

Biaxial Minerals: The Spindle Stage and EXCALIBUR II

The following is a recipe for determining the three principle refractive indices of a biaxial mineral (n_α , n_β , n_γ) using a detent spindle stage and the computer program EXCALIBUR II.

I. Aligning the spindle stage

- Affix the spindle stage on the microscope with the spindle pointing W and with the set screw loosely tightened.
- Center the axis of the spindle stage so that a mounted crystal will be under the cross hairs.
- Tighten the set screw.
- Carefully determine the stage position (M_R) that orients the spindle axis E-W as follows:
 - (a) Set the spindle position to 0° ($S=0^\circ$)
 - (b) Identify a stage position with the spindle approximately E-W ($\sim M_R$).
 - (c) Rotate the stage **clockwise** until the crystal is extinct. Record the stage position (M_0).
 - (d) Return the stage to where the spindle is approximately E-W ($\sim M_R$).
 - (e) Set the spindle position to 180° ($S=180^\circ$).
 - (f) Rotate the stage **anticlockwise** until the crystal is extinct. Record the stage position (M_{180}).
 - (g) Calculate the exact E-W position (M_R) from the equation: $M_R = (M_0 + M_{180})/2$.
 - (h) Rotate the stage to position M_R .

II. Extinction angle measurements

- Set the stage to M_R (spindle axis E-W).
- Set the spindle to 0° ($S=0^\circ$).
- Rotate the stage **clockwise** until the crystal becomes extinct.
- Record the spindle position (S) and the stage position (M_S).
- Return the stage to M_R .
- Set the spindle to $S=S+10^\circ$.
- Rotate the stage **clockwise** until the crystal becomes extinct.
- Record the spindle position (S) and the stage position (M_S).
- Repeat the above steps until 18 extinction angles have been measured (for $S=0^\circ$ to $S=170^\circ$).

III. Running EXCALIBUR II

- Find a free Macintosh computer in SR-126.
- Turn on the Macintosh (back left, middle).
- Open the Mineralogy Folder
- Open the EXCALIBUR Folder
- Create a data file containing your extinction data (using the Edit program) in the format shown on the next page. Be sure to follow the format exactly. I recommend opening the test data file, modifying it by inserting your data, and using the SAVE AS command to save your data in a file with your name on it. The test input file may be locked, which means you will get some funny messages. You won't be able to SAVE, but you will be able to SAVE AS.

```

your title                !(following the four stars)
clockwise                !numbers on our microscope stages increase clockwise
589 /                    !one wavelength must be entered
/                          !slash must be included
    0.0      ###.##      !right justified at columns 10 and 20
    10.0     ###.##      with decimal point
    20.0     ###.##
    30.0     ###.##
      :           :
      :           :
    170.0    ###.##

```

- Save the data file.
- Quit Edit.
- Double click on the EXCALIBR application.
- When asked, type the name of your data file.
- When asked, type the name to be used for the output file.
- **Wait** for EXCALIBR to do its work. (It takes a couple of minutes on this computer.)
- When EXCALIBR stops, open the output file from within the Edit program.
- If the run was successful, print the output file by selecting PRINT from the **File** menu.

IV. Refractive index measurements

- Be sure to use the values at the **end** of the output file.
- $2V$ is given as the "Optic Axial Angle"
- To get the acute bisectrix horizontal and E-W (to measure n_γ if positive, n_α if negative), use the spindle position S for "Vector AB" and the stage position for "E-W Polar./E+MR"
- To get the obtuse bisectrix horizontal and E-W (to measure n_α if positive, n_γ if negative), use the spindle position S for "Vector OB" and the stage position for " E-W Polar./E+MR "
- To get the optic normal horizontal and E-W, use the spindle position S for "Vector ON" and the stage position for " E-W Polar./E+MR (to measure n_β)."
- Note: the crystal should be at or near extinction (low retardation) for each of these measurement positions.