

COMMUNICATIONS FROM THE OXFORD MINERALOGICAL
LABORATORY. NO. XIV.

On the identity of Poonahlite with Mesolite.

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[Read January 26, 1909.]

Introductory and Historical.

AMONG the zeolite specimens from the neighbourhood of Bombay in the Oxford University Collection are several of the well-known type, showing pale green crystals of apophyllite associated with white stilbite and white silky needles labelled as 'poonahlite', on a matrix of purplish-brown amygdaloid, with a layer of a bluish-green, earthy mineral lining the amygdules and underlying the zeolites.

The name poonahlite was originally given by H. J. Brooke,¹ in 1831, to a mineral occurring on specimens which he had received from Henry Heuland. He states that the poonahlite formed slender crystals accompanying apophyllite from Poonah, and was at first taken for mesotype or needlestone, but that it had a prism-angle of $92^{\circ} 20'$. He mentions also that the crystals traversed the mass of the apophyllite and matrix, and among several hundred crystals which he had examined, he had not observed one with a natural termination.

This description so exactly fits the specimens at Oxford that there can be little doubt that these represent the material described by Brooke; and the matter is placed beyond question by the fact that a similar specimen in the British Museum was bought as poonahlite at a Heuland sale in the very same year in which Brooke's description was published.

The only point on which there appears to be a discrepancy is the angle of the prism, which is given by Brooke as $92^{\circ} 20'$, while the

¹ H. J. Brooke, *Phil. Mag.*, 1831, ser. 2, vol. x, p. 110. A. Dufrénoy ('*Traité de Minéralogie*,' 1847, vol. iii, p. 428) wrongly attributes the name to Gmelin, who, however (*Ann. Phys. Chem. (Poggendorff)*, 1840, vol. xlix, p. 538), speaks of it as having been given by Brooke.

Oxford crystals have angles lying within a few minutes of $91^{\circ} 29'$, as stated below. That there is no great variation in the angles of crystals on different specimens is indicated by the fact that a crystal from a specimen in the British Museum has angles of $91^{\circ} 20'$ and $91^{\circ} 32'$, while one which Mr. A. Hutchinson has kindly sent me from Cambridge has $91^{\circ} 29'$ ¹

Since Brooke's time, material described as 'poonahlite' has been variously identified by different writers with scolecite and with mesolite.

Gmelin,² in 1840, gave an analysis of 'poonahlite' from Poonah, associated with apophyllite and apparently similar to that named by Brooke, which showed only 0.66 % of soda, but an excess of about 4 % of alumina at the expense of lime as compared with scolecite of the formula $\text{CaAl}_2\text{Si}_3\text{O}_{10} \cdot 3\text{H}_2\text{O}$.

Kenngott³ described yellowish-white and translucent, to colourless and transparent, crystals with a prism-angle of $91^{\circ} 49'$, associated with apophyllite from Poonah, and identified them with antrimolite, i. e. with mesolite, to which this name had been given by Thomson in 1836. His material was not analysed, and he merely quoted Gmelin's numbers as having settled the composition of poonahlite. Apart from the yellowish colour, Kenngott's crystals appear to have agreed closely in character and association with those described below, except that small, greyish-white, spherical groups of herschelite⁴ [= chabazite] are mentioned, along with the apophyllite and stilbite.

Petersen⁵ analysed some 'vitreous to silky, white to colourless, thin crystal-bundles and prismatic aggregates' sometimes over an inch long, of a zeolite from Poonah, occurring in a melaphyre-amygdaloid with apophyllite. His analysis showed this 'so-called poonahlite' to be scolecite.

In 1881, Luedecke⁶ examined crystals 'from Kandallah' and found

¹ In addition to the direct reflections from the faces, the transparent crystals also yield on the goniometer very distinct images by internal reflection at the back faces, and it is possible that these may have led to some confusion in Brooke's measurements.

² C. G. Gmelin, *Ann. Phys. Chem.* (Poggendorff), 1840, vol. xlix, p. 538.

³ G. A. Kenngott, *Sitz.-Ber. k. Akad. Wiss. Wien*, 1850, vol. v, p. 237; Kenngott's *Uebers. mineralog. Forschung*, for 1850-1, 1853, p. 82; Haidinger's *Ber.*, 1851, vol. vii, p. 189.

⁴ Some of the Oxford specimens show small globules, which, however, are probably gyrolite.

⁵ T. Petersen, *Neues Jahrb. Min.*, 1873, p. 852.

⁶ O. Luedecke, *Neues Jahrb. Min.*, 1881, vol. ii, p. 14.

them to be scolecite. This seems to have been taken by Hintze¹ as proving poonahlite to be scolecite and not mesolite; but there is nothing to show that Luedecke's material was similar to Brooke's.²

An analysis, quoted by Hintze, of scolecite 'from the East Indies' by W. J. Taylor,³ clearly refers to a different occurrence, as the author speaks of 'globular masses, of a radiated structure, 5 to 6 inches in diameter'.

An analysis by Collier, published in the fifth edition of Dana's 'System of Mineralogy' (1868, p. 429), of a zeolite from 'the Ghauts' having the composition of scolecite, may possibly also refer to another mineral.

Occurrence and Associations of Poonahlite.

Some time ago, certain brilliant, colourless prisms, occurring on one of the Oxford specimens (Reg. No. 1339) and similar to the silky needles in size and habit, attracted my attention as being excellently suited for optical examination.

The microscope showed at once that they could not be scolecite, as the plane of the optic axes was found to be transverse to the prism. On the other hand, the optical characters did not appear to agree with those of mesolite; which, however, were at that time but very imperfectly known.⁴ It thus became necessary to determine the composition of the crystals, and an analysis was made, of which the results are given in the table below.

The specimen above referred to consists of white, sheafy stilbite crystals (2 cm. diameter) with pale green crystals of apophyllite, of 7 mm. diameter, showing the forms $a \{100\}$, $c \{001\}$, $p \{111\}$, as well as masses of small, colourless crystals of the same form and about 1 mm. diameter. The poonahlite forms brilliant, square, transparent prisms, up to $2\frac{1}{2}$ cm. long and 1 mm. in diameter, which are partly or entirely embedded in the apophyllite and stilbite. In addition to these there are also some silky-white, radiating groups (2 cm. radius) of more or less perfectly crystallized prisms, which are identical in their optical properties with the transparent crystals. The groups are sometimes

¹ C. Hintze, 'Handbuch der Mineralogie,' 1897, vol. ii, p. 1704.

² The well-known magnificent specimens of stilbite, apophyllite, scolecite, and other zeolites from Poonah, were obtained during the construction of the Great Indian Peninsula Railway. This, however, was not made till 1851, i. e. long after the description of poonahlite by Brooke.

³ See F. A. Genth, Amer. Journ. Sci., 1854, ser. 2, vol. xviii, p. 410.

⁴ Compare C. Hintze, 'Handbuch der Mineralogie,' 1897, vol. ii, p. 1706.

compact, like some varieties of natrolite, but commonly consist of well-defined square prisms (often almost perfectly transparent) lying loosely among white, cottony fibres. The transparency of the prisms usually increases from the centre towards the periphery of a group, and the silky appearance is due to the inclusion of some of the fibres in parallel position. Examination of the fibres in oil under the microscope shows that, though they are exceedingly fine, their optical properties are probably the same as those of the prisms of poonahlite. No attempt has been made to separate them from the silky crystals, which were merely cleaned by rolling between the fingers.

Chemical Composition.

The whole of the material used for analysis was obtained from this specimen. It was very carefully purified (an easy matter, owing to the perfect prismatic cleavage), and the whole of it was passed under the microscope between crossed nicols and ascertained to be free from all traces of apophyllite and stilbite.

A preliminary qualitative examination of some of the silky crystals showed the presence of alumina, lime, and soda, and the absence of magnesia.

Preliminary experiments showed, further, that drying the powder in a water-oven at 97°–100° C. caused but a very slight loss of weight, quite sufficiently accounted for by an increase, due to absorption of moisture, which had been observed on grinding the crystals. A low red-heat was found to be required for the complete expulsion of the water, and no further loss was caused by ignition at bright redness.

The ignited powder, even when not sintered, dissolved with extreme slowness in hydrochloric acid; and it was, therefore, necessary to use separate portions for the estimation of the water and the other constituents. Three determinations were made, using respectively transparent prisms only, silky prisms only, and some of a mixture of both kinds which was used for the main determination of the silica and bases. The results are given in columns I, II, and III. Considering the small quantities used, the slight differences found can hardly be taken to indicate an actual difference in composition between the silky and transparent crystals.

Two determinations of the silica and bases were made with the mixture of silky and transparent material; and the results are given in columns IV and V. The method of analysis was the same in both cases. The powder, dried at 97°–100°, was dissolved (without difficulty) in

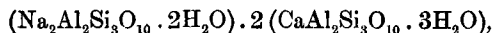
hydrochloric acid, giving a gelatinous mass; and the silica was determined, after a double evaporation, by the loss of weight of the ignited residue caused by fuming with hydrofluoric acid.

In the filtrate from the silica, after removal of most of the acid by evaporation, the alumina and lime were precipitated together, boiling, with ammonia and ammonium carbonate. The precipitate was redissolved in hydrochloric acid, the solution heated to expel carbonic acid, and the alumina separated by hot precipitation with ammonia. The precipitate of alumina was washed with ammonium nitrate solution, and in the case of no. V reprecipitated after solution in nitric acid to remove suspected traces of lime. The lime was estimated in the filtrate by precipitation with ammonium oxalate, and conversion into carbonate.

In the filtrate from the lime and alumina, the total alkalis were estimated as chlorides, after expulsion of the ammonium chloride. A trace of potash was then precipitated with platinum chloride, and the soda obtained by difference.

	I.	II.	III.	IV.	V.	Mean.	Meso- lite.
Weight of substance.	0.0959	0.0878	0.0581	0.2451	0.2494	—	
SiO ₂	—	—	—	46.92	46.51	46.71	46.5
Al ₂ O ₃	—	—	—	26.36	26.54	26.45	26.2
CaO	—	—	—	9.31	9.40	9.35	9.6
Na ₂ O	—	—	—	5.33	5.32	5.33	5.3
K ₂ O	—	—	—	0.11	0.11	0.11	—
H ₂ O	12.72	12.41	12.56	—	—	12.56	12.4
Total	—	—	—	—	—	100.51	100.0

The presence of 5% of soda shows that the present crystals must be referred to mesolite. Their composition, like that of much typical mesolite, agrees indeed with that of a double salt of one molecule of natrolite with two of scolecite, i. e.



which is given for comparison in the last column of the table.

The optical characters also, given below, agree well with those of mesolite from the Færoes, of which a description has quite recently been given by R. Görgøy,¹ who accepts the formula mentioned.

¹ R. Görgøy, Min. Petr. Mitt. (Tschermak), 1903, vol. xxvii, pp. 255-256.

Geometrical and Physical Properties.

In no case have end-faces been observed, but the crystals admit of a very exact determination of the prism-angle, *mm*. Eleven measurements of this angle, made on six selected crystals giving only first-class reflections, gave values varying between $88^{\circ} 28'$ and $88^{\circ} 32'$, the mean being $88^{\circ} 30' 49''$. No other forms than *m* appear to be present.

There is an exceedingly perfect cleavage parallel to the faces of the prism *m*; and the crystals commonly break across about at right angles to their length, but the cleavage (if there be one) in this direction is not sufficiently good to yield a reflecting plane.

The density of three small transparent prisms, determined by means of methylene iodide and a Westphal balance, was found to lie between 2.264 and 2.272.

The appearance of the transparent poonahlite crystals under the microscope between crossed nicols is very striking and characteristic, as they show through a pair of prism-faces brilliant blue or brownish-yellow colours, which are often visible side by side in patches or in more or less regular longitudinal stripes, and are independent of the thickness of the crystal. The colours disappear when the crystal lies parallel to one of the principal planes of the nicols. Some few crystals appear almost isotropic.

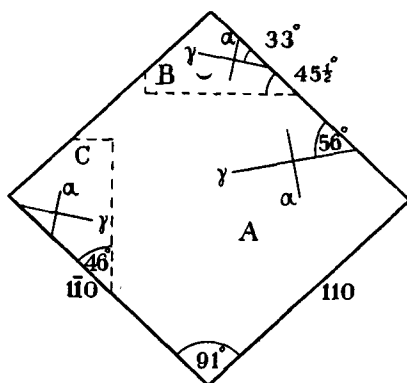
Examination in convergent light shows that the colours are due to the emergence of an optic axis with strong axial dispersion, nearly perpendicular to each of the prism-faces. The axial bar is usually well defined and coloured strongly blue and yellow on its two edges, but occasionally it appears blurred. The inclination of the axis varies slightly, the blue edge of the bar being central in the blue areas, and the yellow edge in the yellow areas. The transverse section described below indicates that this variation is caused by twinning. The blurring of the axial bar, as well as the isotropic character of some of the crystals, is probably also due to twinning.

The plane of the optic axes is thus transverse to the prism, and the axial angle ($2V$) approximately 90° .

A section of a crystal ground parallel to a plane truncating the acute edge of the prism showed a longitudinal junction, indicative of twinning, and the two portions gave extinction angles of 3° and $3\frac{1}{2}^{\circ}$ on either side of the junction in sodium-light. Convergent light showed a central positive bisectrix, with ill-defined axial brushes just visible at the edge of the field. The whole of the field was coloured blue except the small areas outside the brushes, which were yellow.

A section truncating the obtuse prism-edge showed a very similar appearance, with traces of a longitudinal division into two parts having their extinction-directions inclined to one another at a small angle (2° - 3°). Convergent light here showed a normally emergent, negative bisectrix of wide axial angle.

A third section, of 0.6 mm. thickness, ground at right angles to the faces of a stout prism, showed the appearance indicated in the figure. The main area, *A*, showed a definite sharp extinction at about 56° to one pair of edges of the section, and 33° to the other. The two small areas, *B* and *C*, have their directions of vibration parallel, but inclined at 33°



Poonahlite. Transverse section.

and 56° to the same two pairs of edges respectively. All the areas are compensated by a quartz-wedge inserted (approximately) along the shorter diagonal of the prism. Thus, the directions of vibration of *A* and of *B* and *C* are symmetrical about either of the diagonals of the prism. Since the plane of the optic axes is nearly at right angles to the prism, these vibrations will correspond very nearly to the indices α and γ .¹

The optical characters of the sections prove that the crystals must belong to the anorthic system, with twinning about one or both of the vertical pinacoids.

The optic axial angle was determined for sodium-light, using a natural prism. The apparent angle in air, at 20° C., is $76\frac{1}{4}^{\circ}$ about the longer

¹ The optic axes of the two parts of the twin will not be parallel, and a comparison of this section with the blue and yellow stripes visible through its side-faces shows that this is the cause of the patches of colour characteristic of the prism-faces.

diagonal of the prism; whence the value of $2V = 81\frac{1}{2}^\circ$. The double refraction is therefore positive. It is very weak, and no trace of rings is ever seen in the interference-figure. The dispersion about the positive bisectrix is $\rho < v$.

The optic axial angle is very sensitive to changes of temperature, so that a change of colour (or, in convergent light, a displacement of the axial bar) becomes visible on merely warming a crystal gently on a slide. The angle about the positive bisectrix increases with the temperature.

Refractive indices, approximating to α and γ , and (still more closely) to β , were determined by means of two prisms, ground so that their refracting angles were bisected respectively by the macro- and brachypinacoids. The first of these had an angle of $57^\circ 34'$ and gave the following values for sodium-light:—

$$\beta = 1.5046 \quad \gamma = 1.5048.$$

The other had an angle of $58^\circ 27'$ and gave the values:—

$$\beta = 1.5046 \quad \alpha = 1.5044.$$

Conclusion.

It follows from their chemical composition that crystals apparently identical with those described by Brooke as poonahlite must be referred to mesolite. Their optical properties agree well with those of mesolite from the Færoes, and indicate anorthic symmetry. There is no variation in the prism-angle or in the optical characters of the specimens examined, which would point to a variation in chemical composition, and the analyses given by Gmelin and Petersen remain without explanation.