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BOOK REVIEWS

Kimberlites, orangeites, lamproites, melilitites, and minettes: a petrographic atlas. By Roger H. Mitchell. Almaz Press Inc., 1427 Ridgeway Street, Thunder Bay, Ontario P7E 5J7 (FAX: 807-623-7526), 1997, 243 pages. US$100 softbound (ISBN 0-88663-026-6).

By far, the oddest and darkest corner of the igneous realm is the one containing the alkaline rocks. The nomenclature is arcane, definitions are obscure, the classification is convoluted, and petrogenesis is complex. Some people live full-time in that corner and understand these things; the rest of us are hopelessly lost most of the time. Roger Mitchell's new petrographic atlas of kimberlites, orangeites, lamproites, melilitites, and minettes sheds some much-needed light in a part of this dark corner and makes clear, in a six-page summary text and in 400 outstanding color images, the similarities and differences in a petrologically and economically important group of igneous rocks.

Petrographic rendering has evolved considerably over the decades. The epitome of black-and-white line drawings in *Petrology of the Igneous Rocks*, by Hatch, Wells, and Wells, dates back more than a century. Then came an era of fuzzy black-and-white photomicrographic atlases (typified by the various Augustithis atlases), which eventually evolved into atlases of sharp color images (*e.g.*, the MacKenzie, Donaldson, and Guilford atlas of igneous rocks). Mitchell's atlas is now the epitome of color images. It uses uniformly sharp, large (10.3 × 15.2 cm), true-colored images in plane-polarized light (ppl) and crossed nicols (xn), and false-color back-scattered electron (bse) images. Many subjects have been photographed at several different magnifications to permit an overview of the whole rock as well as a detailed examination of the groundmass. The result is eyestrain-free petrography at its best.

In two respects, however, Mitchell-the-artist, presumably judging the image to be paramount, consciously overruled Mitchell-the-scientist. First, each image should have had a standard scale-bar, and either ppl, xn, or bse superimposed on it so the reader could tell at a glance the size and type of image. Second, each image has only a figure number and brief title beneath it. To read the caption, one must turn to the compilation of full captions at the back of the book. The average caption actually fits in the space already available between the images and the bottom of the page, and for convenience of use, such a placing is highly desirable. The few longer captions could have been accommodated in various other ways (reducing font, reducing text, reducing figure).

These aspects aside, Roger Mitchell's petrographic atlas of an important subset of alkaline rocks is an outstanding and indispensable reference for libraries, and essential for anyone doing pure or applied research with these types of rocks.

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Layered Intrusions. Edited by R. Grant Cawthorn. Elsevier Science Inc., P.O. Box 945, Madison Square Station, New York, N.Y. 10160-0757, U.S.A. 1996, 531 pp. + map, US$200 (hardcover, ISBN 0-444-81768-9) or US$93.75 (paper, ISBN 0-444 82518-5).

Last week, I opened the latest (May, 1998) issue of *The Journal of Geology* and therein found two major articles on layering and igneous cumulates, and a discussion/reply on the cumulate paradigm. This illustrates nicely the rapid development and the lack of consensus of geological thought focused on layered igneous rocks. In fact, *Layered Intrusions* is the third hefty tome to be published in the last 30 years that deals with these arresting rocks. The first, in 1967, was Wager's and Brown's *Layered Igneous Rocks*, nearly half of which dealt with Skaergaard. Twenty years later, Ian Parsons edited *Origins of Igneous Layering*, where Skaergaard was reduced to about 7% of the content as the widespread occurrence of layered igneous rocks elsewhere came to be increasingly appreciated. In the volume here under review, Skaergaard falls to about 6%.

Layered Intrusions is the 15th work in the well-known series "Developments in Petrology." It is a glossy, well-produced volume (it ought to be at its price!) holding to high scientific and editorial standards. Following a brief preface by the editor, a two-page introduction by G.M. Brown points out that simplistic models of ortho- and adcumulates have been superseded by the recognition of more complex processes that operate at crystal boundaries and between residual and replenished liquids, adding that "good field observations are hard to refute, whereas the fun begins with the interpretations."

The body of the book is composed of 14 chapters that range from 26 to 50 pages each. The first four are general and genetic, dealing with the mechanisms and development of layering in igneous rocks. With such a diversity of models, this reviewer was left wondering why the vast majority of igneous bodies in the Earth's crust are not layered! The final ten chapters treat specific intrusions, sort of clinical case-studies. The book closes with an author index (complete references are given at the conclusion of each chapter), and an unusually thorough subject index. The 1:20,000-scale University of Oregon colored geological map of Skaergaard, probably already known to most readers of this volume, occupies a pocket inside the back cover.

Space here allows only that I deal a bit with the opening four chapters. The first, "Mechanisms of formation of igneous layering" by H.R. Naslund and A.R. McBirney, points out that although not uncommon in gabbroic and syenitic intrusions, layering is so varied in chemical, mineralogical, and spatial details that no single mechanism can be responsible. The authors deal with some 25 layer-forming mechanisms, with nucleation-rate fluctuations receiving the most exhaustive treatment. This fine overview of the problem should be required reading for advanced undergraduates in igneous petrology. In Chapter 2, "Fluid dynamic processes in basaltic magma chambers", I.H. Campbell discusses in mathematical detail the roles of compositional and thermal boundary layers produced by convection through cooling and crystallization, or by the introduction of new magma. T and P assume critical roles in the development of layering. Add on the effects of the melting of country rock and double-diffusion convection, and the picture becomes really complicated. The petrologist is left with many choices to fit with field observation. "Texture development in cumulate rocks" by R.H. Hunter is the third chapter. The author opens with a fine historical discussion of the labyrinthine terminology of cumulate rocks (p. 79 is particularly informative), and then leads the reader into the plethora of complex processes that produce some degree of textural equilibrium. The result? No definitive textural criteria will distinguish adcumulates formed by *in situ* crystallization, sedimentation, compaction, or recrystallization. Textural development may be both primary and secondary, and examples are given. Hunter closes with a plea that textural terms be genetically neutral.

The last of the opening chapters, "A review of mineralization in the Bushveld Complex and some other layered mafic intrusions" by C.A. Lee, is of particular importance to economic geologists and mineralogists. The author discusses the occurrence of platinum-group elements (PGE) in the Merensky Reef and elsewhere in the Bushveld and, in lesser detail, occurrences in the Stillwater, Great Dyke, Munni Munni, and a half dozen or so other intrusions. He treats the relationship of PGE to chromitites and briefly to mafic and ultramafic pegmatites. He closes with a review of oxide deposits (chromite and magnetite – ilmenite). The chapter is a thorough overview of ore deposits in layered mafic intrusions. Whereas the oxide ores are relatively straightforward, the PGE are diverse in their petrographic and mineralogical settings. Lee stresses the dominant influence of magma source rather than post-intrusion intrachamber magmatic processes in creating ore deposits.

The final ten chapters amount to "topographic petrology": 5. "The Skaergaard Intrusion" by A.R. McBirney; 6. "The Bushveld Complex" by H.V. Eales and R.G. Cawthorn; 7. "The Bjerkreim–Sokndal Layered Intrusion, Southwest Norway" by J.R. Wilson *et al.*; 8. "Layered intrusions of the Duluth Complex, Minnesota, USA" by J.D. Miller, Jr. and E.M. Ripley; 9. "The Fongen–Hyllingen Layered Intrusive Complex, Norway" by J.R. Wilson and H.S. Sørensen; 10. "Layered akaline igneous rocks of the Gardar Province, South Greenland" by B.G.J. Upton *et al.*; 11. "The Great Dyke of Zimbabwe" by A.H. Wilson; 12. "The Rum Layered Suite" by C.H. Emeleus *et al.*; 13. "The Stillwater Complex" by I.S. McCallum; and 14. "The Windimurra Complex, Western Australia" by C.I. Mathison and A.L. Ahmat.

To sum up, *Layered Intrusions* could have been improved with lead-in chapters by the editor to tie together the whole. A lower price (with taxes, the paperback version is more than $CDN150) would make the volume more accessible. That aside, however, this is an up-to-date and exhaustive book in a fast-evolving field. If not an indispensable reference for workers on layered igneous rocks, it is nearly so. Certainly it is an immensely useful source. Parts of the volume, particularly the opening chapters, will enrichen and enliven university seminars and advanced courses in igneous petrology.

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Granite: From Segregation of Melt to Emplacement Fabrics. Edited by J.L. Bouchez, D.H.W. Hutton, and W.E. Stephens. Kluwer Academic Publishers Group, P.O. Box 989, 3300AZ, Dordrecht, The Netherlands, 1997, 358 pages, Dfl. 260 ($US 166) (ISBN 0-7923-4460-X).

The collection of papers in this book arose from a symposium held during the meeting of the European Union of Geosciences (EUG) in Strasbourg (France) in April, 1995. As stressed by the editors in their brief introduction to the book, the papers in this volume emphasize the physical aspects of granite magmatism, topics which they feel have been largely underrepresented (unjustly, they imply) in comparison to geochemical approaches. The term "granite" is used in its broadest sense, but much of the emphasis is on "S-type" granites. Although virtually all of the authors are based in Europe, the range of geographic locales covered in the book is much broader, and includes (in addition to Europe), North America, South America, Africa, and Asia.

Much of the emphasis of the book is on the observation that even granites which "look" undeformed can be shown to have a fabric. This observation is perhaps not surprising, given the low temperature and high viscosity of moving granitic magma. So even "classic" post-tectonic plutons can be termed syntectonic, although the definition of "tectonic" in this context is not entirely clear to me, even after reading the book.

The book is divided into three unequal parts. The first consists of five papers related to the rheologic properties of granitic magmas, and processes of melt segregation. I was most interested in the paper by Laporte *et al.*, which suggested that granitic melts may segregate after less than 10% of partial melting. Part II consists of six papers that focus on the fabric in granites, starting with a paper by coeditor J.L. Bouchez, which is a thorough description of the AMS technique; in it, he shows how magnetic fabrics may be related to structures and emplacement. The papers in this section tend to emphasize modeling to show that the methods reflect real features.

Part III, in my opinion the most interesting and informative part of the book, consists of eight papers that mainly focus on specific plutons and show how the fabric data can be used to infer mechanism of emplacement. I particularly enjoyed the papers by R. Anma and by R. Anma and D. Sokoutis, which dared to emphasize diapiric emplacement in the face of all the previous papers focusing on shear-zone emplacement.

The book is compact and attractive, with high-quality figures and reasonable-quality (black and white) photographs. A few very minor typographical errors, such as "extensionnal" (p. 199) and "of" instead of "for" (p. 232), do not significantly detract from the appearance and readability of the text. Some repetition from paper to paper seems unavoidable because of the necessity to cover the basic techniques for each study. This book is unique because of the approach to granite study. I must admit that I found the first two parts to be rather "heavy-going", and enjoyed most of the papers in Part III more because the applications of the studies were more apparent. This book will be useful to specialists in the field of granite emplacement and probably to structural geologists in general, but is obviously of less direct interest to classical petrologists and mineralogists. It is a very useful reference for up-to-date ideas about the topic, and for excellent descriptions of AMS techniques for the novice in the field. The bibliography is combined for all the papers, which avoids repetition and results in a useful compilation of previous work on the topic of granite emplacement and fabric development. Given the cost of this book, I think that it should be in earth science libraries, but not necessarily in the personal libraries of most petrologists.

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Dana's New Mineralogy (Eighth Edition). By Richard V. Gaines, H. Catherine W. Skinner, Eugene E. Foord, Brian Mason, and Abraham Rosenzweig. John Wiley & Sons, 605 Third Avenue, New York, N.Y. 10158-0012, U.S.A., 1819 pages, US$295, hardbound (ISBN 0-471-19310-0).

Next week I travel to the Andes where one of my tasks will be to interpret and to evaluate economically a series of stibnite veins. Looking for this common mineral in *Dana's New Mineralogy* proved daunting. It was not to be found in the 30-page "Index of Mineral Names in Alphabetical Order". Not knowing Dana numbers by heart, I couldn't find the mineral in the preceding 30-page "Index of Mineral Names in Numerical Order." It is, however, in the 37-page concluding "General Index". Back-tracking, I was now able to determine that stibnite (2.11.2.1) was, in fact, also omitted in the numerical index! Is this the only mineral to have been so ill-treated? I did not verify each of the approximately 3700 species covered, but in passing I noted that pentlandite is also missing.

Once upon a time, "Dana" (*Dana's System of Mineralogy*) was king of the mineralogical mountain in the English-speaking world. For some years, this exalted position has been tarnished. The relative decline of "Dana" has three causes.

In the first place, mineralogy has advanced with enormous rapidity and changed focus. Structural studies, quantitative analyses, and the role of atomic substitutions are ascendant, whereas qualitative analyses and morphological studies are in decline. These tendencies reflect the hardware available to mineralogists. Edward Salisbury Dana wrote in the introduction to his sixth edition of "Dana", published in 1892: "Nearly twenty-four years have passed since the last edition of this work was published; a long period, and one in which the science of Mineralogy has made very rapid progress. In fact, this quarter-century has probably been a time of more active mineralogical investigation than any like period in the past." My! What could Gaines *et al.* say about the past *half* century? It is that long since the publication of the (incomplete) seventh edition. The history is as follows: The first edition of "Dana" appeared in 1837, the second seven years later, in 1844, the third in 1850, the fourth in 1854, the fifth in 1868, the sixth in 1892, and the seventh in 1944–1962 (two volumes covering the non-silicates, and a third volume on the silica minerals; volumes on the silicate minerals were never published). Small supplements to the pre-seventh editions appeared from time to time, chiefly in the *American Journal of Science.*

In the second place, the unique niche once taken up by "Dana" is now occupied by many competitors. Outstanding among these are the *Handbook of Mineralogy* (to date more than 2100 pages and still growing, with two volumes still to hit the press), and the DHZ volumes (for the silicates currently at 3785 pages; with completion of the second edition, the total should close out at well over 5000 pages!).

Finally, much information is now "on line" and available with basic computer technology. Here, though, assurance of accuracy is limited, and it may take an experienced mineralogist to filter wheat from chaff. Caveat emptor!

The cover states *Dana's New Mineralogy Eighth Edition.* It is not billed as *Dana's System of Mineralogy*, and with good cause; as I shall show, the work departs substantially from its illustrious ancestors. The appellation "New" emphasizes this distinctiveness, whereas "Eighth Edition" is appended perhaps to give it genealogical legitimacy.

Dana's New Mineralogy is a substantial tome of 1819 (+ xlv) pages. It measures 24.0 × 15.5 cm and is 5.5 cm thick, weighing in at 1730 g (G = 0.85). It is the work of five principal authors, all reputed mineralogists with a wide variety of backgrounds. The format is as follows.

Introductory pages include a preface, two pages of "Historical Perspective" (some of which I've presented above), an alphabetical list of 74 individuals and some enterprises who extended assistance, and three pages chiefly on the criteria for inclusion of species in the book. Nineteen pages on the "Format of Presentation" follow. Here are described, in their order of appearance, the entries (see below) under each of the ~3700 species recognized to the end of 1995. Confusion at the outset: firstly, not all entries are available for every species. With a run-on, line-after-line presentation (in contrast with the itemized tabular presentation chosen for the *Handbook of Mineralogy*), the reader will need to dart back and forth, mumbling "oops, did I miss G?", only eventually to find that it was not given. Then, abbreviations are used with unbridled vengeance. The authors themselves become muddled using, for example, KC in lieu of KH at several places. I suspect that the first pages of the book to become tattered through use will be the eleven pages of abbreviations (pp. xxxv – xlv). Aside from several errors, I was surprised that the abbreviation DANA is for Doklady Academii Nauk Azerbaijan SSR! WA is Washington and Western Australia; CT is Connecticut and closed tube. MT is for Montana, Mato Grosso Sul, and J.A. Mandarino's and V. Anderson's *Monteregian Treasures.* Also, my Province is normally abbreviated QC or PQ, not QUE (though PQ is used on pp. 223, 227, 1307, and elsewhere).

Presentation of each species begins with a line in bold print, opening with its Dana number. The usefulness of this parameter is much discussed, and the last word is not yet in. Computer-sorting of single- and double-digit Dana numbers can lead to erroneous ordering. Also, initial assignment into classes is not consistent, being based on structure for silicates, and chemical composition for all others. The name of the species and its chemical formula complete the first line.

The body of the presentation begins with the source of the name of the species and the date of its initial description. Notes on groups, polymorphs, synonyms, varieties and polytypes follow, if appropriate. Standard crystallographic data are then given, including crystal system, space group, cell edges and angles, cell content (*Z*), and calculated density (*D*). The strongest eight lines (unindexed, with relative intensities) observed on diffraction patterns are then listed, with references to structure, notes on crystal-structure drawings, habit, and twinning. Notes on physical properties come next, in the order morphology and habit (again?), twinning (again?), color, streak, luster, cleavage and parting, fracture, tenacity, hardness (in the table of Mohs scale, I did not understand "2 – Gypsum – Scratched with the fingernail, as gypsum", but I did enjoy "8 – Topaz – Hard; 9 – Corundum – Harder; 10 – Diamond – the hardest known mineral"), density/specific gravity (measured = G), and various optical properties. Observations on the range of composition and phase relationships with other minerals are given for some species.

Presented next, and of particular interest to collectors, are occurrences and localities, with type localities italicized. Economically important localities, or those providing exceptional specimens, are signaled. Presentations close with the initials of the author primarily responsible for the mineral description (Vandall T. King, not a principal author, shared responsibility for a few), and one or more references from the literature to the integral description.

How are the minerals ordered? Into the traditional Dana classes that got as far as class 50 in the aborted seventh edition. The distribution is as follows:

Native Elements and Alloys (Class 1; 36 pp., 87 descriptions)

Sulfides and Related Compounds (Classes 2 and 3; 167 pp., 532 descriptions)

Oxides (Classes 4–8; 169 pp., 392 descriptions)

Halides [erroneously (?) titled "Halogenides" on p. v] Classes 9–12; 49 pp., 148 descriptions)

Carbonates (Classes 13–17; 104 pp., 202 descriptions)

Nitrates (Classes 18–20; 5 pp., 12 descriptions)

Iodates (Classes 21–23; 3 pp., 9 descriptions)

Borates (Classes 24–27; 33 pp., 124 descriptions)

Sulfates (Classes 28–32; 103 pp., 270 descriptions)

Selenates and Tellurates; Selenites and Tellurites (Classes 33 and 34; 20 pp., 67 descriptions)

Chromates (Classes 35 and 36; 5 pp., 13 descriptions)

Phosphates, Arsenates, and Vanadates (Classes 37–43; 275 pp., 660 descriptions)

Antimonates, Antimonites, and Arsenites (Classes 44–46; 14 pp., 55 descriptions)

Vanadium Oxysalts (Class 47; 8 pp., 33 descriptions)

Molybdates and Tungstates (Classes 48 and 49; 18 pp., 39 descriptions)

Organic Compounds (Class 50; 9 pp., 32 descriptions)

Nesosilicates (Classes 51–54; 112 pp., 147 descriptions)

Sorosilicates (Classes 55–58; 87 pp., 125 descriptions)

Cyclosilicates (Classes 59–64; 69 pp., 80 descriptions)

Inosilicates (Classes 65–70; 117 pp., 150 descriptions)

Phyllosilicates (Classes 71–74; 163 pp., 180 descriptions)

Tektosilicates (Classes 75–80, although not all "Unclassified Silicates" – Class 78 – are in fact tektosilicates; 152 pp., 175 descriptions)

One can see that individual descriptions are mostly about half a page in length. Descriptions of silicates tend to be two to three times longer than those of non-silicates. Although silicates comprise but 23% of the total number of species, they take up 41% of the text pages.

Certain groups (calcite, apatite, amphibole, and so on) are given brief introductions, although commonly they are too short to be useful. The edition includes the 1978 IMA classification scheme for amphiboles, but just missed the 1997 update. The IMA's 1988 report on the nomenclature of pyroxenes is (unfortunately, in this reviewer's opinion) taken into account.

An appendix lists alphabetically 44 new minerals recognized in 1996. Formulae and references are given in this last-minute sprint.

Errors and deficiencies? There are too many, especially in comparison with the virtually flawless sixth and seventh editions. Perhaps my leading gripe is with the free and anarchical use of abbreviations. I cited examples earlier in this review. Some, such as P51CZ, 061Zc, DH22, and MSLM4, resemble radio-tube designations of old.

Another objection of weight is the run-on nature of the descriptions. A case in point: it takes unnecessary concentration to catch passages from crystallographic data to physical properties. Yet, some descriptions (my "lost" stibnite on p. 106, for example) have the terms habit, structure, physical properties, tests, chemistry, optics, and occurrence all in bold print followed by colons. This enhances legibility enormously. It should have been followed throughout.

The absence of chemical compositions greatly reduces the usefulness of *Dana's New Mineralogy*, as does the paucity of crystal drawings, which are so helpful in mineral identification. The few drawings given are primitive in comparison with those in the seventh edition. The computer-generated structure drawings are clear and well presented. However, the use of "W" for H_2O is an unfortunate shortcut. Also, where is the OH in the epidote structure (p. 1195)? Worse, where is the H_2O in the faujasite structure (p. 1659)?

I referred earlier to errors in the alphabetical and numerical indexes. Stibnite and pentlandite are not alone. Diacritical marks appear to have derailed the typesetting software used by the publisher. Just two examples: bütschliite and bøgvadite follow, in that order, byströmite; örebroite (following oyelite) ends the listing of minerals beginning with the letter "o". (Here I might add that Swedish is my native tongue, and "ö" is the last letter of the alphabet).

Some minor specific errors: The figures on pages 1 and 11 are identical, and the orientation given in the caption is wrong. Who described cavansite, revdite, and pentagonite (pp. 1566 and 1567)? It is PO_4 (not TO_4) on p. 927, and Reginald Aldworth (not Adsworth) Daly on p. 1524.

Finally, I miss the monotony-breaking ditties that were sprinkled through the seventh edition. In the eighth, about the only one that I caught was that William Wilcox (wilcoxite; 31.9.9.1) was killed by Apaches in 1880. One is left feeling that the present authors are humorless compared to Palache, Berman and Frondel.

For whom is *Dana's New Mineralogy* intended? Certainly it will be an indispensable reference to collectors and to curators of large collections. The up-to-date assignment of Dana numbers alone assures that. Would I personally choose to use the book? Probably only to a limited extent. There are just too many other references available that are more complete and more "user friendly". For example, for basic data such as name (with origin), formula, and basic crystallographic data, the Mineralogical Association of Canada's Special Publication 1, *Encyclopedia of Mineral Names* is a magnificent, accessible, and inexpensive source. For more complete data, the *Handbook of Mineralogy* is exceptionally trenchant and convenient (one awaits with impatience the volumes in press). For silicates, the DHZ series, particularly the second edition, is without peer. Two examples will suffice: The garnet and amphibole groups, respectively 15 and 33 pages in *Dana's New Mineralogy*, occupy no less than 230 and 725 pages in DHZ! For the silica minerals, although partly out of date, the 334 pages in volume III of the seventh edition far overshadow the 26 pages in the work here under review.

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ERRATA

In the article entitled "Grenvillian metamorphism of the Sudbury diabase dyke-swarm: from protolith to two-pyroxene — garnet coronite", by K.M. Bethune and A. Davidson (*Can. Mineral.* **35**, 1191-1220, 1997), please note that references to Bethune (1998), published in *Precambrian Research*, should read Bethune (1997). Furthermore, on page 1198, left-hand column, line 3 should conclude with the word "xenocrysts": "phenocrysts should be considered xenocrysts".