

indicates that the probable space group is $P3$ or $P3m1$ rather than $P\bar{3}$ as reported by Milton *et al.* Another kind of crystal malformation produces a pseudo-orthorhombic appearance (Fig. 4).

The axial ratio derived from goniometric measurement of the nine crystals is $c:a=2.077$, in agreement with the ratio 2.087 from the cell dimensions of Milton *et al.* (1965).

This investigation was suggested by Prof. Charles Milton, George Washington University, and Dr. Joan R. Clark, U. S. Geological Survey after Prof. J. D. H. Donnay, The John Hopkins University called their attention to errors in the original description.

REFERENCE

- MILTON, C., B. INGRAM, J. CLARK AND E. DWORNIK (1965) Mckelvyite, a new hydrous sodium barium rare-earth uranium carbonate mineral from the Green River formation, Wyoming. *Amer. Mineral.* **50**, 593-612.

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NEW DATA ON NIGERITE¹

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Bannister, Hey and Stadler (1947) showed that nigerite has the approximate formula $(Zn, Mg, Fe) (Sn, Zn)_2 (Al, Fe)_{12} O_{22} (OH)_2$. They reported that it is trigonal with symmetry $\bar{3}m$, and a and c are equal, respectively, to 5.72 and 13.86 Å. The value of a is about four times the radius of an oxygen ion, while c is about six times the closest-packed oxygen interplanar distance.

Jacobson and Webb (1947) described nigerite overgrowths on the (111) planes of gahnite, and Bannister *et al.* (1947) noted the closest-packed structural correspondence in (111) of gahnite being parallel to (0001) of nigerite. McKie (1963) has pointed out the relation between nigerite, taaffeite and the högbomite polytypes, all of which have similar values of a , and values of c which are multiples of about 2.3 Å, the closest-packed oxygen interplanar distance.

In the course of a general study of polytypism, we obtained a specimen of nigerite from the Egbe District, Kabba Province, Nigeria, catalogue number M 24546 of the Royal Ontario Museum, Toronto, Canada. This material appeared to be identical to that described by Jacobson and

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Webb (1947) and Bannister *et al.* (1947), with the nigerite occurring in hexagonal platelets up to about 2 mm in diameter, often in oriented overgrowths on gahnite with (111) of gahnite parallel to (0001) of nigerite. Some gahnite crystals have nigerite overgrowths on several (111) faces.

Series of both Weissenberg and precession photographs were obtained on fragments of several crystals from this one sample. The following crystallographic parameters were determined:

$$\begin{aligned} a & 5.79 \pm .03 \\ c & 56.20 \pm .3 \text{ \AA} \end{aligned}$$

Space group $R3m$, $R32$ or $R\bar{3}m$

These results are similar to those of Bannister *et al.* in that the values of a are equivalent, but this value of c is about four times that of the latter work. This value of c indicates that our material is a polytype with 24 oxygen layers in the repeat unit and should properly be designated as a 24R structure. In a discussion of högbomite polytypes, McKie (1963) used a nomenclature based on a double oxygen layer as a repeat unit and thus this is a 12R polytype in this reference system. However, since the nomenclature of other polytype systems is based on the single layer as a repeat unit, and since the translation relating layers may be such that the number of single layers is odd, the nomenclature based on a single oxygen layer as a repeat unit is to be preferred. Indeed, we have found the anion closest-packed phase senaite to have an odd number of layers per unit cell.

On both Weissenberg and precession films a set of reflections which are much more intense than average were observed which define a sublattice. This has the subcell dimensions $a = 5.79 \text{ \AA}$ (equal to a of the superlattice) and $c = 14.05 \text{ \AA}$ ($\frac{1}{4}$ of the value of c for the superlattice). The sublattice pseudoextinction rule defines the sublattice to be of type 3R. This subcell is dimensionally equivalent to the primitive cell defined by Bannister *et al.* (1947) for their material.

The gahnite, on which the nigerite occurs in oriented overgrowths, is cubic with $a = 8.11 \text{ \AA}$. It may be referred to hexagonal axes. Such a reference system has a and c equal to 5.73 and 14.04 \AA respectively, and is 3R in type. This is identical both in dimensions and cell type to the subcell defined in our material. The structural relationship between nigerite and gahnite was recognized by Bannister *et al.* (1947) in their material through the similarity in powder patterns. The gahnite-like subcell is readily seen in the most intense diffraction lines.

The nigerite occurs in our hand specimen in hexagonal platelets up to about 2 mm in diameter. Diffraction patterns from the smaller complete

platelets indicate that the crystals are twinned, since a nonspace group general extinction rule is observed. Comparison with photographs from untwinned crystal fragments shows the twin law to be two-fold rotation about the three-fold axis. This is consistent with the known structural relations since an individual closest-packed layer has pseudo six-fold symmetry, but real three-fold symmetry. Thus, the crystal should twin with the pseudo-symmetry element, two-fold rotation, as the twin element. Examination of the (0001) faces confirms the existence of twin related growth features.

It is apparent that the material defined as nigerite occurs as more than one polytype, analogous to the högbomite group. Such a relation was to be expected and specimens even from the same locality must be carefully examined to define their structural relation. We have obtained identical results on several crystals from the same hand specimen, with no indication either of the presence of a second polytype, or of disorder as a function of stacking faults, as is possible in such systems. In addition it is possible that these and related oxide polytypes, which have very complex compositions which can be defined completely and adequately only upon structure analysis, may be compositionally distinct, as a function of the stacking of units of different, but fixed and related, structures and composition. Such a possibility is well defined by analogy to work by Kohn and co-workers (1965) in the Ba-ferrite system.

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