

SHORT COMMUNICATIONS

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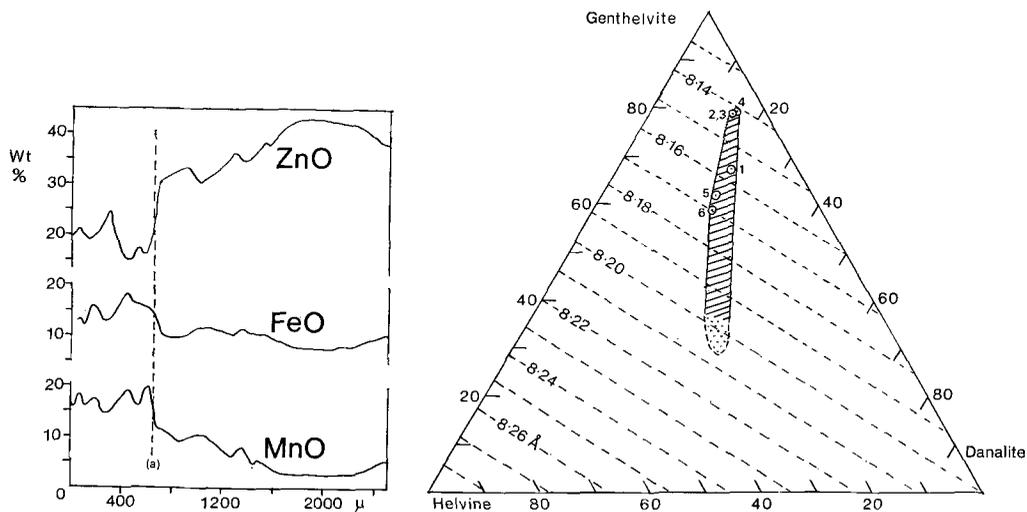
Zoned genthelvite from the Cairngorm Mountains, Scotland

THE large crystals of genthelvite from the cliffs of Coire-an-Lochain in the Cairngorm mountains are represented in the British Museum (Natural History) collection by two boxes of loose crystals (specimen numbers B.M. 1966, 309 and 1966, 310). Following Morgan's (1967) description of the occurrence, an 11.46-cm-diameter X-ray diffraction photograph was taken, for inclusion in the Museum's file of standard patterns, from the powdered mineral analysed by A. A. Moss for Morgan's paper. This film showed marked line splitting, not detectable on films taken with a 6-cm camera, indicating the presence of more than one helvine-group phase in the powder. This short paper reports on chemical and X-ray investigations into the nature of these phases.

The genthelvite originally described by Morgan consists mostly of rough tetrahedra with evidence of layered growth. Their most obvious feature is a thin (about 0.5-mm) crust with a brownish sub-metallic lustre partially covering a dark brown-green tetrahedron. One of the tetrahedra was sectioned vertically and centrally with a Lastec saw and the exposed surface polished for electron-probe microanalysis.

The line splitting on the powder photograph was originally thought to be due to a difference in composition and cell dimensions between the main genthelvite tetrahedron and the crustal layer. However, the polished mount showed that zoning is not confined to the two phases observed in the rough crystals: growth layers, triangular in plan, occur throughout the tetrahedron, varying from greenish and opaque at the centre to brownish and translucent nearer the surface. Concentration profiles across the section were obtained for the three variable cations Fe, Mn, and Zn, using an electron-probe microanalyser (fig. 1). There is a marked fall in zinc concentration when the main tetrahedron gives place to the outer layer ((a), fig. 1). However, the zinc content does not change only at this interface but decreases irregularly outward from the centre of the crystal, whereas iron and manganese increase. The area defined by this Zn-Fe-Mn variation is shaded in the triangular helvine-group composition plot (fig. 2), and it occupies a region in which few other compositions have previously been reported (Dunn, 1976). The Cairngorm genthelvite contrasts with that described by Haapala and Ojanperä (1972) from Kymi, southern Finland, which showed the same type of oscillatory zoning, but with zinc enrichment in the outer parts of the crystals and iron enrichment in the central parts.

Moss's chemical analysis (1) is plotted on this figure, as are five electron-probe analyses (Table 1), three (2, 3, 4) from the central region of the genthelvite crystal, and



FIGS. 1 and 2: FIG. 1 (left). Electron-probe traverse showing zoning across a portion of a Cairngorm genthelvite crystal. FIG. 2 (right). Composition range of Cairngorm genthelvite.

TABLE I. *Genthelvite analyses and unit cell data*

	1	2	3	4	5	6
SiO ₂	30.8	31.7	31.8	31.0	31.3	31.0
BeO	14.2	(14.2)	(14.2)	(14.2)	(14.2)	(14.2)
FeO	9.9	7.3	7.3	7.5	9.9	10.3
MnO	5.8	2.9	2.8	2.5	8.4	9.5
ZnO	37.0	42.4	42.6	42.7	34.1	32.6
S	5.1	5.2	5.2	5.2	5.4	5.3
Less O ≡ S	2.6	2.6	2.6	2.6	2.7	2.7
	100.2	101.1	101.3	100.5	100.6	100.2
<i>a</i> meas.		8.1431 Å	8.1398	8.1389	8.1700	8.1692*
<i>a</i> calc.		8.143	8.143	8.141	8.166	8.170

1. Analysis by A. A. Moss (in Morgan, 1967).

2, 3, 4. Central region of genthelvite crystal } Electron-probe analyses.

5, 6. Outer part of crystal

* Also *a* 8.2066 Å at another point in the outer crust.

two (5, 6) near the edge (a). Spot analyses were not made in the very inhomogeneous crustal layer, owing to the difficulty of correlating the compositions and cell dimensions in areas of rapidly varying composition. The standards used in these analyses were pure metals for Fe, Mn, and Zn, analysed olivine for Si, and pyrite for S. Beryllium could not be measured with the electron probe and Moss's figure of 14.2 % BeO was used throughout. The measured intensities were corrected using the Mason, Frost, and Reed (1963) computer program.

X-ray powder-diffraction photographs were made from material removed from the polished mount as close to the analysed spots as possible. Glass *et al.* (1944), by linear extrapolation of measured unit cells, derived the end-member cell sizes: helvine, a 8.29 Å; danalite, 8.20 Å; and genthelvite, 8.12 Å. These values are superimposed on fig. 2 and enable the cell sizes measured to be compared with those derived from the analyses (Table I). Considering the amount of zoning and the difficulty of extracting material for X-ray from the precise spot analysed, the agreement is satisfactory. One of the X-ray films, taken on material from the outer crust of the spectrum, showed faint lines from a cell with a 8.2066 Å, indicating that in places the composition extends even further into the helvine-danalite field (the area dotted in fig. 2).

The zoned crystals of genthelvite from Coire-an-Lochain vary in composition from a central region of $G_{79}D_{16}H_5$ to a crustal coating around $G_{29}D_{38}H_{33}$. Moss's analysis in Morgan (1967) represents the bulk composition and falls mid-way between the compositions of the measured phases determined by electron-probe microanalysis. The data of Oftedal and Saebo (1963) on a number of Norwegian helvine-group minerals show a non-linear variation of cell dimension with composition. If the trends shown in their work are applied to the calculated cell dimensions in Table I, the effect would be to increase slightly the larger cell dimensions (5 and 6) and decrease slightly the smaller dimension (2, 3, and 4). This would not conflict with the results obtained, but a thorough examination of a large number of relatively homogeneous samples is necessary in order to test their findings.

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