BOOK REVIEW

OPTICAL CRYSTALLOGRAPHY. By F. Donald Bloss. Mineralogical Society of America (Monograph Series, Publication no. 5), 1999, Washington, D.C. 239 p. ISBN number 0-939950-49-9. $32.00. ($24.00 for MSA members).

An Introduction to the Methods of Optical Crystallography, by F. Donald Bloss, was first published in 1961. That edition still stands as a classic in the field. It is technically sound and the explanations are, for the most part, clear and understandable even to a typical sophomore-level geology major. The 1961 edition was reprinted, but not revised, in 1967, and for many years it remained a widely used textbook for undergraduate courses in optical mineralogy. If the number of adoptions and the overall popularity of this book declined over the following years, it was the result of several factors:

(1) The need for the student to have a second textbook with mineral descriptions, data, and other reference material;

(2) The escalating cost of textbooks no doubt weighed on the consciences of professors;

(3) The publication of several new competing textbooks in optical mineralogy; and

(4) The trend in many colleges and universities toward de-emphasizing optical theory (the "how" and "why") in favor of a "cookbook" approach (e.g., "Insert your gypsum plate, and if it turns blue, it's positive."). Coupled with this last item has been a trend toward a decrease and even total elimination of the use of the oil immersion method and a complete reliance on thin sections.

In the past 15 years or so, the number of geology departments in the U.S. that require or even offer a course in optical mineralogy has decreased considerably, and the training our students receive in mineralogy and petrology is shrinking in scope. If the trend continues, we are headed toward a time when the only required course in this area will be a condensed course in "earth materials." The skills and the understanding of optical mineralogy will be lost. I believe it is in this light that the MSA has chosen to reprint Bloss' textbook, with some minor changes, so that the language and concepts of this field will be preserved in some form, rather like Sequoyah saving a written form of the Cherokee language for posterity.

This new printing has been a long time coming. One unfortunate effect of the great length of time between editions is that microscopes have evolved. In the first edition, six different models of polarizing microscopes were shown. In the new edition, the sole model of petrographic microscope that is depicted has a fixed objective lens and is focussed by raising and lowering the *stage*; however, the discussions on Becke lines and focussing still talk about raising and lowering the *objective*. Because a raised objective is the same as a lowered stage, beginning students have difficulty with this. Even worse, in more than one spot, the text says "as the *microscope* [italics added] is raised upward…" (I shudder to think what my students would do if they actually read that!)

In many of the figures that accompany the discussion of biaxial interference figures, a numerical aperture of 0.85 is assumed. It is a shame, but a reality, that in today's world, few student-model petrographic microscopes have high-power objectives with a numerical aperture of 0.85. The passage of time between editions may be emphasized by the following observation. In Chapter 4 of the first edition, a specific type of focussing system is said to be found in "some *newer* models." In the new edition, the same system is said to be found in "some *older* models." [Other things have gotten older too! At the end of Chapter 3, in the first edition, the footnote reads: "The normal human eye is unable to see clearly any objects closer than 25 cm, the so-called distance of distinct vision." In the new edition, the following has been added to this footnote: "This distance usually increases with age." Yes, I can relate to that!]

Except for new chapters on spindle-stage and dispersion staining techniques, the revisions are few in number and do not substantially improve on the original. Furthermore, errors and problems have been introduced. For example, in producing this new edition, the publisher seems to have reproduced (and in almost every case also reduced in size) the figures from the earlier edition, while adding slight modifications to the shading or labels in those figures. This has not improved the figures; in fact, the figures in my 34-year old copy are far superior to those in the new edition. In some reduced figures, subscripts are now too small to see. The addition of darker shading renders many of the figures ineffective. For example, in Figure 2–2 the darker shading obscures the polarization direction of the reflected ray. The new edition has changed the units used for wavelength from angstroms to nanometers, it appears, mainly by chopping off the last zero with a razor. A fragment of the last digit remains in a number of figures (e.g., Fig 5–8). Other figures with serious problems introduced by the revision process include Figures 6–14; Figures 8–15B (lower portion); and Figures 10–23A. Figures 10–18 and 10–19 are reversed.

The sparse additions of text material have not been carefully edited. Numerous typographical errors have cropped up. As a one-time prospective English teacher, I have found optical mineralogy to be an ideal platform from which to teach my students the correct use of "principle" and "principal." Alas, the revisions have resulted in an incorrect "principle." Horrors! Much of the new text tends to be overly detailed and verbose, and thus not in keeping with the bulk of the material written earlier. Explanations become needlessly cumbersome and less understandable.

The new *Overviews*, at the beginning of each chapter, constitute a useful addition for the reader. However, they suffer from numerous typos, and in my opinion, they should stand alone and should not contain references to figures within the chapter to follow.

Inconsistencies abound. Some items are updated; but, whereas "illumination system" has been introduced in describing microscopes, in some places "substage mirror" persists. Pronouns have been made gender-neutral in some places, but not in others. References are inconsistent: some are included as footnotes, some at the end of a chapter, some at the end of the book, and some are completely missing. Although every chapter has a beginning *Overview*, the format at the end of each chapter is inconsistent. Some chapters have *Questions and Problems* (Chapters 1, 2, and 3), while some have *Review Questions* (Chapters 8 and 11), *Recommended Readings* (Chapters 5 and 13), a *Summary* (Chapter 6), a *Thought question* (Chapter 7), or none of the above.

The interference color chart has incorrect units on the ordinate (nanometers instead of millimeters); also this axis should be labeled with *t* for easy reference to the retardation / birefringence formula (Eqs. 8–3) on the facing page. The birefringence of quartz (of all minerals) is incorrectly listed on the color chart. The caption that accompanies the chart spends half its space talking about how kyanite can deviate from its normal stoichiometry and how this will affect its birefringence. In my view, this will unnecessarily confuse the beginning student. I suspect that the use of the word "outcrop" (for the intersection of a ray projection with a focal surface), and the use of the term "crystal plate" (to indicate a mineral fragment with flat, horizontal lower and upper surfaces), will also result in student confusion.

In a uniaxial flash figure, the isogyres separate and leave in the quadrants containing the optic axis. [In the new edition this phenomenon is ascribed to Lommel's Rule. It would be nice to have a reference for the reader who is unfamiliar with this rule.] This is essential to know when determining optic sign, or locating the ε vibration direction. This was not explained in the previous edition, so the addition of Figures 8–9 and the accompanying text is most welcome. However, I was puzzled by the omission of the same concept with respect to biaxial optic normal and obtuse bisectrix figures: i.e., the isogyres separate and leave in the quadrants containing the acute bisectrix. Again, this is extremely useful information.

The description of how the Becke Line is produced has never been particularly satisfying to me. Two mechanisms are offered, the lens effect and the internal reflection effect, but the diagrams show perfectly parallel vertical light rays. If this were the case, then there should be no Becke lines for vertical-edged grains, like the very first mineral that students normally see under oils–halite. Figs. 5–4 is troubling in this regard. Figure 5–5 and the discussion on oblique illumination is generally improved, although there are typos in the new sections, and the description of colors of the Becke lines for a grain-oil match are inconsistent (Figs. 5–9: "orange enters grain; sky-blue enters oil;" but the text says: "orange-tinged yellow (some say orange) [enters grain]; green-tinged blue [enters oil]").

The discussion concerning dispersion in biaxial interference figures could be improved by starting with a discussion of the relationship between crystallographic and optical directions, followed by a mineral that shows "normal" dispersion of the refractive indices (i.e., no variation in 2V or in indicatrix axes as a function of wavelength).

The explanation of the origin of various interference figures was turgid to me in the 1960s. Some of these explanations have been rewritten, and some new diagrams and descriptions of how to recognize various interference figures have been added. Students will continue to struggle with these, especially when there are some inconsistencies in the names given to various figures (e.g., "optic-normal-flash figure," "ON-centered figure," and "optic normal figure" all refer to the same thing). The section describing how to determine the optic sign of a biaxial mineral suggests that the student use a Bxa figure. This is certainly not an efficient way to go about it. Students will spend hours searching for a centered Bxa figure, one that looks just like the one in the book. Why not suggest they use an optic axis figure? It has already been sought in the previous paragraph ("Determination of Biaxiality").

The new chapters on the use of the spindle stage and on dispersion staining add new dimensions to the text, but in places I fear that they delve a bit deeper than is probably appropriate. This is especially true of Chapter 13 on identification of asbestos fibers. Use of the spindle stage can be extremely enlightening and I am pleased to see its inclusion in the book. Many students finally are able to mentally merge crystallography with optics only after being introduced to the spindle stage. It also opens the door to special applications, notably forensic microscopy; for definitive characterization of non-opaque mineral grains, inexpensively and nondestructively, there is no better technique. In the book, there is information on how to purchase spindle stages, or to gain access to directions on how to construct inexpensive stages that work quite well. The reader will also want to know which cements are the best to use (and are not soluble in various index oils). Two valuable resources are Bloss' book *The Spindle Stage: Principles and Practice* (1981, Cambridge University Press, 340 p.), the source of many figures in this new book, and Mickey Gunter's website <www.uidaho.edu/~mgunter/>, from which EXCALIBR may also be downloaded.

Those instructors who choose not to use immersion oils miss out, along with their students, on a tremendous opportunity to extract a great deal more information from mineral grains than afforded by exclusive use of thin sections. But more than that, they miss out on a chance to gain a deeper and more correct understanding of the optical principles involved. Nevertheless, oils truly seem to be on the way out. High refractive index oils, in particular, present problems with respect to safety regulations for today's teaching labs.

Despite all the issues, this book has quite a few things going for it. The explanation of the origin of interference colors is lucid, and I have always thought that the use of the transmission formula to show what happens with *parallel* polars is well worth the effort. To really drive home the concept, have the class predict what they will see when viewing their accessory plates under parallel polars, and then check it out for themselves. The writing style contains a certain charm that is generally lacking in newer books; one of my favorites is "[observe the calcite rhomb] while moving the head from side to side, cobra-like." And you certainly can't beat the price for this book these days! If you don't own a copy of the original (1961) version, be on the lookout for one when browsing used book stores, or consider purchasing this new edition, especially if you have interest in using or teaching use of the immersion method and the spindle stage. For those departments and faculty that persevere in teaching the immersion method, and can devote the time required to help students gain a real conceptual understanding of optical mineralogy, this book is a real asset.

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