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On Hamlinite from the Binnenthal, Switzerland.

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IN a paper read before this Society in 1904[1], dealing with a number of new minerals from the Binnenthal dolomite, Mr. R. H. Solly described under the name of bowmanite some small, honey-yellow crystals belonging to the rhombohedral system and forming either hexagonal plates or combinations of rhombohedron and basal planes of octahedral habit. Mr. Solly afterwards handed over the small amount of available material to me for further examination.

In density, hardness, cleavage, habit, and sign of birefringence, the crystals were found to resemble hamlinite, the phosphate of aluminium and strontium, described by W. E. Hidden and S. L. Penfield[2] from the herderite locality at Stoneham, Maine, and later by Penfield[3] from Oxford Co., Maine. They differed from this mineral, however, in being pseudo-hexagonal—the hexagonal plates showing a division into biaxial sectors, while hamlinite from Stoneham was stated to give a perfectly normal uniaxial interference-figure.

The quantity of material (amounting only to a few milligrams) was too small to admit of an analysis being made, but from qualitative tests of a few minute grains, the mineral appeared to be a phosphate of lime and alumina, with small amounts of iron, water, and possibly magnesia. In the light of later work, however, it seems probable that the calcium and magnesium found here may have been derived from traces of dolomite.

Since that time Mr. Solly has kindly obtained for me some more specimens, found in 1905 and 1906, so that I have been enabled to make a more detailed study of the mineral and to collect sufficient pure material for some quantitative experiments, which have resulted in its identification with hamlinite.

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[1] Min. Mag., 1905, vol. xiv, pp. 72-82.

[2] Amer. Journ. Sci., 1890, ser. 3, vol. xxxix, p. 511.

[3] Ibid., 1897, ser. 4, vol. iv, p. 313.

Occurrence.—The crystals, which rarely exceed 1 mm. in diameter (the largest I have seen being a hexagonal plate 1·3 mm. in diameter and 0·7 mm. in thickness), and are usually much smaller, occur on the surface of cracks and cavities in the white dolomite, associated with hyalophane, colourless crystals of barytes, and modified rhombohedra of dolomite, often lining the surface; sometimes also small, colourless crystals of quartz and minute, black crystals of rutile. The dolomite is generally rich in brown flakes of biotite and often contains granular iron-pyrites, while crystals of blende and iron-pyrites are also present on some specimens. In one case, some crystals of hamlinite are scattered over the surface of a rough prism of rathite. Perfect, symmetrically-developed crystals of hamlinite frequently occur embedded loosely in a white, powdery material, from which they are easily freed by rubbing between the fingers.

Crystalline Form.—The crystals are very simple, the only forms observed being $c\{111\}$ and $r\{100\}$, of varying relative sizes, sometimes with minute faces of $f\{11\bar{1}\}$ on the edges or corners.

Two types of habit may be distinguished, viz. (1) flat hexagonal plates with modified edges, sometimes aggregated in rosettes, and (2) stouter crystals showing the unit rhombohedron and resembling either octahedra or cubes according to the size of the faces of $c\{111\}$.

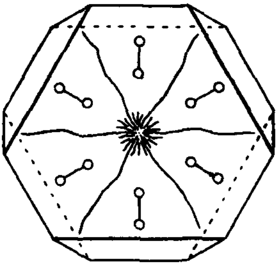
The crystals are generally very symmetrically developed, but the facets are almost always uneven and do not yield good reflexions of the signal. Measurements between faces giving only single images, on four tabular crystals, gave values varying between 53° 44′ and 55° 49′ for the obtuse angle cr, and between 123° 44′ and 125° 52′ for the corresponding acute angle, the means being 54° 58½′ and 125° 4½′ respectively.

This agrees well with the measured angle found by Penfield (about 55°), though the angle adopted by him (calculated from $rr = 87^\circ\, 2'$) was $cr = 52^\circ\, 40'$.

There is a good cleavage parallel to $c\{111\}$.

The colour varies considerably, crystals ranging from nearly colourless to reddish-brown. The flat, hexagonal crystals are characteristically pale in colour with a brown spot in the centre.

Optical Properties.—Some of the smaller, tabular crystals appear isotropic under the microscope (except at the extreme edges), and in convergent light show a normal uniaxial interference-figure, with moderately weak, positive birefringence; but larger ones always show a division into six, more or less regular, triangular, biaxial sectors, which possess weak birefringence compensated by a quartz-wedge inserted radially. The sectors are separated by wavy, dark lines along which, and also at the centre of the crystal, the interference-figure is uniaxial (see fig.). The sectors extinguish together in pairs, roughly parallel to the corresponding edge of the hexagon, and each gives a positive biaxial figure with the axial plane nearly perpendicular to that edge. The axial angle (2E) varies from 0° up to about 50°.



Optical orientation of hamlinite from the Binnenthal.

Thus the crystals are pseudohexagonal, the variation in the optical properties being due to the overlapping of twin-lamellae parallel to the cleavage, as in the case of the micas, chlorites, &c.

The angles between the edges of the hexagonal plates do not appear to be exactly 60° (values were observed varying between 58½° and 62°), while the extinction-directions in the sectors are frequently not quite parallel to the edges, but deviate sometimes as much as 5° from this position, and on adjacent sectors include angles of 57°–63°.

The symmetry of the component crystals may thus be lower than that of the orthorhombic system, but the observations are not sufficiently concordant to warrant any definite conclusions being drawn from them.

The darker (reddish-brown) crystals are slightly pleochroic, when viewed along the plane of cleavage, vibrations parallel to the cleavage (ω) being reddish-brown, while those perpendicular to it (ϵ) are yellow.

Specific Gravity.—The density of twelve selected crystals, apparently quite pure, was determined by means of methylene iodide and a Westphal's balance, and found to vary from 3·219 up to 3·266. That of hamlinite from Stoneham is given as 3·228, while the crystals from Oxford Co. analysed by Penfield varied between 3·159 and 3·283.

The hardness is about 4 or rather more.

Chemical Composition.—The mineral is insoluble in hydrochloric acid, as sharp crystals, after boiling with the acid, showed under the microscope no sign of being attacked and were unchanged in colour; they are, however, readily decomposed on fusion with alkaline carbonates.

The results of a preliminary examination, made on 0·0659 gram of slightly impure material, which proved to contain about 6 per cent. of silica (probably from admixed hyalophane), are given in column I of the table. The powder (dried at 98° C.) was ignited in a platinum crucible to constant weight. It was then fused with alkaline carbonates, dissolved in nitric acid, and the phosphoric acid precipitated (after separation of the silica) by ammonium molybdate and weighed as magnesium pyrophosphate. The estimation of alumina and the other constituents could not be carried out owing to the presence of impurities in the ammonium molybdate used.

An attempt was then made on the main portion of pure material (0·1127 gram) to determine the water directly by Penfield's method (column II). The powder was heated to low redness in a boat of platinum-foil, and the water found amounted to 12·4 per cent., while the loss of weight of the boat was 12·9 per cent. The water was markedly acid, and probably contained a little hydrofluoric acid, as the glass was slightly attacked and the outside of the boat showed a slight deposit of silica. The cause of the low value here obtained is probably an insufficiently high temperature, as it was afterwards found that intense ignition was required to drive off the last portions—whether of water or fluorine. Owing to the small amount of material available, no attempt has been made to determine the proportions of these two constituents.

	I.	II.	III.	IV.	Penfield.
P_2O_5	24.2	26·1	...	...	30·31
Al_2O_3	...	35·6	...	...	32·65
SrO	...	...	19.2	20·5	19.29
BaO	...	...	0.2	0·1	4·08
H_2O	...	[12·4]	...	...	12·48
F	...	...	...	...	2·04
Loss on ignition	15·6	[12·9]	15·6	16·0	
K_2O	...	...	...	0·4	
SiO_2	5.9	3·8	0.9	0·7	
Insoluble in HCl	...	...	2·1	...	

The silica and phosphoric acid were determined as before. The figure for alumina is probably not very reliable, owing to the difficulty of separating it from the large amount of molybdic acid present.

As the numbers so far obtained approximated to those given by Penfield for hamlinite from Oxford Co., Maine (quoted in the last column), I made a direct test for barium and strontium, without previous separation of phosphoric acid.

Columns III and IV give the results of two determinations made with 0·0340 and 0·0568 gram respectively of a fresh sample of material. They may not therefore be quite comparable with the previous determinations. The loss of weight was determined in a platinum crucible and was found to be complete only after long and intense ignition. The powder, which was found to be slowly soluble after ignition, was dissolved in hydrochloric acid, the silica separated by evaporation in the usual way, and barium and strontium then precipitated as sulphates. On applying Fresenius's method of separation by double precipitation with ammonium chromate, as used by Penfield for hamlinite, barium was found to be present only in traces.

Considering the small amount of material used, the agreement with Penfield's numbers for hamlinite, when taken in connexion with the similarity in crystalline characters, appears to be sufficiently close to prove the identity of the two minerals. The difference in the optical characters is only such as might be expected in a pseudosymmetric substance, and may possibly be connected with the difference in the mode of occurrence,—the hamlinite from Maine being found in granitic rock, associated with herderite and bertrandite.