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Prof. Hünefeld

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continuity is essentially universal, and that a breach of it is metaphysically, as well as physically, impossible.

The severest test to which the validity of this mode of reasoning can be put, is to apply it to the pure mathematical relations of space and quantity, to which, if the law of continuity have any necessary existence in the nature of things, it ought to apply with the greatest rigour. We find, accordingly, that all the changes of magnitude in those quantities of which the value is dependent on that of certain other quantities, accompany corresponding changes in these latter quantities, in a manner strictly conformable with the law of continuity.

[To be continued.]

XXII. *On the Titaniferous Iron-slag of Königshütte in Upper Silesia, and on the Probability of its containing Tantalum.*
By Prof. HÜNEFELD, of Greifswalde*.

ALTHOUGH the investigations of Wollaston, Walchner, Rose, Du Ménil, Cordier, Vauquelin, Peschier, Berzelius, Zinken, Schrader, Karsten, and others, have shown that titanium is widely distributed, it has been nowhere found in great quantities. Wollaston found it in 1822 in the slag of the great iron-works at Merthyr Tydvil in Wales, in regular pale copper-coloured cubes†; and Walchner found the same in the slag of the pea-iron-ore of the High-furnace of Kandern in Baden‡; and Karsten, before this, in those of the Königshütte§. Karsten's observation has been but rarely mentioned, and has been especially neglected by Berzelius. It seems to me that it is particularly calculated to extend our knowledge of titanium (at least for the German chemists); and this has induced me to give an account of the titaniferous slag of the Königshütte, which I examined in 1824 at Breslau. I must however premise, that I had then no opportunity of combining the investigation, as to quantity, with that as to the nature of the substances.

The slag containing titanium, which was given to me for examination by my friend M. Müller, was thickly covered and filled with pale copper-coloured cubes of titanium; and I found that Dr. Wollaston's description was applicable to them in all respects. Peschier, it is well known, has declared it to be titanate of iron, of which, however, too little proof has been offered for it to be admitted as a fact ||.

* From Schweigger's *Jahrbuch*, N. S. Band xx. p. 332.

† See Philosophical Magazine, vol. lxii. p. 18. and lxiii. p. 15.

‡ Ibid. vol. lxvi. p. 124. § Karsten's *Archiv*. iii. 524.

|| Walchner has declared himself decidedly against this opinion, and
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A portion of the slag was digested in aqua regia: the greater part of it was dissolved, with evolution of sulphuretted hydrogen gas, whilst a considerable number of the small cubes of titanium remained undissolved, having a perfect metallic lustre. But besides these, there remained in the residuum a blackish powder, containing grains and minute laminæ, nearly of the colour of silver, and having a metallic lustre, to which I shall return in the sequel. Another portion of the slag was ignited with nitre, in order to oxidate the titanium. The melted mass dissolved in water gave a beautiful green solution, which, when exposed to the air, soon assumed first a deep red, and then a dark violet colour, and at last lost all colour *, whilst portions of the protoxides of manganese and iron were deposited. Subsequently, this deposit (marked *a*) and the sides of the vessel became covered with fine crystalline iridescent laminæ and needles, probably titanate of potash precipitated by the substances having attracted carbonic acid from the air.

The residuum of the dissolved mass in the porcelain crucible was washed and dried, by which it assumed the colour of iron-rust. It was partly dissolved in muriatic acid, and thereby gave a solution of iron, and left a blackish powder (*b*). The filtered strongly alkaline re-acting liquid was evaporated, and mixed with nitric acid (*c*). After standing somewhat longer, it gave crystals of nitre, and then others of an indistinct form. They were mostly white, somewhat opalescent, not easily soluble grains of salt, cracking and decrepitating between the teeth, and which, with salt of phosphorus, were melted before the blowpipe into a clear bead, which within the flame received no colour, either by itself or mixed with tin. The solution was rendered somewhat turbid by caustic ammonia, and white flakes were deposited. Boiled and dissolved with potash, and acidulated with muriatic acid, infusion of galls precipitated it of a dark yellow; but hydrosulphuret of potash and ferroproussiate of iron gave no precipitate; which leads me to suppose that those grains of salt were *tantalate* of potash.

The fluid *c* had the following properties. With an alcoholic infusion of galls, a yellowish-orange precipitate was formed, which was dissolved on being heated; and when it was concentrated, it gave a brown liquid, which remained clear on

shown that the iron between the laminæ of the cubes of pure titanium had been mechanically interposed; whence (like Wollaston) he also explains its magnetism.

* The cracks of the crucible contained a beautiful orange-red efflorescence in needles, which were not examined. Were they manganesate of potash, or sulphuret of titanium with sulphuret of potassium? (Vid. Berz. *Jahresber.* v. 134.)

cooling.

cooling. Sulpho-cyanate of potash dissolved in alcohol produced a red colour; with a greater addition, a dark rose colour; but with impure sulpho-cyanate of potash (still containing ferroprussiate of potash), a greenish white precipitate; with the ferroprussiate of potash itself a dark grass green precipitate, which was in part dissolved in the remaining liquid, giving it the same colour; and it was also dissolved by nitric acid. This last solution turned gradually brownish green *. Another solution made with muriatic acid, gave, by contact with a cylinder of zinc, the usual indications of titanium.

The black powder *b* was digested in aqua regia, which extracted the iron and manganese, leaving however a considerable proportion of a black powder, which under the burnisher gave an iron-gray streak of a metallic lustre, became inflamed even before it arrived at a red heat, and yielded a whitish substance, which, with a few deviations, bore the characters of *tantallic acid*. These deviations were probably produced by a small portion of manganese, which was indicated in the trial by the blowpipe.

I subsequently obtained, through the friend above mentioned, a larger quantity of slag containing titanium. It had a still greater quantity of large and small regular cubes of titanium, which were affixed on the outside as well as to the inner cavities of the slag. They had nearly all the same regular form and the rose copper colour, except a few very small groups, which tended somewhat to an orange tint, and had but a faint brilliancy (sulphuret of titanium?). But besides these visible crystallizations of titanium, the slag had some other interesting substances upon it.

1. Granules of metal melted into it of the shape of beans or spheres, weighing from two to thirty grains.

2. Cavities of different sizes, the sides of which, when filed, had a fine lustre as of steel.

3. Several grains of metal as it were sprinkled in the slag, of a globular or oblong shape, with a metallic lustre, and a colour between that of silver and that of tin. In their chemical properties they resembled the small lustrous metallic leaves which have been mentioned above; they scratched glass, gave a shining powder, and seemed therefore to be *tantalium*, such as we have found it hitherto described.

4. Melted grains of metal, partly globular, with a tint verging upon the colour of brass.

5. Portions of melted slag, of a dark rose red nearly. They

* See Pfaff's *Neue Versuche über das Verhalten der Titansäure gegen verschiedene reagentien* (New Experiments on the Habitudes of Titanic Acid with different re-agents); *Jahrb.* b. xv. p. 372; and Pfaff's *Analyt. Chem.* b. ii. p. 523.

all showed, on being filed, a fine metallic lustre, were very hard and tough, but not malleable, some scratching glass distinctly, others but feebly.

No. 1.—The metallic granule was attracted by the magnet, showed, when filed, a bright steel-lustre, which continued in the air; it was very hard, not ductile, but after many blows with a hammer, flew into several pieces, and showed a fine-grained fracture. These fragments could not be melted even in the most intense flame of the blow-pipe; they only became slightly diminished in lustre. Treated with muriatic acid, they yielded odorous hydrogen; the muriatic acid dissolved iron, the granule turned black, and after a longer digestion crumbled into a black dust. In aqua regia, a little more was dissolved; about five-sixths remained, which, when washed and polished with a glass stick, gave a streak of a metallic lustre similar to molybdena. When moistened, it gave a smell of hydrogen gas, such as is given by manganese. Thus it remains undecided whether this quality belongs to a small residuum of manganese, which however is probably the case, since the black powder treated with salt of phosphorus yielded a pearl of a faint amethyst colour, whilst otherwise nearly the whole covered the pearl of salt of phosphorus with a metallic pellicle; and this result remained unchanged on the experiment being continued. Treated with soda and borax, no other re-action took place but that of the salt being covered with a metallic pellicle, which remained unchanged even after the pearl had been repeatedly touched with solution of caustic potash, and a scrap of tin added to it. If, however, the granule of slag had not been sufficiently treated with aqua regia, the black metallic powder gave a blueish green substance with soda, with salt of phosphorus, a yellowish brown pearl in the external flame, a greenish one becoming clear on cooling in the inner flame, and which therefore contained iron and manganese.

After several experiments made with the black powder, I could perceive, at least in this manner, no indication of titanium; but another granule, also treated with aqua regia, left undissolved small rose copper coloured crystals of titanium. Another piece of a melted granule in the titaniferous slag gave on the filed surface visible particles of titanium, as it were sprinkled among it. The granule just described could be filed like the other portions described in what follows, adhering a little to the file.

No. 2.—These parts proved to be almost entirely the same as the former, but were a little harder, and yielded more of the black metallic powder.

No. 3.—They scarcely lost any thing in aqua regia, preserved
their

their lustre, and did not crumble. Similar granules remained behind in another experiment with the same solvent, scratched glass, and when beaten and broken with a hammer, made red hot with caustic potash, and treated with the blowpipe apparatus as well as with humid re-agents, did not give any indications of titanium. A portion, however, having been melted with potash, and acidulated with nitric acid, the solution remained for several days exposed to the air, and being afterwards filtered, was by means of a solution of galls precipitated rather abundantly, of a dirty orange colour; whilst hydrosulphuret of potash produced a scarcely perceptible turbidity (*tantalum*?).

No. 4.—The brass colour was only superficial, the mass underneath almost entirely resembling Nos. 2 and 3.

No. 5.—The dark rose red, yellowish, and metallic colour of these pieces extended deeper in the last-mentioned portions; they evidently contained titanium, were more difficultly filed, were magnetic, and might contain a mixture of iron and titanium on the surface, one of tantalum and iron, and some titanium itself further in.

The black powder obtained from the portion of slag of the other mass, was ignited with carbonate of soda; the mass, which when cold appeared white with blueish green margins, was dissolved in water, in which the green colour, which is the property of manganese, disappeared. A white, somewhat loose and flaky powder was precipitated. The remaining fluid, mixed with muriatic acid, when treated with oxalate and ferroprussiate of potash, gave a yellowish red precipitate, small in quantity. The fluid, when exposed to the atmosphere, turned to a fine grass-green, without the least deposit of cyanuret of iron; it was not acid. An infusion of galls produced a dirty yellowish white precipitate, which after some time became grayish white, and subsequently yellowish green. Sulphocyanate of potash produced a reddish deposit. Neither the solution nor the precipitate gave any indications of titanium on being treated with salt of phosphorus; nor even after a short contact with a cylinder of zinc, tin or iron, muriatic acid having first been added to the solution. But on mixing another portion of the dissolved mass with nitric acid, drying it and treating it with salt of phosphorus and tin before the blowpipe, I obtained, by adding a little oxide of iron, a glass of a hyacinth colour, which by a greater addition of the evaporated solution, turned to a violet blue, and became almost transparent.

On comparing these experiments with the slag, with the known chemical properties of the substances, it is evident that they contained not only an abundance of *titanium* (as has been shown

shown before by Karsten), but probably also *tantalum*. As both these metals are so scarce, especially *tantalum*, I have thought it of use to call the public attention to this slag.

It is not improbable but that the titanium originated by reduction from prototitanate of iron and manganese, and the tantalum from the tantalates of the same bases (*tantalite*). It would be a very meritorious performance, and highly important to the geology of Silesia, if any one would institute a strict examination of the iron ore which yielded this slag, as well as of its locality, and the process of smelting it undergoes. Perhaps by so doing some pure tantalum, or combinations of that metal, as well as of titanium (and perhaps wolfram), may be found in larger or smaller quantities. It need scarcely be mentioned, that titanium is found in the Riesengebirge of Silesia, especially in the Iser (*Iserin*) in the shape of *nigrin*.

XXIII. Notices respecting New Books.

THE following are the Contents of those Parts lately published, of the Philosophical Transactions, and of those of the Linnean and Astronomical Societies :

Philosophical Transactions for 1827.—Part II.

On a new form of the differential thermometer, with some of its applications. By William Ritchie, A.M.—On the structure and use of the submaxillary odoriferous gland in the genus *Crocodylus*. By Thomas Bell, Esq.—On the permeability of transparent screens of extreme tenuity by radiant heat. By William Ritchie, A.M.—On the derangement of certain transit instruments by the effects of temperature. By Robert Woodhouse, A.M.—On some of the compounds of chromium. By Thomas Thomson, M.D.—Rules and principles for determining the dispersive ratio of glass; and for computing the radii of curvature for achromatic object-glasses, submitted to the test of experiment. By Peter Barlow, Esq.—On the change in the plumage of some hen-pheasants. By William Yarrell, Esq.—On the secondary deflections produced in a magnetized needle by an iron shell in consequence of an unequal distribution of magnetism in its two branches. First noticed by Captain J. P. Wilson. By Peter Barlow, Esq.—On the difference of meridians of the royal observatories of Greenwich and Paris. By Thomas Henderson, Esq.—On some observations on the effects of dividing the nerves of the lungs, and subjecting the latter to the influence of voltaic electricity. By A. P. W. Philip, M.D.—On the effects produced upon the air cells of the lungs when the pulmonary circulation is too much increased. By Sir Everard Home, Bart.—Theory of the diurnal variation of the magnetic needle, illustrated by experiments. By S. H. Christie, Esq. M.A.—On the ultimate composition of simple alimentary substances; with