OPTICAL EVIDENCE OF POLYSYNTHETIC TWINNING IN ARSENOPYRITE

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Abstract

Crystal structure determinations have shown that arsenopyrite is monoclinic rather than orthorhombic. It was necessary to postulate mimetic twinning of polysynthetic twins to account for its pseudo-orthorhombic diffraction effects and symmetry. This twinning has been observed on polished sections under polarized light. The attitude of the twins precludes orthorhombic symmetry.

It has been shown elsewhere by Buerger[1] that the minerals of the arsenopyrite group having a general formula $AB'B''$ are superstructures based on the marcasite structure and have the symmetry of the space group C_{2h}^5. In order to account for the apparently orthorhombic diffraction effects observed in rotation and Weissenberg photographs, and the orthorhombic symmetry of individual crystals, it was necessary to postulate the existence of mimetic twinning. It is the purpose of this paper to present in a formal manner corroborative evidence of an optical nature which was mentioned by Buerger[2] and which demonstrates the validity of the twin hypothesis.

Twinning was apparently observed by Scherer[3] as a result of etching the brachydome of arsenopyrite crystals. Scherer interprets his results as follows:

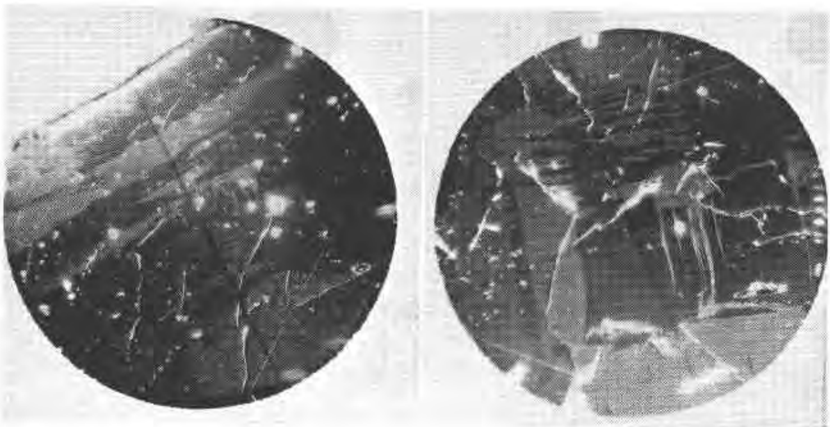
> The condition that there appears on the base four compartments which behave equally indicates twin formation. This presupposes the assumption of asymmetrical individuals and therefore has little claim on truth. It was clear to me that probably the etch lines result from varying degrees of solubility of the component parts of the crystal, a supposition which forced the hypothesis of a layer synthesis of the arsenopyrite. . . .

This interpretation will be shown to be incorrect.

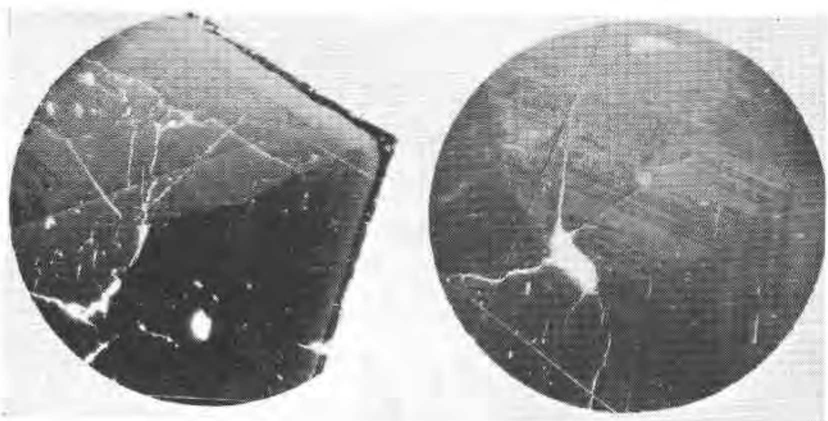
Small single crystals of arsenopyrite were polished in several orientations by means of a polishing device especially designed for the purpose. The apparatus and method of preparing polished sections in predetermined orientations have been described.[4] Briefly, the crystal is cemented to an adjustable head which fits both the two-circle goniometer and the polishing machine, oriented on the goniometer in the desired manner and transferred to the polishing machine. The cut is made by a rotating wheel covered with emery paper, and it is polished with dry chrome on linen.

[1] Buerger, M. J.: *Zeits. Krist.*, (A) **95**, 83–113 (1936).
[2] Buerger, M. J.: *Op. cit.*, 95–96.
[3] Scherer, F.: *Zeits. Krist.*, **21**, 354–387 (1892).
[4] Buerger, M. J., and Lukesh, J. S.: *Am. Mineral.*, **21**, 667–669 (1936).

A number of sections were cut in various orientations on crystals from different locations. Specimens from Spindelmuhle and Saxony (?) in Germany, and Sulitjelma, Norway, as well as a large crystal of unknown origin all showed polysynthetic twinning under the polarizing microscope.



Figs. 1 and 2. Surface of Sulitjelma crystal nearly parallel to (001). Crossed nicols. ×64.



Figs. 3 and 4. Surface of Spindelmuhle crystal nearly parallel to (001). Crossed nicols. ×60. All crystallographic notation referred to the old arsenopyrite orientation.

The accompanying illustrations (Figs. 1–4) are photomicrographs of cuts on two crystals. Figures 1 and 2 are on a crystal from Sulitjelma and 3 and 4 on one from Spindelmuhle.

Crystals from Sulitjelma

The cut illustrated is nearly parallel to (001). Figures 1 and 2 are different parts of the same surface, the edge shown in Fig. 1 being the intersection of the cut with a dome face. The cross-hairs indicate the directions of the *a* and *b*-axes, with the *a*-axis parallel to the dominant twin direction. The attitude of the twin planes was determined from these cuts and others in different orientations. The twins which are seen parallel to the *a*-axis in a cut normal to the *c*-axis were found to be parallel to (011). Those in the direction of the *b*-axis were found also to be dome twins, making an angle of about thirty-seven degrees with (100). The (011) twins were in all cases the dominant ones.

Crystals from Spindelmuhle

Figures 3 and 4 are parts of the same surface cut nearly parallel to (001). The angle in Fig. 3 is the junction of $(\bar{1}\bar{1}0)$ and $(\bar{1}10)$ and the light and dark areas are the individuals of a twin. The extinction effects observed on this and all other cuts preclude the composition hypothesis of Scherer. If the etch results were due to a layer synthesis, the areas which are sharply contrasted would be equivalent and would extinguish coincidentally. In Fig. 4 there can be seen the center of the crystal with two sets of twin boundaries at right angles to each other. From this and other cuts the twin planes were found to be parallel to (100) and (010). These two sets of twin planes divide the base of the crystal into the four areas noted by Scherer on etching the brachydome. Each of the four areas is also twinned parallel to the prism faces, a form of twinning analogous to that found in the Sulitjelma crystals. On the basis of the latter type of twinning, a re-orientation of the Spindelmuhle crystals seems indicated, interchanging the *a* and *c*-axes. All crystallographic notation used in this discussion is referred to the conventional arsenopyrite orientation.

Preliminary observations were also made on crystals of manganite. Twinning was found, but it was not studied in detail. The inference from this is that twinning can be expected in other members of the arsenopyrite group.

From a crystal structure point of view, the pinacoid twins found in the Spindelmuhle crystals are the most important. The pinacoids of two of the three orthorhombic space groups to which arsenopyrite might be assigned from *x*-ray diffraction data are symmetry planes. Since twinning cannot occur on a symmetry plane, these two space groups must be discarded. The third possible orthorhombic space group can be eliminated and the monoclinic nature established by reasoning which is beyond the scope of this paper.[5]

[5] Buerger, M. J., *Op. cit.*