of a nearer affinity with oxygen.

b) *Hundred* grains of the foffil, moft finely levigated, were mixed with a cauftic alkaline lye, containing 300 grains of the falt. This mixture, being firft infpiffated to drynefs in a filver veffel, was then ignited for half an hour. After re-frigeration, I foftened the mafs with water, fuperfaturated it to a great excefs with muriatic acid; and having infpiffated it to a gelatinous confiftence, I diluted it again with water, digefted and filtered it. The *filiceous earth*, then obtained and ignited, weighed $43\frac{1}{2}$ grains.

c) The yellow muriatic folution was combined with cauftic ammoniac to over-faturation. A quantity of brown *oxyd of iron*, rather in large proportion, fell down, which weighed 47lb. when wafhed, dried, and ignited. The fluid left by this remained unchanged, when combined with mild alkalis.

d) This oxyd of iron was re-diffolved by digeftion, in muriatic acid, and precipitated by Pruffian alkali. After the feparation of this blue precipitate of iron, the remaining folution was examined, firft with cauftic ammoniac, and next with mild foda. It fuffered no change in either cafe.

Wherefore this foffil, which, from its large proportion of iron, might, perhaps, deferve to be claffed under the genus of iron, with the denomination of *opaline iron ftone*, is, in the *hundred*, compofed of:

Oxyd of iron . . .	47
Silex	43,50
Water	7,50
	98

L.

L.

CHEMICAL EXAMINATION
OF
*MENILITE**.

THE fossil here treated of, and of which *Delabre* and *Quinquet* have given the firſt notice †, is found at *Menilmontant*, near *Paris*. It there occurs at a depth from 60 to 80 feet under a ſeam of clay *(Thonbank)*, in a ſtratum of ſtones that belong to *Werner's poliſhing ſlate*, and is found in larger or ſmaller pieces, for the moſt part detached, and kidney form, or rather in nodules. The colour of its external ſurface is a tarniſhed blue; but its fracture is of a hair-brown, with ſome greaſy luſtre. Its texture appears externally foliated or fine-ſlaty. This, however, is to be conſidered merely as impreſſions from the adhering finely-lamellated *gangue* or matrix; and ſhould be diſtinguiſhed from the coarſe ſlaty texture of the ſtone itſelf, which can only be obſerved when ſeparate. It readily burſts into fragments, which are flat-conchoidal in the croſs fracture, but coarſe-ſplintery in the longitudinal fracture, and are tranſparent in the edges. It cuts glaſs, though it greatly yields to the file, which produces a grey-white ſtreak on it. When it is ſtruck with ſteel, only a few ſingle ſparks are emitted. Its ſpecific gravity is 2,185.

In the ſyſtematical arrangement of minerals, this ſtone has formerly been reckoned among the genus of clay, and accordingly placed as a variety of pitch-ſtone, with the name *blue pitch-ſtone*. Againſt this, an anonymous author has

* *Chemiſch. Annal.* 1790. 2 Th. S. 297.

† *Journal de Phyſique*, Paris, Sept. 1787.

ſtarted

ftarted fome doubts, in a letter to *de la Metherie* ‡, in confequence of experiments which he has made, by moiftening fome pieces of the ftone, and expofing them for feveral months to open air; upon which he found, that fulphat of magnefia had gradually been formed. By this he was perfuaded, that this fpecies of ftone belongs to the magnefian genus, and fhould be added to the fteatites, ferpentine and pot-ftone. With what propriety, will appear from what follows.

A.

From the pieces chofen for this enquiry I firft feparated the earth adhering to their outfide. I then introduced *hundred* grains into a fmall glafs retort, inferting its neck into a bottle containing lime-water. The retort was placed between the coals, or in open fire, and the heat gradually increafed to the ignition of its contents. At the very beginning there paffed over fome drops of water, and foon after I faw the lime-water in the receiver growing turbid. In this laft, when the receiver had been removed, I perceived a bituminous-empyreumatic fmell, which, at firft, alfo feemed to be fomewhat ammoniacal. The pieces of the ftone in the retort were rendered black and refplendent, like jet *(Gagas)*, and had loft eight grains. But by a ftill ftronger ignition in an open crucible, they loft again that black colour, and became at firft blueifh, then grey-white, lofing, at the fame time, three grains more in weight.

I then combined them, previoufly ground to fine powder, with double their quantity of carbonated pot-afh, and put them into an open fire, in a filver crucible. The mixture entered into fufion, without my intending it, and foamed fo

* *Journal de Phyfique*, Paris, Fevr. 1789.

ftrongly

ftrongly that it lifted up the lid of the veffel, and run over in part. Seeing this, I directly withdrew the crucible from the fire, and found that the remaining portion of the mafs had melted into a clear greenifh glafs; which, as it cooled, attracted moifture from the air, and diffolved entirely in a little water.

Although I could not farther proceed in this examination, on account of having loft part of the mafs; yet I forefaw, from thefe facts, that this foffil is not a very compounded fpecies of ftone, but rather that it is likely to confift almoft entirely of mere filiceous earth. This conjecture was again confirmed by the following experiment.

B.

a) I reduced *one hundred* grains of the rough ftone to an impalpable powder; and having mixed them with twice their weight of carbonated pot-afh, I ignited the mixture in a filver crucible, during five hours, in a degree of heat fo moderate, that there was no danger of its fufing. When triturated, it diffolved in water, affifted by heat, leaving only a few undiffolved particles. By fuper-faturation with muriatic acid, the mixture congealed to a thick, intumefced flime. After farther dilution with water, digeftion, and filtering, there remained 84 grains of *filiceous earth*, upon being wafhed, dried, and heated to rednefs.

b) When the fluid, feparated from this laft, had been concentrated by evaporation, and, while yet hot, faturated with mild foda, a brownifh-white precipitate fell down; which, being re-diffolved in nitro-muriatic acid, there ftill feparated fome *filiceous earth*, weighing 1½ grain, when ignited.

c) The liquor, freed from this, was treated with Pruffian alkali; and the quantity of the blue precipitate then pro-

 duced

duced indicated half a grain of *oxyd of iron*, attractible by the magnet. After the feparation of this laft, *aluminous earth*, weighing one grain in the ignited ftate, was thrown down by cauftic ammoniac. Carbonated foda, with the affiftance of heat, precipitated from the remaining fluid a flight portion of loofe earth; which, after ignition, fcarcely weighed half a grain, and, upon trial by fulphuric acid, fhowed itfelf to be *calcareous earth*, accompanied by a trace of *magnefia.*

In confequence of this analyfis, *hundred* parts of *menilite* contain:

Silex	85,50
Alumine	1
Oxyd of iron	0,50
Lime	0,50
Water and carbonic matter	11,
	98,50

From the conftituent parts here produced, it is obvious, that this foffil can, by no means, belong to fteatites, or to ferpentine, or to the pitch-ftone, as the proportions of thofe ingredients, in conjunction with the infufibility of *menilite**, fufficiently prove. Perhaps this foffil may be confidered as a variety of the *femi-opal*, approaching to flint *(Feuerftein).*

The inconfiderable trace of magnefia does not feem to belong to the mixture or compofition of this foffil. It rather originates from particles, that have entered into it from its matrix, which contains a fmall portion of magnefia, as will appear by the following analyfis.

* See Effay I. No. 69.

LI.

CHEMICAL EXAMINATION

OF THE

POLISHING-SLATE

(Polierschiefer of Werner.)

*From Menil-montant.**

THE *polishing-slate*, found at *Menil-montant*, which serves as a matrix to the *menilite*, spoken of in the last Essay, possesses a bright white-grey colour; is meager and rough; of a dull earthy fracture; strongly adhering to the tongue; and split, in a slaty manner, by slender horizontal rifts. Its specific gravity is only 2,080. When thrown into water, it imbibes it with a crackling noise, and copious air-bubbles are disengaged. By trituration it affords a very loose powder, which, on ignition, loses 19 in the hundred, and acquires thereby a pale red colour.

I shall not relate in detail the method by which I performed its decomposition, as it was the same with that of the preceding fossil. But I shall only mention the result, according to which the constituent parts of *polishing-slate*, and their proportions to one another, in the hundred, are:

Silex	66,50
Alumine	7
Oxyd of iron	2,50
Magnesia	1,50
Lime	1,25
Water	19
	97,75

* *Chemische Annalen*, 1790. 2ter Theil. Seite 302.

LII.

CHEMICAL EXAMINATION

OF THE

SILICI-MURITE (Meerſchaum.)

From the Levant *

THE plaſtic *ſilici-murite (myrſen, kil, keffekil)* from *Eſki-Scheher*, in *Natolia*, the external characters of which, along with ſome obſervations upon it, have been given by *Karſten* †, ſhould, on account of its exterior appearance, be rather added to the argillaceous genus, and in particular to the ſpecies of tripoli, than to the genus of magneſian earths, under which it has been placed ſince its analyſis, publiſhed by *Wiegleb* ‡.

However, as it appears from the paper of *Wiegleb*, that the ſilici-murite decompoſed by him was not then in its crude native form, but had been wrought into tobacco-pipe heads, and as from this circumſtance it might become doubtful whether the foſſil, employed by him in that ſtate, was genuine; I thought it of ſome uſe to repeat his enquiry, by analyſing ſome genuine ſilici-murite in its natural ſtate.

For this purpoſe I ſelected two varieties; the firſt of which differed from the other, by a whiter colour, a ſomewhat ſmaller degree of hardneſs, and a greater looſeneſs when powdered.

* *Beob. u. Entd. a. d. Naturkunde*, vol. V. Berlin, 1794, page 149.

† Loc. cit. page 143.

‡ *Neuſte Entdeckungen in der Chemie*, 5 Theil. Seite. 3.

A.

A.

a) The ſpecific gravity of the whiter variety in pure lumps, freed from their porphyraceous matrix, is 1,600. Of this I ſubjected *hundred* grains to a briſk red-heat in a crucible, by which they loſt 30 grains. But, in other reſpects, they ſuffered no alteration obſervable in their external appearance: as, by the reſult of a previous experiment, hereafter to be mentioned, the loſs of weight, which this foſſil ſuſtains by ignition, is five parts of water and one of carbonic acid. The above loſs of 30 grains is, conſequently, divided into 25 grains of *water* and five grains of *carbonic acid.*

b) The remaining ignited 70 grains were ground to a moſt ſubtle powder, which I firſt worked with water to a pulpy conſiſtence. Half an ounce of ſtrong ſulphuric acid was then added, and all the fluid diſtilled over to dryneſs. The reſidue being ſoftened with boiling water, its undiſſolved portion was ſeparated by means of the filter. Which laſt, edulcorated, dried, and ignited, conſiſted of $50\frac{1}{2}$ grains of white, very looſe *ſiliceous earth.*

c) The clear, colourleſs liquor ſhewed, by the taſte, that it was a ſolution of *ſulphated magneſia.* When concentrated by evaporation, it depoſited, as it cooled, a ſmall quantity of ſelenite, in tender ſpear-ſhaped cryſtals. This being decompoſed by mild ammoniac, afforded one grain of carbonated lime, for which half a grain of pure *calcareous earth* muſt be reckoned.

d) When the ſelenite or ſulphated lime had been ſeparated, the ſolution yielded, by cryſtallization, only ſulphat of magneſia. From this ſalt, re-diſſolved in water, and decompoſed in a boiling heat, by carbonat of pot-aſh, $37\frac{1}{2}$ grains of car-

bonated

bonated magnefia were obtained, which were reduced, after an hour's ignition, to 17¼ of pure *magnefia*.

An *hundred* parts of this *whiter filici-murite*, therefore, contain:

Silex	. . . . *b*)	. . . .	50,50
Magnefia	. . . *d*)	. . . .	17,25
Lime	. . . . . *c*)	. . . .	0,50
Water	. . . . *a*)	. . . .	25
Carbonic acid	. . *a*)	. . . .	5
			98,25

I could not afcertain, in the *humid way*, the proportion of the carbonic acid ingredient in this foffil; fince acids do not completely diffolve or decompofe it in the cold, and hence do not at all effervefce with it, or only imperceptibly. For this reafon, I attempted it in the *dry way*. I introduced 200 grains of pulverized filici-murite into a fmall glafs retort, connected with the hydrargyro-pneumatic apparatus, and kept it in ignition until the veffel was near fufing. The water that paffed over I collected in the intermediate fmall fpherical cavity of the conducting pipe, while the gas was caught in a receiver above the mercury. The water weighed 35 grains. It was yellowifh, and emitted a fmell like petroleum; it alfo manifefted an obfcure veftige of ammoniac, which, however, was foon after fucceeded by a feeble trace of an acid. But the gas, deducting the common air contained in the apparatus, amounted to 13 cubic inches, whofe weight is nearly feven grains. This was entirely abforbed by lime-water, from which it precipitated carbonated lime or crude calcareous earth.

B.

The *other fort of filici-murite*, the colour of which inclined to the grey, loft 39 grains in the *hundred*, and acquired by it

the

whitenefs of chalk. Its decompofition was performed in the fame manner as that of the foregoing. In the refult, the folloing appeared to be its conftituent parts in the *hundred*:

Silex	41
Magnefia	18,25
Lime	0,50
Water and carbonic acid. .	39
	98,75

Befides thefe two varieties of filici-murite, I have likewife analyfed a third, in which I have found the proportion of magnefia confiderably greater, but that of filex much fmaller in the fame ratio. But as this confifted of one fingle fragment only, I was not able to repeat the experiment. Yet I mention this, becaufe it fhews that Nature does not always obferve an invariable proportion in the two chief conftituent parts of filici-murite; as, indeed, is alfo the cafe with refpect to various other foffils.

LIII.

LIII.

CHEMICAL EXAMINATION
OF THE
SEMI-INDURATED STEATITES.
(Speckſtein of Werner.)
From Bareuth.

THOUGH the *common Steatites*, which occurs at *Göpfersgrün*, near *Wunſiedel*, in the principality of *Bareuth*, is found in conſiderable quantity, yet it has till now been met with only in detached, larger or ſmaller, reniform lumps. It is diſtinguiſhed from other ſpecies of ſtones of the ſame genus particularly by this, that it is found ſometimes in hexahedral priſmatic cryſtals, with ſix-ſided pyramidal terminations, and, but very lately, in double hexahedral pyramids*, imbedded in maſſive indurated ſteatites.

a) *Two hundred* grains of this ſteatites, finely ſcraped by the knife, were ſubjected to red-heat, in a covered crucible, during one hour. They loſt by this 11 grains of weight, and the ignited powder of the ſtone received an iſabella-yellow colour.

b) This powder I mixed in a ſilver-crucible with a cauſtic lye, of which the alkaline part, or the pot-aſh, was double the weight of the pulverized ſtone; and, after having evaporated it to drynes, I kept it in ignition for half an hour. This maſs was again diſſolved in water, and digeſted

* This rare cryſtallization of the *Bareuth-ſteatites*, reſembling the double hexahedral, calcareous, Derbyſhire-ſpar, is found in the collection of Mr. *Frick*, Maſter of the Mint at Berlin.

with

with muriatic acid, added in excefs. *Siliceous earth* was thus feparated, amounting to 119 grains, after wafhing, drying, and ignition.

c) The muriatic folution was combined with carbonat of pot-afh, heated to the degree of ebullition. The brownifh precipitate, thereby produced, was treated with muriatic acid; the folution evaporated, and the dry faline mafs ftrongly ignited during half an hour. Having re-diffolved this faline mafs in water, and feparated the brown oxyd of iron by filtration, I combined the clear folution with carbonated pot-afh, at the temperature of boiling. By thefe means, 147 grains of very loofe and white *magnefia* were precipitated. One half of this, re-diffolved in fulphuric acid, and cryftallized, afforded pure fulphat of magnefia. The other half, when heated to rednefs, weighed 30½ grains.

d) The brown-red oxyd of iron, that had feparated from the aqueous folution of the ignited faline mafs (*c*), weighed nine grains. But, as the portion of iron, exifting in the mixture of fteatites cannot be confidered as perfectly oxyded, but only as being in the ftate of an oxyd of iron, ftill attractible by the magnet, I deflagrated linfeed-oil upon it, in a covered crucible.—This *oxyd of iron* now weighed only five grains.

According to this analyfis, the *Steatites* from *Bareuth* confifts, in *hundred* parts, of:

Silex	*b*)	59,50
Magnefia	*c*)	30,50
Oxyd of iron . . .	*d*)	2,50
Aqueous particles, driven out by a red-heat		5,50
		98

LIV.

LIV.

CHEMICAL EXAMINATION

OF THE

*STEATITES FROM CORNWALL**.

(Soap-rock, Seifenſtein.)

THE *Steatites* of *Cornwall* (*Talcum Smectis*, *Lin.*) occurs at the Cape *Lizard*, in ſerpentine mountains, which it cuts through in ſmall, perpendicular, or *rake veins*. The fineſt ſort of it is white, with blueiſh, or reddiſh ſpots, reſembling marble. While freſh from the mine, it is ſo ſoft, that, like ſoap, it may be abraded with the knife. It is uſed in making porcelain. The working of theſe mines is carried on by the Houſe of the Porcelain-manufacture at *Worceſter*; which pays 20l. ſterling for the ton, at 20 cwt.; becauſe, the bringing it out to the day is extremely uncertain and dangerous, the ſerpentine rock breaking in ſo frequently. There alſo occurs in theſe mines another ſort of it, leſs fine, and having ſpots of iron-ochre; as well as a third, brown-red variety, mingled with green. Not far from thence, at *Ruan minor*, alſo in ſerpentine, there is found, both a grey-white and a light-ſlate-blue ſoap-rock, or ſteatites, and alſo a whitiſh ſteatites, croſſed by calcareous ſpar, which gives it a ſmooth, ſhining fracture.

It was the firſt, fineſt ſort of ſteatites, that was the ſubject of the following analyſis.

---

* *Beobacht. u. Entdeck. a. d. Naturkunde*, vol. I. Berlin, 1787, pages 163 and 192.

a) One

a) *One ounce* of it, in felected pieces, was expofed to an intenfe red-heat, placing the glafs-retort in open fire. There diftilled over a little pure tafteless water. The fteatites loft thereby 75 grains, and acquired a fomewhat darker colour, and a confiderable degree of hardnefs.

b) It was next, after previous pulverization, intimately mingled and ignited with two ounces of carbonat of pot-afh in a porcelain-pot. The concreted mafs was levigated with water, and digefted with an over-proportion of muriatic acid. By this, a large quantity of a white, loofe, flimy earth, fubfided; which, upon edulcoration, drying, and expofure to red-heat, weighed 204 grains, and was pure *filiceous earth*.

c) When the filtered folution had been combined with Pruffian alkali, a blue precipitate arofe, which I collected, wafhed, dried, and ignited with a little wax. The whole of it obeyed the magnet, and weighed feven grains; of which, fubtracting the portion of iron belonging to the pruffiated pot-afh employed, 3½ grains are the *oxyd of iron*, entering as a conftituent part into fteatites.

d) From the folution, freed from iron, I now precipitated its earthy ingredient, by carbonated pot-afh. It weighed 192 grains, when wafhed, and gently ignited. Thefe were covered with a proportionate quantity of diftilled vinegar, fomewhat concentrated by freezing; and, after this, digefted in a low heat, and thrown upon the filter. The earth that remained on the paper, and which weighed 93 grains, when deficcated and ignited, was mixed with three times its weight of ftrong fulphuric acid; the mixture evaporated nearly to drynefs in a fand-heat; the dry faline mafs liquefied in water; and, laftly, filtered. By this treatment there yet remained 26 grains of *filiceous earth*.

e) The

e) The fulphuric folution (*d*), therefore, contained 67 grains of earth; which, precipitated by alkali, and examined in the ufual way, was found to be merely *aluminous earth.*

f) Of the firft 192 grains of the earthy precipitate (*d*), 99 grains were taken up by the acetic acid. Thefe I likewife precipitated by means of carbonated pot-afh. The earth thus obtained was tried by fulphuric acid, and found to be mere *magnefia.*

Therefore *one ounce*, or 480 grains, of this *Steatites from Cornwall* have yielded:

Silex	*b*) 204 grs.	} . .	230 grs.
——	*d*) 26		
Magnefia . .	*f*)		99
Alumine . . .	*e*)		67
Oxyd of iron .	*c*)		3,75
Water . . .	*a*)		75
			474,75
		Lofs .	5,25
			480

Or, an *hundred* parts of it, averaging the fmall fractions, contain:

Silex	48
Magnefia	20,50
Alumine	14
Oxyd of iron	1
Water	15,50
	99

LV.

CHEMICAL EXAMINATION

OF THE

CHINESE AGALMATOLITE.

(Plaſtic ſtone. Bildſtein.)

BY the name *Plaſtic Stone* (agalmatolithus), I denote that foſſil, which hitherto has been called *Steatites* from *China*; ſince this laſt denomination of it, as indicating a ſtone belonging to the magneſian, or muriatic genus, can no longer be retained with propriety, as will appear from the following analyſis of that foſſil.

The want of rough pieces of this ſtone I ſupplied by employing figures cut of it; the genuineneſs of which is rendered indiſputable by the known peculiar taſte or *character* of the Chineſe art.

On breaking ſeveral of theſe little carved figures, I obſerved that two varieties may be diſtinguiſhed of the ſtone uſed for them by the Chineſe artiſts; which I denominate the *tranſparent* and the *opake*.

A.

Tranſparent Chineſe Agalmatolite.

The colour of this is olive and aſparagus-green, verging through various ſhades to a greeniſh-blue. Inwardly it is very much glittering, and of a greaſy luſtre. The chief fracture is indiſtinctly thick-ſlaty, but the croſs-fracture

 evidently

evidently ſmall-ſplintery. It is ſtrongly tranſparent, inclining to the ſemi-tranſlucid; ſoft, and of a greaſy feel, &c. Its ſpecific gravity, 2,815.

a) *Two hundred* grains of this agalmatolite, finely ground, loſt 11 grains of weight by a moderate ignition for half an hour.

b) After the firſt ignition, the powder of the ſtone was mixed with equal parts of carbonated ſoda, and once more ſubjected to red-heat for half an hour in a ſilver-crucible. The mixture returned from the fire in the form of a moderately coaleſced powder. I diluted it with water, and ſuper-ſaturated it with muriatic acid; which diſſolved the whole of it without leaving any obſervable reſidue. But when the ſolution had been put in a ſand-heat to evaporate, it formed a thick gelatinous coagulum; and after digeſting it for ſome time, it was filtered. The collected *ſiliceous earth*, waſhed and ignited, weighed $105\frac{1}{2}$ grains.

c) The muriatic ſolution, ſaturated with cauſtic lixivium, thickened to a milk-white maſs. By a ſlight exceſs of the alkaline lye, it again diſſolved entirely to a limpid, colourleſs fluid, leaving only a few light-brown, looſe flakes, which, upon edulcoration and ignition, weighed four grains.

d) Theſe four grains of brown reſidue were treated by digeſtion with muriatic acid. *Siliceous earth*, weighing $2\frac{1}{2}$ grains in the ignited ſtate, was then ſeparated. This done, the ſolution was combined with pruſſiat of pot-aſh, and the blue ferruginous precipitate, thereby produced, was collected. Nothing elſe was found in the remaining fluid. The portion of iron, which it contained before, amounted to $1\frac{1}{2}$ grain.

e) The

e) The alkaline solution (*c*) was saturated to excess with sulphuric acid, and then combined, in a boiling heat, with carbonated soda, to precipitate its earthy contents. The earth, thus obtained, was lixiviated and dried; and afterwards depurated by means of distilled vinegar and ammoniac. Upon desiccation, it weighed 122 grains; but upon ignition, only 72. It was found to be pure ***aluminous earth***; for, when re-dissolved in sulphuric acid, and crystallized with an adequate proportion of acetated pot-ash, it afforded only sulphat of alumine.

Wherefore, the *transparent* variety of the *Chinese agalmatolite*, calculated for *an hundred* parts, contains:

Silex	*b*)	. $52\frac{3}{4}$	
——	*d*)	. $1\frac{1}{4}$	
		54 . . .	54
Alumine . . .	*e*)	. . . .	36
Oxyd of iron . .	*d*)	. . . .	0,75
Water	*a*)	. . . .	5,50
			96,25

B.

Opake Chinese Agalmatolite.

This variety of agalmatolite is reddish-white, flesh-red, and of variously coloured veins. Its fracture is dull, and less distinctly splintery. It is opake, or only very little transparent on the edges; very soft; and feels very greasy. The specific gravity of it is 2,785.

a) *Two hundred* grains of it, finely scraped off from the mass, sustained a loss of 20 grains by ignition. Its original reddish-white colour was by this process changed to a grey.

 b) This

b) This ignited powder was a ſecond time expoſed to red-heat for half an hour, in a ſilver-cruible, with its own quantity of deſiccated mild ſoda; which cauſed it to conglutinate but moderately. The mixture, previouſly drenched with water, was combined with an over-proportion of muriatic acid, and the ſolution evaporated to a jelly.—When this had again been diluted with ſufficient water, it depoſited *ſiliceous earth*, amounting to 122 grains, when collected on the filtering paper, and ſubſequently lixiviated and ignited.

c) The muriatic ſolution was afterwards decompoſed by carbonated pot-aſh, and the thorough ſeparation of the precipitating earth was promoted by boiling. The precipitate, which ſubſided in a highly ſwelled ſtate, was lixiviated, and while yet moiſt, brought into a warmed alkaline cauſtic lye; in which it diſſolved in an inſtant, and left only a ſlight browniſh reſidue.

d) Muriatic acid entirely diſſolved this reſidue. By combination with Pruſſian alkali, Pruſſian blue fell down, the quantity of which denoted one grain of *iron* in the ſtone. The fluid was next, after the ſeparation of the iron, decompoſed in a boiling heat by diſſolved carbonat of pot-aſh, which precipitated a white earth. This laſt effervefced moderately with ſulphuric acid that was poured upon it, and depoſited gypſum; the quantity of which increaſed, in proportion as the volume of the mixture was reduced by evaporation. It weighed, after ignition, five grains, equal to two grains of pure *calcareous earth* in the ignited ſtate. The ſmall quantity of the fluid yet remaining ſhot into cryſtals of ſulphat of alumine.

e) The portion which had been taken up by the alkaline lye (*c*) was thrown down by means of ſulphuric acid, but it it diſſolved again by a ſlight exceſs of the ſolvent. The alum laſt obtained, (*d*), was then added to it, and the whole precipitated afreſh by carbonat of pot-aſh, aſſiſted by a boiling heat. When afterwards edulcorated, dried, purified by means of vinegar and ammoniac, and finally heated to redneſs, the precipitated alumine weighed 50 grains.

f) I then poured ſulphuric acid upon it, and inſpiſſated the mixture on a ſand-bath. The turbidneſs of the fluid, on being again diſſolved in water, was cauſed by the tender *ſiliceous earth*, which then ſeparated, and conſiſted of two grains after ignition. This being ſubtracted, the quantity of *aluminous earth* (*e*) is reduced to 48 grains; which now, by combination with acetite of pot-aſh, and cryſtallization, continued to the end to ſhoot into alum only.

It follows, from this decompoſition of the opake variety of the *Chineſe agalmatolite*, that its conſtituent parts give in the *hundred*:

Silex . . .	*b*)	. 61	. . . 62
——	*f*)	. 1	
Alumine . .	*f*)	. . . .	24
Lime . . .	*d*)	. . . .	1
Oxyd of iron .	*d*)	. . . .	0,50
Water . . .	*a*)	. . . .	10
			97,50

Several examples have ſhewn, that, in the ſyſtematical arrangement of foſſils, the light of chemiſtry ſhould be the guide; and I think the preſent analyſis furniſhes one of the moſt conſpicuous proofs of that point. The three foſſils, which were the ſubject of this and the two preceding

ing eſſays, have to this day been conſidered merely as varieties of *ſteatites:* and yet, how materially do they differ in their conſtituent parts, conſidering that the ſemi-indurated ſteatites (*Speckſtein*), from *Bareuth*, contains, beſides its portion of *ſilex*, merely *magneſia*; that the ſteatites (*Seifenſtein*), from *Cornwall*, is compoſed of *magneſia* and *alumine*; and that the *Chineſe* ſteatites (*Bildſtein*, *agalmatolite*) contains alſo *alumine*, but not the leaſt trace of *magneſia*. This laſt, which muſt now be removed from the genus of magneſia, and added to that of alumine, ſeems to be properly placed along with lithomarga (*Steinmark*).

Among the other ſtones, alſo manufactured by the Chineſe into figures, or little ſtatues, I have likewiſe met with a white, pure, very finely grained *marble*; which, by bare inſpection, is ſufficiently diſtinguiſhed from the Chineſe agalmatolite here treated of.

LVI.

LVI.

ADDITION

TO THE

CHEMICAL EXAMINATION

OF

LEPIDOLITE *.

SINCE the analyſis of *Leucite*, deſcribed in the earlier part of this work, has evidently proved that it contains the *vegetable alkali* as one of its eſſential conſtituent parts; it was to be expected that this alkaline ſubſtance might likewiſe be found in the mixture of various other ſpecies of ſtones and earths. The firſt confirmation of this conjecture has been afforded to me by the *Lepidolite*.

In the examination of this ſtone, here quoted, the loſs of weight in the ſum of its conſtituent parts, which I could not then farther account for, amounted to $6\frac{1}{2}$ *per cent.* † As I ſuſpected that this loſs might ariſe from the vegetable alkali, which at that time was not yet known as a co-conſtituent part of foſſils, I reſolved to undertake a ſecond analyſis of lepidolite.

A.

I reduced, by grinding, 250 parts of the *amethyſtine red lepidolite* to as fine a powder as the hardneſs and lubricity of

* *Eſſay* XIX. page 238.

† See *Eſſay* XXXII. page 355 ſeq.

its fcaly aggregate particles would allow, and digefted it with a large quantity of muriatic acid, in a temperature raifed at intervals to the point of ebullition. The remaining powder of the ftone, when feparated from the muriatic folution and wafhed, was deficcated and ignited. It ftill appeared, as before, in the form of white, very delicate fhining fcales, and weighed 210 grains. Treated with the blowpipe, it fufed, nearly as eafily as lepidolite in the rough ftate, to a fmooth globule.

b) This circumftance making it evident that the muriatic acid had effected only an incomplete decompofition, I reduced again the remaining powder, by long continued trituration, to the moft comminuted ftate poffible, and boiled it once more with a frefh quantity of muriatic acid. The refidue feparated by filtration fhewed now no farther difpofition to melt, and feemed to confift of mere filiceous earth.

c) The muriatic folutions (*a*) and (*b*) were then evaporated to drynefs, in a fand-heat; the faline mafs remaining was pulverized, covered with alkohol, and placed in a warm temperature. A confiderable fediment fettled to the bottom; which, after the fpirituous folution had been poured off, was diffolved in water, combined with fome drops of ammoniac, and filtered. It then left behind it a brownifh flime, confifting of alumine, filex, and oxyd of manganefe.

d) I next evaporated the clear folution that had paffed the filter. It left behind a faline pellicle, confifting of fmall cubes; which, after gentle ignition, in order to drive off the fmall portion of muriated ammoniac exifting in it, weighed 16½ grains. This falt was muriated pot-afh. Diffolved in a little water, and combined with a folution of pure tartareous acid, it formed acidulous tartrite of pot-afh,

(cream

(cream of tartar), which by combuſtion yielded carbonat of pot-aſh.

Now, ſince in 16½ grains of muriated pot-aſh are contained 10 grains of pot-aſh free from water and carbonic acid, there remain 4 grains of this laſt to be reckoned as conſtituent parts in 100 of lepidolite.

B.

a) Two hundred and fifty grains of powdered lepidolite were expoſed to a red-heat, during two hours, in a ſilver-crucible, previouſly mixed with the ſame quantity of very pure carbonated ſoda, that had effloreſced in the air. This mixture came out of the fire a compactly united maſs, of an uniform, lively brick-red. It was pulverized, and ſuper-ſaturated with dilute muriatic acid, and kept in digeſtion till the red colour had totally vaniſhed. The *ſiliceous earth* that ſubſided from this ſolution was afterwards ſeparated by means of the filter.

b) The muriatic ſolution was then evaporated to dryneſs; the ſaline maſs was extracted, by alkohol, in a low heat; the ſediment, left undiſſolved by this laſt, was rediſſolved in water, then combined with a little ammoniac, filtered, and again evaporated to a dry ſalt.

c) The dry ſalt, thus obtained, was again diſſolved in water, and, in combination with liquid acid of tartar, expoſed to a warm temperature. At the beginning, the mixture continued clear; but, gradually, it depoſited minute cryſtalline grains, which, after lixiviation and drying, weighed 12¾ grains. They conſiſted of *regenerated tartar*, from which carbonated pot-aſh was produced by combuſtion.

d) I now returned to the precipitate, ſeparated by means of ammoniac (*b*). This I diſſolved in dilute ſulphuric acid; and, after having added to this ſolution the ſpirituous ſolution of the muriated alumine (*b*), as well as the muriatic ſolution from which the regenerated tartar had been ſeparated, I ſubjected the whole for ſome time to digeſtion; and finally freed it, by filtration, from the remaining browniſh, muddy depoſite. This ſolution, when farther evaporated, without any addition of acetated vegetable alkali, ſhot into regular cryſtals of alum, amounting to 185 grains. The remainder of it, ſtill farther evaporated, congealed to a ſhapeleſs ſaline maſs.

Thus, by the experiment B, the preſence of the alkaline ſaline conſtituent part in lepidolite has received an additional proof: for, theſe 250 grains of this foſſil yielded as much pot-aſh as was neceſſary to the production of the $12\frac{1}{4}$ grains of regenerated tartar, mentioned at (*c*), and likewiſe the quantity entering into the 185 grains of the cryſtallized alum here obtained.

However, the quantity of vegetable alkali naturally contained in lepidolite is more accurately ſhewn by the experiment A; according to which, as mentioned in its place (A. *d*), there muſt be added to its other conſtituent parts 4 *per cent.* of pot-aſh.

Hundred parts of *Lepidolite*, therefore, contain:

Silex	54,50
Alumine	38,25
Pot-aſh	4
Oxyds of mangane ſe and *iron* . .	0,75
	97,50
Loſs, partly conſiſting of water	2,50
	100

In

In my firſt analyſis I noticed my ſurpriſe, that, in this very fuſible ſtone, beſides the ſilex and alumine, no conſtituent part could be found to promote fuſion, except the very trifling portion of the oxyds of manganeſe and iron.

Yet I do not venture to affirm, unconditionally, that this fuſibility of *lepidolite* is owing to this alkaline ingredient now diſcovered in it; becauſe the *leucite*, whoſe earthy parts are likewiſe ſilex and alumine, as well as lepidolite, is, in fact, infuſible, notwithſtanding that it contains the alkaline ingredient in five times the quantity of that of lepidolite.

LVII.

LVII.

CHEMICAL EXAMINATION

OF

URANITE.

FIRST SECTION.*

1.) THE ancient philofophers, who confidered our globe as the center of the material univerfe; and the fun, on the contrary, merely as a planet deftined, like the others, to a periodical circumvolution round the earth, flattered themfelves that they had difcovered a great myftery of Nature, in the agreement of the *feven celeftial bodies*, which they affumed for planets, with the *feven metals* known in thofe times. In confequence of the varions hypothefes which they founded on this fuppofed myftery, they allotted to each metal a certain planet, by whofe aftral effluvia its generation and maturation were to be promoted. In like manner, they took from thefe planets their names and fymbols, to defignate the metals fubordinated to them. But as the above number of metals has long fince been increafed by later refearches; and as the difcovery of new planets has not kept pace with that of metals, the metals newly found out have been deprived of the honour of receiving their names from planets, like the older ores. They, therefore, muft be fatisfied with the name given them accidentally, and, in moft inftances, by the common miner.

* Read in the Royal Academy of Sciences, at Berlin. See *Memoire Chimique et Mineralogique fur l'Urane*, in the *Memoires de l'Academie Royal des Sciences*, &c. Août, 1786, jufqu'à la fin de 1787. Berlin, 1792.

Of

Of late, *feventeen* metallic fubftances have been acknowledged as diftinct metals, each of a nature peculiar to itfelf. The defign of this effay is to add one to that number, the chemical properties of which will be explained in the fequel*.

2.) The particular foffil, by the decompofition of which I have difcovered this new metallic fubftance, is the black, or *pitch-blende (pfeudo-galena* of many) as it has been hitherto called. In the mean time, I fhall continue to ufe that appellation, till, in the progrefs of this effay, the neceffity of giving it a new name will be confpicuous. This foffil is found at *Joachimsthal* in Bohemia, and at *Johann Georgenftadt*, in the metalliferous mountains of Saxony.

Only a few writers appear to have been formerly acquainted with this mineral. *Wallerius* and *Brünich* mention, indeed, under the head Argentiferous Ores of Zinc, the *pitch-blende*, and a black *pitch-ore (Pecherz)* ; but it does not appear that they meant by it, or even have known the above foffil from *Joachimsthal* and *Johann-Georgenftadt*. *Werner*, to whom its fracture, hardnefs, and gravity, fufficiently indicated that it could not be a blende, has transferred it from the clafs of zinc-ores to that of the ores of iron, calling it *Eifen-pecherz* ; though only *ad interim*, until its proper place fhould be afcertained by chemical analyfis. A fubfequent conjecture of his, that this foffil might, perhaps, contain the metallic radical of *tungften*, or *wolfram*, was thought to be fupported by actual experiments made at

* Even this number (17) of metallic fubftances has received an addition, by the *Titanium*, fo lately difcovered, as is fhewn by *Effay* XIV. pages 200 and 210.

Schem-

*Schemnitz**. But this pretended fact is contradicted by the result of the following examination.

3.) The varieties of this fossil, that have hitherto occurred, may be divided into two sorts. The *first* of them is found in brownish-black, massive, and, for the most part, outwardly flat, reniform pieces. It is resplendent both externally and internally; wholly opake, and of an imperfect conchoidal fracture. It is brittle, admits of being easily comminuted by trituration, and affords then a black powder, tending to the greenish. Its specific gravity, upon an average, is 7,500.

To this sort belong, in particular, the pitch-blendes dug at *Joachimsthal*, in the mines, or galleries; *Sächsischer Edelleutstolln, and Hohe Tanne*; where they are accompanied by brown-red ponderous spar.

The *second variety*, to which belongs the greatest part of pitch-blende that occurs at *Johann-Georgenstadt*, is greyish black, and exhibits various degradations, from the glittering to the dull or dim. At that place it is obtained in the mine *Georg Wagsfort*, in larger or smaller masses, between strata of schistose mica (*Glimmerschiefer*); which is nearly in a state of decay. It is usually accompanied by a metallic earth (oxyd), of a yellow, reddish, and light-brown colour; and, besides, also frequently by the *green mica*, as it is called, crystallized in small quadrangular tables. Sometimes it is observed to be invested by compact galena (*Bleyschweif*), or having this latter disseminated in its substance in delicate veins and points. It has also been met with there in the mine *Neujahrsmaassen*, between alternate strata of the fibrous brown iron-stone†.

* See *Bergmannisches Journal*. 1789. Vol. I. page 612.

† A more ample description of its external properties has been given by *Karsten*, in the 4th vol. of the *Beobacht. u. Entdeck. a. d. Naturkunde*. Berlin, 1792, page 178.

4) When

4.) When pitch-blende is tried by itfelf, before the blow-pipe, it undergoes no alteration, and is perfectly infufible. If mixed with foda, or borax, and placed in the fame fituation, it is converted into a grey, cloudy button, refembling fcoriæ. But with a neutral phofphat it produces a clear, green globule. If in thefe trials fome minute metallic grains ever appear, they proceed from the lead interfperfed in the foffil.

5. *a*) I expofed *half an ounce* of triturated pitch-blende to a ftrong red-heat, in a coated glafs-retort. After cooling, I found that it had loft feven grains. A fmall portion of fulphuric acid has alfo paffed over, and in the neck of the retort a little fulphur was obferved to be fublimed.

b) Another equal quantity of pitch-blende was roafted in open fire, that is, on a teft under the muffle, until all its fulphur had volatilized. By this management it loft 20 grains. Upon this I kept it one hour longer in ignition, and obferved that its weight had again increafed eight grains.

6.) To examine the relations of pitch-blende to the *fixed alkalis* in the *dry way*, I triturated $\frac{1}{2}$ ounce of it with one ounce of carbonated pot-afh, and urged the fire to the fufion of the mixture in the crucible. The mafs poured out of the veffel was black-grey, compact, hard, and of a lamellar fracture. When ground, boiled with water, and filtered, the powder of the foffil remained on the paper with its former black colour, and alfo nearly with its original weight. The colourlefs fluid had merely an alkaline tafte, excepting only a flight indication of alkaline fulphuret (*liver of fulphur*); and when faturated with nitric acid, it depofited fome flocculi of filiceous earth, weighing four grains.

By

By this infolubility of pitch-blende, in melting pot-afh, it was decided that it in no way belonged to the foffils which contain tungften, or wolfram.

7.) I now proceeded to examine its habitudes with *acids*.

Dilute fulphuric acid was incapable of effecting a true folution ; it only extracted from it a faint greenifh tincture. Even *concentrated fulphuric acid* did not entirely diffolve this foffil : for, after ½ ounce of pitch-blende had been digefted with one ounce of that acid, in a retort, the liquor being then again diftilled off to drynefs, and the refidue foftened with water, and filtered, its undiffolved part ftill weighed three drachms : and likewife the black colour which it ftill preferved fhewed that no perfect folution had taken place. The fluid that had paffed over was fulphureous acid ; and the folution filtered off from the refidue had a green colour.

8). *Nitric acid*, on the contrary, produced a more complete decompofition of that foffil.

a) *Half an ounce* of the greyifh-black, dull pitch-blende was digefted, in a low-heat, with moderately ftrong nitric acid. It was attacked by the acid with an evolution of red nitrous vapours. I affufed, by degrees, more of the acid, till the difappearance of the black colour of the foffil fhewed that its decompofition was accomplifhed. The folution, when again diluted with water, was of a bright wine-yellow, variegated with the greenifh. It left on the paper a white-grey refidue, weighing 16 grains upon deficcation. This took fire, when heated in an earthen pot, and burned with a fulphureous flame ; lofing thereby 5½ grains. The remaining 10½ grains confifted of filex ; from which nitro-muriatic acid ftill extracted fome portion of iron.

b) One

b) One *half ounce* of the *blacker ſort* of pitch-blende, treated in the ſame manner with nitric acid, coagulated, upon ſolution, to a bright-green gelatinous conſiſtence, in which ſome light grey-yellow particles lay diſperſed. By dilution with water, and filtration, it left 26 grains of a reddiſh-grey reſidue, 6 grains of which were ſulphur, and the remainder an earthy matter, impregnated with iron.

c) When no pure, compact lumps can be had, the pitch-blende, which is ſtill embodied with its matrix, may alſo be employed for extraction with nitric acid. *Twenty-four* ounces of moderately ſtrong nitric acid, affuſed upon 8 ounces of fragments of this impure pitch-blende, previouſly pulverized, attacked it with vehemence; the mixture became hot, and emitted red vapours. After digeſtion for ſome time, I diluted the ſolution with water, and filtered it. The *gangue*, or matrix of the ſhiſtoſe mica kind, exiſting in the foſſil, remained behind as a light-brown mud; which, after waſhing and deſiccation, weighed $4\frac{1}{2}$ ounces, but loſt one drachm more by burning off the ſulphur which it contained. I concentrated the greeniſh-yellow ſolution, by diſtillation, from a retort; by which management nitrat of lead ſeparated, in white glanular cryſtals, amounting to 50 grains.

g) By *muriatic acid* only an incomplete ſolution was produced.

But if this acid be mixed with one third part of the nitric, the *nitro-muriatic acid* ariſing from this combination effects a perfect ſolution.

Half an ounce of pitch-blende, mixed with two ounces of aqua regia, became hot, and was violently attacked by this ſolvent; at the ſame time that the mixture ſtrongly effer-

 veſced

vefced, and the folution was almoft entirely effected for the greateft part. When it had digefted a while, it was diluted with water, and paffed through the filter. Its refidue weighed 13 grains; which, after the combuftion of the fulphur, left nine grains of a filiceous matrix. The folution depofited muriat of lead, while cooling, in minute, white, needle-fhaped cryftals, which, by reduction, yielded a reguline bead of lead, of ¾ grain. After fome time, there appeared in the folution fome beautiful, large, bright, greenifh-yellow cryftals, in rhomboidal fix-fided tables.

10.) Endeavouring to become more accurately acquainted with the metallic principle which is the chief ingredient in pitch-blende, as well as with its chemical relations to other fubftances, I performed various experiments with the nitric and nitro-muriatic folutions before mentioned.

At firft I attempted to find whether a *reduction* of it would take place in the *humid way*. With this view, I filled two glaffes with thofe folutions, immerfing in the one fome polifhed iron, and in the other a thin ftick of zinc. But in neither cafe was any thing precipitated.

11.) Pruffiat of pot-afh threw down, from both thefe folutions, a *deep-brown-red* precipitate, refembling red fulphurated oxyd of antimony (*Kermé's mineral.*). This phenomenon is one of the moft characteriftic properties, by which this metallic fubftance is diftinguifhed. It is true, copper likewife falls down, of a brown colour, if precipitated from acid menftrua by means of Pruffian alkali; but then it appears rather more in the form of flocculi, of a woolly cohefion: whereas the former, on its precipitation, directly fpreads, or diffufes itfelf through the whole volume of the fluid. Still more does the brown-red precipitate, obtained by precipitating the oxyd of molybdena from its muriatic

muriatic ſolution, by means of Pruſſian alkali, reſemble that mentioned above. However, beſides that the colour of this laſt is brighter, theſe two metallic ſubſtances are, in every other reſpect, ſo different, that they cannot eaſily be miſtaken for each other.

If the pitch-blende, as is moſtly the caſe, be accidentally accompanied by a portion of iron, the precipitate appears, at firſt, of a dirty black, but, after the ſeparation of this, its colour is a purer brown.

12.) *Sulphuret of ammoniac* precipitates the metallic ſubſtance of pitch-blende, diſſolved in acids, of a *brown-yellow* colour; in which caſe, the mixture is uſually covered by a white-grey pellicle of a metallic luſtre.

13.) By *tincture of galls*, or gallic acid, added to exceſs, only a ſlight quantity of a blackiſh precipitate is produced. But if the predominant part of the acid be neutralized by an alkali, a copious precipitation of a *chocolate-brown* enſues.

14.) All *alkalis* throw down the metallic portion from the acid ſolutions of pitch-blende, of a *yellow colour.* This affords another character peculiar to that metallic ſubſtance. The ſhades, or degradations of that yellow colour, are various, according to the degrees of purity of the foſſil, and, likewiſe, according to the nature of the alkaline ſalt employed in the proceſs.

The fixed alkalis promote the precipitation, in the moſt complete manner, if they are uſed in their cauſtic, or pure ſtate. The precipitate is then commonly lemon-yellow; but it inclines more to the white, if carbonated alkali is employed as a precipitant.

15.) If more carbonated alkali be added than is required to ſaturate the acid, part of the metallic oxyd will be rediſſolved; but it falls again down, of a lemon-yellow, by ſaturating the exceſſive portion of the alkali. A ſimilar re-diſſolution, in carbonated fixed alkali, happens, when the yellow oxyd, recently precipitated and waſhed, while yet moiſt, is mixed with deliqueſced pot-aſh, and digeſted in a boiling heat. If, to the ſaffron-yellow ſolution, after ſeparation of the undiſſolved reſidue, nitric acid is added, it throws down the diſſolved part of a pale yellow colour.

On repeating this experiment with cauſtic lixivium, the colour of the metallic oxyd changed to a dark-brown. But this lixivium, being afterwards examined, was found to contain nothing of that oxyd. This circumſtance ſerves to prove that it is not the alkali, but the carbonic acid combined with it, that contributes to effect the ſolution before noticed.

16.) Somewhat different was the colour of the precipitate which I have obtained from the greeniſh nitric ſolution of the blacker variety of pitch-blende (8. *b.)*, by means of cauſtic ſoda; for this inclined from the yellow to the green. This is not owing to a latent portion of copper in the foſſil; as the precipitate gives neither colour nor taſte to cauſtic ammoniac poured upon it.

17.) This yellow metallic oxyd readily diſſolves in acids.

When treated with dilute *ſulphuric acid*, gently warmed, it was ſoon diſſolved, leaving only the portion of lead which ſtill remained in it. The ſolution, duly evaporated, afforded a lemon-yellow metallic ſulphat, cryſtallized in ſmall accumulated columns.

18.) The

18.) The folution of the yellow metallic oxyd in weakened *nitric acid*, and made to cryftallize by evaporation, at firft depofited a fmall quantity of nitrat of lead, and, afterwards, beautiful, clear, oblong, hexagonal tables, of a pleafing, light-greenifh colour; fome of which were $\frac{3}{4}$ of an inch long, and $\frac{1}{4}$ of an inch broad. To preferve thefe cryftals in their original perfection, they muft be kept in a clofed veffel, as they feem liable to fome decay by the accefs of air.

19.) The folution of this metallic oxyd, prepared by *muriatic acid*, evaporated to the point of cryftallization, and left ftanding in the cold, at firft yielded fome muriated lead, in fine needles; but, after this, it fhot into yellowifh-green cryftals, the fundamental figure of which appears to be the rhomboidal, or oblique quadrangular table.

20.) By diftilled *vinegar*, ftrengthened by freezing, this metallic calx was diffolved, with the aid of digeftion. After gentle evaporation, this folution afforded fine, clear, topaz-yellow cryftals, in regular, four-fided, thin columns, with tetrahedral pointed terminations, fome of them one inch long. When I fubjected fome of thefe cryftals to ignition, beginning with a low heat, the metallic oxyd left, after the expulfion of the acetic acid, preferved the fame figure, for the moft part, which the cryftals had originally poffeffed.

21.) *Phofphoric acid*, likewife, is a folvent of the precipitate obtained from pitch-blende. But this folution does not long continue clear; the phofphated metallic oxyd falling down, by degrees, in yellow-white, amorphous flocculi, of difficult folution in water. A fimilar precipitate alfo arifes on pouring phofphoric acid into the acetic folution of this foffil.

22.) I introduced a mixture of one part of pitch-blende with three of nitre, by fucceffive portions, into a red-hot crucible. The mafs foamed much; but only a weak detonation was obfervable. I kept it in ignition for half an hour, after which I fet it afide to cool. It was of a chocolate-brown; and when this mafs, liquified with water, had been filtered, the powder of the foffil left on the paper remained of the fame colour. The colourlefs lixivium contained ftill fome undecompofed nitre; and acids caufed it to depofite a whitifh precipitate, which for the moft part confifted of filex.

23.) After thefe refearches, I made fome experiments relative to the procefs of *reduction*.—When the yellow metallic oxyd was tried upon charcoal before the blow-pipe, it exhibited the fame phenomena as were mentioned of the crude pitch-blende, (4.); excepting that it acquired a brownifh-grey colour by ignition; and that the brownifh colour of the globule produced, on its treatment with foda and borax, was purer and clearer than that from the rough foffil: in the fame manner as the colour of the green globule arifing from its mixture with an alkaline phofphat, in the like procefs, was more pure and clear.

24.) The trials made by fufion in the crucible gave all exactly fuch refults, as thofe previous fmall trials upon charcoal would allow me to expect.

a) *One* drachm of *rough pitch-blende*, mixed with $1\frac{1}{2}$ drachm of calcined borax, together with fome charcoal-duft, and covered with muriat of foda; and

b) An equal quantity of rough pitch-blende, mingled with two parts of black flux, and a little muriat of foda, where melted, each feparately, in the wind-furnace

furnace with a ftrong fire. In both cafes the foffil was converted into a black-grey, dim fcoria, without any trace of reduction: only that fome metallic grains of lead appeared, originating from the particles of that metal diffeminated in the rough foffil.

25.) In the following experiments I employed the *pure yellow precipitate* before mentioned.

a) *One* drachm of it was mixed with two drachms of black flux, and inferted in a charcoal-crucible;

b) Another drachm was mingled with twice its weight of calcined borax, and likewife put in a crucible made of charcoal; and

c) A third drachm was mixed with 10 grains of charcoal-duft, 20 grains of calcined borax, and two drachms of powdered white glafs.

Thefe mixtures, the crucibles being firft luted, were expofed for one hour and a half to the ftrongeft heat of the melting furnace.

The product, which in all three crucibles was nearly the fame, confifted of a black vitreous fcoria, but exhibited no indication of any metallic button.

26.) Being thus convinced, that the reduction of this metallic oxyd, which I had in view, was not to be accomplifhed by means of faline and vitrifying fubftances, I refolved to treat it merely with combuftible bodies, after the manner of the affays of manganefe. For this purpofe, I triturated 120 grains of the yellow metallic oxyd to a pafte, with linfeed-oil, and caufed the oil gently to burn on a

 teft.

teft. There remained 85 grains of a heavy black powder behind; which I expofed, in a well fecured charcoal-crucible, to the medium heat of the procelain-furnace.

At the fame time, another crucible, containing pure oxyd of *manganefe*, and prepared in the fame manner, was expofed to the fame fire.

When both thefe crucibles were brought back from the furnace, I found, that, in the *fecond*, the reduction of manganefe to the reguline, or metallic ftate, had been moft perfectly accomplifhed. But in the *firft* crucible I found the oxyd, obtained from pitch-blende, in the form of a heavy and only loofely coherent mafs; which by friction between the fingers could be divided into a fine black-brown duft, yet poffeffed of a metallic luftre.

In pouring nitric acid upon a part of that duft, the folution went on with pretty confiderable energy; the mixture growing hot, and giving out a quantity of red nitrous fumes. By this phenomenon, I was perfuaded, that the oxyd had in fome manner been revived to the metallic ftate, although not run into one mafs; and, hence, that this metallic fubftance is more refractory than even manganefe.

27.) To experience, whether this oxyd of pitch-blende, thus far metallized, would not perhaps prove more fufible, I put the remaining portion in a charcoal-crucible; covering it with half its quantity of calcined borax, and the remaining fpace of the veffel with pulverized charcoal. The outer crucible of baked clay, into which the former was inferted, was then well luted, and expofed to the ftrongeft heat of the porcelain-furnace. My expectation, as I found by the refult, was not totally difappointed; for I now obtained a coherent mafs, confifting of conglutinated extremely

tremely minute metallic grains, whofe aggregation, however, was not compact, but finely porous, and like froth. The colour of that metallic mafs was outwardly dark-grey, but inclining on the ftreak to the brownifh. Its metallic luftre, for want of perfect denfity, was but moderate, and the cohefion of its integrant particles only flight. Its fpecific gravity, 6,440.

No alteration was produced, when fmall portions of that regulus were ignited upon charcoal with the affiftance of the blow-pipe. On fufing it with fufible phofphoric falt, the globule, while melting, was coated with a dull, filvery white pellicle, formed by cohering, exceedingly fine metallic globules. On continuing the fufion, this metallic cruft entered deeply into the body of the globule, which at laft acquired the appearance of a dim, grey-green, porous fcoria.

28.) With the view of attempting an artificial mineralization by fulphur, I mixed the yellow oxyd with twice its weight of fulphur in a fmall glafs-retort, and expelled again from it the greateft part of the fulphur, by applying heat. The refidue combined with the reft of the fulphur was a black-brown, compact mafs. But the degree of affinity of this metallic fubftance with fulphur is but low; for, on expofing again this fulphurated mafs, in another retort, to the action of fire, the remainder of the fulphur admitted of being entirely driven out; while the metallic part remained behind in the form of a black, heavy, granular powder.

29.) To inveftigate what colour this metallic oxyd would give to glafs-frits, and what effect it would produce on porcelain, when applied to it as an enamel colour, the following experiments were made.

a)

a) *Silex*		2 drachms,
Mild *pot-aſh*		1 drachm,
Yellow metallic oxyd . .		10 grains,

produced a clear, light-brown glaſs.

b) *Silex*		2 drachms,
Mild *ſoda*		1 drachm,
Yellow metallic oxyd . .		10 grains,

yielded an opake, black-grey glaſs.

c) *Silex*, Burnt *borax*,	of each .	2 drachms,
Yellow metallic oxyd . .		20 grains,

afforded a glaſs perfectly reſembling brown rock-cryſtal (*Rauch-topaz*).

d) *Silex*, *Vitreous phoſphoric acid*, prepared from bones,		2 drachms of each,
Yellow metallic oxyd . .		20 grains,

gave a bright apple-green, opake glaſs, almoſt like chryſopraſe.

e) *Vitreous phoſphoric acid*, from animal bones . .		2 drachms,
Yellow metallic oxyd . .		10 grains,

produced a clear emerald green glaſs.

Theſe tw o laſt vitrifications, by degrees, attracted moiſture from the atmoſphere.

f) The *yellow metallic oxyd*, gently ignited, mixed with a proper flux, and applied to porcelain, and fuſed upon it

 in

in the enamelling furnace, produced a faturated or deep orange-yellow colour.

30.) From the whole of thefe experiments it is manifeft, that the pitch-blende does not belong either to the ores of zinc, or to thofe of iron, nor yet to the genus of tungften or wolfram, and in general to none of the metallic fubftances hitherto known; but, on the contrary, that it confifts of a *peculiar*, *diftinct*, *metallic fubftance*. Therefore its former denominations, *pitch-blende*, *pitch-iron-ore*, &c. are no longer applicable, and muft be fupplied by another more appropriate name.—I have chofen that of *uranite*, *(Uranium)*, as a kind of memorial, that the chemical difcovery of this new metal happened in the period of the aftronomical difcovery of the new planet *Uranus**.

31.) In the pit *Georg Wagsfort*, *at Johann-Georgenftadt*, the *metal uranium* likewife occurs in the form of a metallic oxyd, of an earthy appearance. This is the earthy foffil, already mentioned at the beginning of this effay, which there accompanies the compact uranitic ore under various fhades of colour, paffing from the pale fulphur-yellow into the brick-red, as alfo into the brown-yellow. The light-yellow and reddifh varieties are the pureft; fince, when diffolved in nitric acid, and treated with Pruffian alkali, they immediately precipitate of a brown-red colour. The darker varieties, on the other hand, contain more or lefs of iron. This earthy oxyd of uranium has formerly been taken for an ochre of iron. It has likewife been confidered, as the product arifing from a previous decay of fhiftofe mica, which forms the gangue, containing this foffil in the mine juft mentioned.

* This is called *Georgium Jidus* in England only.—Tranfl.

32.)

32.) To this place likewife belongs the *green mica*, as it was formerly called, that is alfo dug from the fame pit. This beautiful foffil is found in the fiffures, rifts, and partings of the rock, as well as upon the earthy uranitic oxyd; for the moft part, in the form of thin quadrilateral tables, fome of which approach to the cubical figure. Its colour is variable, paffing from the emerald green to that of the green-finch, to a lemon-yellow, and even to the filver-white.—It is alfo found on the *Tannenbaum* at *Eibenftock*, moftly upon brown hornftone-quarz, though but very fparingly.

33.) It is indeed certain, upon various grounds, that this foffil is not a true mica. Yet its nature continued to be a matter of queftion, until *Bergmann*, on analyfing it, thought that he had difcovered in it muriated copper and argil; and it was upon this authority that *Werner* has given it the name *Chalcolite*. Notwithftanding this, *Bergmann* ftill entertained fome doubt concerning the refult of his own experiments; efpecially as he could examine only a very fmall quantity of it.

34.) But according to my experiments, this green mica, or chalcolite, is a *cryftallized oxyd of uranium, coloured by copper*. After having procured, with great trouble, and facrificing feveral fpecimens, a fmall quantity of exquifitely pure cryftals, I poured upon them nitric acid, which diffolved them quietly, and entirely in the cold. Into one part of this folution I dropped nitrated filver; but no turbidnefs enfued, though *Bergmann* afferts that he has obtained muriat of filver. (Horn-filver).

Into another portion of the folution of the green cryftals I introduced a polifhed fteel-fpring, and found that it became incrufted with a coppery coating of metallic luftre.

The

The remainder of that ſolution was ſaturated with cauſtic ammoniac. A blueiſh-grey precipitate fell down, and the liquor, likewiſe, aſſumed a blue colour. I then added as much ammoniac, as was neceſſary to diſſolve all the copper contained in that fluid; after which, I decanted the bright blue ſolution from the precipitate: affuſing upon this laſt ſucceſſive freſh portions of ammoniac, until this alkaline fluid was no longer tinged blue. The reſidue, which had been thus freed from copper, I re-diſſolved in nitric acid, dividing the ſolution into three parts. When a poliſhed watch-ſpring had been immerſed in the *firſt*, neither copper, nor any thing elſe was precipitated. By combining the *ſecond* portion with Pruſſian alkali, a brown-red precipitate ſufficiently copious was obtained. From the *third* portion, cauſtic pot-aſh threw down a pure yellow oxyd of uranium.

Copper, however, ſhould not be conſidered as an eſſential conſtituent part of the cryſtallized oxyd of uranium; ſince I have not found the leaſt trace of it in another variety, that had a pure wax-yellow colour.

SECOND SECTION.

ANOTHER more pure variety of compact uranite, of a luſtre almoſt metallic, which I afterwards received from *Joachimsthal*, induced me to repeat its analyſis.

A.

a) *Five hundred* grains of this uranitic ore were powdered, and digeſted in a gentle heat, with nitric acid of a moderate ſtrength. The quantity of the acid employed, not being ſufficient to effect a total ſolution, the mixture appeared like a fluid, rendered turbid by a fine brick-red mud; but which diſappeared on the addition of another ſmall portion of nitric acid. The ſolution became clear, while a light-grey flocculent matter ſeparated, and was of a greeniſh aſpect. The reſidue collected by filtering weighed

30

30 grains after drying. When placed upon a teft, gently heated, its *fulphureous* part was confumed with a faint flame; and the remainder proved upon trial to be mere *filiceous earth*, weighing 25 grains.

b) The nitric folution was in part generally evaporated. It depofited nitrat of lead; which, when re-diffolved in water, and combined with fulphuric acid, yielded 35 grains of fulphated lead. Thefe indicate almoft exactly 25 grains of *metallic lead.*

After this feparation of the lead, the nitric folution gradually fhot into longifh hexahedral plates of a light-yellow colour, fomewhat inclining to the green. This nitrat of uranium, re-diffolved in water, and treated with cauftic pot-afh, afforded 440 grains of yellow precipitate.

c) The remainder of the folution, that would no longer cryftallize, when tried by Pruffian alkali, fhewed by the blue colour of its precipitate, that it had been contaminated with iron. This precipitate was then inpiffated, driving out the nitric acid by means of heat; after which it left a refidue weighing 40 grains. This laft, when boiled again with nitric acid, and filtered, left on the paper a red *oxyd of iron*; which, triturated with linfeed-oil, and ignited, obeyed the magnet, and weighed 13 grains.

Since, therefore, an *hundred* parts of this ore contain no more than *one* part of *fulphur*, and, on the other hand, *five* parts of *lead*; there remains no doubt, but that this fmall quantity of fulphur belongs to the lead exifting in the ore. For this reafon, I no longer confider the black uranitic ore, including its varieties, and taken by itfelf, as an *ore mineralized by fulphur*, but as an *imperfect metallic oxyd*; that is to fay, combined with but little oxygen. This condition, fo nearly approaching the metallic ftate, is the caufe why the folution of this oxyd in nitric acid is attended with extrication of heat and nitrous vapours.

Hence,

Hence, according to what has been ſaid, the ſhining black *ore of uranium* from *Joachimſthal* is compoſed, in *one hundred* parts, of :

Sulphat of lead	6
Silex	5
Oxyd of iron, attractible by the magnet	2,50
URANIUM	86,50
	100

B.

With the yellow oxyd, that had been precipitated from the ſolution of the uranitic nitrat, freed from iron, (A. 6.) I inſtituted ſeveral experiments, with a view of its *reduction.* Theſe, however, did not completely anſwer my deſire, to obtain a pure metallic button, run into a compact maſs. Of thoſe experiments, the following is that which has beſt ſucceeded.

Fifty grains of this oxyd, when ignited, were formed with wax into a ball, and in a well-cloſed charcoal crucible expoſed to the moſt vehement heat of the porcelain-furnace, the intenſity of which gave 170 degrees in *Wedgwood's pyrometer*. The metallic button obtained weighed 28 grains, and preſented a dark-grey, hard, firmly cohering, finely-grained, of very minute pores, and, outwardly, glittering maſs. On raſping this with the file, or rubbing it with another hard body, the metallic luſtre appeared on the place, thus laid bare, of an iron-grey colour; whereas in the other aſſays that were leſs perfect, the ſtreak of the uranitic regulus is uſually more verging to the browniſh. This metallic button likewiſe ſurpaſſed in ſpecific gravity thoſe before obtained; being, 8,100.

LVIII.

CHEMICAL EXAMINATION

OF TWO NEWLY DISCOVERED

TITANITES.

THE diſcovery of *Titanium*, in the red Hungarian ſhörl*, and in the ſmall hair-brown cryſtals, from the country about *Paſſau*†, having ſo much excited the attention of Chemiſts and Mineralogiſts, it was natural to expect, that this new metallic ſubſtance would alſo be found in other places. The event has ſhewn, that this expectation was not ill founded.

The chemical analyſis made at *Paris* by *Vauquelin* and *Hecht*, with a foſſil, diſcovered by *Miché* and *Cordier* at *St. Yrieux*, in the department of *Haute-Vienne*, has ſhewn, that this metallic ſubſtance is likewiſe a native of France ‡.

To this the preſent eſſay affords a new addition, by giving the analyſis of two other *titanites*, but lately diſcovered.

FIRST SECTION.

Titanite from Spain.

I HAD the pleaſure of receiving from the collection of *Baron Racknitz* at *Dreſden*, which is particularly rich in

* See *Eſſay* XIV. page 200.

† *Eſſay* XV. page 211.

‡ *Journal des Mines*. Paris. No. XV. page 10.

Spaniſh

Spanifh minerals, a foffil whofe outward characters juftified the fufpicion, that it might be an ore of Titanium.

It occurs at *Cajuelo*, near *Vuitrago*, in the province of *Burgos*.

The internal colour of it is a light reddifh-brown, inclining in fome places to the copper-red; but externally it is coated with white clay. It feems to have the form of a hexahedral column, with a flat fix-fided pyramidal termination; but inftead of the actual point, it has a regular excavation, which refembles an inverted, hollowed, hexahedral pyramid. In the infide, that foffil has a ftrong femi-metallic luftre. Its crofs-fracture is very diftinctly ftraight lamellar; and its longitudinal fracture imperfectly and fmall conchoidal. It is very little tranfparent on the edges; brittle, very hard, and of difficult levigation, by which it affords a greyifh-brown powder. The fpecific gravity of it is = 4,180.

One *hundred* grains of it, finely ground, and mingled with 600 grains of mild pot-afh, were brought to fufion in a crucible. The melted mafs was of a pearly-grey, which, upon re-diffolution in hot water, depofited the *oxyd of titanium* of a perfectly white colour. When this had been filtered off from the colourlefs alkaline fluid, and lixiviated with water, till the wafhings no farther indicated any trace of alkali, it was deficcated, and found to weigh 175 grains.

This titanic oxyd readily diffolved in muriatic acid, and was precipitated from it of a permanent green, by Pruffian alkali, and of a lively brown-red, by gallic acid; and in general, in all its other properties, it agreed with the white oxyd of titanium, extracted from the red Hungarian fhörl.

SECOND SECTION.

Titanite from Aschaffenburg.

WITH the foregoing titanite from Spain another foſſil correſponds, which Prince *Dimitri Gallitzin* has found ſeveral years paſt not far from *Aſchaffenburg*, in the *Speſsart* foreſt, preſerved in his collection as a mineral not yet aſcertained.

Its interior colour is a deep reddiſh-brown; externally it paſſes ſomewhat into the lead-grey, and exhibits ſilver-white ſcales of mica adhering to it. The ſpecimen, here examined, was a rounded priſmatic, and, as it appeared, a four-ſided cryſtal; the alternate angles of whoſe facets ſeemed to be obtuſe, and the ends apparently not yet completely cryſtallized. Its fracture exhibits a ſtrong ſemi-metallic ſplendour. The longitudinal fracture is ſtraight foliated; the croſs fracture, imperfectly conchoidal. It is untranſparent, brittle, and very hard. Its ſpecific gravity was found to be 4,055.

One hundred grains of this titanite were finely powdered, and fuſed with 600 grains of carbonated pot-aſh. The maſs, when fixed by cooling, preſented a greeniſh ſurface, and a pearly grey fracture. Upon pulverization, and ſolution in water, the filtered alkaline liquor was likewiſe greeniſh, but ſoon loſt its colour. The lixiviated and dried *oxyd of titanium* weighed 166 grains. Its white colour had a little of a reddiſh tinge, ariſing, perhaps, from a ſmall portion of mangaueſe; the traces of which were ſhewn by the external greeniſh colour of the melted maſs, as well as afterwards by that of the alkaline liquor.

As for the reſt, the metallic oxyd obtained from this foſſil of *Aſchaffenburg* exhibited in every reſpect the ſame habitudes or relations, as the preceding from *Spain*, or that which had been ſeparated from the *Hungarian* titanite.

LIX.

LIX.

CHEMICAL EXAMINATION

OF SOME

FERRUGINOUS TITANITES.

FIRST SECTION.

Iron-ſhot Titanite from Cornwall.

WITHIN a few years a foſſil has been brought into notice by the name *Menachanite*, which has been found in the pariſh of *Menachan*, in *Cornwall*, and conſiſts of grey-black, ſand-like grains, obeying the magnet. Mr. *M^cGregor*, of Menachan, who dedicates his ſtudy to mineralogical chemiſtry, has given not only the firſt information of this foſſil, but alſo a full narrative of his chemical reſearches concerning it. The chief reſult of theſe is, that menachanite has for its conſtituent parts iron, and a peculiar *metallic oxyd of an unknown nature**.

By the following examination it will appear, that this ſubſtance, which, beſides iron, forms the ſecond chief component principle of menachanite, is preciſely the very ſame which conſtitutes the Hungarian red ſhörl; namely, *oxyd of titanium.* With this opinion alſo, moſt of the phenomena, noted down by *M^c Gregor*, in his operations with menachanite, agree.

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* *Crell's Chemiſche Annalen.* 1791. vol. I. pages 40 and 103.

Though

Though I was eafily, convinced of this fact by my own experiments, it feemed, on the other hand, very difficult to feparate entirely the iron from the titanic oxyd; and, hence, to afcertain the true proportion of thefe two ingredients to each other. Paffing over various experiments which I made with this defign, I will relate only the two following, by which I obtained the oxyd of titanium, freed the moft from iron.

A.

a) *Two hundred* grains of menachanite, finely powdered, were mixed with ten times their quantity of a lixivium, compofed of equal parts of cauftic pot-afh and water. This mixture, being inpiffated to drynefs in a polifhed iron-pot, lodged in a fand-bath, was afterwards ignited in open fire. The mafs ran into thick fufion, and affumed in cooling a dirty dark-green colour.

b) By dilution with water, it gave a greenifh folution, from which a dark cinnamon-brown powder fubfided, which, detained on the filter, edulcorated, and dried, appeared very loofe, and weighed 374 grains.

c) The green alkaline fluid foon loft its colour, and depofited fome brown flakes, which upon trial were found to be an impure *oxyd of manganefe*, and weighed half a grain. When this liquor had been treated with an over-proportion of muriatic acid, and again neutralized with carbonated potafh, it afforded a whitifh precipitate, which afterwards was decompofed into feven grains of ignited *filex*, and two grains of *oxyd of titanium*.

d) The 374 grains of brown-powder (*b*) were mixed with fix ounces of muriat of ammoniac, and fublimed in a retort.

retort. The ſal-ammoniac volatilized of a ſtrong yellow. The reſidue had the form of a looſe, iſabella-yellow powder, and was found to be ſtill contaminated with iron. When freed from this metal by previous lixiviation with water, and ſubſequent digeſtion with muriatic acid, it was of a grey-white, after a repeated waſhing and drying, and amounted to 168 grains.

e) This grey-white metallic oxyd, proving inſoluble in acids, was fuſed in a crucible with five times its quantity of carbonated pot-aſh, and poured out. After congelation, the ſaline maſs preſented a pearly white; was compact, and of a coarſe-ſtriated fracture. On triturating, and waſhing it with water, the metallic oxyd was left behind of a perfectly white colour. This, when edulcorated and dried, weighed 276 grains, and ſhewed itſelf in every reſpect to be a completely pure *oxyd of titanium.*

f) To obtain the iron, I diſſolved in water the ſublimed muriat of ammoniac *(d)*, mixed the ſolution with the water employed for edulcorating the reſidue, which thereby became muriated, and then I ſaturated the whole with cauſtic ammoniac. The brown *oxyd of iron*, thus ſeparated, was dried, drenched with linſeed-oil, and heated to redneſs. It weighed 100 grains, and was rapidly and entirely attracted by the magnet.

B.

I effected another complete decompoſition of menachanite in the following ſhorter way.

a) *Two hundred* grains of menachanite were prepared for their decompoſition in the ſame manner as explained before at *(A. a,* and *b)*; and the light-brown powder, thus obtained, was ignited for half an hour in a crucible. It now received a blackiſh chocolate-brown colour, and weighed 260 grains.

b) After having affuſed upon it three ounces of muriatic acid, I evaporated it in a porcelain veſſel to a moderately deſiccated maſs; the colour of which was yellow, like the yolk of eggs, and mixed with orange-yellow. It was then diluted with water, and put on the filter. The filtered liquor contained muriated iron, and the waſhed reſidue exhibited on the paper a fine, heavy powder, of an iſabella-yellow, which, dried in a low-heat, weighed 106 grains.

c) I mixed this with a quintuple portion of carbonated pot-aſh, and brought it into fuſion in a crucible. The maſs, when poured out, and fixed by refrigeration, was of a pearl-grey, with ſome light-browniſh ſpots. Upon triturating, and edulcorating it with water, the titanic oxyd remained behind as a flocculent, yellowiſh-white powder, amounting to 226 grains, when deſiccated in the air.

d) This oxyd readily diſſolved in muriatic acid, and entirely, without leaving any reſidue. However, it was not perfectly free from iron; ſince the precipitate produced from it by the infuſion of galls did not exhibit that deep-yellow-red-colour, which is peculiar to the pure gallated oxyd of titanium. On this account, I cauſed the ſolution to boil upon a ſand-heat; by which management the titanic oxyd ſeparated from the liquor in the form of white gelatinous flocculi. It was then collected on the filter, and lixiviated with water, until this laſt was no longer blackened by gallic acid.

e) The titanic oxyd, again deſiccated, appeared now of a bright yellow colour, and was not attacked by acids in its preſent ſtate. To render it again ſoluble, I ignited, and urged

urged it by heat to fuſion, with five times its quantity of carbonat of pot-aſh. The pearl-grey maſs, then produced, and ſoftened by warm water, depoſited the metallic oxyd of a perfectly white colour, weighing 230 grains, after edulcoration and drying. Muriatic acid readily diſſolved this oxyd, which now, upon trial, appeared to be pure *oxyd of titanium*, abſolutely *free from all iron*.

f) The fluids, that held the muriated iron in ſolution, were combined with cauſtic ammoniac; and the *oxyd of iron* precipitated by that means, when moiſtened with linſeed-oil, and ignited, was found to weigh 102 grains.

With regard to the proportion of titanium to iron in menachanite, it cannot be determined in the direct way. The reaſon of this is, that the weight of the ſeparated oxyd of titanium varies very much, according to the different degrees of ſaturation with oxygen, and perhaps alſo with carbonic acid; and moreover, according to the degree of deſiccation, &c. With greater certainty may the ſtate of the iron contained in menachanite be determined; which ſeemingly agrees with that of *Ethiops martial*, or black oxyd of iron, attractible by the magnet. Allowing this, the conſtituent parts of *Menachanite* in the *hundred* may be aſſumed as follows:

Oxyd of iron, attractible by the magnet .	51
Oxyd of titanium	45,25
Silex	3,50
Oxyd of manganeſe	0,25
	100

C.

In order to become acquainted with the habitudes of menachanite in fire, I ſubjected it to the following experiments.

 a) Expoſed

a) Expoſed in a *charcoal-crucible* to the fire of the porcelain-furnace, it proved infuſible. Its grains were rendered ſomewhat more porous; its black colour had become paler, and its luſtre leſs brilliant. At the ſame time its ſurface was found overlaid with minute grains of iron.

b) But in the *clay-crucible*, the menachanite entered into perfect fuſion, and in this ſtate was imbibed by the pores of the veſſel; the places of which, that had been penetrated by the melted foſſil, were externally brown, but in the fracture black and reſplendent.

SECOND SECTION.

Ferruginous Titanite from Aſchaffenburg.

MENACHANITE is not the only inſtance of a foſſil compoſed of the oxyds of iron and titanium. Beſides that from Cornwall, ſimilar mixtures occur in various countries, differing only in the proportions of their reſpective ingredients. A proof of this is afforded by the following examination of a foſſil, which Prince *Dimitri Gallitzin* has likewiſe found in the *Speſsart* foreſt, near *Aſchaffenburg*, together with the pure titanite deſcribed and examined in the preceding ſection. The ſpecimens given me for the ſake of this enquiry, by that zealous promoter of mineralogical ſcience, are of various ſizes; the largeſt is two inches long, one inch broad, and half an inch high. Moſt of them are free from the *veinſtone*, or matrix; but ſome are embodied in a grey, flat-conchoidal quarz *(Fettquarz)*. Their colour is iron-black, accompanied outwardly by a moderate, but inwardly by a ſtronger, metallic luſtre. The foſſil itſelf is compact and opake. Its fracture is uneven, and of a fine grain; its fragments indeterminately angular. It is very brittle, hard, and is only with difficulty ground to a ſubtle

powder

powder, which has a black colour. Its ſpecific gravity is 4,740.

By the magnet this foſſil is not in the leaſt attracted, not even its ſmalleſt ſplinters; nor does it itſelf attract the leaſt particle of iron. The more remarkable is it, therefore, that it is poſſeſſed of the property of indicating, like the loadſtone, the adverſe poles, by contrarily attracting and repelling either end of the poles of the magnetic needle, or any moveable magnetic bar.

a) One hundred grains of the foſſil, finely pulverized, were boiled down to dryneſs upon a ſand-bath, in a poliſhed iron-crucible, with two ounces of alkaline lye, one half of which conſiſted of cauſtic alkali. The veſſel was then placed between burning charcoal, urging the heat to the ignition of the maſs; whereby it fuſed with the conſiſtence of a thick ſyrup. The refrigerated maſs was of a dirty browniſh hue. On being ſoftened with water, its undiſſolved part ſubſided as an incoherent, reddiſh-brown powder, weighing 144 grains, after waſhing and deſiccation. The alkaline liquor was deſtitute of colour, and had taken up nothing of the foſſil.

b) Upon theſe 144 grains a ſufficient quantity of muriatic acid was poured, and again evaporated from it nearly to dryneſs. On diluting this combination with water, an iſabella-yellow precipitate fell down from it. This laſt, collected on the filter, edulcorated, and dried, and then heated to fuſion with five times its quantity of carbonated pot-aſh, yielded a grey-white maſs, from which, after dilution with water, I obtained a yellowiſh-white powder, which, cleared by waſhing from the ſaline particles, and deſiccated, weighed 45 grains. It alſo, when accurately examined, ſhewed evidently, that it was *oxyd of titanium.*

c) The

c) The portion of iron, ſuſpended in the muriatic ſolution, was precipitated by cauſtic ammoniac, and, when collected, it was moiſtened with linſeed-oil, and ſubjected to a low red-heat. This *iron* weighed 78 grains, and the whole of it obeyed the magnet.

As, therefore, no other conſtituent part exiſted in the foſſil, I may fairly conſider the remaining part as its *titanic* portion. According to which, an *hundred* parts of the foſſil contain:

Oxyd of iron . .	78
Oxyd of titanium .	22
	100

THIRD SECTION.

Ferruginous Titanite from Ohlápián.

A.

At the works at *Ohlápián*, in *Tranſylvania*, where auriferous ſands are waſhed, there occurs a *titanite* mixed with leſs iron. It conſiſts of compreſſed, or flat, rounded grains, for the moſt part of the ſize of a lentil, in which, now and then, ſlight traces of a deſtroyed cryſtalline form are obſervable. Its colour is greyiſh-black, inclining to the browniſh-red. It is opake; externally of a middling, internally of a brighter, metallic luſtre; of a lamellar texture; very hard, brittle; and reducible, by grinding, to a greyiſh-brown powder. Its ſpecific gravity is 4,445.

If heated alone before the blow-pipe, it ſuffers no ſenſible alteration. Nor does the magnet ſhew any action upon this foſſil, either in the rough ſtate, or roaſted.

This

This foſſil is one of the mingled heterogeneous parts conſtituting the auriferous ſands at Ohlápián, which conſiſt of very unequal grains, as well with regard to their ſhape or form as to their bulk. Of theſe accumulated ſands, the larger grains conſiſt, for the greateſt part, of this titanic ore.

The middle-ſized grains are partly light-crimſon, partly carmine-red. They are opake, and have half a line, ($\frac{1}{24}$ of an inch) in diameter. They bear great reſemblance to ſpinell, or, on account of their conchoidal fracture, to the ruby, or red ſapphire.

The ſmalleſt of them, which ſeem to be *grains of quarz*, are yellowiſh-white, very tranſparent, or ſemi-pellucid, acute angular, and in their diameter hardly $\frac{1}{120}$ part of an inch wide.

Of this laſt ſize there exiſt alſo many fine black grains in the general maſs, which probably are likewiſe *titanium*.

Theſe, and the granular quarz, conſtitute by far the greateſt part of the whole. The mingled heap, from *one ſixth* to *one fourth* part, conſiſts of the red grains; but the larger titanic grains lie but ſparingly diſtributed among them.

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a) *Two hundred* grains (by weight) of theſe minute titanites, previouſly pulverized, were mixed with a lixivium made of 600 grains of cauſtic pot-aſh in a ſilver veſſel, and after being evaporated to dryneſs, gently ignited for half an hour. This maſs came out of the fire of a verdigris colour, with brown-red ſpeckles. When diffuſed in water, and paſſed through the filter, it left on the paper a looſe, bright, and brown-red powder. The filtered alkaline liquor had at firſt a deep-green colour, but which ſoon diſappeared; and it depoſited *oxyd of manganeſe*, weighing four grains after ignition. When this precipitate had been removed, I ſaturated the fluid with muriatic acid, which threw down a whitiſh precipitate, turning yellow upon deſiccation, and conſiſting of *oxyd of titanium*.

b) This brown-reddiſh powder I boiled in a ſand-heat with muriatic acid, evaporating it afterwards nearly to dryneſs. By this treatment the maſs aſſumed a yellow colour, like the yolk of eggs. It was in the next place diluted with water, and the white *oxyd of titanium*, ſeparating from the fluid, was collected on the filter.

c) This oxyd, being lixiviated and deſiccated, together with the titanic oxyd obtained at (*a*), was mixed and fuſed in a porcelain-veſſel with ſix times their weight of carbonated pot-aſh. This united maſs, when re-diſſolved in hot water, depoſited a very white, pure *oxyd of titanium*, now ſoluble in all acids; which in this ſtate of purity, and after waſhing and exſiccation, amounted to 275 grains.

d) Cauſtic ammoniac precipitated the *oxyd of iron*, that was held in ſolution by the muriatic fluid (*b*). This being collected, waſhed, and expoſed, with ſome linſeed-oil, to a gentle red-heat, was found to weigh 28 grains.

On calculating by the method noticed in treating of menachanite, it appears that an *hundred* parts of this *foſſil from Ohlápián* conſiſt of:

Oxyd of titanium	84
Oxyd of iron	14
Oxyd of manganeſe	2
	100

B.

B.

By this difference diſcovered in thoſe three foſſils, with reſpect to the proportion of their two chief conſtituent parts to each other, their claſſification in the mineralogical ſyſtem is rendered ſomewhat difficult.—If the predominant conſtituent parts be aſſumed as the baſis of a mineralogical arrangement, the *foſſil from Ohlápián* will take its place as a ſpecies of the titanium genus, under the name of *ſidero-titanium*; but the *menachanite*, together with the *foſſil from the Speſsart*, would conſtitute a new ſpecies belonging to the genus of iron, and obtain the denomination of *titano-ſiderum*.

To conclude: as, beſides in the foſſils here treated of, I have diſcovered in various others, of the genus of iron, ſome traces of this new metallic ſubſtance (as, for example, in the ſmall *magnetic iron-grains from Ceylon*, which are often found there in conſiderable quantity, on waſhing the collected hyacinth, and other ſmall looſe fragments of gems), it is neceſſary, that for the future, in the more accurate examinations of the iron ſtones and ores of iron, regard ſhould alſo be had to *titanium*, as one of their poſſible ingredients.

LX.

LX.

CHEMICAL EXAMINATION

OF THE

GARNET-SHAPED ORE of Manganeſe.

IN the granitic rocks of the *Speſsart*, near *Aschaffenburg*, whoſe chief aggregate parts are coarſe-granular fel-ſpar, moſt frequently of a fleſh-red, grey-quarz, and a little ſilvery-white mica; there likewiſe ſometimes occur, as acceſſary ingredients, ſome black priſmatic ſhörls, but, ſtill ſeldomer, a foſſil, hitherto unknown; the analyſis of which I have made the ſubject of the preſent eſſay, and which, in the mean time, I deſignate by the name of *garnet-ſhaped ore of mangane ſe.*

The merit of its diſcovery belongs to *Prince Dimitri Gallitzin*; and that of the deſcription of its external characters, here ſubjoined, to Mr. *Karſten.*

" The varieties of this foſſil moſt recently collected poſ-
" ſeſs a *deep-hyacinthine red* colour, which, in ſome, changes
" to the *reddiſh, or yellowiſh-brown*; and ſome burſt pieces,
" that appear to have already ſuffered ſome decay, are in-
" wardly ſpotted *greeniſh.*

" Their form of cryſtallization is not quite diſtinct; *no*
" *perfect cryſtals* having been yet found. But to judge
" from the fragments inſpected, as well as from the caſts,
" (the originals of which exiſt in the cabinet of *Prince*
" *Gallitzin)*, their leading figure ſeems to be a *double eight-*
" *ſided*

" *ſided pyramid*, ſharpened off on both ends with four ſur-
" faces. This pointed termination is *more flat*, and all
" the angles are *more rhombic*, than in the garnet. Their
" edges are partly without truncation, and partly in a re-
" verſed order; ſo that two and two joined to each other
" have their faces formed by the truncation, but the third
" remains entire. Thoſe cryſtals are in part of a *middling*
" *ſize*, in part *ſmall*, and *very ſmall*, all of them *imbedded*
" in granite.

" Externally they are *finely*, and, as it ſeems, *alternately*
" *ſtriated.*

" At the ſame time they are *ſhining*. The ſmalleſt va-
" rieties alone, in which the ſtriæ almoſt entirely eſcape
" obſervation, are ſtrongly reſplendent, of a luſtre between
" the gloſs of fat and the brilliancy of the diamond.

" Internally, (where the foſſil is undecayed) it is through-
" out *very reſplendent*, of a fine diamond luſtre.

" Its *fracture* is in *two directions*; namely, thoſe which
" correſpond with the ſtriæ, *straight-laminated*; but in all
" other directions, making an angle with the ſtriæ, *ſmall*
" *conchoidal.*

" The *fragments* appear to be angular, of an indefinite
" form.

" In thoſe ſpecimens which I have before me, I do *not*
" perceive *detached* or *inſulated pieces.*

" The foſſil is alſo *strongly tranſparent*, more or leſs, on
" the edges.

" *Semi-*

" *Semi-indurated*, in a higher degree than pitchſtone;
" Very *brittle*; and *not* particularly *heavy*.

" Its *ſpecific gravity*, at a mean ratio, I have found to
" be 3,600."

A.

a) Ignited by itſelf upon charcoal, this foſſil is by degrees converted into a round greeniſh-black globule.

b) By borax it is gradually diſſolved into a clear olive-green pearl.

c) Neutral phoſphoric ſalt acts upon it only in a languid and imperfect manner, and forms with it by ſolution a very rifty globule, of a faint amethyſtine tinge. If nitre be projected upon it, while red-hot, the ſalt remaining upon the charcoal, after detonation, acquires ſome deep amethyſt-red ſpots.

B.

a) *Hundred* grains yielded, by grinding to fineneſs, a reddiſh-yellow powder. This was covered with a lye containing 300 grains of carbonated pot-aſh; and when previouſly inſpiſſated to dryneſs, it was ſubjected to red-heat. The ignited deep-green maſs, diffuſed in water and filtered, afforded a lixivium of the ſame colour. By ſaturating it with nitric acid, its green colour was changed to a red. When expoſed to a warm temperature, all its colour diſappeared, and the fluid depoſited brown flocculi, which, collected, weighed 4½ grains.

b) The

b) The lixiviated refidue was of a deep black-brown, and weighed, upon deficcation, 141 grains. Nitric acid, with which it was digefted, fhewed by itfelf alone no folvent power upon it; but attacked it only when I added fugar to the mixture. The black-brown colour of the mixture difappeared; and from the folution, now become clear, *filiceous earth* feparated, amounting to 35 grains, upon edulcoration and red-heat.

c) To the clear, bright-yellow, nitric folution, cauftic ammoniac was added to excefs of faturation. A light-brown precipitate enfued. The remaining colourlefs fluid, reduced by evaporation to a fmaller volume, continued unchanged, on combining it with carbonated pot-afh.

d) I re-diffolved this precipitate (*c*) in muriatic acid, and treated the folution, firft with lefs cauftic pot-afh than was required to neutralize the little predominant portion of uncombined acid. Upon this, I added to it a folution of 400 grains of tartrite of pot-afh (*tartarus tartarifatus*), which produced a copious, ftraw-yellow precipitate, in fine grains. The whole mixture was again evaporated to drynefs, then ftrongly ignited in a porcelain-crucible, and the black-brown refidue was lixiviated with a fufficient quantity of water.

This refidue, when dried again, together with the preceding, of 4½ grains (*a*), was once more ignited. It then appeared in the character of a fine *oxyd of manganefe*, and weighed 49 grains.

I digefted once more this manganefian oxyd with nitric acid, adding fucceffive portions of fugar, and, laftly, diluting the mixture with water, and filtering it. On the paper there remained *oxyd of iron*, which, edulcorated, and heated

L l to

to redneſs, weighed 14 grains; and, after a ſecond ignition with wax, was quickly attracted by the magnet. By deducting this, there remain, therefore, 35 grains for the *oxyd of mangaueſe.*

f) The water employed to lixiviate the ignited maſs (*d*) exhibited now a colourleſs alkaline ſolution. When fully neutralized with muriatic acid, and treated with carbonat of ſoda, a white, looſe earth was precipitated, which, edulcorated and ignited, weighed $14\frac{1}{2}$ grains. This earth, diſſolved in ſulphuric acid, and, when made to cryſtallize by proper management, afforded, throughout the proceſs, cryſtals of *alum.*

Wherefore, *hundred* parts of this *garnet-ſhaped ore of manganeſe* have yielded:

Oxyd of manganeſe	*e*) . . .	35
Oxyd of iron . .	*e*) . . .	14
Silex	*b*) . . .	35
Alumine . . .	*f*) . . .	14,25
		98,25

LXI.

LXI.

CHEMICAL EXAMINATION

OF THE

NATIVE OXYD OF TIN.

(Tin-ſtone. Zinnſtein).

FIRST SECTION.

Experiments in the dry way.

THE *aſſay of tin*, or the proceſs of producing metallic tin in the *dry way*, by reviving a ſmall quantity from the tin-ore, (called *Tin-ſtone*) or the *native oxyd of tin*, with the leaſt poſſible loſs of weight, has hitherto been ſubject to many difficulties. I have always obtained unequal, and hence uncertain reſults, in the repeated experiments, which I have made, according to the directions given in the elementary treatiſes on *Docimasy*, or *Art of aſſaying Metals*; that is to ſay, by combining the tin-ores to be aſſayed with fixed alkalis, with borax, and the like. The cauſe of this failure chiefly depends on the ſolubility of the oxyd of tin in the alkaline additions, employed as fluxes in the proceſs.

On the contrary, the following *aſſays*, performed in the ſimpleſt manner, without any addition, and merely in charcoal-crucibles, have always given me much more certain, and, on repeating them, conſtant reſults, with the exception of an inconſiderable difference.

A.

Aſſays in charcoal-crucibles.

1.) *Brown, cryſtallized tin-ſtone (Zinngraupen)* from *Schlackenwalde*, in *Bohemia*, of the ſpecific gravity of 6,760. *One hundred grains* of this, in entire pieces, were introduced into the cavity of a charcoal-crucible, cloſing its orifice with a ſtopper of the ſame materials. This charcoal-crucible was then tightly inſerted and faſtened in another of baked clay, placed upon the forge-hearth before the nozzle of the bellows, and the contents of the firſt, reduced to the reguline ſtate, by directing thither a briſk current of air for half an hour. The metallic button of tin produced was a little blackiſh on its ſides, and its ſurface coated with a greeniſh cruſt. It weighed 72½ grains.

2.) *Light-brown, acicularly cryſtallized tin-ſtone (Needle-tin)* from *Polgooth*, in *Cornwall.*

The preſent differs from the many other varieties of Corniſh tin-ſtones in this, that it is an aggregate of very minute, for the moſt part capillary, four-ſided columnar cryſtals, of a light-brown colour, and vivid luſtre. Where the accumulation does not paſs into compact tin-ſtone, the ſmall interſtices are filled up by chlorite.

The ſpecific gravity of this oxyd of tin, in crude lumps, is 5,845; but when in the ſtate of picked and well waſhed ore *(Schlich)*, it is 6,750.

Hundred grains of this waſhed needle-tin, reduced in the charcoal-crucible, in the ſame manner as the foregoing, afforded a button of metallic tin, weighing 77 grains, with ſome fome fuperincumbent fcoriaceous globules; which weighed two grains, and were probably fome remnants of chloritic earth.

3.) *Cryftallized grey tin-ftone*, having fome white tranfparent fpots, from St. *Agnes*, in *Cornwall*. The fpecific gravity of thefe cryftals is 6,840. *One hundred* grains, treated in the fame manner, yielded 74 grains of revived tin.

4.) *Stream-tin (Seifenzinnftein)* from *Ladock*, in *Cornwall*. *One hundred grains* of this ore, confifting of loofe blackifh grains, and of the fpecific gravity of 6,560, were reduced in this way to 76 grains of reguline tin.

5.) *Stream-tin*, from *Alternon*, in *Cornwall*.

The colour of this, which muft be reckoned among the pureft tin-ores, is in fome places darker, in others lighter. Of all the tin-ftones, which I have weighed on the hydroftatic-balance, I have found the prefent the moft ponderous; its fpecific gravity being 6,970.

The reduced, or metallic tin, obtained from *hundred* grains of this ore, weighed 76 grains.

6.) *Wood-tin*, from Cornwall.

This remarkable fpecies, which till now is only known in fhivery loofe fragments, or *ratchill* of the miners (*Gefchieben*), occurs in the wafhing works of tin, in the neighbourhood of St. *Colomb*, *Roach*, and St. *Denis*, in *Cornwall*; but in fmall quantities only. Ufually the pieces are but fmall; thofe that have the fize of a bean belong to the fcarcer ones*.

* A fpecimen of wood-tin, of the fcarceft magnitude, exifts in the exquifitely fine collection of *Baron Racknitz*, at *Drefden*. It is *two* inches long, and *one* broad.

This ore, the only one of its kind, is externally diftinguifhed from the common tin-ftones, chiefly by the total abfence of any cryftalline form; while, on the other hand, it exhibits its peculiar, bundled or fafcicular fracture. Its external characters have been fully defcribed by *Werner** and *Karften*, chiefly†.

I found the fpecific gravity of wood-tin-ftone to be 6,450.

One hundred grains of it, reduced in the manner already mentioned, *viz.* fimply in the charcoal-crucible, gave 73 grains of reguline tin.

By the fame method, I have fubjected to the *procefs* of *reduction* various other tin-ftones, as well as wafhed and pounded tin-ores, and have conftantly obtained, in the refult, from 72 to 77 *per cent* of reguline tin. The fmall portion of iron, commonly contained in tin-ftones, ufually fticks to the furface of the reduced tin, in very minute grains; and it is owing to this, that the button of tin is moved when the magnetic needle is approached to this part of its furface.

It is worth remarking, that ufually fmall cavities are formed in the button of revived tin, as it cools and becomes fixed; which fmall fiffures are covered by minute lamellæ, that, in colour and brillancy, refemble polifhed gold in a very illufive manner.

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* *Beobach. u. Entdeck. a. d. Naturkunde.* vol. I. Berlin, 1787, page 152.

† *Ibidem*, vol. IV. 1792, page 397.

B.

B.

Habitudes of Tin-ſtone, when expoſed to heat in a crucible made of clay.

1.) *Brown-tin-ſtone* from *Schlackenwalde*, expoſed to a porcelain-fire, in a baked clay-crucible, ran into a clear denſe glaſs, greeniſh-grey in the middle, but of a bright yellow on the ſides, and at top. The ſurface was inveſted with a dull whitiſh cruſt. The interior ſides of the veſſel were glazed of a milk-white, and overlaid with many ſmall groups of light-brown, tender, needle-ſhaped cryſtals. The inner ſurface of the crubible lid, had alſo ſimilar detached cryſtals adhering to it.

2.) *Needle-tin* from *Polgooth*, ſubjected in a clay-crucible to the heat of the porcelain-furnace, likewiſe produced a compact, light-browniſh, tranſparent glaſs; covered on the upper ſurface with a browniſh, dim, and ſhrivelled, or furrowed cruſt.

3.) *Stream-tin* ore from *Alternon*, committed in the ſame manner to the porcelain-furnace, in a crucible of baked clay, yielded a compact light-yellow, and ſtill ſomewhat clearer glaſs, that was found coated by a dull cruſt, of an iſabella-yellow.

SECOND SECTION.

Experiments in the humid way.

THE extreme reſiſtance which tin-ſtone oppoſes to acid menſtrua has hitherto always prevented the complete ſucceſs of its decompoſition in the *humid way*; the reaſon of muſt be ſought for in the highly intimate and difficultly deſtructible combination of tin with oxygen. To be diſſolved in acids, tin indeed, like other metals, requires a commenſurate proportion of oxygen. But if that proportion be exceeded, as is the caſe with tin-ſtone, with *putty* or *tin-aſhes* (the white, perfect oxyd of tin by ignition with acceſs of air) with the oxyd of tin corroded by nitric acid, and ſimilar other calces of that metal; the ſolution cannot take place, unleſs the exceſs of oxygen cauſing this impediment be previouſly removed.

A.

Till the preſent period, *Bergmann** was the only author, who has ſhewn a method of analyſing tin-ſtone in the humid way: but unfortunately, I, as well as other chemiſts†, have ſufficiently experienced its imperfection. However, I entertained a hope, that the proceſs recommended by him would moſt likely ſucceed when employed for wood-tin; on the ground, that of all tin-ſtones, this at leaſt yields in ſome manner to the attack of acids; as I obſerved that 60 grains of it, reduced to an impalpable powder, and ſubjected to vigorous and long continued digeſtion with three ounces of nitro muriatic acid, had loſt five grains of weight.

For this purpoſe, I digeſted 120 grains of finely pulverized *wood-tin*, for ſome time, with *one* ounce of concentrated ſulphuric acid, and the aſſiſtance of a boiling heat. After this, I added by degrees two ounces of muriatic acid, and

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* *Opuſcula Phyſica et Chemica.* vol. II. page 437.

† *Chemiſche Annalen.* 1786, 2 Band, page 126.

having

having digefted it once more, I diluted the whole with water, and decanted the clear fluid from the undiffolved refidue which fettled at the bottom. The fame procefs was repeated twice with this laft, adding each time half the above mentioned quantity of the acids. That portion, which continued infoluble, retained its original appearance, and weighed ftill 98 grains. The folution exhibited a yellow colour. When part of it was tried by Pruffian alkali, the blue tinge manifefted fome latent portion of iron. The whole of the folution was, upon this, faturated with carbonated pot-afh; which produced a dirty white precipitate, weighing 27 grains in its dry ftate. Muriatic acid poured upon this precipitate rapidly diffolved it; and, on plunging into the folution, diluted with water, a thin ftick of metallic zinc, there fettled round it fubtle lamellæ of reguline tin.

Yet, although, in this way the folution of *wood-tin* was in part accomplifhed, it would not fucceed with other fpecies of tin-ftones, treated in the fame manner. Such acids, as have been employed for this purpofe, diffolved indeed the fmall portion of iron entering into the foffil, but exhibited feldom a flight trace of diffolved tin; and the powder of the tin-ftone, fubjected to the experiment, fuftained only a very flight alteration in its appearance and weight.

Befides this, another circumftance connected with this method is yet to be remarked; which is, that each time, when muriatic acid is poured on the concentrated and heated fulphuric acid, clouds of muriatic vapours arife, detrimental to the health of the operator.

Therefore the problem, to decompofe, in the *humid way*, tin-ftones, and other calces of tin, fully faturated with oxygen, has by no means been folved by the procefs prefcribed by *Bergmann*.

B.

B.

Among thofe fubftances, which, by their near affinity with oxygen, afford a rational conjecture, that, by depriving tin-ftone of part of its oxygen, they might prepare or render it fit for its folution in acids, *fulphur* principally feemed to deferve the trial.

Hundred grains of finely powdered *tin-ftone*, from *Schlackenwalde*, mixed with an equal quantity of fulphur, were introduced into a fmall glafs-retort. This being connected with a receiver, was lodged in a fand-bath, and gradually heated to an incipient ignition of its contents. When this procefs was accomplifhed, I found the fulphur fublimed, without any change in its natural ftate; while the refidue, which preferved the former white-grey colour of the pulverized tin-ftone, was hardly conglutinated, but had here and there fome folitary, very minute, glittering, golden-yellow fcales of *aurum mufivum* fpread on its furface. This refidue was ftrongly digefted with muriatic acid. But although the muriatic fluid, feparated from it by filtering, had, on combination with alkali, afforded fome oxyd of tin; yet its quantity was too inconfiderable, to make it reafonable to expect in this way a complete folution of tin-ftone.

C.

After the above mentioned, and feveral other unfuccefsful attempts, I proceeded to the application of *cauftic-potafh*. It was with fatisfaction, that I found in this the means of accomplifhing my purpofe: fo fully, that at prefent the *complete analyfis of tin-ftone in the humid way* is no longer fubject to any difficulty.

1. *a*)

1. *a*) One *hundred* grains of tin-ftone from *Alternon*, in *Cornwall*, previoufly ground to a fubtle powder, were mixed in a filver-veffel with a lixivium containing 600 grains of cauftic pot-afh. This mixture was evaporated to drynefs in a fand heat, and then moderately ignited for half an hour. When the grey-white mafs, thus obtained, had been foftened while yet warm, with boiling water, it left on the filter 11 grains of an undiffolved refidue.

b) Thefe 11 grains, again ignited with fix times their weight of cauftic pot-afh, and diffolved in boiling water, left now only $1\frac{1}{4}$ grain of a fine yellowifh-grey powder behind.

c) The alkaline folution (*a* and *b*), which was in fome degree colourlefs, was faturated with muriatic acid. A brilliant white, tender oxyd of tin was thrown down, giving to the mixture a milky appearance. This precipitate, re-diffolved by an additional quantity of muriatic acid, was precipitated afrefh by means of carbonated foda. When lixiviated and dried in a gentle heat, it acquired the form of bright-yellowifh, tranfparent lumps, having in their fracture a vitreous luftre.

d) This precipitate, being finely powdered, foon and entirely diffolved in muriatic acid, affifted by a gentle heat. Into the colourlefs folution, previoufly diluted with from two to three parts of water, I put a ftick of zink; and the oxyd of tin, thus reduced, gathered around it in delicate, dendritic laminæ of a metallic luftre. Thefe, when collected, wafhed, dried, and fufed, under a cover of tallow, in a capfule placed upon charcoal, yielded a button of pure metallic tin, weighing 77 grains.

e) The

e) The above mentioned refidue of 1¼ grain, left by the treatment with cauftic pot-afh (*b*), afforded with muriatic acid a yellowifh folution ; from which, by means of a little piece of zink introduced into it, ½ grain of tin was ftill depofited. Pruffian alkali, added to the remainder of the folution, produced a fmall portion of a light-blue precipitate ; of which, after fubtracting the oxyd of tin now combined with it, hardly ¼ of a grain remained, to be put to the account of the iron contained in the tin-ftone, here examined.

In thefe experiments, (excepting only a flight indication of *filex* amounting to about ¾ of a grain), no trace has appeared, either of tungftenic oxyd, which fome Mineralogifts have fuppofed to be one of the conftituent parts of tin-ftone, nor of any other fixed fubftance. Therefore, what is deficient in the fum, to make up the original weight of the foffil analyfed, muft be afcribed to the lofs of oxygen ; and t us the conftituent parts of *pure tin-ftone from Alternon* are to each other in the following proportion :

Tin	77,50
Iron	0,25
Silex . . , . .	0,75
Oxygen	21,50
	100

2.) I repeated the fame experiment with wafhed *needle-tin* from *Polgooth*, and obtained nearly the fame refult.

3.) *Hundred* grains of *brown tin-ftone* from *Schlackenwalde*, decompofed in the fame manner, by means of cauftic alkaline lye and muriatic acid, yielded 75 grains of reguline tin ; but its portion of iron amonnted to ½ grain.

LXII.

LXII.

CHEMICAL EXAMINATION

OF THE

*NATIVE SULPHURET OF TIN**.

(Tin-pyrites. Zinnkies.)

THE *Tin-pyrites*, or *ſulphuret of tin*, which at *Wheal Rock*, in the pariſh of St. *Agnes*, in *Cornwall*, at the depth of 20 fathoms under ground, forms a vein of 9 feet in thickneſs, is the firſt, and as yet the only inſtance of a natural tin-ore mineralized by ſulphur. *Bergmann*†, it is true, mentions ſuch an ore as coming from Siberia; but it has never yet been found there; and what this celebrated chemiſt has conſidered as ſuch, and examined, was not a true foſſil, but a ſuppoſitious product of art ‡.

The colour of this tin-pyrites is grey, of various degradations from the light to the dark, and in the purer ſpecimens approaching to the ſilvery white. It is found in ſmall lumps, poſſeſſes a moderate metallic luſtre, and exhibits an uneven, ſmall-grained fracture. Its texture appears to be foliated, and its fragments are, for the moſt part, indeterminately an-

* *Beob. u. Entdeck. a. d. Naturkunde.* vol. I. pages 155 and 169.

† *Opuſc. Phys. et Chem.* vol. III. page 158.

‡ *Crell's Chem. Annalen*, 1790, vol. I. page 53.

gular.

gular. It is alfo very brittle, and eafily triturated*. Its fpecific gravity, as I found, is 4,350.

According to the following analyfis, the conftituent parts of this ore are *Tin*, *Copper*, *Iron*, and *Sulphur*. For this reafon, the name of *Bell-metal ore* has been given it, not very improperly.

Tin pyrites contains, befides the copper chemically mixed with it a sone of its conftituent parts, likewife copper-pyrites; which in part is coarfely, and in part finely difseminated in it. From this accidental ingredient, I previoufly freed, as much as poffible, the tin-pyrites, or native fulphuret of tin, fubjected to the following examination.

A.

Half an ounce of tin-pyrites was heated to rednefs in a fmall glafs-retort. In the receiver a moifture was found, making about two drops, impregnated with fulphureous acid. The neck of the retort became thinly lined with a little grey and yellow fublimate, of about ¼ grain of weight; which, when placed on a glowing coal, firft fmelled and burned like fulphur; but after this, a faint odour of arfenic was perceptible. The tin-pyrites loft three grains of weight.

B.

Two drachms of tin-pyrites were roafted in a calcining-pot, till no longer any fulphureous fmell could be obferved.

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* A more detailed defcription of the external properties of tin-pyrites, by *Karften*, may be feen in *Beob. u. Entd. a. d. Naturkunde.* vol. IV. page 391.

By

By this the ore was converted into a red calx or oxyd, weighing two drachms and 20 grains. It was then mingled with equal parts of calcined borax, half a part of white glafs, and one fourth part of colophony. Being introduced in this ftate into an affay-crucible (*Tute*), lined with powdered charcoal, and covered with common falt, it was kept in a ftate of ftrong fufion for half an hour: by which treatment it yielded a metallic button of a grey colour, 10 grains in weight, but very brittle; fo much fo, that by a gentle ftroke with the hammer it flew in pieces. The remainder of the reduced metal lay difperfed in fmall grains among the pulverulent fcoriæ, mingled with the charcoal-duft, that was employed to line the veffel.

C

a) *Two drachms* of finely triturated tin-pyrites were treated with an aqua regia, compofed of one ounce of muriatic and ½ ounce of nitric acid. Within 24 hours the greateft part of the metallic portion was diffolved in it, without application of heat; while the fulphur rofe up, and floated on the furface of the menftruum. After the mixture had been digefted upon it for fome time in a low fand-heat, I diluted it with water, and filtered it. It left 43 grains of fulphur on the paper, ftill, however, mixed with metallic particles. When the fulphur had been gently burnt off on a teft, there ftill remained 13 grains; of which eight were diffolved by nitro-muriatic acid. The remaining part was then ignited with a little wax; upon which the magnet attracted one grain of it.—What remained was part of the filiceous matrix, and weighed three grains.

b) The folution of the metallic portion (*a*) was combined with carbonat of pot-afh; and the dirty-green precipitate, thus obtained, was re-diſſolved in muriatic acid, diluted with three parts of water. Into this fluid a cylinder of pure metallic tin, weighing 217 grains, was immerſed. The reſult was, that the portion of copper contained in the ſolution, depoſited itſelf on the cylinder of tin; at the ſame time that the fluid began to loſe its green colour, from the bottom upwards; until, after the complete precipitation of the copper in the reguline ſtate, it became quite colourleſs.

c) The copper thus obtained weighed 44 grains. By briſk digeſtion in nitric acid, it diſſolved, forming a blue tincture, and left one grain of tin behind, in the character of a white oxyd. Thus the portion of pure copper conſiſted of 43 grains.

d) The cylinder of tin, employed to precipitate the copper, now weighed 128 grains; ſo that 89 grains of it had entered into the muriatic ſolution. From this, by means of a cylinder of zinc, I re-produced the whole of its diſſolved tin, which was looſely depoſited on the zinc in a tender dendritical form. Upon being aſſured, that all the tin had been precipitated, I collected it carefully, lixiviated it cleanly, and ſuffered it to dry. It weighed 130 grains. I made it to melt into grains, having it previouſly mixed with tallow, and under a cover of charcoal duſt, in a ſmall crucible; which done, I ſeparated the powder of the coal by elutriation. Among the waſhed grains of tin, I obſerved ſome black particles of iron, which were attracted by the magnet, and weighed one grain. Deducting this, there remain 129 grains for the weight of the tin. By ſubtracting again from theſe laſt thoſe 89 grains, which proceeded from the cylinder of tin employed for the precipitation of the copper (*b*), there remained 40 grains for the portion of tin contained in the tin-pyrites examined. Hence, including that one grain of

 tin,

tin, which had been feparated from the folution of the copper (*c*), the portion of pure tin contained in this ore amounts to 41 grains.

The *educts*, or fubftances, extracted in this procefs from tin pyrites, were confequently :

Sulphur	30 grains.
Tin	41
Copper	43
Iron	2
Vein-ftone, or *gangue* .	3
	119

Which makes in an *hundred* parts :

Sulphur	25
Tin	34
Copper	36
Iron	2
	97

However, this proportion of the conftituent parts is not always conftant. The darker varieties of tin-pyrites, in particular, are confiderably poorer in tin ; as, from one of them I fcarcely obtained one half of the above quantity of reguline tin : but their proportion of iron increafes.

D.

Although, in the courfe of thefe experiments, no trace of any filver, or lead, which had been fufpected to exift as an ingredient in this foffil, had appeared ; yet, for the fake of greater certainty, I inftituted the following trial. The tin-pyrites, that had been ignited in the retort (A) was treated with nitric acid ; which attacked it, emitting copious red vapours. After fufficient digeftion, I diluted the mixture with water, and feparated the remaining fulphur and oxyd of tin by means of the filter; combining, afterwards, the clear, blue folution, both with muriatic and fulphuric acids. But, by its continuing clear and unchanged, it fhewed that neither filver nor lead are prefent in this ore.

E.

The ready folubility of tin, contained in this ore, in the nitro-muriatic, as well as in the muriatic acid, which does not take place in tin-ftones, and all other oxyds of tin fully faturated with oxygen, is a fufficient proof that, in this ore, the tin held in folution by the fulphur, in a manner, approaches the ftate of native, or reguline tin. This is farther corroborated by the following experiment.

1. *a*) I expofed *half an ounce* of tin-pyrites, mixed with the fame quantity of corrofive fublimate, to a fand-heat, in a fmall retort, connected with a receiver. At the very firft moderate action of the fire, a heavy fluid paffed over, attended with heavy white vapours; and, on the increafe of heat, a grey-yellow fublimate, for the moft part cryftallized in needles, fettled on the neck of the retort; at the fame time that on its upper convexity an impure black-grey cinnabar, or fulphuret of mercury, depofited.

b) The ftrongly-fuming fluid in the receiver, which gave out thick white fumes, weighed one drachm, and perfectly refembled common *fuming liquor of Libavius*, or fublimed folution of muriat of tin. From this, by dilution with water, and faturation with pot-afh, the oxyded tin was thrown down, as a white, very tumid precipitate, which, edulcorated and dried, weighed 30 grains.

c) The

c) The fublimate, feparated from the neck of the retort, was pulverized, digefted with water, and filtered. The refidue which it left on the paper amounted to 203 grains, when deficcated. Thefe were diffolved in nitro-muriatic acid, with the exception of 15 grains of fulphur; and the mercury fell down, in the reguline ftate, from the folution, by putting copper into it. The aqueous folution of the fublimate, obtained by the digeftion, and precipitated by carbonat of pot-afh, afforded 16 grains of oxyded tin; which were added to the preceding (*b*).

d) The oxyd of tin was then diffolved in muriatic acid, and again precipitated, in the metallic ftate, by a piece of zinc, plunged into the folution. This reguline tin, when collected, wafhed, and melted with tallow, weighed 20 grains. I flattened it by beating with the hammer; cut it into pieces; digefted it with nitric acid; and dropped Pruffian alkali into the fluid, filtered off from the oxyd of tin. The few brown flocculi precipitated by that alkali, proved that the muriated tin had carried along with it a flight portion of copper.

2.) By way of a comparative experiment, I repeated this procefs with a fpecies of pure *tin-ftone*; but, in this cafe, not the leaft trace appeared of any folution of the tin. The mercurial fublimate volatilized in its ufual needled form, and the tin-ftone remained in the retort unaltered.

LXIII.

CHEMICAL EXAMINATION

OF THE

MOLYBDAT OF LEAD,

(*Yellow Lead-ore*),

From BLEIBERG.

*FIRST SECTION**.

1.) THE *yellow lead-ore*, or *Molybdat of Lead*, from *Bleiberg*, near *Villach*, in *Carinthia*, conſtitutes, in the genus of lead, a particular, very diſtinguiſhed ſpecies of ore, occurring in many beautiful varieties. Its colour is waxy-yellow, of various ſhades; ſome inclining to the reddiſh, others to the whitiſh-grey. For the moſt part it is cryſtallized in tables, of from four to eight ſides, which ſometimes ſtand ſingly on their edges, or narrow ſides, and, at times, are cellularly concreted. Thoſe ſpecimens of it are rather ſcarce in which the cryſtals form a cube, or an octahedron, inſtead of a table.

The matrix, in which this ore is imbedded, is a compact lime-ſtone, of a yellow, whitiſh, or grey colour.

2.) Moſt mineralogiſts ſeem to have become acquainted with this lead-ore, only ſince the time that *Jacquin* † publiſhed his treatiſe on it; after whom *Wulfen* ‡ has contri-

* *Beob. u. Entdeck. a. d. Naturkunde.* vol IV. 1792, page 95; and vol. V. 1794, page 105.

† *Miſcellanea Auſtriaca.* vol. II. Vienna, 1787.

‡ *Xav. Wulfen. Abhandlung vom Kärnthner Bleiſpathe.* Wien, 1785.

buted

buted to the knowledge of this ore, by the elegant and accurate defcription which he has given of it. As to the conftituent parts of the yellow lead-ore, the following experiments will fhew that the fubftance with which the lead is combined in this mineral is not the oxyd of tungften, as has been erroneoufly fuppofed, but the *oxyd of molybdena*.

3.) The firft point which I had in view, was to feparate this lead-ore carefully from the adhering extraneous parts. Finding that diluted nitric acid fhewed in the cold no action on this foffil, I affufed upon the quantity of it deftined for this analyfis fmall portions of this acid; pouring it off again as foon as the effervefcence ceafed. This procefs I repeated, till, at laft, no more effervefcence enfued on adding a frefh portion of the acid. Upon this the ore was wafhed with water, and deficcated. The nitric acid employed for this purification contained the calcareous earth proceeding from the matrix, which outwardly adhered to the ore, and formed gypfum with fulphuric acid, by means of which I precipitated it. At the fame time, a confiderable portion of a fine, red iron-ochre was wafhed off by this procefs, which diffolved by digeftion in muriatic acid, leaving a flight refidue, confifting of lead-ore and filiceous earth.

4.) *Two drachms* of the above-mentioned cryftals of lead-ore, thus purified, were mixed with an equal quantity of carbonated pot-afh, and expofed to the fire in a fmall crucible. It entered into fufion without effervefcence. The refrigerated mafs exhibited a faint reddifh tinge, and was covered on its upper part with fcales, refembling litharge. Having foftened this alkaline mafs with water, and filtered, I faturated the colourlefs folution with nitric acid. By this the mixture was not rendered very turbid; but, on the next day, I found the bottom of the glafs covered with tals of ¼ of an inch long, ſtanding upright; which I examined as follows:

a) Their figure conſiſts of ſmall, brilliant, accumulated rhomboidal tables.

b) On the tongue they manifeſt a weak metallic taſte.

c) Under the blow-pipe, upon charcoal, they fuſe very quickly and calmly into little globules, or drops, which are inſtantly imbibed by the ignited coal.

d) In the ſilver ſpoon they melt into grey ſpherules, which become ſhrivelled as they cool; and, during the current of air, urged through the blow-pipe, they depoſit a white ſubſtance, which covers the ſpoon.

e) When put upon a globule of alkaline phoſphat, fuſed on the charcoal, they are rapidly diſſolved, and tinge it either of a graſs, or olive-green, according to the quantity in which they are added.

f) They entirely diſſolve in water, by the aſſiſtance of heat.

g) Pruſſian alkali produces from this ſolution a copious, flocculent precipitate, of a *light-brown* colour.

h) If, into the aqueous ſolution (*f*) a little muriatic acid be dropped, and a ſmall piece of tin be put into it; or, if ſome of thoſe cryſtals are immerſed in a muriatic ſolution of tin; in both theſe caſes the fluid acquires a *deep-blue* colour.

In conſequence of theſe appearances, I think I do not err in conſidering theſe cryſtals as *molybdic acid*, neutralized by pot-afh; becaufe, in a comparative experiment, the fame relations were fhewn by molybdic acid, that had been prepared from molybdena of *Altenberg*, by detonation with nitre, and fubfequent precipitation, effected by nitric acid, from the filtered folution of the mafs produced by the detonation, and which acid likewife affumed a cryftalline form in drying.

5.) As it was obvious, from the ftate of the calciform lead, which remained on the paper when I filtered the folution of the fufed mafs (4), that the whole of the yellow lead-ore employed had not been decompofed, I repeated the experiment, increafing, however, the proportion of the alkali; fo that, for two drachms of the ore, I took 10 drachms of carbonated pot-afh. I alfo kept the mafs for a fomewhat longer time in fufion; after which it was poured out, levigated, foftened with water, and thrown upon the filter. This alkaline folution I faturated with muriatic acid, at firft only incompletely; whereby, at a warm temperature, a white precipitate was produced, in the form of a cheefy coagulum. This precipitate contained, indeed, molybdic oxyd, but mixed with a greater portion of oxyded lead; which laft, upon folution in muriatic acid, feparated in needle-fhaped cryftals of muriat of lead.

When this precipitate had been feparated from the alkaline folution, which before was faturated with only half the quantity of muriatic acid required, I combined that fluid with an additional portion of the fame acid to its complete faturation. It became again turbid, but only moderately fo. Upon this, a white precipitate accumulated, like ftarch, fubfiding in cold water; which, carefully edulcorated and dried, was examined in the fame manner as the cryftalline precipitate mentioned before, (4). Its habitudes were perfectly the fame; except that it would not diffolve alone in water, but formed a clear ſolution, only when a few drops of muriatic acid had been added.

The fluid was now concentrated by evaporation; after which the oxyd of molybdena, ſtill contained in it, fell down as a fine, *heavy*, *yellow powder*; which, after proper lixiviation and drying, exhibited a beautiful, ſaturated lemon-colour.

6.) The white oxyd of lead, which remained upon the paper on filtering the ſoftened maſs, produced by the fuſion of the ore with pot-aſh (4), was found contaminated with a portion of ſiliceous earth. When treated upon charcoal, it did not entirely melt into a metallic button; but part of it was converted into a clear, bright, yellow globule of glaſs of lead (vitreous oxyd): for the admixed ſiliceous earth prevented the reduction of the whole portion of lead; in the ſame manner, as is the caſe when it is attempted to reduce upon charcoal a glaſs of lead, that has been made of three parts of oxyded lead and one of ſilex. For this reaſon, I diſſolved the above-mentioned oxyd of lead in dilute nitric acid, ſeparated the ſiliceous earth by filtration, and precipitated the metal from the ſolution, by means of ſulphuric acid, in the character of ſulphated lead.

7.) I likewiſe examined the actions of ſome of the acids upon this *Carinthian lead-ore*.—One drachm of it was digeſted with a copious quantity of nitric acid; which diſſolved the greateſt part, but not the whole of it. In the ſolution were obſerved white, looſe flocculi diſperſed, which dried upon the filtering paper in the form of a membrane, and became tarniſhed of a blue by expoſure to daylight. This ſubſtance had much reſemblance to the molybdic oxyd, obtained from molybdena in the humid way, by repeatedly diſtilling nitric acid from it. The filtered nitric ſolufolution contained, befides the portion of lead, a confiderable quantity of molybdic oxyd. Sulphuric acid precipitated the lead from it; and Pruffian alkali afterwards threw down the molybdena in loofe, brown, red particles.

8.) *One drachm* of this yellow-lead ore, previoufly purified, afforded a clear folution, by digeftion with muriatic acid. The folution went on gradually, and was nearly complete and colourlefs; but it foon depofited white cryftals of muriated lead. Only a flight portion of filex was left behind, which I feparated. While I was concentrating the fluid, the faline cruft fettling on the fides of the evaporating difh became tarnifhed of a fine blue; which as often difappeared as the cruft was re-diffolved in the fluid, on gentle agitation. When the concentrated fluid had been decanted from the muriat of lead, which ftill fubfided, it affumed a beautiful deep-blue, but loft that colour again by dilution with water. When afterwards faturated with potafh, it dropped a white oxyd of molybdena.

9.) *Oxyd of lead*, and *oxyd of molybdena*, therefore, are the conftituent parts of the *yellow lead-ore* from *Bleiberg*, in *Carinthia*. This combination is remarkable, as it is the firft inftance of the kind; fince molybdena has not yet occurred any where, except in its proper ore (*Wafferbley*). From the foregoing experiments there alfo refult fome other obfervations, by which the knowledge of the chemical properties of that metallic fubftance (*molybdena*) is greatly enlarged. To thefe belongs its external form, as it occurs partly in the cryftalline ftate, partly as a white, and partly as a lemon yellow oxyd. In the *firft* ftate, it is foluble in fimple water, as well as in acids; in the *fecond*, a fmall addition of muriatic acid promotes its folution in water; but in the third, or that of a yellow oxyd, it refufes to diffolve both in water and in acids. The caufe of this difference confifts in this, that in the two firft cafes it has been neutralized with the portion of alkali that remained combined with it; whereas, in the laft cafe, that is, in the form of a yellow earth, it is more in the ftate of a mere metallic oxyd.

10.) This appearance of the molybdic oxyd with a yellow colour, has probably been the reafon for confidering the fubftance, by which this yellow lead-ore is mineralized, as tungftic acid.

However, the blow-pipe alone is fufficient to diftinguifh thefe two metallic fubftances from each other; for, the yellow *molybdic oxyd* lofes its colour at the firft contact with the point of the flame, and is rendered *olive-green*; it alfo immediately runs into a fmall globule, or drop, which is very foon abforbed by the charcoal; and, laftly, when fufed with a neutral phofphat, it tinges the button which thence arifes of a *green* colour.

The *yellow oxyd of tungften*, on the contrary, exchanges, by ignition, its yellow colour for a *blue* or *black*, at the fame time that it remains upon the charcoal as perfectly infufible; and when fluxed with phofphoric falt, it gives a *fky-blue* colour to the faline globule.

SECOND SECTION.

Having thus obtained, by means of the experiments here explained, the knowledge of the *conftituent* parts of the *yellow lead-ore* from *Carinthia*, I had yet to difcover their *proportions* to each other. This I accomplifhed in the following way.

a) *A hundred* grains of the cryftals above defcribed were carefully freed, in the manner before mentioned, from the ad-

adhering calcareous earth and ochre of iron, and then finely pulverized. They were then diſſolved in muriatic acid, aſſiſted by heat, alternately affuſing upon them the acid, and a large quantity of water. In this inſtance a trace of ſiliceous earth, though ſcarcely diſcernible, appeared.

b) The greateſt part of muriat of lead, generated in the proceſs, was depoſited in fine needles, even before the ſolution had completely grown cold. The ſuper-natant clear fluid was then poured off, reduced to a ſmaller volume by evaporation, and freed from the muriated lead, which ſtill ſeparated. The muriated metal, collected with care, and briſkly deſiccated, weighed 74½ grains. By diſſolving it in hot water, and ſteeping into the ſolution a poliſhed piece of iron, the lead precipitated upon this laſt in fine lamellæ, and in the metallic ſtate.

c) But in order to find more accurately what proportion this muriated lead might bear to pure oxyd of lead, I made the following experiment.

Two hundred grains of lead, cut into ſhreds, were diſſolved in 300 grains of nitric acid, diluted with 10 ounces of water, and, with the aſſiſtance of digeſtion, in a boiling heat. The ſolution was then divided into two parts.

> *α*) Into one half I dropped muriatic acid, as long as it produced any turbidneſs; evaporating afterwards the mixture to the moſt perfect dryneſs of the reſidue. The muriat of lead here produced weighed 133 grains.
>
> *β*) From the ſecond half of the nitric ſolution I precipitated the oxyd of lead by diſſolved cauſtic pot-aſh. This oxyd, when edulcorated and briſkly dried till it began to turn yellowiſh, amounted to 115 grains.

From this it followed that thofe $74\frac{1}{2}$ grains of muriated lead, obtained from 100 grains of the yellow molybdat of lead (*b*), are equal to 64,42 grains of pure *oxyd of lead.*

d) The concentrated muriatic folution of molybdena, which had a blue colour, was mixed with nitric acid, and lodged in a fand-bath for farther evaporation. Being thus circumftanced, it was again divefted of its blue colour, and a yellow oxyd of molybdena feparated. But when the evaporation had been carried on to complete drynefs, I collected and weighed the remaining lemon-yellow *oxyd of molybdena*; and found it amount to $34\frac{1}{4}$ grains.

Wherefore, *one hundred* parts of the pureft cryftals of the *yellow lead-ore*, from *Carinthia*, contain:

Oxyd of lead	64,42
Oxyd of molybdena . . .	34,25
	98,67

LXIV.

LXIV.

CHEMICAL EXAMINATION

OF THE

SULPHURET OF COPPER,

(Vitreous Copper-ore. Kupferglanzerz)

From SIBERIA.

AMONG the copper-ores, the firſt place belongs to the *grey*, or *vitreous Copper-ore*, it being the richeſt in copper, and containing, beſides its mineralizer, which is ſulphur, the feweſt foreign admixtures. Its purer varieties poſſeſs a degree of ſoftneſs, ſo that they admit of being in ſome manner cut with the knife; and on the recent cut they reſemble metallic lead in colour and luſtre.

This ore uſually occurs in compact maſſes; it is ſeldom cryſtallized. Of this latter ſort I poſſeſs ſome from *Poldice* and *Dolcoath*, in *Cornwall*, in *druſes* (groups of regular cryſtals) of minute white-grey, reſplendent, tetrahedral, truncated pyramids.

For the ſubject of my enquiry, I took the maſſive, compact, moderately-ſoft vitreous copper-ore, from the mine *Gumeschefskoi*, on the river *Turja*, in the diſtrict of *Catharineburg*; where it is found in conſiderable large maſſes, which, in the *partings*, are inveſted with azure copper-ore, and fibrous malachites. It was freed from theſe previouſly to its being ſubjected to the following experiments.

A.

A.

a) Upon *two hundred* grains of the ore, coarfely powdered, moderately ftrong nitric acid was affufed, which attacked and diffolved them with frothing and extrication of red vapours. The folution was clear, and the fulphur alone in the ore was left behind, floating in the fluid, in grey, loofe, flocculi, without any other refidue; which indicated that no antimony was prefent. The fulphur collected on the filter was heated in a fmall crucible to inflammation, and it burned with its peculiar odour, without any trace of arfenic; yet leaving a flight portion of oxyded iron and filiceous earth.

b) The folution, which had a pure blue colour, was treated firft with muriat, and then with fulphat of foda. But none of thefe, nor any other falt, rendered it turbid, or produced any other alteration; by which it appears, that this ore contains neither *filver* nor *lead*.

B.

a) To determine, with proper accuracy, the proportion of the conftituent parts, I repeated the examination in the following manner. *Two hundred* grains of the powdered ore were combined and heated with muriatic acid, to the degree of boiling. But as this acid alone manifefted no action on it, I added nitric acid gradually, by drops; which exerted a ftrong attack in each inftance. When the folution of the ore had been accomplifhed, I feparated the fluid from the fulphur floating on the furface; and digefted this laft once more with a frefh quantity of muriatic acid, dropping into it fome nitric acid; after which I collected it upon the filter. This fulphur, wafhed and deficcated, weighed $38\frac{1}{2}$ grains, out of which, after its combuftion, $1\frac{1}{2}$ grain

grain of *ſiliceous earth* remained; ſo that the true amount of *ſulphur* was 37 grains.

b) The ſolution exhibited a glaſs-green colour. I divided it into two parts. Into one half poliſhed iron was immerſed; upon which the *copper* precipitated of a dendritical form, and pure metallic brilliance. It weighed 78½ grains, when waſhed, and immediately deſiccated in a moderate temperature.

c) In order to aſcertain the proportion of iron contained in the ore, I combined the other half of the ſolution with cauſtic ammoniac added to exceſs of ſaturation. The precipitated iron remained behind, in the form of a ſubtle brown mud, which, collected on the filter, deſiccated and ignited, weighed three grains. But as the iron is contained in the mixture of the ore, not in this calciform ſtate, but in the reguline, which laſt is to the firſt in the proportion of 3 to 4, theſe 3 grains of oxyded iron give 2¼ of *metallic iron* to be added in the computation.

Therefore, *hundred* parts of the *Siberian vitreous copper-ore* conſiſt of:

Copper	B *b*) . . .	78,50
Iron	*c*) . . .	2,25
Sulphur	*a*) . . .	18,50
Silex	*a*) . . .	0,75
		100

C.

Copper-ores eminently belong to thoſe kinds, the component principles of which are but imperfectly determined by analyſis *in the dry way*. The reaſon of this is, partly, that

that the alkaline ſalts employed for the reduction, exert, during fuſion, as well as in the humid way, a very ſtrong ſolvent power on copper.

But although the reducing flux, compoſed of glaſs, borax, and charcoal-duſt, recommended by *Gellert*, *Tillet*, and others, inſtead of alkalis, is reckoned one of the beſt; yet I have always found the common *black-flux*, if employed in the following manner, the moſt effectual.

Two *docimaſtic centners* (each of 100 parts, conſidered for as many pounds), of the triturated ore were mixed with half a centner (or 50 parts), of charcoal-duſt, and properly roaſted until all the coal was conſumed *. I then blended it with $\frac{1}{2}$ centner of colophony and 6 centners of the black flux, covering the maſs in the aſſay-crucible with common ſalt, and expoſing it to a forge heat. After the coals were completely red, the blowing of the bellows was kept up for 20 minutes. The fuſion being accompliſhed, I found, under a well-fluxed ſcoria, 138 parts of a fine *red*, or *refined copper*; which is 69 *per cent*.

However regularly this aſſay in the *dry way* was performed, yet it produced $9\frac{1}{2}$ *per cent*. leſs than the true proportion of the copper in the ore amounts to. The *humid way*, therefore, is, in every reſpect, the moſt certain to diſcover the true quantity of copper in any ore.

* The roaſted-ore weighed 210 pounds.

LXV.

LXV.

CHEMICAL EXAMINATION

OF THE

VARIEGATED COPPER-ORE.

(Bunt-kupfererz. Purple Copper-Ore, by Kirwan.)

THE *variegated Copper-ore* is diftinguifhed in its external appearance from the *vitreous*, to which it is the neareft a-kin, by its variegated colours, refembling thofe of tarnifhed fteel; and, with regard to its conftituent parts, it differs from it in containing lefs copper, but, on the contrary, more iron.

FIRST SECTION.

Variegated Copper-Ore from Hitterdahl.

THE variegated copper-ore occurring at *Hitterdahl*, in *Norway*, in lumpy maffes, exhibits, on its recent fracture, a mixture of colours of light-blue, tin-white, and copper-red; which, however, by expofure to air, gradually change into a more uniform fteel-blue.

A.

One hundred grains of the pulverized ore were fubjected to gentle digeftion with nitric acid, whofe action upon it was but moderate. From the refidue, the fulphur was driven out by combuftion. This refidue, when a fecond time digefted with nitric acid, diffolved in it, leaving only a flight portion of a red oxyd of iron. On examining the

 folution,

folution, firft by common falt, and then by Glauber-falt, it continued limpid and unchanged.

B.

a) Upon *two hundred* grains of the powdered ore muriatic acid was affufed, the mixture heated, and then combined in fmall portions with nitric acid. The folution, which was thus performed, had a brown colour while concentrated; but as foon as it was diluted with water, it acquired a green. The remaining fulphur was grey, tenacious, and fpongy, and weighed 72 grains when dry. By flow combuftion it left 35 grains, of which, after extraction by muriatic acid, five grains ftill remained behind. Thefe loft one grain more of fulphur by burning, and the remaining four grains diffolved entirely in muriatic acid. Whence the quantity of *fulphur* amounted to 38 grains.

b) The muriatic folution was divided into *two* equal parts; and the *copper* was precipitated from one of them by means of iron. It amounted to 69½ grains.

c) The other half was fuper-faturated with cauftic ammoniac, and the oxyd of iron which fell down was collected. This, when moiftened with linfeed-oil, and expofed to a low red-heat, weighed 10 grains; which are equal to 7½ grains of *metallic*, or reguline *iron*.

Thus, in *one hundred* parts of this *variegated copper-ore* from *Norway* were found:

Copper	B. *b*)	69,50
Sulphur	*a*)	19
Iron	*c*)	7,50
Oxygen		4
		100

By

In ſupplying the deficiency in the ſum of weights of the copper, iron, and ſulphur, from the hundred, by putting *oxygen* in the account, I mean to characterize this laſt as a conſtant conſtituent part of the variegated copper-ore, producing in it thoſe variegated colours: in the ſame manner, as in ſteel, in copper-pyrites, and other metallic ſubſtances, the beginning of their oxydation is indicated by a ſimilar diverſity of colours.

In the laſt mentioned ſubſtances, however, the changeable colours are only owing to external cauſes; for which reaſon, they preſent themſelves only on the ſurface, when long expoſed to air. On the contrary, the variegated copper-ore is penetrated throughout its whole maſs by the oxydating principle. This correſponds with the deficiency of weight to make up the ſum of the fixed conſtituent parts of the ore here analyſed; whereas no ſuch loſs is obſervable in the vitreous copper-ore, treated and decompoſed by the ſame method. It is on this account alſo, that the action of the nitric acid is leſs ſtrong, and the diſengagement of nitrous gas is leſs copious, in the variegated than in the vitreous copper-ore.

SECOND SECTION.

Variegated Copper-Ore from Rudelſtadt.

THE native place of this variety of variegated copper-ore is the mine *Friederike Juliane*, at *Rudelſtadt*, in *Sileſia*, in which a rich vein has lately been opened, of beautiful native ſilver, imbedded in ponderous ſpar, and accompanied by pyramidal red ſilver-ore, along with cryſtallized white cobalt-ore (*Glanzkobalt*), that has raiſed the ardent wiſhes of the proprietors for its continuance.

A.

Two hundred grains of the powdered ore, having been twice extracted by means of nitric acid, left behind their fulphureous ingredient, together with a quantity of red oxyd of iron. The folution was filtered, and tried by proper reagents for filver, lead, zinc, arfenic, and the like, and it afforded no indication of thefe, but only of copper and iron.

B.

a) *Two hundred* grains of this ore, in pure pieces, freed from interfperfed quarz, were triturated, and treated with muriatic acid, to which a little nitric acid was afterwards added, and the extraction continued in a moderate warmth. The colour of the filtered folution was a celadon, or blueifh green, with a fhade of grey. The refidue, porous like fponge, weighed at firft 88 grains; but only 56 grains, after its fulphur had been gently burned off. Thefe, digefted in a low heat with muriatic acid, foon diffolved, forming a brown fluid, and left fix grains more of fulphur behind. Hence, the *fulphur* contained in thofe 200 grains amounted to 38 grains.

b) Thefe folutions were mixed together, and divided into *two equal parts*. From one half I precipitated the *copper* in due manner by means of a polifhed piece of iron, and obtained 58 grains.

c) The other half was treated with cauftic ammoniac, until the oxyd of copper, precipitated in the beginning, again diffolved. The oxyd of iron, thus obtained, when collected on the filter, wafhed and deficcated, was moiftened with linfeed-oil, and ignited in a covered crucible. It weighed 24 grains. Hence, as, upon an average, four parts of oxyded iron, attractible by the magnet, are to be eſtimated as equal to three parts of reguline iron, I reckon 18 grains of *metallic iron*, inſtead of theſe 24 grains.

Since, for the ſame reaſon as in the foregoing analyſis, the loſs of weight in the ſum of the fixed conſtituent parts muſt be taken for the *oxygen* combined with the ore, and which eſcaped in the proceſs; the conſtituent parts of the *Sileſian variegated copper-ore*, and their proportions in the *hundred*, will be:

Copper . . .	B. *b*) . . .	58
Iron	*c*) . . .	18
Sulphur . . .	*a*) . . .	19
Oxygen	. . . . .	5
		100

C.

With a view of making an *aſſay in the dry way*, I roaſted two docimaſtic centners with half a centner of powdered charcoal. The roaſted ore, now weighing 206 lb. was then mixed with half a centner of colophony, and ſix centners of black flux. In this ſtate it was put in a crucible, and covered with muriat of ſoda. When kept in fuſion during 20 minutes before the nozzle of the bellows, it yielded a fine button, weighing 96 lbs. of red, or refined copper; which is 48 *per cent.* and hence, 10 lbs. ſhort of what was obtained in the *humid way*, (B. *b*).

LXVI.

CHEMICAL EXAMINATION

OF THE

SIBERIAN MALACHITES.

a) *ONE thoufand* grains of compact, reniform *Malachites*, from the *Turjin* mines, on the *Ural*, were reduced to powder, and heated to complete rednefs in a fmall glafs retort, connected with the pneumatic apparatus. Much carbonic acid gas was difengaged in this procefs, to the amount of 252 cubic inches, without reckoning that part which was abforbed by the water of the apparatus. This gas was entirely abforbed by lime water, at the fame time that a proportionate quantity of carbonated or crude calcareous earth was produced In the intermediate fmall receiver a moifture collected, weighing 78 grains, which, upon trial, proved to be pure water.

b) The pulverulent refidue taken out of the retort appeared of a black colour, and weighed 716 grains. To ferve for the following experiments, it was divided into four parts, at 179 grains each; and hence correfponding to 250 grains of the rough malachites.

1.) *One hundred and feventy-nine* grains of *ignited malachites*, combined with three times its quantity of black flux, were put into an affay-crucible, without lining it, and covered with *muriated foda*. In this fituation it was committed to the fire of the blaft-furnace, and when the coals had become red-hot without the action of the bellows, it was kept melting for

for the ſpace of twenty minutes. After cooling, it was obſerved that, in the broken retort, the whole mixture, under the covering of common ſalt, had run into an uniform, compact, and opake maſs, of the bright red-colour of ordinary ſealing-wax, and that no metallic button had been formed.

It follows from this, that there was not carbon enough preſent to take up entirely the oxygen of the metallic oxyd. Therefore the copper has, by means of this ſmall remainder of oxygen ſtill united with it, been brought into the ſtate of red oxyd of copper; and, as ſuch, it has diffuſed itſelf uniformly through the alkaline ſalt.

2.) *Hundred* and *ſeventy-nine grains* of *ignited malachites* were mingled with three times their quantity of *black-flux*, and 1-10th of *powdered charcoal.* When fuſed in this ſtate, during 20 minutes, under a ſtratum of *common ſalt*, in an aſſay-crucible not lined in the inſide, they afforded a button of reguline copper, which had run well together, and weighed 136½ grains.

3.) Another 179 grains of *ignited malachites*, mixed with *thrice* as many grains of *black-flux*, and one fifth part of their weight of *colophony*, and likewiſed fuſed for 20 minutes, under a cover of muriat of ſoda, in a crucible not ſecured by lining, yielded a well-melted button of reguline copper, weighing 138 grains.

4.) The remaining 179 grains of *ignited malachites* were, like the preceding, melted during the time of 20 minutes, under a cover of *common ſalt.* But the aſſay-crucible had previouſly been lined with powdered charcoal, and the malachites mingled with an equal weight of *calcined borax*, with half its quantity of *white glaſs*, and 1-4th part of *colo-*

 phony,

phony, or boiled turpentine By this procefs I obtained, indeed, a well-fufed button of reguline copper; but with a confiderable lofs, as it weighed only 105½ grains.

B.

In order to difcover more accurately the conftituent parts of malachites, I performed the following experiments.

a) 100 grains of malachites, reduced to powder by trituration, were diffolved in nitric acid; which was effected without leaving any refidue. The folution had a bright-blue-colour, and was faturated to excefs with cauftic ammoniac: but the precipitate produced was entirely, and without turbidnefs, re-diffolved by the excefs of the alkali. This fhewed that the malachites here examined was perfectly free from iron, and fimilar admixtures.

b) I combined *hundred* grains of triturated malachites with a fufficient quantity of fulphuric acid, previoufly diluted with five parts of water, and accurately weighed together with the veffel. After the malachites had been wholly diffolved, which was effected gradually, and with a moderately ftrong effervefcence, the lofs of weight, occafioned by the *carbonic acid gas* that was extricated, was found to confift of 18 grains.

c) *One hundred* grains of the fame powdered malachites were ignited, at a moderate heat, in a covered crucible. The black refidue had loft 29½ grains in weight. If from thefe be fubtracted 18 grains for the carbonic acid, the remaining 11½ grains of lofs will confift of *water*.

Another

d) And laſtly, 100 grains, which had been diſſolved in dilute ſulphuric acid, and precipitated by zinc, yielded 58 grains of pure *copper*.

In conſequence of theſe experiments, the *Siberian malachites* conſiſts, in the *hundred*, of:

Copper	58
Carbonic acid	18
Oxygen	12,50
Water	11,50
	100

LXVII.

LXVII.

CHEMICAL EXAMINATION

OF THE

BISMUTHIC SILVER-ORE,

From *Schapbach*, in the *Black-foreſt*,

In Suabia.

THE *Biſmuthic Silver-ore*, which occurs in the mine *Friederich-Chriſtians*, in the valley *Schapbach*, in the *Black-foreſt*, *(Schwarzwald)*, and for the firſt acquaintance with which we are indebted to Mr. *Selb**, Maſter of the mines at *Wolfach*, has been deſcribed, as to its external characters, by *Widenmann*† and *Emmerling*‡. This mineral deſerved a complete chemical inquiry ſo much the more, as even now ſeveral *Mineralogiſts* ſtill ſeem to doubt of the exiſtence of this peculiar ſpecies of ores.—For this reaſon, I publiſh here its analyſis, which to perform I was enabled by Mr. *Selb*, ſending me of this mineral the quantity neceſſary for the purpoſe.

Since this ore is very much concreted with the *grey quarz*, ſerving to it as a matrix; and ſince in moſt ſpecimens it can be conſidered as only diſſeminated in the quarz, I have employed for its analyſis merely ſuch pieces as are the leaſt mixed with quarz, and, at the ſame time, the moſt free from copper-pyrites and galena, which accompany this ore.

* *Chemiſche Annalen*, 1793. I. Band. Seite. 10.

† *Handbuch der Mineralogie*, Leipzig, 1794, page 716.

‡ *Lehrbuch der Mineralogie*, II. Theil. *Gieſſen*, 1796. Seite 203.

A.

Examination in the dry way.

a) If bismuthic silver-ore, in small fragments, be ignited upon charcoal before the blow-pipe, there soon transude metallic drops of easy fusion; which *eliquate** more perfectly on the addition of borax. The glass of borax acquires by them a yellow colour, resembling that of amber *(Succinum)*, but mixed with white, and in some places also with a copper-red. The metallic button exhibits variegated colours, and continues long in fusion. It is brittle, and appears of a tin-white in the fracture.

b) When *three hundred grains* of this ore, previously triturated, had been exposed to a red-heat, in a small retort, lodged in sand, they afforded,—besides a slight quantity of aqueous moisture, no more than 2½ grains of sulphur; the pure yellow colour of which proved the total absence of arsenic. On the powder of the ore, which coalesced but moderately, some metallic drops were found incumbent. It was then roasted in an open test, until no trace of sulphureous smell could be observed. After this process, it had an ash-grey colour, appeared of a very loose texture, and weighed 313 grains.

On being combined with 1½ ounce of black flux, and reduced in an assaying-crucible, under a layer of culinary salt, it ran into a tin-white metallic button, which weighed 174 grains, would admit of being cut with a knife, and, though it had become malleable, yet was brittle, and fell asunder after some blows of the hammer.

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* On the process of *eliquation*, in general, see *Gren's Principles of Chemistry*, Lond. 1800. vol. II. page 301.—Transl.

This

This metallic bead, when refined by cupellation, under the muffle, afforded a button of *pure reguline ſilver*, weighing $33\frac{1}{2}$ grains.

B.

Examination in the humid way.

a) Upon *three hundred* grains of this ore I poured three ounces of nitric acid, diluted with one ounce of water. A great part of it diſſolved in this menſtruum, even in the cold. The reſidue was afreſh combined with one ounce of the ſame acid, weakened with half an ounce of water, and digeſted in a gentle heat. Both ſolutions, thus obtained, were filtered, mixed, and together evaporated to a ſmaller volume; during which proceſs there ſeparated from the fluid ſome cryſtalline grains, conſiſting of nitrat of lead.

b) The concentrated ſolution had a greeniſh colour.—When afterwards diluted with juſt as much of water as was requiſite to re-diſſolve that cryſtalline ſediment, it was poured into a large quantity of water. This laſt immediately acquired a milky appearance, in a high degree, and depoſited a white precipitate, which weighed $44\frac{1}{2}$ grains, when collected, lixiviated, and dried in the air, and proved, on farther examination, to be *oxyd of biſmuth.*

c) Into the liquor, that had been freed from this oxyd, and was entirely clear and colourleſs, I then dropped muriatic acid, as long as it was rendered turbid by it. The precipitate which then enſued, did not appear to be mere muriat of ſilver; for this reaſon, I digeſted it for ſome time with a moderately ſtrong nitric acid. A conſiderable portion of it was thus re-diſſolved, and left pure horn-ſilver behind; which, upon careful collection, and deſiccation in a briſk heat, weighed 46 grains. Thus, the portion of pure *ſilver* is determined at $34\frac{1}{2}$ grains.

d) The

d) The nitric acid, that had been affused upon the precipitate obtained by the muriatic (*c*), yielded, by dilution with much water, 32 grains more of oxyded bismuth; which, with the preceding 44½ (*b*), gave together 76½ grains.

In order to ascertain the proportion of reguline bismuth in this ore, I dissolved 100 grains of bismuth in nitric acid; and after having concentrated the solution by evaporation, I poured it into a large quantity of water. When of the precipitate, thus produced, nothing more would fall down, on adding more water, I collected it on the filter, washed it, and suffered it to dry perfectly in the air. It then weighed 88 grains. To the water, which had been separated from it, muriatic acid was added by drops; whereby a new precipitate ensued, weighing 35 grains, after edulcoration and drying.

As, by the result of this comparative experiment, *one hundred* grains of *reguline* bismuth have, upon the whole, given 123 grains of *oxyded* bismuth; it follows, that the 76½ grains of bismuthic oxyd, mentioned at (*d*), and obtained from 300 grains of the bismuthic silver ore, contain 62½ grains of *metallic*, or *reguline bismuth*.

e) The remainder of the fluid was farther reduced by evaporation; and, in this process, muriat of lead separated from it in delicate, broad-striated crystals. This liquor was then combined with such a quantity of sulphuric acid, as was requisite to re-dissolve those crystals, and a second time evaporated to a consistence of pap. The precipitate, which thence ensued, was sulphat of lead, weighing 19 grains, when duly collected, washed, and dried.

f) What still remained of the solution, after its having been freed from the lead before contained in it, was saturated

rated with cauftic ammoniac added in excefs. In this way a brown ferruginous precipitate was produced; which was rapidly attracted by the magnet, and weighed 14 grains, when, after previous deficcation, it had been moiftened with linfeed-oil, and well ignited.—For thefe we muft reckon 10 grains of metallic iron.

g) The liquor, which had been fuper-faturated with ammoniac, and which, by its blue colour, fhewed that it held copper in folution, was next faturated to excefs with fulphuric acid. On immerfing then a piece of polifhed iron into it, two grains of *copper* were depofited.

h) The grey refidue of the ore, that was left behind by the nitric acid (*a*), weighed 178 grains. But when its fulphureous part had been deflagrated, in a crucible gently heated, it weighed only 140½ grains. This determines the portion of *fulphur* at 37½ grains.

i) Thefe 140½ grains were digefted with *three ounces* of muriatic acid, in a heat of ebullition; and this procefs was repeated once more with 1½ ounce of the fame acid. Thefe folutions, by means of evaporation, yielded till the end muriat of lead in tender fpicular, and likewife in broad-ftriated cryftals; which, when again diffolved in the requifite quantity of boiling water, then combined with fulphuric acid, and evaporated, yielded 89 grains of fulphated lead. Thus the whole quantity of this fulphat, including the 19 grains mentioned at (*e*), amounted to 108 grains; for which, according to comparative experiments, 76 grains of *reguline lead* muft be put in the computation.

k) That portion of the ore examined, which ftill remained after all the conftituent parts before mentioned have been discovered, consisted merely of the *grey quarzose matrix*; the weight of which, in the ignited state, amounted to 70 grains.

Therefore, those *three hundred* grains of *bismuthic silver-ore*, mentioned above, were decomposed into:

Lead	*i*)	76
Bismuth	*d*)	62,20
Silver	*c*)	34,50
Iron	*f*)	10
Copper	*g*)	2
Sulphur	*h*)	37,50
Quarzose matrix	*k*)	70
		292,20 grains

It follows from this statement, that, exclusively of the *quarzose gangue*, the constituent parts of the *bismuthic silver-ore alone* consist, in the *hundred*, of:

Lead	33
Bismuth	27
Silver	15
Iron	4,30
Copper	0,90
Sulphur	16,30
	96,50

LXVIII.

LXVIII.

CHEMICAL EXAMINATION

OF THE

ANTIMONIATED SILVER,

from Wolfach, in Suabia.

ANOTHER fossil, which is found only in the mines worked in the principality of *Fürstenberg*, is the *Antimoniated Silver*. It occurs there in the pit, called *Wenzelsgrube*, near *Alt-Wolfach*; and its external characters have also been described by *Widenmann** and *Emmerling*†, in their elementary Introductions to Mineralogy.

It has already been proved by *Bergmann* ‡, but more circumstantially by *Selb* §, that this mineral is a compound of *native silver* and *reguline antimony*.

Selb employed in his experiments that variety of antimoniated silver, which, in former times, has occurred more frequently in coarse-granular detached pieces; and he found its proportion of silver to amount from 70 to 75 in the hundred. But the fine-granular variety, which is now dug, is considerably more rich in silver.

* *Handbuch der Mineralogie*, 1794, page 684.

† *Lehrbuch der Mineralogie*, II. Theil. page 162.

‡ Opusc. Phys. et Chem. vol. II. page 416.

§ *Magazin für die Bergbaukunde*, von *Lempe*, III. Theil. page 5.

FIRST SECTION.

Antimoniated Silver in fine Grains.

A.

Examination in the dry Way.

a) A SMALL piece of antimoniated ſilver, when tried upon charcoal, with the aſſiſtance of the blow-pipe, ſoon entered into fuſion. The antimonial part volatilized in its uſual vaporous ſtate, and left the button of ſilver entirely pure behind. Neither of ſulphur nor of arſenic any trace appeared.

b) Twenty-five grains, mixed with four times their weight of lead, and ſubjected to cupellation, yielded a button of pure ſilver, weighing 21 grains.

B.

Examination in the humid way.

a) Nitric acid was poured upon *hundred* grains of antimoniated ſilver, freed from calcareous ſpar adhering to it, and pulverized as much as its toughneſs would admit. The acid ſhewed no conſiderable action in the cold. Therefore I ſubjected the whole to a digeſting heat, in which I kept it, until nitric acid, added afreſh, would not farther attack this powder. Upon this I diluted the mixture with water, ſeparated the reſidue, and precipitated the ſilver from the colourleſs ſolution, by means of copper. The *ſilver*, thus obtained, amounted to 83½ grains, when lixiviated and dried in a warm temperature.

 b) The

b) The refidue exhibited a reddifh-white colour, after being wafhed and deficcated in the air, and weighed 25 grains. It foon diffolved in the muriatic acid, with which it was digefted; leaving behind it a fmall portion of muriated filver, which, upon reduction, by means of foda, in the fmall fpoon, ftill gave ½ grain of *filver*.

c) I poured the muriatic folution into a large quantity of water. By this management it was decompofed, and let fall a white, tender precipitate; which, dried in a gentle heat, weighed 20½ grains. This precipitate, upon trial, proved to be an oxyd of antimony, perfectly refembling *powder of algaroth* (oxyd of antimony by the muriatic acid). One part of it I re-diffolved in muriatic acid; and the folution, when poured into water previoufly impregnated with fulphuret of ammoniac, yielded golden fulphur of antimony, of a pure orange colour. The remaining part gave, by reduction with tartar, a metallic button; which, on being blown off with the bellows, entirely evaporated, without leaving any refidue.

Therefore, fince, by the refult of other comparative experiments*, 16 grains of reguline antimony may be reckoned for thofe 20½ grains of the metallic oxyd (*c*), the conftituent parts of the *fine-granular* variety of the *antimoniated filver* are in the following proportion:

Silver	84
Reguline *antimony* . . .	16
	100

* See page 130 of this work.

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SECOND SECTION.

Antimoniated Silver in coarſe Grains.

ONE *hundred* grains of the coarſe-granular variety of *antimoniated ſilver*, when decompoſed in the ſame manner as the preceding, yielded :

Silver	76
Reguline *antimony* . . .	24
	100

LXIX.

CHEMICAL EXAMINATION

OF THE

CRYSTALLIZED, BRIGHT, WHITE

COBALT-ORE,

(Glanzkobalt),

From TUNABERG, in *Sweden.*

THE cryſtals of the *Bright*, *White Cobalt-ore*, which occurs at *Tunaberg*, in *Südermannland*, together with the copper-pyrites (*yellow copper-ore*), are diſtinguiſhed by the ſtronger metallic luſtre of their external ſurfaces, which renders them leſs liable to decay, as well as by their ſize, of a rather uncommon magnitude *.

The colour of their ſurface and recent fracture is a tin-white paſſing into the grey; and the form of theſe cryſtals conſiſts, for the moſt part, in variations of the cube, with unequally truncated edges, and ſtriated lateral facets. The *ſtriæ*, or ſmall channels of each ſurface, are parallel to thoſe of the oppoſite one, but perpendicular to thoſe of the ad-

* One of theſe cryſtals, extremely beautiful and large, and detached from others, is in the poſſeſſion of M. *Mierotto*, Counſellor in the Eccleſiaſtical Department at Berlin; whoſe collection of minerals is ſo highly inſtructive with regard to the *Geognoſy* of the countries ſituated on the *Baltic ſea*. This cryſtal is 1½ inch long, of the ſame height, one inch broad, and weighs 4½ ounces.

joining

joining ſide. This remarkable direction of the *ſtriæ* has, till now, been found only in this cobaltic ore, and in ſome cubes of ſulphur-pyrites, ſtriated in the ſame manner. The fracture of theſe cryſtals is uneven, and exhibits a foliated texture.

I. *Experiments in the humid way.*

A.

One *hundred grains* of this cobalt-ore were digeſted with nitro-muriatic acid, in a boiling heat. The metal diſſolved but ſlowly, and in a ſmall quantity. As long as the ſolution was hot, it appeared of a dark emerald-green; but, upon cooling, it turned reddiſh-brown. No arſenic would depoſite from it. Hence, the above menſtruum did not ſeem likely to effect the decompoſition which I intended of the cobaltic ore.

B.

a) Hundred grains of rough white cobalt-ore, when gently digeſted with nitric acid, diſſolved in it gradually; however, leaving behind them 16½ grains of ſmall, white-grey, reſplendent globules, which conſiſted of arſenic, together with a little ſulphur. By boiling with water, this arſenical ingredient was diſſolved, and there remained 1½ grain behind; of which ½ grain of ſulphur deflagrated on a ſmall hot teſt. The remaining 1 grain was oxyd of cobalt.

b) The browniſh-red nitric ſolution was evaporated to a part, on a ſand bath. In this proceſs there ſtill ſeparated an oxyd of arſenic, in the form of a white cryſtalline incruſtation; which, collected after cooling, and by degrees lixiviated with a little water, weighed 30 grains after deſicca-

 tion.

tion. It again entirely diffolved in the water with which it was boiled.

c) Both the folutions of the arfenical oxyd in water fhewed exactly the fame appearances which are exhibited by any other aqueous folution of arfenic. By combination with lime-water, they yielded *arfeniat of lime*; with fulphuret of ammoniac they produced *yellow fulphuret of arfenic* (orpiment), and the *green pigment* of *Scheele* with ammoniacal oxyd of copper.

d) When the nitric folution of cobalt would no longer depofite any arfenic, I diluted it with water, and precipitated, by means of vegetable alkali, the oxyded cobalt; which, at firft, had a peach-flower colour, and, towards the end, that of lilac. On diffolving this laft, precipitated in muriatic acid, and diluting the folution with water, the liquor acquired a rofe-red colour, and afforded the well-known fympathetic ink prepared from cobalt.

Therefore, the conftituent parts of the *cryftallized, white cobalt-ore*, feparately produced in this analyfis, confift, in the *hundred*, befides the portion of cobalt itfelf, of 45 grains of arfenical oxyd, and ½ grain of fulphur: but of any portion of iron no trace appeared.

However, as I had reafon to fuppofe that the ingredient proportion of arfenic here ftated might, perhaps, not be the true one, I endeavoured to afcertain it more accurately in the dry way.

II. *Experiments in the dry Way.*

A.

a) *Four hundred* grains of white cobalt-ore, coarfely powdered, were heated to rednefs in a fmall glafs retort, con-

nected

nected with a receiver, and kept in the ſtate of ignition for ſome time. After cooling there appeared in the neck of the retort no more than *one* grain of ſublimed arſenic, together with a ſlight trace of ſulphur.

b) The contents of the retort were then introduced into a ſmall open matraſs, and once more ſtrongly ignited; but no ſublimation enſued.

c) Upon this, I mixed the cobalt with 1-4th part of its weight of powdered charcoal, and calcined it in a ſhallow open pot. At this inſtant the arſenic eſcaped in vapours; but ſlowly, and it coated metallic ſubſtances, that were held over the pot, with a thick white cruſt. The ſmell of this vapour reſembled that of garlic, only in very moderate degree; and it ceaſed to be emitted after the roaſting had been continued for two hours.

But, by this calcination, the cobalt was not yet entirely deprived of all portion of arſenic; for, when it had been diſſolved in nitric acid, and the ſolution concentrated by evaporation, there was ſtill ſome arſenic depoſited.

B.

a) For this reaſon, another *two hundred* grains of rough, white, cobalt-ore, previouſly triturated, were, in the firſt inſtance, mixed with 100 grains of charcoal-duſt, and calcined. This roaſting was twice repeated, mixing the ore each time with 50 grains of powdered charcoal; after which it no longer emitted any trace of exhaling arſenic. The cobaltic oxyd, which now, to appearance, had been entirely freed from arſenic, weighed 104 grains, and exhibited a black colour.

b) Thefe 104 grains were mingled with carbonat of pot-afh and crude tartar, of each three drachms. The mixture, when introduced into a fmall crucible, and covered with muriat of foda, was kept in the fire, before the nozzle of the bellows, during 20 minutes. The cobalt, thus reduced to the reguline ftate, was found to weigh 75 grains. Its external furface had a finely knit, or interwoven appearance. But when I endeavoured to break it by the hammer, it proved to be hard, and fomewhat tenacious. Its internal furface was partly porous; partly it exhibited a rough fracture, paffing into the *hackly*, that is, prefenting fharp points to the feel.

c) After thefe 75 grains of metallic cobalt had been pounded, they were roafted, in a brifk fire, for two hours; upon which the calcined cobalt appeared again in the character of a black oxyd, with an increafe of weight of 18 *per cent.*

Since it may be prefumed, with probability, that this cobaltic oxyd, which has been re-produced from the reguline cobalt revived at (*b*), contains oxygen in the fame proportion with the oxyd prepared by roafting the rough cobalt ore; and, as confequently, thofe 104 grains (*a*) of oxyded cobalt have contained 88 grains of pure reguline cobalt; it follows, that the conftituent parts of this *white cobalt-ore*, from *Tunaberg*, are, in the *hundred:*

Reguline *cobalt* . . .	44
Sulphur	0,50
Reguline *arfenic* . . .	55,50
	100

LXX.

LXX.

CHEMICAL EXAMINATION

OF THE

COBALTIC ORE OF MANGANESE,

From RENGERSDORF, in *Lusatia.*

THE fossil that was the object of the present enquiry occurs near *Rengersdorf*, in *Upper-Lusatia*, in a stratum of quarz, which, on the *Heideberg*, comes up to the day. It has, till now, been considered as a *black hæmatitic iron-stone**, until the late Professor *Leske* has introduced it as a *black cobalt-ore*†. However, as he declared to entertain a wish that this classification, which he founded partly on the external characters of this fossil, partly on some previous experiments made with it ‡, might be farther examined by a chemical analysis, it was by this declaration that M. *Westrumb* was induced to undertake this task.

From the appearances which this celebrated chemist observed on experimenting with this fossil, it resulted, that it contained *manganese*: but, on the other hand, he denied it to contain a portion of *cobalt*§, which, however, *Leske* had suspected in it.

* Schwarzer, Glasköpfiger Eisenstein.

† Schwarzer Erdkobalt.

‡ *Reise durch Saxen* von N. G. *Leske.* Leipzig, 1785. Page 230—230.

§ *Kleine Phys. Chem. Abhandlungen*, von *Westrumb*, 2*ter* Band, 2 Heft, 1788, page 183.

My

My examination of this mineral ſubſtance, of which I have received a ſtock from M. *de Gersdorf*, the worthy proprietor of the eſtates of *Meſſersdorf* and *Rengersdorf*, where it is found, has convinced me that, beſides manganeſe, it indeed contains cobalt: but it has, at the ſame time, ſhewn, that the preſence of cobalt is hid by the predominant portion of manganeſe combined with it, or, at leaſt, rendered unobſervable on the firſt inſpection of the foſſil.

A.

a) The rough foſſil, when treated upon charcoal, under a ſtream of air, continued for ſome time from the blowpipe, fuſes into an apake, blueiſh ſcoria.

b) Phoſphoric ſalt produces with it, by the ſame treatment, a crimſon-red vitreous globule.

c) Borat of ſoda is tinged by it of a dark hyacinthine-red; which colour, on adding a ſlight portion of arſeniated ſoda, paſſes into a pale blue.

d) One *hundred* grains of this foſſil were firſt calcined in a gentle heat, and afterwards ignited during half an hour. The foſſil loſt thereby 17 grains in weight, and its blackiſh colour was changed to a dark aſh-grey. During this proceſs of roaſting, there could not be obſerved either ſmoke or ſmell; and the loſs conſiſted merely of *aqueous particles*.

B.

a) *Five hundred* grains of this foſſil, previouſly comminuted in the mortar, were digeſted with a moderately ſtrong

mu-

muriatic acid. There eſcaped vapours of oxygenated muriatic acid. By continuing the digeſtion at the degree of ebullition, the mixture loſt its brown colour, and the fluid became green, leaving a white earthy reſidue behind. But, on diluting the ſolution with water, its green colour diſappeared, and the filtered liquor acquired a weak browniſh-red. The réſidue, ſeparated by filtration, weighed 206 grains, after ignition.

b) I then reduced the volume of the muriatic ſolution by evaporating it; during which proceſs *ſiliceous earth* was depoſited, weighing 10 grains, when collected on the filter and ignited. After this I ſaturated the ſolution with diſſolved cauſtic pot-aſh, added in exceſs, kept the mixture for ſome time in digeſtion, and filtered it. A muddy reſidue remained on the paper, the dirty light-brown colour of which rapidly turned black on expoſure to air.

c) The fluid ſeparated from this reſidue was neutralized with muriatic acid, and then combined with carbonat of pot-aſh. It depoſited *aluminous earth*, the quantity of which, after ignition, amounted to 12 grains.

d) The above black reſidue (*b*) was again diſſolved in muriatic acid, and thrown down by mild vegetable alkali. The precipitate appeared of a pale-reddiſh colour. When edulcorated and dried, I ſubjected it to ſtrong red-heat, for one hour, in a calcining pot. It returned from the fire of a greyiſh-brown hue, and weighed 178 grains.

e) I ſubjected theſe 178 grains, for ſome time, to digeſtion, in a boiling heat, with a moderately ſtrong nitric acid, diluting afterwards the ſolution with water, and filtering it. There remained a tender, black reſidue behind, which, upon edulcoration, drying, and ignition, weighed 80 grains,

grains, and was *oxyd of manganefe.* In order to try it for iron, I again digefted it with nitric acid; in which, on the addition of a little fugar, it immediately diffolved, without leaving iron, or any other refidue. When again precipitated by means of carbonated pot-afh, it fell down as a carbonated oxyd of manganefe, of a white colour, verging into the ifabella yellow.

f) Hence the nitric folution ftill contained 98 grains of the mentioned 178; but from the firft there muft be fubtracted *one* grain for copper, difcovered in the fequel. By mild vegetable alkali, this re-diffolved portion was again precipitated, of a pale colour of peach-flower; and this precipitate, as the following examinations of it have fhewn, confifted of an accurate mixture of *oxyds of cobalt* and *manganefe.*

g) The 206 grains, which remained on diffolving the crude foffil (*a*), were mixed with twice their weight of carbonated pot-afh, and moderately ignited during two hours; after which they were covered with water, fuper-faturated with muriatic acid, and evaporated to a gelatinous confiftence: and when the *filiceous earth* had been feparated, wafhed, and ignited, it was found to weigh 114 grains.

h) I then neutralized the remaining muriatic liquor with carbonat of pot-afh, and combined it afterwards with oxalat of pot-afh: but by this neither any precipitation nor turbidnefs has been effected. It was then combined with cauftic ammoniac, which threw down *aluminous earth*, the quantity of which, after ignition, confifted of 90 grains. The ftill remaining portion of the fluid continued clear on the addition of carbonated foda.

i) With a defign to afcertain the proportion of copper which enters into this foffil, and the prefence of which has al-

already been obſerved in the previous experiments, I affuſed ſulphuric acid upon 500 grains of the rough foſſil, evaporated the fluid on a ſand-bath, ſoftened the inſpiſſated maſs with water, and immerſed, after filtration, a poliſhed plate of iron into the clear ſolution, which had acquired a pale roſe colour. The plate of iron became gradually incruſtated with a cupreous pellicle; which, when carefully collected, weighed no more than ½ grain; and thus one grain of *oxyd of copper* muſt be put in the computation.

Therefore, the *five hundred* grains of the foſſil here examined have been decompoſed into:

Oxyd of cobalt, mixed with *oxyd of magneſia*	B. *f*)		97
Mere *oxyd of manganeſe*	*e*)		80
Oxyd of copper	*i*)		1
Silex	*b*)	10	124
——	*g*)	114	
Alumine	*c*)	12	102
——	*h*)	90	
Water	A. *d*)		85
			489

C.

But, that the 97 grains mentioned at (B. *f*), and which were obtained in the carbonated ſtate, have really conſiſted of a mixture of oxyded cobalt and manganeſe, has been proved by the following experiments; the phenomena of which, at the ſame time, were compared with thoſe that are exhibited by the pure carbonated oxyd of manganeſe.

1. *a*) The colour of the above precipitate, in the carbonated ſtate, is the pale peach-flower red, and changes, on ignition, into the light-brown.

b) The

b) The colour of the carbonated manganefian oxyd is white, inclining to the ifabella-yellow; and that of ignited oxyd of manganefe is black-brown.

2. *a*) If the ignited cobalto-manganefian precipitate be digefted with nitric acid, in a boiling heat, it leaves behind it a refidue in the form of a fubtle, black powder. If then carbonated pot-afh be added to the filtered folution, which has a very pure, but dilute rofe-red colour, the diffolved matter is thrown down by the alkali, of its former peach-flower red. The black refidue, left unattacked by the nitric acid, when heated to rednefs, and digefted in a heat of ebullition with a frefh portion of nitric acid, is re-diffolved for the greateft part; and its diffolved portion is again precipitated, of a pale red colour, by mild pot-afh.

b) The ignited black-brown oxyd of manganefe, by itfelf alone, is infoluble in nitric acid; the acid that is boiled with it continues colourlefs, and lets nothing fall down on being faturated with an alkali.

3. *a*) If the above compound precipitate of cobalt and manganefe be diffolved in muriatic acid, and abundantly fuperfaturated with carbonated ammoniac, the clear fluid which ftands over the fediment acquires, after fome time, a dilute colour, refembling that of the bloffom of flax-weed.

b) The oxyd of manganefe, on the contrary, when diffolved in the fame manner in muriatic acid, and precipitated by carbonat of ammoniac, added to excefs of faturation, leaves the liquor ftanding over the fediment entirely colourlefs.

4. *a*) On adding the mentioned cobaltic precipitate of manganefe to a neutral phofphat, fufed upon charcoal, the clear globule becomes tinged of a pure fapphire-blue colour,

which continues unchanged by the outer, as well as by the inner flame of a candle, directed on it by the blow-pipe.

b) Oxyd of manganefe, alone, produces with the phofphoric falt a globule, which is devoid of all colour when urged by the interior flame, but acquires an amethyftine red by the heat of the exterior.

5. *a*.) The combination of borax with the cobalto-manganefian precipitate, upon the charcoal, before the blow-pipe, produces a glafs globule of a dirty blueifh colour, inclining to the blackifh-grey. But as foon as a fmall quantity of arfeniated foda is added, a pure fapphire-blue colour appears.

b) Oxyd of manganefe imparts to borax, when vitrifying upon the coal, a dark amethyftine, and fometimes a hyacinthine red colour. But the glafs globule is immediately rendered colourlefs by the addition of arfeniat of foda.

6. *a*) When the precipitate compounded of cobalt and manganefe is diffolved in concentrated muriatic acid, the folution acquires a pale rofe colour, and it becomes grafs-green by heating. As the folution cools, its green colour difappears, and the pale-red returns. If this folution be diluted with water, and employed inftead of ink, the characters written with it become vifible, of a green colour, on warming the paper gently; but, upon cooling, that colour difappears, and returns again when warmed; and fo on, alternately. However, if the paper be heated too ftrongly, the traces made on it acquire a brown and permanent colour.

b) The folution of oxyd of manganefe alone, in concentrated muriatic acid, is, for the moft part, entirely colourlefs: neither does it acquire any tinge by warming it. The traces written on paper with this folution, previoufly diluted with water, continue invifible if the paper be expofed to a gentle heat only: but by a ftronger heat they turn brown, and lofe no more that colour, even after cooling.

D.

All thefe phenomena fufficiently evince the prefence of cobalt in the above compound reddifh precipitate. However, fince the colours exhibited by this precipitate are, in all their changes, paler than thofe which are produced by the oxyd of cobalt prepared from genuine cobalt-ores, it appears that the cobaltic is its fmaller part. The manganefe, on the contrary, conftitutes the greater portion: and it feems that in this precipitate there obtains an intimate union between thefe two metals: for, although a great part of the manganefe may be made feparable by ftrong ignition, by which it is rendered infoluble in nitric acid; yet I could not fucceed in feparating entirely the remaining part of manganefe from the ingredient cobalt, by repeated ignition and boiling in nitric acid.

It is on account of the manganefe, fo intimately combined with the cobalt, that neither the crude foffil, nor the reddifh precipitate feparated from it, imparts a true blue colour to vitrifying fubftances.

Yet, notwithftanding this, the mentioned arfenical addition (5. *b*) affords a practicable means of rendering the ingredient portion of manganefe ineffectual in tinging glaffes. The reafon of this is, that the manganefe combines, and enters into a ftate of complete faturation with the oxygen, which it feizes from the admixed arfeniat of foda. And as, in this fituation, it does not, of its own accord, tinge vitri-

fying

fying fubftances, it likewife no longer prevents the cobalt from imparting a pure fapphire-blue colour; as is confirmed by the following experiments.

1. To *five* parts of that peach-flower coloured precipitate, previoufly diffolved in muriatic acid, I added a folution of *two* parts of arfeniated foda, and effected a precipitation by means of carbonated foda. The precipitate, in this inftance, acquired a lavender-blue, inftead of a reddifh colour; and, when added to a globule of borax, melted upon charcoal, it immediately coloured it of a pure fapphire-blue.

2. *a*) *Silex*	½ ounce of each.
Calcined borax	
Reddifh cobalto-manganefian precipitate	10 grains,

mixed and vitrified in a porcelain-pot, afforded a glafs of a weak and cloudy amethyft-colour.

b) *Silex*	½ ounce of each,
Calcined *borax*	
Of the above *lavender-blue arfenical precipitate* . . .	10 grains,

yielded a glafs of a very pure fapphire-blue colour, though not of that intenfity which an equal quantity of oxyded cobalt, prepared from the common good cobalt-ores, imparts to fimilar glafs-frits.

3. *a*) *Silex*	½ ounce of each,
Carbonated *pot-afh* . . .	
Rough foffil	2 drachms.

produced a fmalt-blue glafs, the violet colour of which too much inclined to a dirty brown-red.

b) *Silex*		} ½ ounce of each,	
Carbonated *pot-aſh*			
Rough foſſil	2	} drachms,	
Arſeniat of ſoda	1		

gave a ſmalt-blue glaſs, of a pure violet colour.

4. It yet remained to examine what colour would be produced by the cobaltic portion of this compound metallic oxyd, in the encauſtic painting on porcelain. For this purpoſe, a part of the *lavender-blue arſenical precipitate*, prepared as before (No. 1.) was conveyed upon porcelain-veſſels, previouſly ignited, and then fuſed upon them. The painting returned from the furnace in every reſpect of a pure cobalt-colour, though rather weak.

Beſides theſe experiments, I performed a number of others with ſeveral variations, with a deſign of aſcertaining the proportion of cobalt in the ore here examined, as well as of ſeparating its oxyd of cobalt in a ſtate entirely free from all admixture of manganeſe. But, ſince the reſult would not anſwer my wiſhes, I abſtain from giving here an account of thoſe experiments; and am, at preſent, ſatisfied with having demonſtrated the preſence of *cobalt* in this *black*, *earthy ore of manganeſe* from *Rengersdorf*.

LXXI.

LXXI.

CHEMICAL EXAMINATION

OF THE

NATIVE SULPHAT OF COBALT.

(Kobaltvitriol)

From HERRENGRUND, *in Hungary.*

AT *Herrengrund*, near *Neusohl* in *Hungary*, a vitrolic salt occurs, in pale rose-red, transparent crystals, of a *stalactitical* form; which is considered by some as a *sulphat of manganese*, but by others as a *sulphat of cobalt.*

To remove this doubt, I undertook the following examination of this fossil; and the result decided for the *latter* opinion.

Hundred grains of this metallic salt, when dissolved in water, and precipitated by carbonat of pot-ash, afforded seven grains of a loose, pale-blueish precipitate, which turned black on exposure to a red-heat. This precipitate, when fused upon charcoal, imparted to the glass-globule produced by the vitrification of a phosphoric neutral salt, as well as to that which is obtained in the same manner from borax, a pure sappharine blue colour. Its remaining part, that had not been employed for these experiments, yielded, upon solution in dilute muriatic acid, a sympathetic ink; the traces of which directly assumed a yellowish-green colour on warming the paper, but disappeared again as the paper cooled.

 LXXII.

LXXII.

CHEMICAL EXAMINATION

OF THE

*MINERAL SPRINGS AT IMNAU**,

In SUABIA.

AMONG the many various *mineral waters* with which beneficent Nature has provided feveral parts of *Germany*, there are fome which, by accident and good fortune, have acquired fame and credit; while others, on the contrary, though not lefs valuable, have either continued to be totally unknown, or have undefervedly fallen into neglect and oblivion.

To thefe latter belong the *mineral-fprings* at *Imnau*, a borough in *Suabia*, fituated between *Tübingen* and *Rothweil*, in the eftate *Haigerloch*, which is the property of *Prince Hohenzollern-Sigmaringen*.

Although thefe fprings had been famous as early as the times of *Taberna-montanus*, I have not yet feen of them any account earlier than that given by *Cafpar* †. But how little fatisfactory his information can be with regard to the

* *Chemifche Annalen*, I. Band. page 1792,. 333.

† *Befchreibung des Saeurbrunnens zu Imnau*, &c. durch Sam. *Cafpar*. Med. Dr. und Phyficus zu *Sulz* am *Neckar*. Ulm. 1733, 8*vo*.

na-

nature and conftituent parts of the water, may be concluded even from the date of its publication; as, in general, at that time a well-founded chemical analyfis of water could not even be thought of.

By the care of *Dr. Mezler*, phyfician to the Court of Hohenzollern-Sigmaringen, I obtained, of the mineral-water at Imnau, a quantity fufficient for examination, in five well-ftopped, and numbered bottles; the waters of which were taken from as many contiguous fprings, flowing into one common refervoir.

When the water arrived at Berlin it was found bright and clear; it frothed ftrongly on being poured into glaffes, and had an agreeable and ftrong tafte of carbonic acid. From this defcription only the water from the fprings 4 and 5 ought to be excepted; becaufe, with refpect to fmell, as well as tafte, it feemed to be impregnated with fulphurated hydrogen-gas.

Each of the waters contained in thofe bottles I have firft previoufly tried by means of *re-agents*. They were then fubjected to analytical examination, in order to produce their conftituent parts in a feparate ftate.

A.

Examination by means of Re-agents.

I. *Tincture of Litmus.*

a) The *crude* water of all the five bottles, acquired by the tincture of litmus, a fine red colour.

b) When it had been *reduced* to one half *by boiling*, and filtered, it continued blue, on the addition of that tincture.

II.

II. *Paper tinged with a decoction of Brafil-wood.*

a) The colour of the *crude* water changed the red colour of the paper to a violet.

b) *Boiled* water produced no change in the colour of that paper.

III. *Lime-water.*

On mixing equal parts of lime-water, and the water from each bottle feparately, the mixture was rendered cloudy and of a milk-white; but it rapidly became again clear.—However, by the addition of more lime-water, a quantity of carbonated lime fell down.

IV. *Concentrated Mineral Acids*

difengaged from the water of each bottle numerous air-bubbles.

V. *Carbonat of Ammoniac, and Carbonat of Soda,*

produced a precipitate, which was thrown down entirely white, from the waters of the 1, 2, and 3 bottles; but that of the 4 and 5 bottles had an afh-grey colour.

VI. *Cauftic Ammoniac, and cauftic Soda,*

yielded the fame precipitates as at V. but in a lefs quantity.

VII. *Spirituous Tincture of Nut-galls.*

The water of the bottle, No. 1, fuffered no change from it, except that it acquired a weak yellowifh fhade. But in the waters of the bottles marked 2, 3, 4, and 5, a pur-

ple

ple precipitate was thrown down by this tincture, and the supernatant liquor acquired a violet colour, inclining to the green.

VIII. *Oxalic Acid*

immediately effected a copious precipitation.

IX. *Muriat of Barytes*

produced a precipitate in but a moderate quantity.

X. *Sulphat of Magnesia*

a) Threw down from the rough water, after 24 hours, a precipitate sufficient to be observable.

b) But the boiled water, combined with the same salt, was not rendered turbid, and it continued clear.

XI. *Nitrat of Silver.*

The water of bottle 1 continued at first unaltered, but afterwards it became a little opalescent. Those of the bottles No. 2 and 3 were altered very little; they, however, acquired a brownish tinge. The waters of bottles 4 and 5 were immediately rendered blackish, and deposited a black sediment.

XII. *Acetate of Lead.*

In the waters of the bottles 1, 2, and 3, it produced a white, and in those of the bottles 4 and 5 a dirty, light-brown sediment.

XIII. *Running Mercury,*

preferved in the waters of the bottles 1, 2, and 3, its bright luftre; but it became tarnifhed of a blackifh hue, when immerfed into the waters taken from the 4th and 5th bottles.

XIV. *Leaf of beaten Silver.*

Small pieces of this continued unchanged in the waters of the 1, 2, and 3 bottles; but in thofe of the 4th and 5th they became tarnifhed, firft of a gold, and then of a copper-colour.

B.

Analytical Examination.

As a detailed explanation of every feparate experiment would occafion unneceffary repetitions; to avoid thefe, I fhall relate only, in a few words, the method which I purfued in thefe refearches. To this I fhall add, in a fummary way, the conftituent parts which I have difcovered in the water of each particular fpring, together with their proportion to each other.

I. *Examination of the gafeous conftituent part.*

It has already refulted from the preceding refearches, that this mineral water is richly impregnated with carbonic acid gas. To afcertain the quantity of this gas, its extrication and collection were performed by means of the mercurial pneumatic apparatus.

On examining the waters taken from the bottles No. 4 and 5, the mercury in the cylinder became incruftrated, at

its

its upper furface with a brown pellicle, during the operation; but this did not take place with the waters of No. 1, 2, and 3.

The gas, that was difengaged from the water of each bottle, was totally abforbed by lime-water, and produced carbonat of lime. But in the common air, that occupied the fpace left in the retort after the introduction of the mineral water, and which was driven over along with the carbonic acid gas, I could not difcover any extraneous matter.

II. *Examination of the fixed conftituent parts.*

a) *One hundred cubic inches* of water (reckoning the weight of water, filling the capacity of *one* cubic inch, equal to 290 grains of diftilled water), from each fpring feparately, were evaporated at a moderate temperature in a glafs-difh. The water

of the bottle No.	1,	left	$31\frac{3}{4}$ grains
. . . .	2,	.	$34\frac{1}{2}$
. . . .	3,	.	$36\frac{1}{4}$
. . . .	4,	.	$39\frac{3}{4}$
. . . .	5,	.	38

of a dry refidue. That of No. 1 had a white, thofe of No. 2 and 3 a light reddifh-grey, and thofe of No. 4 and 5 a reddifh colour, of a little deeper caft.

b) All thefe refidues were firft treated with alkohol, during 24 hours. The ardent fpirit became imbued with a faint yellowifh colour, and when feparated by filtration, and evaporated, it left behind it fo flight a portion of a brown mafs, that its farther decompofition was not well practicable. For this reafon I collected it, by means of alkohol, into one mafs, from all the five evaporating-difhes, and after having fuffered the fpirit again to exhale, I obtained a refidue weighing four grains. When this refidue had been re-diffolved in very little alkohol, there remained $1\frac{1}{2}$ grain of *muriated foda:* and on combining the fpirituous folution with fulphuric acid, $1\frac{1}{2}$ grain of *refinous matter* was feparated. But the fulphuric folution yielded fulphat of magnefia; for which one grain of *muriated magnefia* may be put in the computation.

c) After this extraction of the feveral refidues, by means of ardent fpirit, I affufed water upon each of them feparately, and agitated the mixture feveral times. After 24 hours the aqueous extracts were, by means of the filter, feparated from the undiffolved portion, and made to cryftallize: firft, with the affiftance of a gentle heat, and then by fpontaneous exhalation in the open air. Every one fhot into prifmatic cryftals, which confifted merely of *fulphated magnefia*; with the exception of that which had been obtained from No. 1, and which alone was accompanied with a nearly unobfervable trace of *felenite*, or gypfum. Thefe faline lixivia left at laft a brown moifture behind, which hardly amounted to a few drops, and contained fo fmall a quantity of *gummous-extractive* matter, that it could not be eftimated.

d) Upon the portion that remained undiffolved in water, I poured alkohol, and afterwards I dropped nitro-muriatic acid into it, until all effervefcence and action of the acid ceafed. On this procefs a fmall quantity of a muddy refidue remained behind; which, when collected upon the filter, and ignited, left *filiceous earth* behind it.

All thefe folutions, previoufly filtered, were faturated with cauftic ammoniac. By this combination, an hardly obfervable turbidnefs was produced in the folution of the refidue left from the water of the bottle No. 1. But in thofe of the other *four* refidues a ferruginous precipitate enfued;

 which

which was carefully collected upon the filter, then washed, dried, ignited, and weighed. This I dissolved again in nitro-muriatic acid, in order to separate a small portion of *filiceous earth* ; which still has been mixed with it, and was afterwards collected, ignited, and weighed, for the purpose of ascertaining the true weight of the iron, which the preceding precipitate had contained, by subtracting the weight of the silex from the whole weight of the former. After which, this portion of iron was reduced, in the computation, to a corresponding quantity of *carbonated oxyd of iron.*

e) After having thus separated the ferruginous part, I reduced the solutions, in some degree, by evaporation ; I combined them with a fourth part of their volume of alkohol, adding, then, concentrated sulphuric acid by drops, which immediately threw down a quantity of selenite. I continued dropping in the acid, as long as any of this sulphat of lime would fall down. The selenite was collected on the filter, and when it had been edulcorated with a mixture of water and alkohol, I again decomposed it, by boiling with an aqueous solution of carbonated soda. The *carbonat of lime*, thus separated, was washed, dried, and weighed.

f) To discover whether the fluid remaining from the separated gypsum contained any magnesia, I evaporated it to some part, and combined it with carbonat of soda, at the degree of boiling heat. However, no precipitation took place.

According to the results of these inquiries, *one hundred* cubic inches of the waters of the *mineral springs* at *Imnau* contain :

I.

I. *Water from the Bottle No.* 1.

Sulphat of magnesia, with a trace of *selenite* . .	5,75 grains
Muriat of soda	0,30
Muriat of magnesia . .	0,20
Carbonat of lime	25
Silex	1
Resinous matter	0,30
	32,55 grains

Carbonic acid gas, 104 cubic inches.

II. *Water from the Bottle No.* 2.

Sulphat of magnesia	5 grains
Muriat of soda	0,30
Muriat of magnesia . . .	0,20
Carbonat of lime	27,75
Carbonated oxyd of iron . .	0,75
Silex	1
Resinous matter	0,30
	35,30 grains

Carbonic acid gas, 105 cubic inches.

III. *Water from the Bottle No.* 3.

Sulphat of magnesia . . .	5,50 grains
Muriat of soda	0,30
Muriat of magnesia . . .	0,20
Carbonat of lime . . .	28,25
Carbonated oxyd of iron . .	1
Silex	1
Resinous matter	0,30
	36,55 grains

Carbonic acid gas, 104 cubic inches.

IV.

IV. *Water from the Bottle No.* 4.

Sulphat of magneſia . . .	6	grains
Muriat of ſoda	0,30	
Muriat of magneſia . . .	0,20	
Carbonat of lime	31	
Carbonated oxyd of iron . .	1,50	
Silex	1	
Reſinous matter	0,30	
	40,30	grains

Carbonic acid gas, 112 cubic inches.

V. *Water from the Bottle No.* 5.

Sulphat of magneſia . . .	5,75	grains
Muriat of ſoda	0,30	
Muriat of magneſia . . .	0,20	
Carbonat of lime	29,75	
Carbonated oxyd of iron .	1,50	
Silex	1	
Reſinous matter	0,30	
	38,80	grains

Carbonic acid gas, 115 cubic inches.

It will be obſerved, that the ſum of the ſeparate conſtituent parts, in each of the above *five* computations, is a little greater than the weight of the entire dry reſidue, that has been at firſt obtained (B. No. 2. *a.*). This is to be accounted for by the water of cryſtallization, which enters into the ſulphat of magneſia.

C.

C.

In this fummary ftatement will be found wanting the *fulphurated hydrogen gas*, fufpected before in the waters of the 4th and 5th bottle, or fpring (page 581); the prefence of which, however, feemed to be indicated by their tafte and fmell, as well as by the dark colour of the precipitate thrown down by acetated lead, and by the tarnifhing of the reguline mercury and filver-leaf (A. No. 13 and 14), immerfed into them.

However, fince I have experienced in other inftances, that, in mineral waters, thefe and fimilar indications originate but rarely from real fulphurated hydrogen gas, and that more frequently they arife from the admixture of putrefying organic matters; I entertained a doubt: whether that putrid vapour be an effential ingredient in the waters of the fprings No. 4 and 5? Of this doubt I informed Dr. *Mezler*, requefting him to examine this object on the fpot. And it refulted from the refearches, which he made, that this fmell, refembling that of fulphurated hydrogon gas, was owing merely to the putrefcent ftate of a cement, which had been employed in the conftruction of fome pipes, through which it was found neceffary to force the water of the *fourth* and *fifth* fprings into their appropriate refervoirs. This caufe has been fince removed; hence thefe fprings are, at prefent, entirely free from all extraneous contamination. When the whole of the water had been pumped out of the refervoirs, and, confequently, when Dr. *Mezler* was enabled to examine water, that had recently iffued from thefe fprings, he found, neither by the tafte nor by the fmell, the leaft trace of that hepatic odour. Befides this, he filled, under the furface of the water, four bottles; the *firft* of which contained fome clear pieces of white arfenic;

arſenic; the *ſecond*, ſome cryſtals of purified acetate of lead; the *third*, beaten leaf-ſilver; and the *fourth*, running mercury: ſtopping all theſe bottles cloſely. After 24 hours, the arſenic was found as white as before; the precipitate produced by the acetated lead was of a beautiful white; and the metallic luſtre of the ſilver and mercury was not in the leaſt impaired.

END.

ERRATA.

Page	Line			read	
54	20	—	*affect*	read	effect.
120	31	—	36	. . . .	35
139	8	—	122	. . . .	112
147	13	—	$160\frac{5}{8}$	. . . .	$160\frac{3}{8}$
278	22	—	2 5	. . . .	$2\frac{2}{5}$
309	17	—	5—7	. . . .	15. 1. 7.
342	8	—	1 *grain.*	. . . .	$1\frac{1}{4}$ grain.
354	29.30	—	*would ſhoot*	. . . .	would not ſhoot.
359	18	—	*carbonic*	. . . .	muriatic.
362	14	—	2,40,0	. . . .	2,490
404	1	—	*carbonated free ſoda*	. . . . .	cauſtic ſoda.
450	16	—	47 *lb.*	. . . .	47 grains.
461	6	—	*muriatic*	. . . .	ſulphuric
475	8	—	after *leucite*, read, whoſe earthy parts, like thoſe of lepidolite, are alſo ſilex and alumine, &c.		
479	12	—	*ſulphuric*	. . . .	ſulphureous.
500	24	—	*muriatic*	. . . .	ſulphuric.

219 transfer note (*) to page 218.
400 transfer note to —— 399.

Some other typographical errors, and miſtakes of leſs importance, are recommended to the Reader's kind indulgence.

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