

A RAPID METHOD TO DETERMINE THE OPTICAL ORIENTATION OF BIAxIAL MINERALS. M. E. Gunter¹ and B. Twamley², ¹Department of Geological Sciences, University of Idaho, Moscow, Idaho, 83844, mgunter@uidaho.edu, ²University Research Office, University of Idaho, Moscow, Idaho.

Introduction: Determining the optical orientation for biaxial minerals requires careful observations and measurements to be made with a polarizing light microscope and some type of x-ray diffraction equipment. The goal is to determine the angular relationship between the biaxial indicatrix and the crystallographic axes of the mineral. For the orthorhombic case, this means to determine which of the six permutations of X,Y,Z (the optical directions) coincide with the a,b,c axes. For monoclinic minerals, one must find which of the three principal refractive index directions coincides with b, and then the angular relationships of the other two with a and c. Lastly, for triclinic minerals, the angles must be determined between X,Y,Z and a,b,c because, in general, none of the optical directions coincides with the crystallographic axes.

By using the spindle stage and its associated computer program, EXCALIBUR [1,2], the orientation of the optical indicatrix is found and cast into the microscope/spindle stage coordinate system. Next, the goniometer head is transferred to a single crystal diffractometer and, in turn, the orientation of the reciprocal lattice is found in the coordinate system of the diffractometer. All that remains is to determine the necessary coordinate transformations to find the optical orientation of the mineral by relating the orientations obtained from the microscope and x-ray diffraction.

Orientation of crystallographic axes: A single crystal diffractometer can be used to determine an orientation matrix. The three columns of the matrix provide information on the orientation and lengths of a^* , b^* , c^* . To obtain the directions of the a^* , b^* , c^* from this matrix, each row must be normalized into a unit vector. This is accomplished by multiplying row 1 by $\frac{1}{\sin(\theta) \sin(\phi)}$, row 2 by $\frac{1}{b \sin(\theta) \sin(\phi)}$, and row 3 by $\frac{1}{c \sin(\theta) \sin(\phi)}$. The following matrix was determined in this manner for the new monoclinic mineral dickthomssenite [3].

| a^* | b^* | c^* |
|---------|--------|---------|
| 0.1626 | 0.3973 | 0.9173 |
| 0.9758 | 0.0671 | -0.0745 |
| -0.1433 | 0.9150 | -0.3922 |

The above matrix lists the unit vectors cast into a Cartesian coordinate system. These vectors can also be plotted stereographically (figure to right) by casting them into the coordinate system used with the spindle stage [1], yielding, a^* : $S=-8.4^\circ$, $E=80.6^\circ$, b^* : $S=85.8^\circ$, $E=66.6^\circ$, c^* : $S=-100.7^\circ$, $E=23.5^\circ$. (Solid dots plot on the upper hemisphere, hollow dots on the lower.) See [1] for details of this plotting method.)

Indicatrix orientation: EXCALIBUR is used to determine the orientation of the biaxial indicatrix based

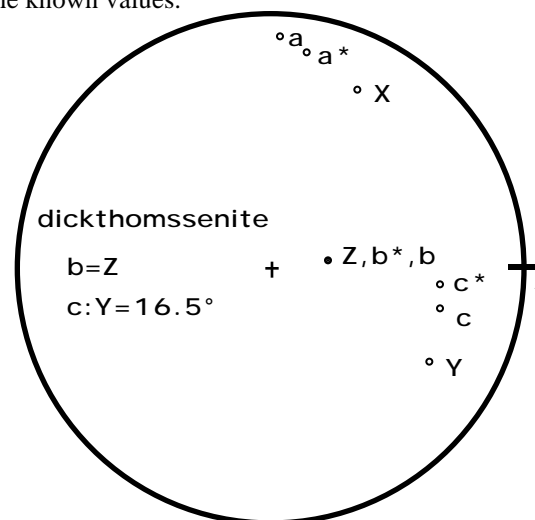
on extinction measurements. However, the coordinate systems differ for the spindle stage and the diffractometer. To make our spindle stage coordinates coincide with our diffractometer's (Siemens/Bruker SMART 1000), the x and z axes must be switched. This amounts to switching row 1 and row 3 of the orientation matrix obtained by EXCALIBUR; this transformed matrix is given below for dickthomssenite:

| X=AB | Y=ON | Z=OB |
|---------|---------|--------|
| 0.4076 | 0.8225 | 0.3966 |
| 0.8776 | -0.4728 | 0.0786 |
| -0.2522 | -0.3161 | 0.9146 |

These vectors are also plotted stereographically below: X: $S=-16.0^\circ$, $E=65.9^\circ$, Y: $S=-146.2^\circ$, $E=34.7^\circ$, Z: $S=85.1^\circ$, $E=66.6^\circ$.

Optical orientation: Given the above two orientation matrices, the optical orientation can be determined by observations and measurements made on the stereoplot, or are calculated. By observation it is clear $b=Z$. To determine $c:Y$, c must be located. On the stereoplot, c is found by plotting it as the normal to the plane that contains a^*b^* , or its direction is calculated by the cross product of a^*b^* . Next, the c direction can be plotted and $c:Y$ measured or the dot product of c and Y calculated. Either method results in $c:Y=16.5^\circ$.

This method was checked with two orthorhombic crystals of known optical orientation and one triclinic crystal. For all three cases we obtained values within 1° of the known values.



References: [1] Bloss F. D. (1981) The spindle stage: Principles and practice. [2] Bartelmehs K. L. et al. (1992) *Zeit. f. Krist.*, 199, 185-196 [3] Hugh J. M. et al. *in preparation*.