Wollastonite solid solutions from Scawt Hill, Co. Antrim.

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WOLLASTONITE at Scawt Hill, Co. Antrim, occurs as a constituent of both the exogeneous and endogeneous contact-zones of the dolerite.[1] In the former it is associated only with flint nodules in the metamorphosed chalk, in the latter, however, commonly as a minor constituent of certain of the hybrid types.

In my original account a wollastonite-bearing augite-dolerite from this latter zone was figured without further description in the text (plate XVII, fig. 3). In examining the optical characters of wollastonites associated with hedenbergite, I had occasion to turn again to the wollastonites of this particular rock type.

As indicated in the explanation of the figured section (loc. cit., p. 467), the dolerite is built essentially of sharply zoned brown titan-augite, labradorite, wollastonite, iron-ores, interstitial thomsonite, analcime, and accessory sphene. In this aggregate wollastonite forms subidiomorphic crystals averaging 1 mm. in size, and from a series of sections its predominant forms can be readily made out. As seen in cross-sections the chief forms developed in the ortho-zone are *a* (100), *c* (001), *v* (101), *a* ($10\bar{2}$), with usually prominent development of (001) and (100), less commonly (101). Such sections provide material for the determination of the optical orientation. They are sensibly normal to the axis β. Crystallographically these Scawt Hill wollastonites agree with the normal wollastonite, but the sections reveal that there are significant optical departures. In normal wollastonite $\alpha : c = 32°$, but these sections reveal that the extinction-angle is invariably greater than 32°, and has usually values greater than 40°.

In a series of sections, a common value is $\alpha : c = 43°$, bringing the axis γ almost perpendicular to the face *v* (101), repeatedly observed

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[1] C. E. Tilley, Min. Mag., 1931, vol. 22, p. 439.

as an edge. These results required a closer investigation of the refractive indices of the material. By use of immersion liquids it becomes clear that the wollastonites of this rock have variable refractive indices. This is further emphasized by the occurrence of cleavage fragments showing parallel growths with noticeably different refraction. The highest values recorded in this variable material determined on homogeneous cleavage fragments were α 1·646, γ 1·662. In sections normal to the acute bisectrix these high refracting wollastonites show a distinct oblique extinction, values up to 6° from the zone of cleavages being recorded. A section orientated normal to β isolated from a rock section was found to possess refractive indices α 1·642, γ 1·657, $\alpha : c = 44°$. Furthermore, these wollastonites show high optic axial angles. In five sections examined 2V has a value varying between 60° and 63° (cf. wollastonite, 2V 40°).

A striking feature of the rock is the strongly zoned character of its minerals. This statement applies both to the plagioclase and the pyroxene. In the latter, the zones are sharply defined and not gradational, a lighter core being surrounded by a dark-coloured shell. In many of the wollastonites a similar sharp zoning is to be observed, brought out both by varying extinction and interference-tint as well as by refraction. The core, often of irregular shape as if resorbed, has a lower refraction than the shell. Cross-sections of such material show a core with γ 1·640, $\alpha : c = 36°$, followed by a shell with γ 1·658, $\alpha : c = 44°$. In some cases the zones are less regularly developed. Determinations of 2V in core and shell show that the core has a distinctly lower optic axial angle. In two such zoned sections examined the core has 2V 46–47°, and the shell 2V 60–62°.

Wollastonites with these optical characters have not so far been recorded among rocks, but the recent work of Bowen, Schairer, and Posnjak[1] on synthetic melts of the system $CaO–FeO–SiO_2$ has shown that similar optics are obtained from the synthetic wollastonite crystals in which solid solutions with $FeSiO_3$ are involved. In the system $CaSiO_3–FeSiO_3$ wollastonite solid solutions with a maximum content of 76 wt. % $FeSiO_3$ were obtained, the refraction, optic axial angle, and extinction-angle (measured against the zone of cleavages) increasing with rising iron content. In this binary system a solid solution with refractive indices comparable with the highest obtained from the Scawt Hill wollastonites contains approximately 25 wt. %

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[1] N. L. Bowen, J. F. Schairer, and E. Posnjak, Amer. Journ. Sci., 1933, ser. 5, vol. 26, p. 193. [M.A. 5–454.]

$FeSiO_3$. Ferguson and Merwin[1] report wollastonite solid solutions in the system CaO–MgO–SiO_2, and the maximum content of dissolved substance is reported by them as equivalent to 17 % diopside. In a later study Schairer and Bowen[2] state that solid solution rises to 22 wt. % diopside. The former authors give the optical characters of wollastonite with the maximum amount of dissolved material as α 1·619, β 1·631, γ 1·634, 2V 40–65°.

FIG. 1. Wollastonite-bearing dolerite, Scawt Hill, Co. Antrim.

Showing two zoned crystals of wollastonite: (1) with dark core and light periphery; (2) slightly darker core (extinction $\alpha : c = 36°$) and lighter coloured periphery (extinction $\alpha : c = 43°$). The remaining constituents are augite, labradorite, iron-ores, and thomsonite (centre). Crossed nicols. × 34.

As might be expected, the refractive indices of the iron-bearing wollastonites rise more rapidly with increasing iron than the magnesian-bearing varieties do with increasing magnesia. The optical characters of the Scawt Hill wollastonites is to be ascribed to solid solution in which, considering the chemical environment of

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[1] J. B. Ferguson and H. E. Merwin, Amer. Journ. Sci., 1919, ser. 4, vol. 48, p. 92. [M.A. 1–168.]

[2] J. F. Schairer and N. L. Bowen, Amer. Min., 1936, vol. 21, p. 193 (abstract only).

their growth, probably iron and magnesia play a part. The solid solution is doubtless of a more complex character than that of their synthetic analogues, but, considering the iron-rich character (compared to magnesia) of the Scawt Hill hybrids carrying a similar titanaugite as the rock in which they are developed, it is probable that they are essentially iron-wollastonites. In fine powder much of the wollastonite separates with the pyroxene in the electromagnetic separator, and with heavy liquids crystals appear in a light and heavy fraction. Small crystals isolated from these fractions gave specific gravities of 2·91 and 3·11 respectively. A micro-chemical test with potassium ferrocyanide showed the presence of iron. Insufficient material, however, is available to extract these wollastonites from the rock for chemical analysis.

By analogy with the properties of the synthetic solid solutions, the shells of zoned crystals with higher refraction and optic axial angle represent iron-wollastonites of higher iron content than the cores. Wollastonites of this character do not occur in the exogeneous contact-zone of Scawt Hill and are only recorded now from the hybrid rocks carrying titanaugite. Of the three types of association of the Scawt Hill wollastonites the environment of the latter corresponds to that of the highest temperature and, as might be expected, to that of most extended solid solution.

In the synthetic system $CaSiO_3$–$FeSiO_3$ the course of the inversion curve wollastonite solid solution $\rightarrow$ hedenbergite was approximately determined. The results show that, even at temperatures of 500° C., wollastonites might be expected to contain up to 20 % $FeSiO_3$ in solid solution. In the more complex natural system solid solutions of the character now described were doubtless stable to the close of the consolidation of the rock containing them, below which, if a metastability region is entered, unmixing would be inhibited by virtue of slow reaction at lowered temperatures.