WULFENITE SYMMETRY AS SHOWN ON CRYSTALS FROM JUGOSLAVIA*

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ABSTRACT

Wulfenite crystals from Schwarzenbach, Jugoslavia, are in two distinct habits; (1) Pymidal crystals indicating that [001] is polar. (2) Tabular crystals twinned on $\{00\bar{1}\}$. The morphology, etch tests and the presence of piezoelectricity indicate that wulfenite symmetry is tetragonal-pyramidal (4).

In the summer of 1953, the Harvard Mineralogical Museum purchased a fine collection of wulfenite specimens that came from the Helena Mine, Schwarzenbach, Jugoslavia. They are beautifully crystallized and of a rich orange-yellow color. The crystals are essentially of two distinct habits, Figs. 1 and 2, both of which indicate that wulfenite crystallizes in the tetragonal-pyramidal crystal class.

Morphology. Considerable uncertainty exists regarding the symmetry of wulfenite. From the morphology of most crystals one would conclude that the symmetry is tetragonal-dipyramidal ($4/m$). A few crystals have

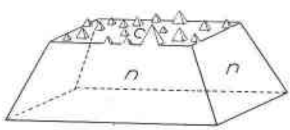

FIG. 1

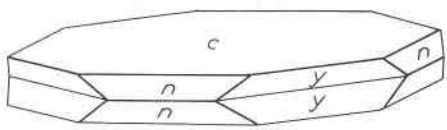

FIG. 2

FIG. 1. Pyramidal wulfenite crystal.
FIG. 2. Wulfenite twinned on $\{00\bar{1}\}$.

been described that indicate tetragonal-pyramidal (4) symmetry. In Volume II of the *System of Mineralogy* (1951), the symmetry is accepted as (4) on rather unconvincing evidence.

The crystals from Jugoslavia, as illustrated in Figs. 1 and 3, range in maximum dimension from 1 millimeter to 2 centimeters. They have a simple habit with the only important forms being $n\{011\}$, $c\{001\}$ and $\bar{c}\{00\bar{1}\}$. The $\{001\}$ form on the larger crystals is covered with overgrowths of small pyramids, $\{011\}$; the $\{00\bar{1}\}$ form is a plane surface. This habit indicates that the [001] axis is polar but the evidence is no more convincing than that supplied by the pyramidal crystals from

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Inverness-shire, Scotland, described by Russell (1946); and wulfenite from various other localities described by Bach (1926).

The second habit, as illustrated in Figs. 2 and 4, is platy with the crystals flattened on {001}. The maximum dimension across the plates is 3 centimeters, and the ratio of width to thickness is about 10:1. All of the crystals of this platy type are twinned on {00$\bar{1}$} and show re-entrant angles where the faces of $\bar{y}${11$\bar{3}$} join one another. The only other forms are *n*{011} and *c*{001}. Hlawatsch (1925) also noted re-entrant angles on wulfenite from Mies, Carinthia.

Etching. This twinning definitely indicates that [001] is polar but is contrary to the conclusions reached by Honess (1927) and Royer (1936)

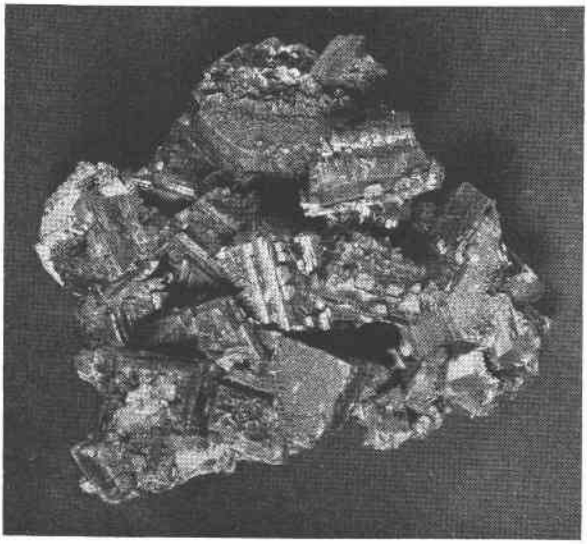

Fig. 3. Pyramidal wulfenite crystals. $\times\frac{1}{2}$.

by etching wulfenite. These earlier works showed that etch pits on (001) and (00$\bar{1}$) were identical, indicating a horizontal symmetry plane.

To check these etching results, planes corresponding to (001) and (00$\bar{1}$) were ground and polished on one of the pyramidal crystals from Jugoslavia. Also, the broad opposing faces of one of the twins were ground and polished. These crystals were then etched in dilute nitric acid for 12 hours. The pyramidal crystal showed a marked difference in the etching on (001) and (00$\bar{1}$), whereas the etching on the opposite faces of the twin was identical and similar to that on (001) face of the single individual. As a further check, one of the individuals was completely ground from a twin and the broad faces of the remaining part polished. After etching in nitric acid for 12 hours, the appearance of the faces corresponded to the (001) and (00$\bar{1}$) faces of the etched pyramidal crystal.

The etching produced on the (001) face of each crystal is a dull irregular pitted surface crossed by shallow grooves producing a square pattern. The grooves make an angle of about 15° to the trace of (011) on (001). On the opposite surfaces etching produced square pits, the pyramidal sides of which give brilliant reflections. The edges of the etch pits make an angle of about 15° with the intersection of (01$\bar{1}$) on (00$\bar{1}$). The etch pits described by Honess (1927) on wulfenite crystals from the Red Cloud Mine, Arizona, are similar to this second type.

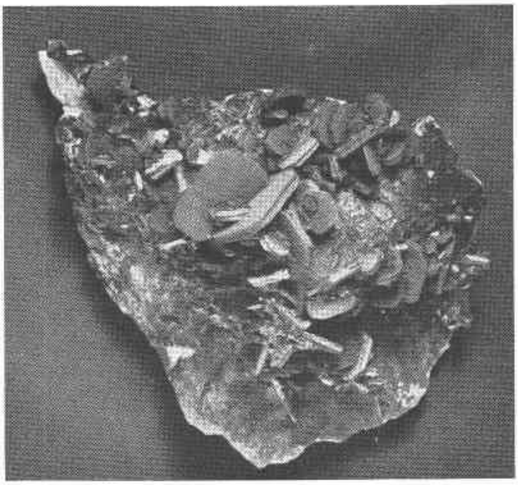

FIG. 4. Wulfenite crystals twinned on 001. $\times\frac{1}{2}$

Etching of a tabular crystal from the Red Cloud Mine gave results similar to those reported by Honess; that is, the etching on the two basal faces was the same. This crystal and a pseudocubic crystal from the Ahumada Mine, Mexico, were then cut in half along what appeared to be the horizontal symmetry plane. Etching half of each crystal gave dissimilar patterns on (001) and (00$\bar{1}$). From the results of etching, one must conclude that wulfenite belongs in the tetragonal-pyramidal symmetry class and that most crystals are twinned on a pedion, either {001} or {00$\bar{1}$}.

If we consider that the crystal represented in Fig. 1 is in the correct position with {001} at the top, the etching indicates that the twin (Fig. 2) has {00$\bar{1}$} as the composition plane. This is contrary to all other wulfenite crystals examined by etching, in which {001} is the composition plane. There is insufficient evidence to make a broad generalization but it may well be that twins with composition plane $\{00\bar{1}\}$ have re-entrant angles, whereas those with composition plane $\{001\}$ have a pseudo-dipyramidal symmetry.

Piezoelectricity. The absence of positive tests for piezoelectricity in wulfenite has argued for the symmetry $4/m$. However, one could not expect to detect it in a crystal twinned on a plane normal to [001]. Since most wulfenite is twinned in this manner, it is likely that the test may never have been made on a single individual. Using one of the pyramidal crystals from Jugoslavia, a feeble but definite piezoelectric response was obtained. A similar response was also given by one individual of a twin pair. The positive electrical pole of these crystals is at the (001) face.

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