Rare zinc-copper minerals from the Rhodesian Broken Hill mine, Northern Rhodesia.

By F. P. Mennell, F.G.S., M.I.M.M.

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AMONG the lead and zinc minerals which occur in the Rhodesian Broken Hill mine workings at what used to be No. 1 Kopje (now represented by a hole in the ground) copper compounds are occasionally to be seen. Their quantity is always very small,[1] but they are readily noticeable on account of their colour. They include malachite, chessylite, cuprite, copper-glance, and undetermined phosphates, and, what is more interesting, double salts of copper and zinc.

One of these is a pale bluish-green material often forming hair-like crystals, lining cavities in the oxidized zinc ore. It dissolves in acids with effervescence, yielding a solution which reacts for copper and zinc, while the crystals examined under the microscope are optically biaxial and give straight extinction. Water is given off in the closed tube, leaving a black residue. This mineral is no doubt *aurichalcite*, the hydrated basic carbonate of zinc and copper.

The copper phosphates[2] referred to above usually occur as greenish incrustations on other minerals, and are often intimately mixed with parahopeite. It has so far proved impossible to collect any of them free from admixture in appreciable quantity, although they are not particularly uncommon.

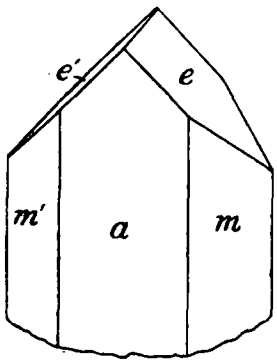
There is another, however, far rarer, which occurs as groups of independent blue crystals on the southern margin of the lead ore-body close to its junction with the enclosing zinc ore. In spite of careful search, little more than a gram of this mineral has been collected, but owing to its well-crystallized condition its characters are readily determinable. It was at first thought probable that it was new, perhaps related to the monoclinic copper-zinc arsenate barthite described from

[1] The average amount of copper in the ore is estimated at about 0·035 per cent.

[2] An undetermined mineral, probably a copper phosphate, is mentioned by L. J. Spencer in his description of the minerals from this mine. Mineralog. Mag., 1908, vol. 15, p. 2.

Otavi in South-West Africa by Henglein and Meigen.[1] The large amount of water present, however, contradicted this assumption, and suggested *veszelyite*,[2] which a study of the crystalline form seems to confirm, although not entirely in accord with Schrauf's original conclusion. The following are the characters of the mineral from the Rhodesian Broken Hill mine:

Monoclinic, with the forms a (100), m (110), e (011). A minute pyramidal face was also noted on one crystal. The small, tabular crystals are flattened parallel to a (100) and are generally aggregated together in sub-parallel or divergent groups. There is no good cleavage, crushed fragments being very irregular in shape. Measurements made with the aid of the rotating stage and cross-wires of an ordinary petrological



Crystal of Veszelyite from Broken Hill, Rhodesia.

microscope gave the approximate values $ee' = 85°$, $mm' = 70°$, edge ee' to edge mm' (i. e. the angle β) $= 76°$. Colour, deep ultramarine-blue. Streak, nearly white. The mineral is perfectly transparent, with vitreous lustre; it is not pleochroic. The refractive index is moderate and the double refraction strong. Gives straight extinction. Dispersion, $\rho < \nu$. Hardness $3\frac{1}{2}$–4.

Crystals examined under the microscope through a show, in polarized light, a complicated system of twin-lamellae at and near the position of maximum darkness. They appear to be divided in two longitudinally, with fine striations inclined at about 45° to the dividing line on either side and therefore parallel to the dome-faces e. The result is a sort of

[1] M. Henglein and W. Meigen, Centralblatt Min., 1914, p. 353.

[2] A. Schrauf, Anz. Akad. Wien, 1874, p. 135; Zeits. Kryst. Min., 1879, vol. 4, p. 31; see also Dana's Mineralogy, 6th ed., 1892, p. 841.

herring-bone structure, and the appearance of a section showing it is extremely similar to that of a cubic mineral with anomalous double refraction. This polysynthetic character is not visible in the more highly illuminated positions, and the crystals examined through *a* show in convergent light an optic axis on the edge of the field of view.

The composition is that of a hydrated basic phosphate of zinc and copper, as determined by blowpipe and other reactions.[1] An analysis unfortunately came to a premature end owing to an explosion in the laboratory which broke the beaker containing the solution and nearly had serious consequences to the analyst, Mr. G. C. Norris, B.A., assistant chemist at the mine. The water only had been determined: this amounted to 17·62 per cent. Heated in the bulb-tube before the blowpipe, the mineral blackens with very little decrepitation, giving off water. Flame coloration, green. Readily soluble in cold hydrochloric acid, and even more so after ignition, yielding a green solution. This reacts for zinc, copper,[2] and phosphoric acid: it seems to contain little or no arsenic. The mineral is also slowly soluble in ammonia, yielding a deep-blue solution.

It will be seen that the angles of the crystals correspond well enough with those given by Schrauf for veszelyite, as shown below:—

Rhodesian Mineral.		Veszelyite (Schrauf).	
ee'	= 85° about	mM	= 84° 47′
mm'	= 70 „	$e\epsilon$	= 70 43 — 70° 51′
edge $ee' : mm'$	= 76 „	edge $e\epsilon : mM$	= 76 10

Schrauf gives a triclinic axial system, but this is rejected by Dana, with a considerable show of reason. Mr. L. J. Spencer kindly examined a minute specimen showing a few crystals. He also informs me that the British Museum specimen of veszelyite, from Moravicza, Hungary, shows crystals of the habit figured by Schrauf (fig. reproduced by Dana), which differ from the Rhodesian crystals in the absence of the plane *a* (100); also that these crystals are greenish-blue rather than blue. In this respect it differs from the Rhodesian specimens, which are a particularly fine blue. The difference in colour may, perhaps, be due to the presence of a notable amount of arsenic in the original veszelyite (10·41 per cent. As_2O_5). It may also be stated that some of the blue Broken Hill crystals showed greenish edges, evidently due to incipient alteration.

[1] Veszelyite seems to have the composition $7(Cu,Zn)O.(P,As)_2O_5.9H_2O$. Water found 17·05 (Schrauf), calculated 18·1 per cent.

[2] After removal of the copper as sulphide, there is a copious zinc precipitate with potassium ferrocyanide.

As it appears to be mainly phosphate, the Rhodesian mineral might be claimed as new. The original veszelyite, however, has a P : As ratio of 3 : 2, and it is perhaps best to keep the name veszelyite for all varieties in which the phosphate molecule predominates, though it is unfortunate that the original description was of an intermediate stage between arsenate and phosphate. It will be noted that the orthopinacoid *a*, which is the dominant form on the Rhodesian crystals, is new, and renders them very different in appearance from the original specimens of veszelyite, as will be seen from the figure. Veszelyite has hitherto been recorded only from a single locality in Hungary, where it appears to be quite rare.

ADDENDUM BY L. J. SPENCER.

The very small specimen sent by Mr. Mennell in the folds of a letter shows the sky-blue crystals with brilliant colour and lustre, and measuring about 1 mm. across. They are grouped in sub-parallel positions; the faces *a* and *m* are much striated parallel to the prism-edge, and the *e* faces are striated parallel to the edge *ae*. Consequently only approximate measurements could be obtained on the goniometer. The means obtained from four crystals are $am = 34\frac{1}{2}°$ (limits 31°–37°), $ee' = 85° 35'$ (85° 29′–85° 40′), and $ae = 80°$ (78°–82°). From these angles the axial ratios are calculated as $a : b : c = 0{\cdot}71 : 1 : 0{\cdot}95$, $\beta = 76\frac{1}{3}°$. The plane of the optic axes is parallel to the plane of symmetry, and through the tabular face *a* one axis emerges just outside the field of view. The other axis is visible through *e*. The acute positive bisectrix lies in the acute angle β at about 33° to the vertical *c*-axis, and the optic axial angle, 2H in olive-oil, is about 43°. The refractive index is about 1·63. Crystals sink in methylene iodide, indicating that the specific gravity is greater than 3·33.