Optically uniaxial Augite from Mull.

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With an analysis by E. G. Radley.

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THE mineral here described was recently collected by the officers of the Geological Survey during their work for the six-inch map of the Island of Mull. It is present as minute phenocrysts in a dark, glassy, magnetite-bearing rock,[1] which is intruded as sheets in the Tertiary lavas nearly one mile south-south-west of Pennygael.

The small rounded crystals of augite are seldom more than $\frac{1}{2}$ mm. in diameter and are traversed by irregular cracks. They contain a few negative crystals, and are occasionally darkened, probably with included magnetite. They appear to have been reabsorbed to some extent by the matrix.

For the purpose of separating the mineral, the rock was reduced to a moderately fine powder and immersed in Thoulet's solution. The augite fell with about an equal amount of magnetite and a few flakes of mica. The mica particles were lost during the washings, and the magnetite was then picked out with a magnet, leaving augite with a certain number of pieces of the base weighted with augite. This residue was boiled with dilute nitric acid and separated by methylene iodide, in which the augite sank readily. The mineral thus obtained was washed with benzene and taken for analysis; it was quite free from other heavy minerals.

A number of the larger grains were embedded in Woodwardian cement and ground to a thick section. In this it could be seen that the optical properties are extremely uniform, the extinction being the same through-

[1] An analysis of the rock has been given in the Summary of Progress of the Geological Survey of Great Britain for 1912, 1913, p. 69 (Slice No. 15990).

out each grain, and no sign of zonal structure was observed. In grains of low birefringence could be seen an almost uniaxial interference-figure, which showed little or no resolution into hyperbolae. The birefringence was measured by means of the micrometer focusing-screw, and the mean value 0·028 was obtained on sections which showed the highest tint in the centre of the interference-figure.

The refractive index could not be determined directly on account of the smallness of the grains. Mixtures of methylene iodide and monoiodobenzol were therefore made, having indices respectively equal to those of the ordinary and extraordinary rays in the augite. These, when adjusted with small pieces of the mineral, and illuminated by a narrow beam from the monochromatic apparatus, showed the Becke line moving in one direction for red light and in the opposite for green. A fairly accurate value was so obtained for the ordinary ray (the mixture here being almost pure methylene iodide); that for the extraordinary was possibly slightly low, since the maximum value had to be taken. The refractive indices of the liquids were then measured on the Hutchinson universal apparatus, and the values obtained for sodium-light at room-temperature were—

$$\omega = 1{\cdot}714,\ \epsilon = 1{\cdot}744;\ \epsilon - \omega = 0{\cdot}030.$$

The mineral is markedly pleochroic:

ordinary ray, smoky-brown; extraordinary ray, pale-yellow.

The cleavage is rather difficult, and no measurement of the cleavage angle could be obtained. In the crushed fragments it could be seen that there are two cleavage directions approximately at right angles, but it was impossible to get a reliable value for the extinction on the cleavage surfaces. A large number of readings were therefore taken and a statistical curve plotted, having the extinction values as abscissae and the numbers of readings at each value as ordinates. The curve showed a well-defined maximum at 30°, though there were numerous readings from 26° to 41°. Very few readings of 45° were obtained. If the lath-shaped pieces are supposed to be tilted in the prism-zone by adhering fragments, equal numbers of readings should occur on either side of the correct value. In the present case the most frequent reading was 30°; and of the total number of 324 readings, 163 fell between 0° and 30°, and 161 between 31° and 45°. The most probable value for the extinction-angle on the cleavage seems, therefore, to be $30\frac{1}{2}°$. The sign of the elongation is almost uniformly positive, and assuming the prism angle mm' to be 90°, the angle $c\dot{c}$ is calculated as approximately 40°.

No measurements of the crystal forms could be obtained, but it seems most probable that the optic axis here occupies a position similar to that of the acute bisectrix in the biaxial pyroxenes.

The following analysis of the separated mineral has been made by Mr. E. G. Radley in the Survey Laboratory :—

SiO_2	49·72	0·82318	0·83379	
TiO_2	0·85	0·01061	(acids)	
Al_2O_3	0·90	0·00881		
Fe_2O_3	1·72	0·01075		
FeO	27·77	0·38569		
MnO	0·98	0·01381		
(Co,Ni)O	nil	—		
CaO	3·80	0·06786	0·87686	
MgO	12·69	0·31442	(bases)[1]	
K_2O	0·12	0·00127		
Na_2O	0·23	0·00370		
Li_2O	trace	—		
H_2O at 105° C.	0·08	—		
H_2O above 105° C.	1·27	0·07055		
	100·13			

Specific gravity at 17° C., 3·44.

The mineral is sharply distinguished from the usual type of diopside by its low content of lime. The alumina is also low, the composition approximating to the pure metasilicate ratio 1 : 1. In fact, the composition is almost that of a hypersthene, and the analysis is quite within the limits of the hypersthenes quoted by Hintze. The mineral agrees generally in physical properties and in composition with the pyroxenes of low axial angle discussed by Wahl,[2] as far as data for these exist. It may be remarked that the rock in which this augite occurs is considerably more acid than the diabases of the series chiefly dealt with in Wahl's paper. This mineral would appear to differ also, in several essential details, from the 'pigeonite' of Winchell, notably in the specific gravity, birefringence, extinction-angle, and lime and titanium content. The two minerals agree in having a low axial angle, but in other respects they must be regarded as distinct.

[1] Sum of molecular ratio of bases, neglecting $(Al, Fe)_2O_3$, 0.85730.

[2] W. Wahl, Min. Petr. Mitt., 1907, vol. xxvi, pp. 1–131. A somewhat similar mineral was described by A. N. Winchell, Amer. Geol., 1900, vol. xxvi, p. 199, under the name of pigeonite. Cf. Lacroix, Min. de la France, 1910, vol. iv, p. 767.