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BOOK REVIEWS

An Introduction to Igneous and Metamorphic Petrology. By John D. Winter. Prentice-Hall Inc. (available in Canada from Pearson Education Canada, 195 Harry Walker Parkway North, Newmarket, Ontario L3Y 7B4.) xx + 697 pages, CDN $107.48, ISBN 0-13-240342-0.

In his preface, Prof. Winter tells us that "This is designed for use in advanced undergraduate or early graduate courses in igneous and metamorphic petrology" (p. xvii). It is indeed a fine text but, as I shall show, it is not for quite such a broad audience.

An Introduction to Igneous and Metamorphic Petrology opens with a particularly lucid preface. The lengthy text that follows is divided into two parts: I. Igneous Petrology (20 chapters, 406 pages), and II. Metamorphic Petrology (10 chapters, 225 pages). The volume concludes with an 8-page appendix on the CIPW norm (the table of contents on p. vi promises three appendices; in reading the Preface I found that the "missing" appendices are printed on the book's inside covers, though not in the order stated), 41 pages of references (about 1500 in all!), and a reasonably complete 11-page general index (authors are not included). From 3 to 32 selected pertinent references are given at the end of each chapter.

The first four chapters (Some Fundamental Concepts; Classification and Nomenclature of Igneous Rocks; Textures of Igneous Rocks; Igneous Structures and Field Relationships) summarize fundamental igneous petrography. The IUGS classifications is well handled, and I found the table (3–1) of igneous textural terms a useful condensation. Chapter 5 through 9 (An Introduction to Thermodynamics; The Phase Rule and One- and Two-Component Systems; Systems with more than Two Components; Chemical Petrology I Major and Minor Elements; Chemical Petrology II Trace Elements and Isotopes) deal with the nitty-gritty of chemistry and, as the author admits (p. xviii): "By the time many students reach Chapter 9 they may fear that they are in the wrong course, or worse, the wrong major!" The good student will find it well worth while to persevere, as he is taken through Gibbs free energy, $F = C - \phi + 2$, and some systems of geological importance (SiO_2, H_2O, plagioclases, and several others), ternary eutectics, and the role of fluids.

The chemical petrology chapters introduce analytical techniques and results, variation diagrams of several stripes, and magma series. Chapter 9, where the student strokes his chin and scratches his head, treats elements distributions (nicely explained!), partition coefficients (including rare earths and spider diagrams) and discrimination diagrams (MORB, IAT ...). Table 9–6 is a concise summary of trace elements and their usefulness in petrology. The chapter closes with isotopes: stable (oxygen) and radiogenic, touching on the standard systems of petrological and geochronological pertinence. The ensuing 11 chapters deal, in a general sense, with clans of igneous rocks (an approach introduced by R.A. Daly nearly a century ago), but here with a decidedly up-to-date and quantitative view. They begin with basalts and their mantellic origins, and proceed to differentiation, fractional crystallization, magma mixing, and several other processes that lead to the diversification of magmas. Chapter 12 deals with layered mafic intrusions (petrography and petrology), and uses Bushveld, Stillwater, and Skaergård as preferred examples. The next three chapters deal chiefly, though not exclusively, with basalts: mid-ocean ridge volcanism (a minomer; petrologists seem unduly influenced by the beautifully symmetrical Mid-Atlantic Ridge), oceanic intraplate volcanism, and continential flood basalts. The last of this triad makes all too clear our feeble understanding of the origin of plateau basalts. Here, it must be kept in mind that these are not stand-alone chapters. Much essential background was given earlier, particularly in chapters 8 through 11. Subduction-related igneous activity is treated in chapters 16 (island arcs) and 17 (continental arcs). Emphasis is on extrusive rocks, with only a broaching of plutonic belts. These are dealt with in some detail in the following chapter: Granitoid Rocks. Table 18–3 goes a long way to demystify S-, I-, A-, and M-type granites, and Table 18–4 nicely summarizes the tectonic setting of granitoids, though it is not all-inclusive. The final two chapters of igneous petrology mop up what is left: unusual but petrologically significant rocks. Chapter 19 deals with non-orogenic alkaline rocks, with heavy emphasis on Africa. Carbonatites and kimberlites receive special attention. The final chapter, on anorthosites, is only seven pages long; it adds but little and exposes our ignorance.

Part II, Metamorphic Petrology, is only a bit more than half the length of Part I. Some of this shortening is due to the earlier coverage of chemical and basic thermodynamic background in chapters 5 through 9.

The first of the metamorphic chapters is introductory, touching on the agents and types of metamorphism

and on the six fundamental protoliths. It concludes with examples: the Scottish Highlands, Otago, and several others. I found this chapter particularly well written and an unusually concise opening to a subject that many students feel to be daunting. The following two chapters complete the generalities. The first is a short (7 pages) exposition on the thorny topic of the classification of metamorphic rocks. The second is much longer (37 pages) and covers structures and textures of metamorphic rocks. Textures in high-strain rocks and shear-sense indicators as well as regional tectonites are given special attention. Well-chosen line drawings and a summary table (23–1) strengthen the chapter to the point where it is nearly a course in itself. The next chapter brings the student back to physical chemistry with discussions on equilibrium and the mineralogical phase rule in metamorphic rocks. Both concepts are developed with unusual clarity. The chapter concludes with common chemographic diagrams and their manipulation. J.B. Thompson's AFM projection is rightly emphasized. The next, chapter 25, introduces the concepts of facies and facies series and applies them rigorously to mafic rocks. P–T–t paths are introduced at the chapter's close. Metamorphic reactions are covered in chapter 26, and include phase transformations and a panoply of reactions, including volatile and redox reactions, and in introduction to petrogenetic grids. Chapter 27 is a heavyweight, 26 pages on the thermodynamics of (chiefly) metamorphic reactions. It brings the student back to the complexities introduced in chapters 5 and 6, and concludes with a long and thoughtful section on geothermobarometry, not excluding its pitfalls. Again, the author uses a summary table (27–4) listing useful geothermobarmeters (64 of them, with references!). Pelites, a preferred workhorse, are discussed in great detail through three facies series, and with representation on no less that 29 AFM diagrams, in chapter 28. The phenomenon of partial melting and the conundrum of migmatites are also covered. The metamorphism of calcareous and ultramafic rocks are lumped (unfortunately, in this reviewer's opinion) in the next chapter. The final chapter reviews metamorphic fluids, mass transport, and metasomatism. Probably much of this chapter is beyond the needs of an undergraduate course.

This is a thorough and excellent text, and today possibly the best and most accessible in the fields covered. It is carefully tied to the computational tools now freely available (Excel, TWQ ...), and to the author's Web page. Problems (some worked out) are useful guides given at the close of nearly a dozen of the chapters. The challenging alphabet soup of modern petrology, from AFC to XRF, is at least incompletely summarized on the inside back cover (here I learned that TLA is a "three-letter acronym"!). The text is metric throughout, and sphene and hyperthene, fully legitimate names in this reviewer's world, are used unashamedly. The text is written in an easy conversational style, yet is rigorous and not at all superficial. Kudos! In places the author brings the reader to the personal level, to share his anxiety in trying to convey such a complex subject to the student in a digestible fashion (see especially p. 293–294, 362, and 364).

Even an outstanding book has its warts. I would like to have seen theory and practice better separated. For example, the deep introduction of the concepts of facies and facies series with the mafic rocks (chapter 25), in my view, dilutes both. Preferable would be to present all theory at the outset, and to follow that with a "cookbook" (à la Winkler). Such an approach would also make it easier for the instructor of a shortened course to pick and choose. I found no serious fundamental errors, but some little ones will intrigue the careful reader. Here are a handful. The scales on Fig. 4–5 are meaningless. "At 660 km, the coordination of Si in mantle silicates changes from the familiar IV-fold to VI-fold, as in the mineral perovskite" (p. 5). Perovskite, of course, has no Si. Errors are found in the captions to Figs. 3–2 and 3–9. Then, what are the 12% of lavas missing at Mt. Misery (Table 16–1)? The Monteregians aren't an example of alkaline magmatism associated with continental rifting (p. 364). Diagrams and line drawings are well prepared and reproduced clearly; the black-and-white photos, on the other hand, are mushy and add little. Consistency in the directionality of pressure on the Y axes of diagrams would have been desirable (see Figs. 10–2 to 10–4; 10–9, –10, and –12, as opposed to all the others). Split infinitives here and there break the continuity of an otherwise smooth style. Mass and density are confused in a few places, and adverbs of time are misused locally: S-type granites are "always peraluminous (often strongly so)" (p. 350). The spell-checker did its job, I found but a single typo: "fractional heat" for frictional heat (p. 437).

Would I use this text? Well, yes and no. Certainly I would use it for a first-year graduate course. It is far ahead of other texts in the fields, being modern, complete, clearly written, and most assuredly, user-friendly. Probably I would not use it as an undergraduate text, and certainly not in an emasculated petrology course offered at so many North American universities at the dawn of the 21st century. Why? *An Introduction to Igneous and Metamorphic Petrology* is just too complete. An analogy would be using an SUV to drive two blocks to the corner store to buy a liter of milk. Also, the book does not lend itself easily to partial harvesting; the topics are just too intertwined. Although the author tells us (p. xvii) that he uses it "for a one-semester combined course by selecting from the available chapters", he wrote the book and may find the approach feasible. For others, however, the task would be daunting. No, the instructor cannot simply say "We shall treat chapters A, B, and C, but not chapters X, Y, and Z." It won't work smoothly. This is just not the text for a dumbed-down

course. There are many other texts available for such use.

To conclude, *An Introduction to Igneous and Metamorphic Petrology* is an excellent text for beginning graduate courses (one each in Igneous and Metamorphic, please!), and a useful reference for serious undergraduates. It is an unusually complete and well written modern text that may be, in fact, the best available in its fields today.

Rock-Forming Minerals. **4A**. *Framework Silicates: Feldspars* (2nd edition). By W.A. Deer, R.A. Howie, and J. Zussman. The Geological Society, London, 2001. xii + 972 pages. US $192. Distributed by AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101-0979, U.S.A. (ISBN 1-86239-081-9).

Of the five volumes of the first edition (1962–1963) of DHZ that we all know so well, volume 4 was the thickest at 3.5 cm, and 435 pages. It covered feldspars, silica minerals, feldspathoids, scapolite, zeolites, and a scattering of other tectosilicates. Less than four decades later, in the 2nd edition, the feldspars alone take up nearly a thousand pages (!) in a volume fully 5 cm thick. Furthermore, printed in type 10% smaller than that used in the 1st edition, and with a larger area of each page (238 *versus* 222 cm^2) used for text (+ figures and tables), 100 pages of the 2nd edition encompass nearly 120 pages of the first. This is a semi-quantitative measure of recent progress in silicate mineralogy.

Volume 4A of *Rock-Forming Minerals* is dedicated to William Scott MacKenzie, Emeritus Professor of Petrology, University of Manchester, "in appreciation of his valuable contributions, over some 50 years, to so many aspects of mineralogy and petrology, and in particular to research on feldspars" (p. vi). The volume is dominated by two sections which together constitute fully 93% of the whole: 1) Alkali feldspars (618 pages), and 2) Plagioclase (282 pages). The remainder is made up of the brief prefaces to the 1st and 2nd editions, a four-page introduction, 32 pages on the barium feldspars, 5 pages each on buddingtonite ($NH_4AlSi_3O_8$) and reedmergnerite ($NaBSi_3O_8$), and a 19-page general index far superior to the overly skimpy indices of earlier volumes of the second edition. The two principal sections are so long, books unto themselves for all practical purposes, that references in each are apportioned in five groups that follow, respectively, chapters on 1) structure, morphology, and twinning, 2) chemistry and experimental work, 3) optical properties, 4) distinguishing features (omitted in the table of contents), and 5) paragenesis. In all, references run through early 2000 and are spread amongst 171 full and partial pages. Although I did not count them, I estimate their number at 3500! The first edition listed 600 references for the feldspars (yes, I counted those). The distribution of references between alkali feldspars and plagioclase was then 45:55; in the 2nd edition it is 61:39. Certainly, this hints that orthoclase and its associates have been the preferred field of research in the feldspars over the past 40 years.

The format of the second edition is similar to that of its predecessor, though there is much more of nearly everything. Explosive growth has been especially pronounced under the headings structure and experimental work, at least an order of magnitude in each. Advances here are due chiefly to remarkable developments in instrumentation and imaging (see, for example, the wonderful Nomarski images, Figs. 480 and 483). Paragenesis, too, has undergone a great expansion, perhaps excessively so in volume 4A. The paragenesis of the alkali feldspars, neatly summarized on 17 pages in the first edition, now occupy no less than 178 pages! Where the second edition shows little or no growth, with respect to the first, is in the number of chemical compositions listed. This is surprising in view of the coming of age of the electron microprobe. Aside from analyses exclusively for minor trace elements or *REE*s, the number for the alkali feldspars grew only from 78 to 99, whereas for plagioclase the number actually fell from 87 to 78. This decrease is in part due to the authors having excluded the classical analyses of Amelia (Virginia, U.S.A.) albite, an omission regretted by this reviewer. However, more major-element analyses would have added little. The feldspars are not chemical wastebaskets.

In earlier reviews of other volumes of the second edition of *Rock-Forming Minerals*, I commented on the apparent paucity of typographical errors. In general, this has proven true, but in using those volumes on the bench through the years, I have found dozens, though all are minor and obvious. So, when I say the same for volume 4A, that errors are sparse, I keep tongue in cheek for I confess to not having read from cover to cover, word-by-word, nearly one thousand pages, nor having verified the 30 tables, nor having scrutinized all captions to the 590 figures. A few misspellings are to be found (thay for they, p. 347; Wausaw for Wausau, p. 78), but none are of consequence. As a Quebecker, I was surprised to find my Province expanded to include Perth (p. 5), a town in Ontario, 75 km southwest of Bytown (now Ottawa).

What could be altered to enhance the presentation? I would like to see optical data accompany the chemical data (as was done in the first edition). This commonly is more useful than the broad optical summaries given on the opening page of each of the sections. The figures (especially graphs and histograms) would be rendered more useful with tick marks on the right-hand ordinates (again, as was done in the first edition). Some figures would even benefit from a light-line gridded overlay.

Finally, the figure captions should have been right-justified. Some captions have lines of exaggeratedly uneven length, making them hard to read.

For routine or survey petrographic studies, the first edition is clearly adequate. It is only in detailed petrological interpretation of feldspar-bearing rocks that the second edition assumes an essential role. The volume offers a purview of all aspects of feldspar mineralogy and, through the monumental muster of references, the road to yet greater detail. Students in graduate-level mineralogy or petrology courses, and those preparing for Ph.D. exams, will find that selected parts of this volume offer particularly useful summations. It is unfortunate that the high price (nearly CDN $300) puts this fine book beyond the reach of many.

In short, volume 4A of *Rock-Forming Minerals* is a huge book, physically and intellectually. It is a personal monument to three prestigious scientists now beyond their ages of retirement. A tip of this reviewer's hat to their patience, persistence, and above all, to the depth of their knowledge and experience which together led to this magnificent synthesis.

Beneath our Feet (*The Rocks of Planet Earth*). By Ronald Holden Vernon. Cambridge University Press, 2000, viii + 216 p. CDN$46 hardcover (ISBN 0–521–79030–1).

How wonderful to discover than an eminent geologist and master of structural petrology, who has spent nearly half a century studying and interpreting rocks, all the while has kept an artistic eye on the beauty of the objects of his scientific achievements. In *Beneath our Feet*, Prof. Vernon has taken the time to share some of this enchantment with a wider audience. But who? After a first reading, I was perplexed: Is this book intended for geologists? Non-geologists? Mlle Nathalie C., a young woman who perchance is sitting next to me on this VIA train as I write these words? With but little reflection, the answer is clear: all of the above.

Prof. Vernon's central thesis is that rocks at all scales are endlessly varied and beautiful. He notes the public's fascination with lunar and martian rocks, while stressing that by comparison, earthly rocks are ever so much more sightly. In support of his tenet, we are offered a suite of 163 magnificent color photographs (+ 11 line drawings, also in color). These range from aerial views, to outcrops, to hand specimens, to thin sections. Many are first-rate; my favorite: the deformed granite cobble (no, it's not a pebble) in folded conglomerate on p. 171.

The book is presented in 11 chapters with catchy titles. These are preceded by a brief Introduction in which the author states: "...this is not meant to be an introductory textbook on geology. It's just meant to give you enough information to appreciate the very basic processes responsible for the beautiful rocks of Planet Earth" (p. 3–4). The opening two chapters cover the most elemental principles of mineralogy (including optical!) and plate tectonics, all in but 158 lines of text! Chapter 3 deals with flow (mostly in solids), from microscopic to whole-Earth scale. The remaining chapters deal more directly with rocks: mantle rocks (chapter 4), igneous rocks (chapter 5, the longest of all), cataclastic rocks (chapter 6), sedimentary rocks and fossils (chapter 7), metamorphic rocks (chapter 8), hydrothermal rocks (chapter 9), tectonites (chapter 10), and meteorites (chapter 11). The book closes with a list of six references for additional reading (this reviewer would have made some different choices), a basic glossary of some 60 terms, and an unusually complete 6-page index.

Although the writing is mostly clear and spelling is impeccable, there are some errors and shortfalls. The concepts of mass and density are confused (pp. 17, 66). Contrary to the author's contention, only rare volcanic bombs carry nodules of mantle rocks (p. 53). The "megacrysts" (p. 82) are phenocrysts. The definition of aluminosilicates "depending on whether aluminum is present or not" is aberrant (p. 16). Certainly, by no measure is plagioclase an aluminosilicate (p. 73). Finally, I have a few bones to pick with the illustrations themselves. Several lose their effectiveness by being far too dark (especially Figs. 3, 51, 52, 61, 70, 71, and 109). The photo of Shiprock (Fig. 51) fails to convey the significance of the exposure; many elementary texts carry better photographs, including the copy of Longwell, Knopf and Flint that I used as an undergraduate 48 years ago. It takes a sharp eye indeed to spot Wizard Island in Figure 93, missing entirely is the 9-cm knife in Figure 116, and Dactyl was omitted from Ida's portrait (Fig. 165). Figures 39 and 143 lack scales, and I question the accuracy of the scales in Figures 45 and 55. Then, to this reviewer, the "brittle fault zones containing breccia" (Fig. 21) look more like irregular bodies of granite crowded with inclusions. Finally, the front cover photo mentioned on p. 4 is located on the rear of the dust jacket.

Let me end on upbeat notes. *Beneath our Feet* is a delightful excursion into the visual beauty of petrography and mineralogy. It shows that some facets of the Earth sciences that may appear dry to the newcomer are, in fact, sources of extraordinary beauty: elegant forms and wonderful collages of color. So, if you are a geologist, a non-geologist, or Mlle Nathalie C., this book is for you. The price is affordable. It would make a fine Christmas present.

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