Optic properties of centimeter-sized crystals determined in air with the spindle stage using EXCALIBRW

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Abstract

Extraction data sets for four centimeter-sized anisotropic crystals were collected in air with standard spindle-stage methods and submitted to a new Windows-based version of EXCALIBR, termed EXCALIBRW. EXCALIBRW solved these data sets with varying degrees of accuracy related to the external shape of the crystal: the more rounded the crystal, the more precise the results. For an olivine crystal ground into a sphere, the results were similar to those obtained for a crystal immersed in an index-matching fluid. However, even for samples bounded with growth or cleavage faces, the program determined the orientation of the optical indicatrix and 2V with an error of only 1°–2°. Thus, this logical extension of spindle-stage methods is helpful: (1) to orient centimeter-size single crystals for various types of mineralogical measurements (e.g., spectroscopy or diffusion studies in which it might be undesirable to place the sample in a liquid); (2) as a non-destructive means of identifying gemstones based upon a determination of their optical class (i.e., isotropic vs. uniaxial vs. biaxial); and (3) for optical characterization by determination of 2V. In addition, the newest version of EXCALIBRW is easier to use, mathematically more robust in its solution algorithms, and provides solutions for crystals in less favorable orientations than the earlier versions of EXCALIBR.

Introduction

The spindle stage has been in use since the early 1900s (Gunter 2004; Gunter et al. 2004; and reference therein) as a means to orient single crystals on a polarizing light microscope, but it was not until the work of Wilcox (1959) in the late 1950s, followed by Bloss and coworkers in the late 20th century, that the spindle stage became a robust mineralogical research tool. [See the preface of Bloss (1999), Gunter (2004), and Gunter et al. (2004), for some historical perspectives and Bloss (1981, 1999) and Gunter et al. (2004) for a thorough discussion on the use of the spindle stage in research and teaching.] The major contributions made by Bloss and coworkers over the past 30 years were the refinement of spindle-stage hardware and the development of the computer program EXCALIBR (Bloss and Riess 1973), which solved extinction data sets (i.e., microscope stage settings that cause a crystal to go extinct as the spindle stage is incremented, see Table 1) to yield the orientation of the biaxial indicatrix and determined a precise value of 2V.

The 1973 version of EXCALIBR was improved upon and thoroughly discussed in Bloss (1981), further refined and made PC/Mac compatible in 1988 (Gunter et al. 1988), then completely rewritten and renamed EXCALIBR II in 1992 (Bartelmehs et al. 1992). EXCALIBR II has been improved further and the DOS interface has been replaced with a Windows Graphical User Interface (Gunter et al. 2004 and discussed herein). The major goal of the present paper is to introduce EXCALIBRW to the mineralogical community and show its use with centimeter-sized single crystals whose extinction data sets are collected in air rather than the normal data collection on micrometer-sized crystals whose extinction data sets are routinely collected in index-matching fluids. (The most recent version of EXCALIBRW can be obtained for free by contacting Stanley Evans at Stanley_Evans@comcast.net.)

Experimental Methods

EXCALIBRW

This newest version of EXCALIBR was tested on large samples whose extinction positions had been measured in air and one smaller sample that was measured in an index-matching fluid for comparison (i.e., treated as a control). The newest version of EXCALIBR is a revised version of EXCALIBR II (Bartelmehs et al. 1992), which in turn was a completely rewritten version of EXCALIBR (Bloss 1981; Gunter et al. 1988). EXCALIBRW II introduced several improvements over EXCALIBR, mainly: (1) the extinction positions could be measured at any 5° value (i.e., spindle-stage setting) and were not restricted to 10° increments; (2) the input data were free format; and (3) several bugs were fixed, notably the standard error calculations for 2V, for the orientation of optical directions, and for the statistical algorithm used to determine whether dispersion of a given optical direction occurred when extinction data sets were collected at multiple wavelengths. EXCALIBRW further improves on EXCALIBR II in that the program is Windows compatible and creates a user interface that is self-explanatory (Fig. 1). Moreover, EXCALIBRW