

CRYSTALLOGRAPHIC ORIENTATION OF
SODIUM MOLYBDO-TELLURATE*

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The description of sodium molybdo-tellurate crystals by Donnay and Mélon appeared in a recent issue of this journal.¹ We found that, besides the orientation chosen by these two authors, there exists another one, which has the advantage of bringing out the tetragonal pseudo-symmetry of the crystals. This orientation is easily found by applying the rules given by Fedorov.² According to his method, a crystal description is summarized in a so-called "complex symbol"; the latter may be written as follows for sodium molybdo-tellurate:

$$\begin{array}{rcc} 40 & +14 & 7 \\ & 46; & -18 \\ & - & 1 \end{array}$$

The following information can be obtained from mere inspection of the above "complex symbol": (1) the unit-cell is pseudo-tetragonal; (2) the unit-cell is body-centered; (3) according to Fedorov's terminology, the crystal is "negative," as indicated by the small value of the "principal number" (46°), and it is to be expected that the crystals are elongated parallel with the pseudo-tetragonal axis. That very habit is illustrated by the clinographic projection given by Donnay and Mélon.³

The orientation according to Fedorov's method is given here (Fig. 1). It can be derived from the morphological orientation of Donnay and Mélon⁴ by applying⁵ the transformation: $\bar{1}\bar{1}0/111/001$.

* Translated from the Dutch by J. D. H. Donnay.

¹ Häüy-Bravais lattice and other crystallographic data for sodium molybdo-tellurate, *Am. Mineral*, vol. 18, pp. 225-47, 1933.

² E. von Fedorov: *Das Krystallreich*.

³ *Op. cit.*, Fig. 7, p. 245.

⁴ *Op. cit.*, Projection VI, Fig. 6, p. 243.

⁵ The transformation determinant is written in the abbreviated form: $uvw/u'v'w'/u''w''w'''$. The new face-symbol (pqr) is derived from the old one (hkl) by the formulae:

$$\begin{aligned} p &= u \ h+v \ k+w \ l, \\ q &= u' \ h+v' \ k+w' \ l, \\ r &= u''h+v''k+w''l. \end{aligned}$$

The new axial elements are:

$$\begin{aligned} \ddot{a}:\ddot{b}:\ddot{c} &= 1.1214:1:0.7583 \\ \alpha &= 78^\circ 3'; & \beta &= 82^\circ 37'; & \gamma &= 87^\circ 23'; \\ A &= 101^\circ 43'; & B &= 97^\circ 0'; & C &= 91^\circ 7'. \end{aligned}$$

The squares of the reticular densities for the various forms have been determined by the partially graphical method of Sokolov

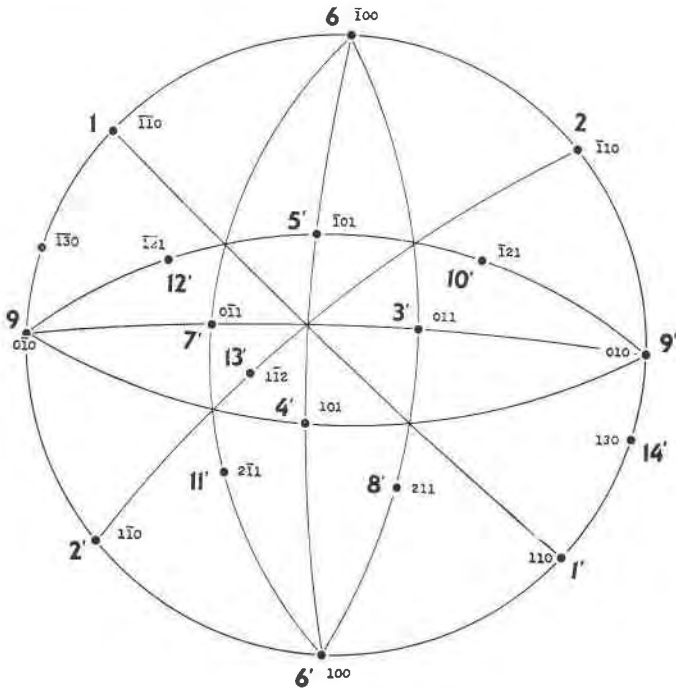


FIG. 1. Sodium-Molybdo-Tellurate.

and Artemiev. Observe that the square D^2 of the reticular density is inversely proportional to the square S^2 of the reticular area given by Donnay and Mélon in their Table 2.

The Fedorov orientation, as well as that of Donnay and Mélon, gives the correct sequence of forms (the numbers in bold face in the above table are those which Donnay and Mélon assigned to the observed forms listed in the order of decreasing importance). The fourteen forms with the highest reticular densities are listed above the dashed line in the table, whether they be actually ob-

TABLE OF RETICULAR DENSITIES

| No. | Form-symbols (Fedorov orientation) | D^2 (D =reticular density) |
|-----|---------------------------------------|---------------------------------------|
| 1 | 110 | $4 \cot^2 45^\circ = 4.00$ |
| 2 | 110 | $4 \cot^2 46\frac{1}{2}^\circ = 3.60$ |
| 3 | 011 | $4 \cos^2 30^\circ = 3.00$ |
| 4 | 101 | $4 \cos^2 30\frac{1}{2}^\circ = 2.97$ |
| 5 | 10 $\bar{1}$ | $4 \cos^2 40^\circ = 2.35$ |
| 6 | 100 | $\cot^2 34^\circ = 2.20$ |
| 7 | 0 $\bar{1}$ 1 | $4 \cos^2 44\frac{1}{2}^\circ = 2.04$ |
| 9 | 010 | $\cot^2 38^\circ = 1.64$ |
| 8 | 211 | $4 \cos^2 53^\circ = 1.45$ |
| | 121 | $4 \cos^2 56^\circ = 1.25$ |
| 10 | $\bar{1}$ 21 | $4 \cos^2 58^\circ = 1.12$ |
| 11 | 2 $\bar{1}$ 1 | $4 \cos^2 58^\circ = 1.12$ |
| | $\bar{2}$ 11 | $4 \cos^2 58\frac{1}{2}^\circ = 1.09$ |
| | 2 $\bar{1}$ 1 | $4 \cos^2 60\frac{1}{2}^\circ = 0.97$ |
| | | |
| 12 | $\bar{1}$ 21 | $4 \cos^2 62^\circ = 0.88$ |
| 13 | 1 $\bar{1}$ 2 | $\cos^2 32^\circ = 0.72$ |
| 14 | 130 | $4 \cot^2 68^\circ = 0.65$ |

served forms or "possible forms." These fourteen forms determine the numerator of the expression W (see below), which Fedorov considers a measure of the "correctness" of the adopted orientation. Three "possible forms," $\{001\}$, $\{1\bar{2}1\}$, $\{112\}$, occur below the dashed line and above form No. 12. The square of the reticular density is about 0.94 for all these three forms.

Fedorov's expression W , alluded to in the last paragraph, is: $W = R/J \cos 2a \cdot \cos v \cdot \cos t$, in which a , v , and t have the values 1° , 7° , and 14° , respectively, R is the sum of the squares of the reticular densities of the fourteen known forms, and J is the sum of the squares of the reticular densities of the fourteen theoretical forms with the highest reticular densities.

Substituting, we find: $W = 0.93$.

According to Fedorov's conception, this value of W makes the orientation very satisfactory.

It remains to be seen in what relation the two orientations stand with respect to each other. The three primitive translations of Fedorov's cell, reduced to the same scale as that of Donnay and Mélon, are:

$$\bar{a} = 1.381, \quad \bar{b} = 1.232, \quad \bar{c} = 0.935.$$

The unit-length c is thus the same for both cells. Furthermore, a simple calculation shows that the parameter of the zone [110] in Donnay and Mélon's notation, is 1.383; while the parameter of their zone [111] is 1.231. The two lattices are then seen to coincide. The only difference lies in the choice of the unit-cell defining the lattice: whereas Donnay and Mélon emphasize the minimum lengths of the primitive translations, Fedorov aims at bringing out the pseudo-symmetry.

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