

VIII. "On Jargonium, a new Elementary Substance associated with Zirconium." By H. C. SORBY, F.R.S. &c. Received June 4, 1869.

At the Soirée of the President of the Royal Society on March 6th, I exhibited various spectra, differing so much from those characteristic of any known substance, that I considered myself warranted in concluding that they were evidence of a new element. Since this may be studied to the greatest advantage in the jargons of Ceylon, it appeared to me that, like as the name zirconium has been adopted for the principal constituent of zircons, so that of jargonium would be very suitable for this constituent of jargons.

At the above-named Soirée I gave away a printed account of the objects I exhibited, and in this I said that the earth jargonia "is distinguished from zirconia and all other known substances by the following very remarkable properties. The natural silicate is almost, if not quite colourless, and yet it gives a spectrum which shows above a dozen narrow black lines, much more distinct than even those characteristic of salts of didymium. When melted with borax it gives a glassy bead, clear and colourless both hot and cold, and no trace of absorption-bands can be seen in the spectrum; but if the borax bead be saturated at a high temperature, and flamed, so that it may be filled with crystals of borate of jargonia, the spectrum shows four distinct absorption-bands, unlike those due to any other known substances" \*.

I have since applied myself almost exclusively to this subject, hoping to have been able to communicate to the Royal Society a full account before the close of this session; but so much still remains to be done, that it is now impossible to give more than a brief outline of some of the more important facts. The delay has not been occasioned by any difficulty in proving it to be a new substance, but because its properties are so unique and have so much interest in connexion with physics that it appeared desirable to carefully examine all other known elements, in order to ascertain whether any exhibit analogous phenomena.

That jargonium is quite distinct from zirconium is proved not only by the spectra, but also by other facts. Both I and Mr. David Forbes have succeeded, by entirely different processes, in separating from jargons zirconia apparently quite free from jargonia, and jargonia nearly, if not quite, free from zirconia; and, even if the separation be not perfect, it is, at all events, more than sufficient to prove that they are distinct. They are certainly closely allied, and are deposited from borax blowpipe beads in microscopical crystals of the same general forms, quite unlike those characteristic of other known earths; but, beyond this, the difference is

\* For the further history of this subject see Professor Church's papers, *Intellectual Observer*, 1866, vol. ix. p. 291, *Chemical News*, March 12 and 19, 1869, vol. xix. pp. 121 & 142, *Athenæum*, March 27; and also my own, *Chemical News*, vol. xix. p. 122, and *Athenæum*, April 3, 1869.

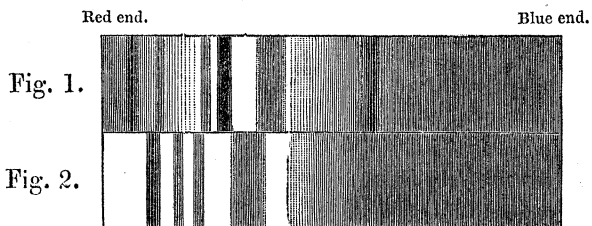
as great as that between any other two closely related elements. Judging from Mr. D. Forbes's analysis, kindly made at my request, and from a comparison of the spectra, the amount of jargonium in different jargons varies up to about 10 per cent. The entire or comparative absence from the zircons of Miask, Fredericksvärn, and various other localities, appears to explain some of the facts which led Svanberg\* to conclude that zircons contain more than one earth. He was so far correct, but failed to establish the existence of any substance with special chemical or physical properties; and if, as is probable, the Norwegian zircons, which, according to his views, contain such a notable quantity of this supposed new earth as to have led him to give it the name *noria*, were from Fredericksvärn, and if the Siberian were from Miask, his *norium* cannot be looked upon as equivalent to my jargonium, which is almost or quite absent from those zircons.

The most remarkable peculiarity of jargonium is that its compounds may exist in no less than three different crystalline states, giving spectra which differ from one another as much as those of any three totally different elements which give the most striking and characteristic spectra. Several substances can be obtained in two physical states, giving different spectra: but usually only one of them is crystalline; the other is the vitreous or colloid condition. Crystalline minerals, coloured by oxide of chromium, do indeed show two types of spectra, but I am not aware that they ever both occur in the same mineral. In the case of jargonium, however, the three types of spectra are all met with in *crystalline* modifications of apparently the *same* compound.

The most characteristic test for jargonium is the spectrum of the borax blowpipe beads, seen with the spectrum-microscope, which enables us to detect it in zircons containing less than one per cent. As much of the earth or natural silicate as will completely dissolve should be melted in circular loops of platinum wire, about  $\frac{1}{8}$  of an inch in diameter, with a mixture of borax and boric acid, and a very strong heat kept up till crystals begin to be deposited, owing to loss of the solvent by volatilization. On removing the beads from the flame they remain clear, and show a few acicular crystals, but give no absorption-bands in the spectrum. On reheating to a temperature just below very dull redness, they turn white, and so very opaque that no ordinary light will pass through them. When, however, a small and very bright image of the sun is formed in their centre, by means of an almost hemispherical condensing lens of  $\frac{1}{2}$  inch diameter, and a cap placed over the object-glass, with a round hole less than the beads nearly in the focus, so as to prevent the passage of extraneous light, they are seen to be illuminated by transmitted light of about the same brilliancy as that of a bright cloud, so as to give an excellent spectrum, without being at all dazzling. In the case of beads containing jargonium, the spectrum differs completely according to the temperature at which the included crystals have

\* Pogg. Ann. 1845, vol. lxx. p. 317.

been deposited. As already mentioned, a clear glassy bead gives no absorption-bands; and when the crystals are deposited at as low a temperature as possible, much below dull redness, and only just high enough to soften the borax, there may be scarcely any trace of bands; but, if a clear bead be quickly raised to a temperature very little below dull redness, it suddenly becomes opaque, and shows a spectrum with a number of narrow black absorption-bands (fig. 1). The most distinct is in the green, then one in the red, and one in the blue; and there are three fainter, one in the orange, and two in the green. On raising the temperature to bright redness all these bands vanish, and four others appear, none of which coincides with the former (fig. 2). Three are situated in the red and orange, and



one in the green, so as to give a spectrum of very different general character. In this state the bead is a pale straw-colour, and not, as before, almost white. In the case of nearly pure jargonium, the bead should not be more than  $\frac{1}{25}$  of an inch thick, or else it would be too opaque. Pure zirconia treated in the same manner gives no bands whatever in any condition; the bead is quite white, and sufficiently transparent when two or three times as thick as just named.

It might be thought that the three different spectra thus briefly described were due to different compounds, if it were not that there is a similar series in the case of the natural crystalline silicate. Some of the jargons of Ceylon have a specific gravity very little inferior to that of pure zircons (4.70), and contain very little jargonium; but those of low gravity (4.20 or thereabouts) contain perhaps nearly 10 per cent., in a form which gives scarcely any trace of absorption-bands. On keeping such a specimen at a bright red heat for some time, the specific gravity increases from about 4.20 to 4.60. Judging from the imperfect data now known, this indicates that the volume of the silicate of jargonium is reduced to about one-half; the hardness becomes somewhat greater, and, when examined with the spectrum-microscope, the spectrum is found to be entirely changed. Instead of a mere trace of bands, a spectrum is seen with thirteen narrow black lines and a broader band, more remarkable than that of any clear transparent substance with which I am acquainted. No such changes occur in the case of zircons free from jargonium, like those from Miask, Siberia; there is no increase in the specific gravity, and no absorption-bands are developed, and, as a general rule, the increase varies

simply and directly as the amount of jargonium which passes from one state into the other. Zircons in their natural condition from various localities contain a very variable absolute and relative amount of these two modifications of jargonium, and there seems good reason to believe that this difference in physical state may materially assist us in determining the temperature at which certain rocks have been formed. I have also met with one example of the third form of spectrum. A brown-red zircon from Ceylon was so dark in one part as to be quite opaque, and therefore I do not know what the original spectrum might have been. On heating it to redness, the whole became a clear pale green; and, without examination with the spectroscope, no one would have suspected any difference between the different portions. That which was originally a pale brown-red then showed the same spectrum as that usually developed by heat, whilst that which was originally very dark showed an entirely different spectrum, corresponding exactly with that of the borate deposited in blowpipe beads at a medium temperature. It also corresponds in general character, but not in detail, with that of the blue spinels from Ceylon, which must, I think, contain a small quantity of jargonium. That part of the zircon which gave this spectrum appears to have had the same remarkably low specific gravity of about 4.0, both before and after ignition, as though the volume of the silicate of jargonium in this state were even greater than in that which gives no bands. All these spectra, due to jargonium, are of a very marked character, and quite unlike those due to any other element in similar conditions.

The alteration produced in jargons by heat is, to some slight extent, analogous to what occurs on heating carbonate of lime in the state of arragonite; but, instead of changing into an opaque mass of minute crystals of another form of the carbonate (calcite), which has a less specific gravity, is less hard, and does not give a different spectrum, they are still as simple and transparent crystals as at first; the specific gravity and hardness are increased, and the spectrum is entirely changed. Iodide of mercury is an excellent illustration of an alteration in the spectrum, due to a change in crystalline form produced by heat; but still the facts differ most materially from those described, and there are only two modifications—the yellow and the scarlet. The existence of three crystalline modifications is similar to what occurs in titanous acid. Anatase, Brookite, and rutile have distinct crystalline forms, but they do not differ much in specific gravity, and their spectra present no characteristic differences. On the whole, the different states of carbon (charcoal, graphite, and diamond) are perhaps the best illustration of the existence of three different conditions in the same substance, since they differ materially in specific gravity and optical characters, one being black, the other having a metallic lustre, and the third being transparent and colourless; but these are variations of the element itself, and not, as in the case of jargonium, modifications of its compounds. So far as I am aware, there is indeed no substance which shows strictly comparable facts.

There cannot then, I think, be any doubt whatever that jargonium is not only a new elementary substance, but is also one likely to throw much light on several important physical questions. By the time that the Society resumes its meetings, I trust that I shall be able to send a complete account of the whole of my investigations, including such facts connected with other substances as may serve to illustrate the very peculiar properties of this hitherto unrecognized element.

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POSTSCRIPT. Received June 18, 1869.

I here subjoin a brief account of the methods employed by Mr. David Forbes\* and myself in separating zirconia and jargonium from one another. He separated apparently pure zirconia by means of strong hydrochloric acid, which dissolved the chloride of jargonium, but left chloride of zirconium undissolved; and obtained the approximately pure jargonium by adding to the solution excess of ammonia, and then considerable excess of tartaric acid, which left most of the tartrate of jargonium insoluble, but dissolved what may turn out to be a mixture of zirconia and jargonium with a third substance, not yet sufficiently studied—perhaps Svanberg's noria. My own analysis was only qualitative. I fused powdered jargon with several times its weight of borax, which gave a perfectly clear glass, completely soluble in dilute hydrochloric acid. After separating the silica in the usual manner, a slight excess of ammonia was added to the hydrochloric-acid solution of the earths, and then some oxalic and hydrochloric acids, which left undissolved apparently pure zirconia that had passed into an imperfectly soluble state. To the solution so much ammonia was added as to give a very copious precipitate, but yet to leave the solution with a very decided acid reaction. After removing the precipitate, which was chiefly oxalate of zirconia, almost or quite free from jargonium, excess of ammonia was added to the solution, and the washed precipitate digested in dilute hydrochloric acid, to remove peroxide of iron. The insoluble portion must have been approximately pure oxalate of jargonium, for it gave the characteristic spectra described below in remarkable perfection. Though this method succeeded far better than I anticipated, I do not yet understand the exact conditions requisite to ensure success, and have been prevented by absence from home from making further experiments.

IX. "Solar Radiation." By J. PARK HARRISON, M.A. Communicated by Prof. STOKES, Sec. R.S. Received June 12, 1869.

In a communication which the author had the honour of making to the

\* Chemical News, June 11, 1869, vol. xix. p. 277.

Red end.

Blue end.

Fig. 1.

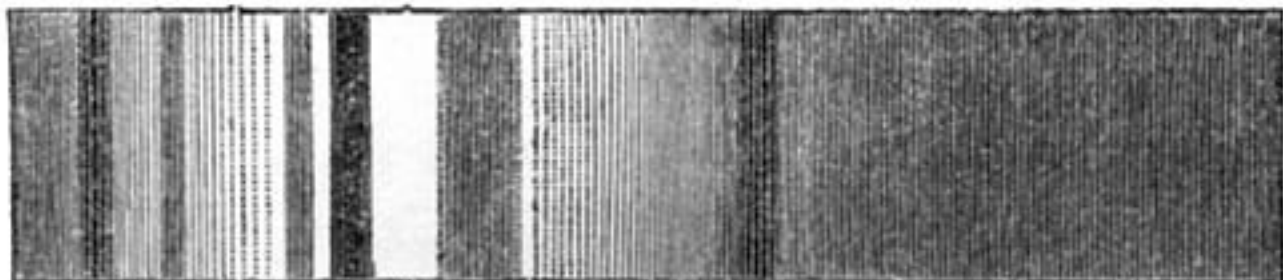


Fig. 2.

