

## BOOK REVIEWS

A COLOR ATLAS OF CARBONATE SEDIMENTS AND ROCKS UNDER THE MICROSCOPE. By A.E. Adams and W.S. MacKenzie (1998). 180 p., John Wiley & Sons, New York. Paper, \$49.95.

As pointed out by the authors, more than half of the world's petroleum is hosted by carbonate rocks; their study is well-justified. These rocks exhibit a most impressive and variable petrology as observed under the petrographic microscope; such variety is due in large part to the many carbonate grain types, particularly bioclasts, and complicated diagenetic processes. Studies of carbonates begin in the field and are commonly concluded by the analysis and interpretation of detailed sophisticated methods (including CL, XRD, stable isotope determination and trace element analysis, etc.). In between lies the petrology phase. The authors clearly state that this atlas was "...designed as a laboratory manual to keep beside the microscope as an aid to identifying grain types and textures in carbonates." Their hopes are that it will appeal to undergraduates, graduate students, and to professionals. For students to get the most from this volume, they should have some background in optical mineralogy.

Although the book is an atlas, it includes a relatively modest amount of text consisting of both background information and reference to features displayed by the more than 300 colored illustrations, mostly photomicrographs (which, by the way are exquisitely done). The book is primarily descriptive; the editors enter into the interpretive when it is necessary to explain the origin of features illustrated.

In their introduction they discuss the six main components of carbonate rocks: grains; matrix; terrigenous components; sparry calcite; replacive crystals (e.g., dolomite); and porosity. They include a short coverage of the main carbonate minerals, past and present. Staining is explained as is impregnation with blue-dyed epoxy.

Fourteen pages with 21 related photomicrographs (the number of photomicrographs given here and elsewhere does not include additional cross-referenced ones) are devoted to "coated grains" (oids, pisoids, oncoids, and some problematic grains). "Peloids, aggregate grains, intraclasts and lithoclasts" are included in a section of 9 pages with 14 photomicrographs. Not surprisingly, the longest chapter (68 p., 143 photomicrographs) concerns "bioclasts". The subdivisions in this section are: bivalves (12 p., 15 photomicrographs); gastropods (3 p., 5 photomicrographs); cephalopods (2 p., 4 photomicrographs); brachiopods (6 p., 15 photomicrographs) corals (5 p., 12 photomicrographs); stromatoporoids (1 p., 2 photomicrographs); sponges (2 p., 4 photomicrographs); bryozoans (5 p., 10 photomicrographs); foraminifera (9 p., 18 photomicrographs); echinoderms (5 p., 13 photomicrographs); calcareous algae (11 p., 19 photomicrographs); worm tubes and vermiforms (1 p., 2 photomicrographs); tentaculitids (1 p., 1 photomicrograph); tintinnids (1 p., 1 photomicrograph); radiolarians (1 p., 3 pho-

tomicrographs); and microbial structures (2 p., 4 photomicrographs).

The second longest section is "diagenesis" with the following subjects following a brief introduction (1 p., 1 line drawing): micritization (1 p., 1 photomicrograph); pedogenic features (1 p., 5 photomicrographs); cementation (18 p., 31 photomicrographs); compaction and tectonic features (6 p., 15 photomicrographs); neomorphism, microspar, and pseudospar (4 p., 7 photomicrographs); dolomites (15 p., 31 photomicrographs); dedolomite (2 p., 4 photomicrographs); and silica, evaporite, and pyrite cements and replacement features (7 p., 8 photomicrographs).

"Limestone classification" covers the Folk (1959) and Dunham (1962) systems in four pages with three tables and two photomicrographs (and many cross-references to photomicrographs elsewhere in the text). In the only departure from conventional petrology there is a section on "cathodoluminescence" (18 p., 14 photomicrographs).

By far and away, the strongest aspect of the atlas is the very high quality of the photomicrographs, which are, of course, the focus of the work. The text is well done and suited for upperclass undergraduates although students at any level can benefit and learn from the photomicrographs. The writing is good and generally clear. The spacious layout of the atlas is appealing. Cross-referencing of both text and photomicrographs is thorough and helpful. There is a brief bibliography and a short but adequate index. I ran into about half dozen typos.

Most of my criticism is relatively minor. Under "bioclasts" stromatoporoid fabrics might be better illustrated. Mature vs. immature areas in bryozoans might have been included. More photomicrographs of microbial structures would be justified. I have a pet peeve about the use of the term replacement for neomorphism; I feel it should be reserved for true replacement as defined. In numerous photomicrographs it would have been helpful to have used arrows or letters to pinpoint specific subjects unequivocally rather than present a more vague verbal location. A magnification is given for each figure but I personally think that a bar scale is more effective. A glossary would have been especially beneficial to the undergraduates.

Certainly there is a substantial overlap between the coverage of this atlas and the older (1978) A.A.P.G. memoir 27 "A color Illustrated Guide to Carbonate Rock Constituents, Textures, Cements and Porosities" by P.A. Scholle. The text of the Scholle volume consists mainly of figure captions. This earlier work contains more photomicrographs (it is a larger volume meaning it is not as manageable around the microscope). Scholle sprinkles in some 40 SEM micrographs. As intimated earlier, the Adams and MacKenzie volume might serve as a bit better an introduction to the subject whereas there is somewhat more detail in the Scholle atlas. Then there is the difference in cost to consider. The present volume sells for \$49.95; the Scholle volume costs only \$29.00. Familiarization with and access to

both is recommended for the beginner but given that the photomicrographs are so superbly done, it behooves even the veteran petrologist to have access to this new publication by Adams and MacKenzie.

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N.L. BOWEN AND CRYSTALLIZATION—DIFFERENTIATION: THE EVOLUTION OF A THEORY. By Davis A. Young. Mineralogical Society of America, Monograph Series, Publication no. 4. 276 pages. \$16.

This book traces in detail the developments in igneous petrology of the theory of crystallization-differentiation as espoused by N.L. Bowen, whose overarching genius generated a revolution in thinking about the diversity of igneous rocks. With the same lucid prose typical of Bowen, Young has driven home the arguments supporting the theory and analyzed Bowen's responses to criticisms. It is the versatility and flexibility of Bowen's counter arguments to the critics that makes this book fascinating reading. Conversely, it is the lack of rigor and substantive documentation by his critics that also strengthened Bowen's theory. Bowen held tenaciously to his theory, but in the end it was his own experiments with colleague O.F. Tuttle that required him to modify his position on the formation of some granites and to accept the possibility of anatexis.

The first six chapters relate the history of the various proposals for explaining the diversity of igneous rocks. In addition, Young outlines the impact of the advances of physical chemistry, thermodynamics, and experimental techniques at the beginning of the twentieth century. But it was Reginald A. Daly who imbued Bowen with a comprehensive, even-handed view of the various theories and implanted the concept of a basic parental source magma derived from depth. Of all these theories, it was Charles Darwin's concepts of crystal settling and filter pressing that played a major role in forming Bowen's prejudice toward crystallization-differentiation, and fractional crystallization as defined by G.F. Becker, as the dominant process. Furthermore, his many field experiences "brought home" the concept of magmatic differentiation.

Young traces Bowen's development of his theory from the germ that emerged from his study at the Geophysical Laboratory of the plagioclase phase diagram, the incongruent melting of enstatite composition, experimental demonstration of crystal settling, and the haplobasalt system diopside-albite-anorthite. From these few studies conducted over a period of only four years emerged the comprehensive theory of crystallization-differentiation. The theory was constructed without the knowledge of the effects of pressure, volatiles, potassium, or iron oxides, deficiencies that he at first had to defend and eventually remedied through additional experimentation.

Chapters 7–14 relate the severe criticisms of his mentor R.A. Daly, field petrologist F.F. Grout of Duluth gabbro fame and Bowen's own colleague C.N. Fenner, and the rebuttal to the many challenges raised. Bowen dismissed all the alternative theories with quantitative argumentation. Young emphasizes

the failure of Bowen's critics to respond with equally rigorous and quantitative arguments. Nevertheless, Bowen set out to correct the deficiencies of information by undertaking with his colleagues laboratory experiments in those systems that would provide a definitive response to the criticisms point-by-point. Fenner's iron-enrichment concept, supported by the Skaergaard residual liquid evidence, did cause Bowen to appeal to the "flexibility" of his theory that provided for residual liquids enriched in silica and alkalis. Fortunately, the dilemma, described in Chapters 15–18, was eventually resolved by E.F. Osborn who showed the important role of oxygen on the course of crystallization, but only after both of the contestants had died.

After Chapter 19 on Bowen's decade-long stay at the University of Chicago where he introduced experimental petrology, Young outlines Bowen's work with O.F. Tuttle bearing on the unlikelihood of ultramafic magmas whose existence was promoted by H.H. Hess. These experiments clearly confirmed Bowen's view of the non-existence of olivine or ultrabasic magmas. In contrast, other experiments with Tuttle on the origin of granite magma not only confirmed the magmatic origin of some granites, but opened the door to all the prior criticisms he had received regarding the volumetric proportions problem, lack of intermediate rock types, expulsion problem, room problem, zoned feldspars, basic fronts, energy considerations, source of granitizing solutions, and others. As Young puts it, "Tuttle took granite studies in a direction that Bowen had been reluctant to go throughout his career...."

In the concluding Chapter 24, Young gives a fair assessment of the dominant role Bowen played in the development of the still currently accepted theory of crystallization-differentiation. He emphasizes Bowen's eagerness to "eliminate the competition" with devastating critiques of the alternative processes with light-hearted, but barbed, good humor. Bowen used every occasion to list the deficiencies of liquid immiscibility, diffusion, Soret effect, volatiles, assimilation, and gaseous transfer as the major cause of igneous diversity. Most importantly, Bowen's dream of seeing experimental petrology take its place in the academic world has been realized. The feud between field and experimental petrologists is long over and the jokes about those "little crucibles" are forgotten. Perhaps Bowen's greatest victory was in persuading field geologists that experimental studies are a necessary supplement to field observations.

Students and professional petrologists, both field and experimental, will benefit greatly from reading Young's enjoyable review. The historian of science will appreciate the footnotes containing references to the biographical details of the players. Of special interest to historians will be Young's comparison of Darwin's role in biological evolution to Bowen's role in igneous rock evolution. Some of Young's critical quotations are unfortunately not referenced and the sources of some of his observations are not noted. Errors in the book are few and trivial. Needless to say, this reviewer, although admittedly a prejudiced admirer of Bowen, can highly recommend Young's book to all interested in the development of an important scientific concept.

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