XXX.—*On Sulphuret of Cadmium, or Greenockite, a new Mineral.* By ARTHUR CONNELL, Esq., F. R. S. E.

(Read 16th March 1840.)

This mineral is found embedded in small crystals in prehnite, at Bishop-town, in Renfrewshire. It had been long supposed by mineralogists to be a variety of zinc-blende; but it was first distinguished from that mineral by Lord GREENOCK, who communicated his opinion to Professor JAMESON; and two small crystals, together less than a grain in weight, were sent to me for chemical examination by the latter, who concurred in the supposition that it was a new mineral.

The crystals sent appeared to be six-sided pyramids, having the faces transversely streaked. Their colour was wine-yellow. Fracture, conchoidal. Lustre, shining or splendid, and vitreous. Hardness about that of calcareous spar; streak orange-red; semitransparent.

A small fragment heated in a glass-tube acquired a beautiful deep carmine-red colour, and on cooling recovered its yellow tint. At a red heat it did not fuse nor volatilize. These reactions at once distinguished the mineral from the native sulphurets of arsenic, to which it bore some external resemblance. In an open glass-tube, the appearances were exactly the same, even when urged by the blow-pipe; it became as before deep red, and on cooling recovered its yellow colour, retaining its lustre and transparency. When a somewhat larger fragment was heated in a glass-tube, it decrepitated violently before assuming the red tint, but no evolution of vapour was observed; and when the particles into which it separated were collected together into one place, and heated till almost black over a spirit-lamp, and then shifted into a different part of the tube, every depth of tint of red was observed according to the temperature.

In powder it was readily soluble in muriatic acid, by the aid of heat, exhaling a strong smell of sulphuretted hydrogen. Carbonate of soda caused a white precipitate, dissolved by ammonia. The muriatic solution by evaporation afforded a white prismatic crystallization, not deliquescent in an ordinary atmosphere. This character distinguished the mineral from zinc-blende, with which the previous reactions had closely corresponded, and suggested the idea that it might be sulphuret of cadmium, a supposition farther strengthened by finding the

above-mentioned change of colour by heat described by BERZELIUS as a character of the artificial sulphuret of cadmium. It was next found that the precipitates caused by potash and by carbonate of ammonia were not dissolved by excess of the precipitants. These reactions all tended to confirm the above idea of the nature of the contained metal; but what left the matter no longer doubtful, when taken in conjunction with the above-mentioned characters, was observing that a muriatic solution with excess of acid, gave a fine yellow precipitate, with a current of sulphuretted hydrogen, exactly similar to that obtained by the same means from a similar solution of metallic cadmium. When a precipitate was no longer caused by the current of sulphuretted hydrogen, and the solution of the mineral was then neutralized by ammonia, a few dark flocks fell of sulphuret of iron. Through the neutralized liquid a fresh current of sulphuretted hydrogen was passed, but no farther precipitation ensued, shewing the absence of zinc, a conclusion farther confirmed by finding that the excess of potash and of carbonate of ammonia, used as precipitants, took up nothing.

The muriatic solution of the mineral gave a yellow precipitate with hydrosulphuret of ammonia, and white precipitates with prussiate of potash, oxalate of ammonia, and phosphate of soda; and no precipitate with sulphuric acid. A piece of zinc threw down reduced metal as a grey ramification.

These various reactions left no doubt that the mineral under examination was sulphuret of cadmium; that it contained no sensible admixture of zinc; and that the only impurity which could be detected was a slight trace of iron. The different observations were farther confirmed by comparative trials made on a solution of metallic cadmium. It was therefore quite evident that the mineral was not only a new one, but one of much interest, since, so far as I know, no *separate* ore of cadmium had ever before been discovered; that metal having hitherto been found merely as a constituent, or more probably as an admixture, in certain ores of zinc, to the extent of a few per cents.

The materials sent to me by Professor JAMESON gave no farther means of prosecuting the examination of the mineral, either chemically or in relation to specific gravity; but by the kindness of Lord GREENOCK, I was furnished for these purposes with the largest, although not the most perfectly formed, crystal which I have yet had an opportunity of seeing. His Lordship has also lately obtained one very finely crystallized specimen, although not of a large size, which is evidently a six-sided pyramid, without any transverse streaking of the faces, and terminating in a short six-sided prism; but as the crystalline form of the mineral is under investigation by Professor JAMESON, and there are some modifications which will require a careful examination, I wish to say nothing farther on the subject of its crystallization, except as respects the particular crystal analyzed.

This large crystal was a somewhat imperfectly formed six-sided pyramid, one of the faces of the pyramid being apparently obliterated by the extension of the two contiguous; the faces being transversely streaked, and with traces also of a six-sided prism. It possessed a slightly reddish yellow colour, and considerable transparency, except in one or two small points, which were dark coloured and opaque. Its streak was orange-red as that of the others. When detached it weighed 3.68 grains. Suspended in distilled water by a fine hair, it lost .76 of a grain, giving its specific gravity as 4.842 at 60° F.; which thus considerably exceeds the specific gravity of zinc-blende. I then detached from it the darker and opaque particles, and substituted for them a small quantity of yellow and transparent portions from another crystallized specimen, also given me by Lord GREENOCK.

3.71 grains thus selected were reduced to somewhat coarse powder, and fuming nitric acid was poured on them, drop by drop, in a deep flask. The action was violent, and attended by a copious evolution of red fumes, but not the least smell of sulphuretted hydrogen was observed. An excess of nitric acid was then added, and the whole digested till all the sulphur which had separated was dissolved. Water was then added, and the sulphuric acid thrown down by muriate of barytes. The sulphate of barytes, after being well washed with hot water, was dried and ignited, and weighed 6.07 grains, equivalent to .837 of sulphur.

The excess of barytes was then removed from the liquid, after concentration by heat, by sulphuric acid. After again concentrating, carbonate of ammonia was added in excess. The carbonate of cadmium was separated by filtration, and well washed, dried, and ignited. The oxide of cadmium thus obtained had an ochre-yellow colour, and weighed 3.28 grains, equivalent to 2.868 of cadmium. A little of it dissolved in muriatic acid, was entirely taken up by excess of ammonia.

The filtered liquid was then evaporated by heat, but no precipitation had taken place when all smell of carbonate of ammonia had disappeared; thereby confirming the previous observations as to the absence of zinc. The evaporation was carried to dryness, and the ammoniacal salt driven off by heat. A residue of .04 remained, of a reddish-white colour, which, in so far as its small quantity permitted examination, was found to be, in part at least, a subsulphate of iron, insoluble in water, and scarce soluble even in acids till previously boiled with potash; but as the proportion of its constituents could not be determined on so little material, the iron could not be computed in any other way than by stating it as a trace in the mineral, its amount, on any view, being very small; and if more than such, this was not the stage of the analysis in which it ought to have been obtained.

We have thus, in the 3.71 grains of the mineral under analysis,

Sulphur,		.837	22.56
Cadmium,		2.868	77.30
Iron, traces,			
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		3.705	99.86

which agrees completely with the theoretical composition of

1 atom Sulphur,		201.16	22.40
1 atom Cadmium,		696.76	77.59
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		897.92	99.99

The mineral is thus a protosulphuret of cadmium, and its formula Cd S.

It is thus evidently, both physically and chemically, a perfectly well characterized and distinct species. The mineral which it ranks nearest in the system is zinc-blende, but from this it differs essentially, not only in its chemical nature, but in its external characters, such as specific gravity, and form of crystallization. I believe a ready mode of distinguishing it from the transparent yellow blende, which it resembles a good deal, and with which it was long confounded, is afforded by the streak, that of the latter being white, whilst that of sulphuret of cadmium is orange-red. The property of becoming red by heat, and returning to yellow on cooling, is possessed in a slight degree by yellow zinc-blende; but the colour which this latter mineral acquires is not carmine, but a sombre rose tint, and never becomes very deep; and by a repetition of the heating process, when carried to redness, it gradually loses the property altogether, along with its transparency; whereas the sulphuret of cadmium may be ignited as often as thought proper, without losing the property or its transparency. This quality, to the extent in which zinc-blende possesses it, does not appear to depend in that mineral on the presence of cadmium, for I was unable to detect that metal in a crystallized and transparent yellow zinc-blende from the Hartz, belonging to Mr ROSE of this city, which acquired a rose tint by heat; and it is scarce necessary to say, that the quality is not possessed by the artificial white sulphuret of zinc thrown down by sulphuretted hydrogen. It therefore appears to depend, in zinc-blende, on the arrangement of particles in crystallization; whilst, in sulphuret of cadmium, it is an inherent quality of the substance, being possessed in perfection by the artificial sulphuret of cadmium, got by sulphuretted hydrogen.

The reactions before the blowpipe may also serve to distinguish the two minerals. It is difficult to act on sulphuret of cadmium, *per se*, from its decrepitating property; but when this can be accomplished on charcoal, the usual yellowish-red ring, arising from the oxidation of sublimated cadmium, is formed around the fragment. When mixed with soda, and acted on, on charcoal, this

ring continues to be formed to the last, whilst, with zinc-blende and soda, a white ring is formed; and in those zinc-blendes which contain a little cadmium, the red ring, according to BERZELIUS, is formed at first only, and is succeeded by the white sublimate of zinc. With borax, the sulphuret of cadmium gives a transparent yellow glass.

I was extremely happy to find, that the idea had occurred to Professor JAMESON, which was early suggested to myself, that the mineralogical name of this substance should be derived from that of the distinguished nobleman who first observed it; and it is satisfactory to think, that the beauty of this mineral, and its interesting nature and properties, render it not altogether unworthy of being associated with Lord GREENOCK's name. I cordially concur in the name of Greenockite, which has been already proposed for it by Professor JAMESON.

It is already known that the artificial sulphuret of cadmium may be used as a pigment. This will also apply to the native, if it could be got in sufficient quantity. I have had some experiments made on a minute scale with this view, with the finely ground powder of the mineral, used as a water colour. Its tint is an orange-yellow, differing from that of any of the ordinary yellow pigments. Mixed with blue it gives a green.

Since the above paper was read, Mr NICOL has informed me that he has satisfied himself that Greenockite possesses the property of depolarizing light. Professor FORBES has also obtained distinct proof of the same fact; and has farther observed a curious effect of dichroism by polarized light, which does not take place with common. These observations lead to the same conclusion which its apparent crystalline form suggested, that the mineral does not belong to the tessular system. But farther investigation is probably necessary to determine whether the form belongs to the rhombohedral system, as the fine crystal already referred to would seem to indicate, or to the prismatic, as the observations of Mr BROOKE, published by Professor JAMESON (*Ed. Phil. Journ.*) since this paper was read, would appear to suggest.