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I.I. Bindheim

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VI. *On the different Kinds of Cadmia, and particularly those of Zinc and Cobalt.* By I. I. BINDHEIM of Moscow.

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Of COBALT.

IT is scarcely a century and a half since people knew how to make use of cobalt ore. Brand, counsellor of the mines in Sweden, first proved that cobalt was a semi-metal, and that it possessed peculiar properties different from those of other metals. He defended his opinion against various objections that were made to it; but it is still believed by some, that it is a mixture of copper, iron, and arsenic: and this seems the more probable, as a fixed blue colour, fit for being employed in the arts and manufactures, is prepared with advantage at Vienna from iron and arsenic. This, however, does not place the circumstance beyond all doubt, for it still remains to be examined whether the arsenic and iron employed for that purpose be free from cobalt; and, until that be ascertained, the fact must be involved in uncertainty; for both, or at least one of them, may be mixed with cobalt.

Lehmann was of opinion, that the colouring matter of cobalt consisted of a fine alkaline earth combined with some particles of copper and iron; and he made experiments on this subject, by which he obtained blue glass. But from the description he gives of his experiments it does not appear sufficiently proved that ingredients free from cobalt were used for the mixture.

The reason why some may have been inclined not to ascribe the principle which colours smalt to a metallic substance may have been, that they employed for their experiments a cobalt ore free from arsenic, and did not apply a sufficiently strong heat, without which the regulus of cobalt is difficult to be fused, and not so easily separated: the principle which gives the blue colour to glass is, however, to be ascribed

ascribed certainly to the metal of cobalt, as has been placed beyond all doubt, and clearly proved by the experiments of M. Meyer, to be found in Sellers' Collections.

Some, on the other hand, have endeavoured to banish cobalt from the number of metals; but no one will certainly any longer doubt of its being a peculiar metal, since it is well established, that simple substances are properly considered to be specifically different when they exhibit various properties which other bodies do not possess, and that every substance is considered as simple when it cannot be separated into different principles, and be again formed from them. Now this is confirmed in regard to cobalt; and it is found that it not only possesses properties different from those of all other metals, but is itself a metal of a totally peculiar kind. Even though there be an analogy between iron, nickel, arsenic, and cobalt; and though, according to the supposed hypothesis, the regulus of cobalt is only a variety of iron, and that it is difficult, if not impossible, to separate it from cobalt; yet the latter still remains a metal of a peculiar kind.

The first and principal researches for discovering cobalt mines were made in the Saxon mountains, and these procured to that country an opportunity of carrying on a considerable trade with this production. Good cobalt ore, fit for colouring, is found at present, though not in such abundance, in Hesse, Wurtemberg, the Harz, Bohemia, Prussia, Silesia, and Sweden.

As far as I know, pure native cobalt has never yet been found; what is commonly pretended to be such, is mineralised by arsenic. It is found in an oxygenated state, and always combined with iron, and also mineralised with carbonic acid; in vitriolic cobalt ore, by the sulphuric and the arsenical acids; and to this belongs the so called flowers of cobalt, found in tender reddish crystals: it is also found mineralised by arsenic, with a little iron, in dull grey cobalt ore; by sulphur and arsenic, with iron, in white arsenical cobalt

cobalt ore; and by a little sulphur, with abundance of iron without any arsenic, in sulphurated cobalt ore.

When such ore is treated in the fire, the arsenic evaporates, and the metallic and earthy particles remain behind, which, in order to be prepared for commerce, must be mixed with pounded quartz or sand, afterwards moistened, and then packed up in casks under the name of *saffor* or *zaffera*. If very fusible glass be melted with a little cobalt ore, and if the mass be finely pulverised, it produces smalt, which, by washing, may be fitted for an article of commerce of different qualities and sorted. This smalt, however, contains in general an impure regulus of cobalt, which often consists of a mixture of cobalt, iron, arsenic, and nickel, and is called *cobalt speise*. If you wish to obtain a pure regulus of cobalt, you must choose for that purpose a cobalt ore as free as possible from foreign metallic substances. You must then roast it carefully according to the proportions of sulphur and arsenic which you find in it, and reduce it by adding carbonaceous matter to take up the oxygen, and a good alkaline flux at a strong fusing heat. If the cobalt ore employed contains bismuth, and is free from nickel, the regulus of bismuth will be found at the bottom of the reduced cobalt in a separated state. This regulus is not pure, and sufficiently free from iron; but it may be brought to purity, though with trouble and a considerable loss of the regulus of cobalt. To effect this, it must be calcined with borax, on a test, in the same manner as copper, until it is no longer attracted by the magnet. Some, however, are of opinion, that iron is not the only metal attracted by the loadstone, and that it exercises an attractive power over the finest blue colouring regulus of cobalt: but there are well-grounded objections against this idea, for that effect takes place only when the latter is not sufficiently freed from iron; and according to the experiments of Bergmann, a composition of one part of iron and three parts of cobalt is attracted by the magnet; but if the proportion

proportion of the iron be considerably less, that effect is not produced.

The specific gravity of a regulus of cobalt, purified as much as possible by the above method, is 7.700*; its colour is a pale greyish blue, but it becomes somewhat darker when exposed to the atmosphere: it is finely granulated on the fracture, and requires a strong degree of heat to be fused, especially when no arsenic is present; and therefore it happens that it is so difficult to extract the regulus by fusion from cobalt ore which contains no arsenic. It is not, however, volatile, like the greater part of the semi-metals; and does not inflame and evaporate, but when calcined becomes a blackish oxyde.

When cobalt is pure, it dissolves in acids with a red colour; when it does not dissolve, it is a sign that it is prevented by some foreign mixture: if the solution be green, it commonly implies the presence of nickel.

With the vitriolic acid cobalt affords brownish red crystals; the nitrous acid dissolves it also of a red colour: by the muriatic acid regulus of cobalt is dissolved with difficulty, but its calx easily dissolves. This solution is red when cold, but when exposed to a heat of 80 degrees becomes green; it shoots into red crystals inclining to blue: if these crystals are dissolved in water, and a little of the muriatic acid be added, it produces that kind of sympathetic ink which becomes green when heated, and invisible when cold. The acetous acid dissolves the calx of cobalt also of a red colour. If such solutions are precipitated by volatile lixivious salts (ammonia), and the quantity necessary for saturation be added, it is redissolved of a dark red colour.

In the wet way the oxalic acid, and in the dry way iron, have the greatest affinity with cobalt. It combines with all metals except silver, lead, and bismuth. Regulus of cobalt unites only weakly with sulphur, but is fully dissolved by sulphat of pot-ash.

* Bergmann Sciagr., but in his Dissertation on Nickel he makes it 8.15.