The Canadian Mineralogist
Vol. 43, pp. 837-845 (2005)

BOOK REVIEWS

Crystallography of Modular Materials. By Giovanni Ferraris, Emil Makovicky and Stefano Merlino (2004). Oxford University Press, 70 Wynford Drive, Don Mills Ontario M3C 1J9, Canada. 370 pages. $225.00 (hardcover). ISBN 0–19–852664–4.

Publication 15 of the highly prestigious International Union of Crystallography monograph series is written by three well-known and highly qualified mineralogists. The contents are as follows: modular series – principles and types (126 pages), with 71 figures and 28 tables of types, OD structures (80 pages), with 52 figures and two tables, polytypes and polytype categories (20 pages), with 16 figures and one table, application of modularity to structure description and modeling (54 pages), with 36 figures and two tables, modularity at the crystal scale – twinning (28 pages), with five figures, references (52 pages), and subject index (10 pages).

Scientists in different fields have used different terminology to describe the same phenomena. To standardize the terminology, this publication summarizes the ideas and data that are spread amongst the mineralogical, chemical, and materials science literature. The tables provide useful lists of the homologues in the sulfosalt subkingdom, such as lillianite, pavonite and kobellite. The mineralogical literature supplies most of the examples, such as wollastonite, perovskite, mica and spinel.

The 850 references span the period 1851 to 2004. More than half are 1988 or later, and most are 2001 to 2003. Many are to *The Canadian Mineralogist*. There are a few minor omissions, inconsistencies and errors. A useful addition to facilitate cataloguing would be a Library of Congress catalogue number and a Dewey Decimal catalogue number on the title page. The entries in the index are printed bold-face in the text, all of which helps makes this book more user-friendly.

The advantages and disadvantages of describing minerals as homologous series or polysomatic series are given. The reason that the mineral superspecies nigerite, taaffeite, and högbomite are now described as polysomes with the adjectival prefixes magnesio-, ferro-, or zinco- rather than polytypes is explained. The terms inophites, heterophyllosilicates and palysepioles are defined. "Chalcedony" is described as a quartz–moganite random mixed-layer. In 1951, Keith Norrish suggested that the interlayer space in illite was occupied by H_3O, only to revise his opinion a decade later. The correct formula for illite is given in *The Canadian Mineralogist* **36**, 909 (1998).

The type is clean, and the text is printed on a high-quality acid-free paper. The crystal-structure figures (about 180) are clear. The price is reasonable. This book is essential for all mineralogical, crystallographic and material science libraries. Mineralogists who wish to be at the cutting edge of mineralogy must be familiar with this book.

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Rock-Forming Minerals. **3A**. *Sheet Silicates: Micas* (2nd edition). By Michael E. Fleet. The Geological Society, London, 2003. xxii + 758 pages. US$209 ($125 to members of GSA, SEPM, AAPG; $104 to members of MSA). Available from AAPG Bookstore, P.O. Box 979, Tulsa, Oklahoma 74101–0979, U.S.A. ISBN 1–86239–142–4.

Certainly nobody who reads this review to its conclusion is unfamiliar with DHZ, the set of five volumes covering the rock-forming minerals published between 1962 and 1963. The publication of a greatly expanded second edition was begun in 1978, and now nears completion. The second edition tenders two-for-one; two volumes in place of each single volume of the first edition. The volume here under review, a massive tome of 758 pages, replaces more or less the first half (102 pages) of volume 3 ("Sheet Silicates", 270 pages) of the first edition. This expansion is nearly tenfold and reflects fairly the colossal growth in our understanding and characterization of this significant group of rock-forming minerals. The volume departs from its predecessors in that none of the founders, W.A. Deer, R.A. Howie, or Jack Zussman, are authors. Volume 3A is entirely the work of a single author, Michael E. Fleet, Professor of Mineralogy at the University of Western Ontario. Authorship has here crossed the Atlantic, from the British Isles to Canada.

Rock-Forming Minerals: Micas (hereafter referred to simply as "vol. 3A") is limited to the true and brittle micas; thus glauconite and other dioctahedral interlayer-deficient micas are excluded. The book follows the basic outline of the first part of vol. 3 of the earlier edition.

Vol. 3A opens with an unusually detailed table of contents (7 pages), lists of abbreviations and symbols (5 pages) and prefaces. These are followed by a general introduction to the mica group (ch. 1, 40 p.), which includes an impressive list of 144 references. The author expresses his regrets that the Mineralogical Society of America's *Reviews in Mineralogy – Micas: Crystal Chemistry and Metamorphic Petrology* (v. 46, 2002) "appeared too late to be extensively referenced" (p. 4). Even so, this first chapter should be required reading for undergraduates and is a fine review for graduate students and faltering (?) professionals.

Specifics on individual members of the mica group make up the succeeding 700 pages as follows (chapters 2 through 8): muscovite and phengite (205 pages, ~1125 references); paragonite (21 pages, ~135 references); other dioctahedral micas (nanpingite... chromceladonite; 15 pages, 47 references); biotite (*s.l.*, 324 pages, ~1450 references); lithium micas (39 pages, ~160 references); other trioctahedral micas (shirozulite... preiswerkite; nine pages, 43 references); brittle micas (margarite, clintonite, and three relatives; 39 pages, ~135 references). The chapters on muscovite and phengite and on biotite go into abundant detail on geothermobarometry, isotopes, and geochronology, far beyond the more limiting structure, chemistry, optical and physical properties, distinguishing features and paragenesis of the first edition. The volume concludes with acknowledgements of secondary source-materials, and a 16-page general index more thorough than those in the earlier volumes of the second edition.

The staggering growth of data and number of mica species since publication of the first edition of DHZ four decades ago reflect chiefly the prodigious influence of the electron microprobe. For example, the pair of dioctahedral micas treated in the first edition took of 24 pages; in vol. 3A, these have swelled to a dozen species that take up 241 pages. Biotite then filled 30 pages, and now fills 324 pages. These are order-or-magnitude swellings!

My sole criticism of vol. 3A is the general short shrift given to optics. Some optical data are summarized in Table 25 and on Fig. 242, but this is insufficient. Furthermore, the 264(!) analytical data-sets supplied are nowhere accompanied by optical data. Some users may find this omission an important drawback. The blending of compositional and optical data made the first edition particularly useful to "first-cut" (rather than "cutting-edge") studies. I found a few typographical errors, but none of importance. Computerized type-setting has wholly eliminated word-breaks. Word spacing thus varies slightly from line to line, but mostly this is benign.

Volume 3A is a significant, integral, and no-nonsense summary of our current knowledge of the micas. The concise and well-written text along with its more than 3000 references will be essential to advanced researchers in mineralogy and petrology. Much of the book will be beyond the grasp of undergraduates, and vol. 3A's usefulness in the petrography laboratory will be less than that of vol. 3 of the first edition of *Rock-Forming Minerals.*

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Pakistan: Minerals, Mountains and Majesty. Edited by G. Agozzino, D. Blauwet, M. Jarnot, S. Muhammad, G. Neumeier, G. Staebler and T. Wilson. Extra Lapis English edition No. 6, Lapis International LLC, P.O. Box 263, East Hampton, Connecticut, 06424, USA, 2004, 96 p. US$25 + $3.50 shipping to non-U.S. addresses, soft cover (ISBN 3–921656–62–1).

For mineral collectors and afficionados in general, this issue provides a feast for the eyes and the imagination. A great many individuals have labored to produce this splendid account of Pakistan's mineral growth in celebration of the courageous people who collect and bring the minerals to market. In this respect, Lapis International acknowledges: the experience and knowledge of Herb Obodda and Giuseppe Agozzino, and their provision of photos and advice on numerous questions, the crucial go-between services of Safiee Muhammad, and the extensive and sustained editorial commitment of Dudley Blauwet.

The first 86 pages of *Pakistan: Minerals, Mountains and Majesty* present the following informative, polished accounts: "Opening Pakistan's mineral market" (Herb Obodda), "Laying the groundwork for Pakistan's evolving mineral market" (Gloria Staebler and Günther Neumeier), "Origins of the Himalayan treasure chest" (Bernhard Grasemann and Erich Draganits), "Picking pegmatite pockets: the road from Gilget to Skardu" (Vera Hammer and Shafiee Muhammad), "In search of yellow-zoned tourmaline" (Syed Musta Fain Kazmi), "World-class localities: the Shigar, Basha and Braldu Valleys" (Dudley Blauwet), "The pegmatites at Chumar Bakhoor: Nagar's treasure trove" (Dudley Blauwet and Shafiee Muhammad), "Red, green and blue gemstones from Hunza" (Vera Hammer), "The deposits at Nangimali: gemstones from Azad Kashmir" ("Cap" Beesley), "Pink topaz from the Katlang Valley" (Vera Hammer), "The many shades of Pakistan's green gemstones" (Vera Hammer), "Pakistan's Alpine-type clefts: rivalling the classic Alps" (Vera Hammer and Andreas Weerth), "Faden quartz – stretched to the limit" (Si and Ann Frazier), "The PGMS: an exotic fall show" (Shafiee Muhammad), and, "Zagi Mountain: a paradise for rare-earth element mineral collectors" (Andreas Weerth and

Herb Obodda). There follows a "Table of Mineral Localities" (Dudley Blauwet, Bill and Carol Smith), and three pages of references.

Photos of mineral specimens, localities, local populace, *etc.*, are superlative, and in many instances, eminently memorable. Even so, winners emerge from the list, among them samples from "Nagar's treasure trove", high in the Himalayas. The main pegmatite (we are told) begins "...above and east of the Silkiang Glacier at about 4,600 meters and drifts upwards approximately 15 to 20 degrees to the southeast." Blauwet and Muhammad report that miners tunnelling at this elevation cannot breathe comfortably, and that the dynamite will not explode. Now that's mineral collecting with a difference!

A key article is Herb Obodda's introductory chapter of reminiscences as the first westerner to make inroads into Pakistan's mineral market. In this account, the reader is invited as a fellow traveller–collector, a plus on any expedition, real or imagined. Maps provided by Obodda for this Pakistan issue are integrated into the overall successful presentation. Tyler Funk follows up with a *hors d'oeuvre* of insights on Pakistan's modern mineral boom. In "Moving Mountains", Qari-Saeed-ur-Rehmann's story, shared with Staebler and Neumeier, admits us to a privileged close-up of some recent highlights in the history of Pakistan's evolving mineral market.

Then there is the tremendously entertaining first-hand account by Blauwet of several world-class collecting localities through the Shigar Valley and its upper tributaries. Again, awesome photos and splendid maps help to tell the tale. Kudos to Vera Hammer and co-authors for several major contributions to this outstanding issue, among them "Picking pegmatite pockets" and their matter-of-fact but highly informative peek at the gemstones from Hunza. Yet another first-class contribution is the overview of Azad Kashmir's little-known gem deposits by Cap Beesley and collegues. This is an altogether engrossing account of "The ultimate field trip" to the heart of the Himalayan home of the senior members, ruby and sapphire, of the precious gemstone community. Here, even the lesser-known gem varieties of pink tourmaline and (unbelievably gemmy!) colorful spessartine (kashmirine™) put in a stellar performance.

Miscellaneous quibbles: Last time I looked, there was no "aqueous border" between Pakistan and Afghanistan (p. 15); surely the intended word is "porous". The map of Central Northern Areas (p. 34-35), although "busy", will doubtless prove enormously helpful to travellers in the region; however, they should be alerted to the curious scale of the map, on which a 50 km distance is divided into 17 parts, each of which is necessarily about 2.94115 km. Forgivable are occasional lapses (*e.g.*, p. 40) where English and SI units appear in the same paragraph. The term "data" (p. 67) implies plurality not singularity. Typos are fortunately few and far between, *e.g.*, (p. 66) "well known" in place of "well know", Celsius is misspelled on page 21. Questions: what exactly is meant by "tehsil" (p. 82, 92), and in the Table of Mineral Localities (p. 86-92), why are certain slots for "minerals" left blank, where, for example, in the case of Hunza, relevant information is available?

Quibbles aside, *Pakistan: Minerals, Mountains and Majesty* stands as a first-rate production. A pleasurable read, this collector's issue is totally in keeping with the high standard that readers have come to expect of *extra Lapis* publications.

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Geology of Gems By Eugenii Ya. Kievlenko. English Edition, edited by A. Soregaroli. Published by Ocean Pictures Ltd., 4871 S. Dudley St., Littleton, Colorado 80123–1942, USA. 2003, 432 p. US$98 by ordinary mail, US$108 by air mail; check or postal order to Mineralogical Almanac, 5341 Thrasher Drive, Cincinnati Ohio 45247 USA. Hardcover (ISBN 5–900395–25–1).

Geology of Gems is touted as "...the first comprehensive English language publication to place gem deposits into a concise geological and genetic framework, which provides an understanding of existing deposits and the environments of gemstone formation." The book is international in scope and covers many major deposits, including deposits in the former USSR and Russian Federation.

In addition to the eighteen chapters (360 p.) devoted to specific gem-forming minerals or mineral groups (corundum, beryl, precious opal, topaz, tourmaline, spinel, garnet, peridot, amethyst, turquoise, amber, lazurite, jadeite, nephrite, charoite, malachite, chalcedony and rhodonite), the introductory chapter (19 p.) "General data on gems"provides just that, whereas the last chapter (20) in nine pages addresses "Economic-geological types of gemstone deposits and the principal regularities in their spatial distribution." In between, each of the 18 chapters on minerals or mineral groups supplies historical and mineralogical data, with discussions concerning chromophores responsible for colored varieties. Descriptions of a selection of major gem deposits and districts are given for each country relative to a geological-genetic classification.

In his foreword to this English edition, Soregaroli notes that while the author's purpose has been to "...provide a framework for the exploration and discovery of new gemstone deposits", it is recognized that a great

deal of confusion exists in the literature with respect to deposits and geographic names and locations. One suspects that part of the problem may stem from the fact that under the communist system, the concept of "precious stones" was categorically rejected for its stress on the value rather than the aesthetic properties of the stones. Soregaroli also remarks that Kievlenko's classification of gemstones (based on value according to early 1990s prices) continues a Russian tradition that dates from the mid-1980s. Whereas such a classification might be viewed by some people as arbitrary and controversial, he suggests that it provides insight into the history of Russian gemstone studies and that it does not detract from the strength of the geological-genetic approach to gemstone deposits throughout the world.

Whether or not readers agree with Soregaroli's assessment, she or he will find a wealth of valuable information here, which on the whole, is delightfully well organized and presented. Unfortunately, no mention is made of many world-class gemstone deposits, much less recent finds such as opal and emerald in Canada. Neither is there any space whatever allotted to diamond, Canadian or otherwise. Come to think of it, diamond seems never to have been accorded isolated special attention in Russia.

Quibbles and questions: Alas, there is no index. References abound throughout the text, although my first example chosen for the test (*e.g.*, Serebritsky 1979) immediately confirms that not all appear in the bibliography. The reverse likely is also true. Misspellings fortunately are not rampant. Selections: "carbonaceons" (Table 7, p. 78-79), "Muwe" for Muva (System) (p. 87); "it's" is incorrectly used to denote possession (p.12), "peuso" for piezo (p. 6). Scale is absent on many maps (pages 187, 190, 212, 246, 277, *etc.*). "Nowello Claims" or "Novello Claims" (p. 88), which is it? What exactly is "irnimite" (p. 395), and rhodolite (Table 6, p. 45)? Hyphenation is haphazard in Table 6.

Overall, *Geology of Gems* provides a pleasant and informative read. The inclusion at the end of the book of 32 pages of color photographs to match the chapters on gem minerals and gemstones is a nice touch too. Unfortunately, many of the maps, resurrected as they have been from the older literature, leave much to be desired, not least of which in many instances is the geographic location and access route(s) to the feature in question. The localities are not likely to be overrun by collectors anytime soon. However, as an advertized first in the field, this book represents a tremendous start.

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Historic Review of the Witwatersrand Goldfields. Written and published by J.R.F. Handley. Available at Geological Society of South Africa, Chamber of Mines, 5 Hollard St., Johannesburg 2001, South Africa. 2004, 224 p. R219.30 + R130.00 (overseas) shipping. Hardbound (ISBN 0–620–32127–X), Collection Leatherbound (ISBN 0–620–32126–1).

This tidy compact volume is dedicated to the late Professor Des Pretorius, who evidently greatly inspired his friend, the author (as he unfailingly did many other fellow geologists), to whom he bequeathed his books and papers. The tremendous amount of information on the Witwatersrand thereby represented provided a basis for the book supplementary to the considerable experience and expertise of Dr. Handley in geology and related fields. The result is little short of a masterpiece of synthesis through which shine not only the historically crucial details of the Witwatersrand goldfields, but also the essential scientific, technical and socio-economic aspects, as revealed in thoroughly considered and executed text, tables and figures.

Historic Overview of the Witwatersrand Goldfields is presented in seven systematically ordered chapters: 1) Discovery, Exploration and Production (46 p.), 2) Historic Review (41 p.), 3) Geology, Geophysics and Geochemistry (31 p.), 4) Mining and Metallurgy (34 p.), 5) A Statistical View of the Witwatersrand Goldfields (8 p.), this chapter complete with 20 carefully constructed graphs which trace the impact of wars, economics, *etc.*, on the industry throughout its history, 6) Private and Government Bodies Associated with Mining (7 p.), and lastly, 7) From the Past into the Future (6 p.), in which Handley offers insightful suggestions on how the industry might best be maintained and sustained. Examples: acquire pygmy-type mining equipment to fit restricted spaces in the stopes; fit linear motors to cases or skips rather than cables; use blind hole borers to sink shafts; use robotically controlled automation to speed up underground transport; restore a sound work-ethic; provide for environmental remediation of mining properties. He further argues that because a review of the South African gold industry since its inception shows its working profit to be about 30%, sensible legislation should be implemented in order to sustain gold mining as an ongoing profitable industry.

Within the Witwatersrand Basin, the so-called "Golden Arc" that contains all the mines, has an area of only 8000 km^2. This is about the size of Prince Edward Island. Yet from this small area, about 47,352 tonnes of gold have been produced, an estimated 31.4% of all the gold produced throughout the world to the end of 1992. According to Handley, an estimated 36,000 tonnes of gold remain to be recovered from the Witwatersrand gold fields. Production reportedly peaked in 1970 at just

over 1000 tonnes, but has fallen in recent years to about 400 tonnes. These are astounding figures. At least as mind boggling is the extent to which South Africa has traditionally turned a blind eye concerning use of its single largest product. Evidently the country has never fostered a jewellery industry; indeed, Handley tells us that legislation and taxes have tended to discourage it. Instead, he points to tiny Taiwan, a center of jewellery manufacture initiated in 1980 with the importation of 8 tonnes of gold, peaking in 1992 at 159.8 tonnes. This, Handley suggests, is a clear illustration of how a new industry might take off in South Africa, given government encouragement in the form of zero taxes (VAT) on gold for fabrication.

Historic Overview of the Witwatersrand Goldfields, provides far more than the business-like title promises. This is a remarkably upbeat account, projecting overall the author's optimistic outlook that the "Rainbow Nation" will continue to exploit the political solution to *apartheid*, which stunned the world in 1990 and led to the emergence of a new democratic nation without violence in 1994. Old laws are with good reason being rewritten and new laws are emerging, among them some intimately relating to the minerals industry. According to Handley: "Correctly balanced, the new laws should encourage exploration, attract local and overseas investment and maintain South Africa as the eminent mining country which it presently is."

This book will be of interest to many people: academics, geologists, engineers, bankers, brokers, in fact anyone who wishes to learn more about South Africa and the world's greatest goldfields. Congratulations to the author for persevering through to completion of such a valuable and detailed document. Des Pretorius, with his eye for detail and ability for synthesis, would be well pleased with the result, and content in the realization that his confidence in a friend has been so well and truly justified.

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Magmatic Sulphide Deposits. By Anthony J. Naldrett. Springer-Verlag, Berlin, Germany, 2004, 727 pages, CDN $215. ISBN 3–540–22317–7.

Magmatic sulfide deposits contain 28% of the world's terrestrial nickel resources, yet they are responsible for 58% of the world's nickel production (Dalvi *et al.* 2004). The most significant sulfide resources are restricted to a small number of large mining camps like Sudbury and Noril'sk, which contain multiple deposits with resources exceeding one million tonnes of contained Ni. On average, a new Ni sulfide deposit is located about once per decade, the most recent example being Voisey's Bay in Labrador.

Magmatic Sulphide Deposits provides an updated summary of the state of understanding of the most important Ni sulfide deposits. This book is an enormously expanded and updated version of his original textbook on the subject (Magmatic Sulfide Deposits, 1989; Oxford University Press), and it is the English Language version of a text that was published in Russian (2003; St. Petersburg University). Enormous value comes from the publication of texts that not only describe the geology of mineral deposits types, but also enhance an understanding of the processes that control their formation. This book provides a wealth of information to the reader in a form that is readily understood by one who is new to the subject. The book provides a measure of Naldrett's success in fostering advanced ore deposit studies at the University of Toronto, as well as bringing the ideas of many other researchers on broader empirical models that contribute to the understanding of ore genesis and exploration of magmatic sulfide.

The introduction summarizes aspects of the classification of magmatic sulfide deposits. The second chapter establishes theoretical considerations that help in understanding experimental studies on the controls on sulfur saturation of magmas, the partitioning of elements between sulfide and silicate melts, and the controls on the compositional diversity in sulfides. Themes developed in the second chapter are carried through in the following chapters, which document and explain the geology and mineralization associated with the most important world-class Ni sulfide deposits at Sudbury, Noril'sk–Talnakh, Voisey's Bay, Jinchuan, the komatiite-associated deposits as a group, and the styles of mineralization of platinum-group element. The final enormously important chapter deals with the applications to exploration, melding information and ideas on regional setting and detailed empirical and quantitative models of ore-deposit formation.

Naldrett has advanced and refined ideas to a point well beyond that published in previous scientific and technical papers. The chapter on Noril'sk makes an especially useful contribution, as it pulls together much of the published data and provides ready access to much detail about the geological and geochemical relationships among the intrusions, the flood basalts, and the ores. He emphasizes the very special set of conditions that gave rise to the Noril'sk ores; although controversy remains about whether the deposits were formed in the conduits to flood basalt magmatism, key empirical relationships are emphasized throughout the chapter, and these are essential relationships that must be explained as our understanding of the Noril'sk deposits is advanced.

In the case of Sudbury, Naldrett provides a careful and considered review of a vast literature, focusing the reader's attention on the relationships involving impact, melt-sheet formation, and the segregation and evolution of the ores. Although he emphasizes how unique the Sudbury system is in the context of other magmatic sulfide systems, there are many aspects of the system that provide a basis for understanding ore formation. Here again, ideas developed in Chapter 2 are expanded to promote understanding of the compositional diversity in the ores, their physical association with physical changes in geometry of the host rocks, and the linkages between ore formation and evolution of the silicate melt.

Throughout the book, the dominating objective is one of understanding the relationships between the host rocks and ores, and tectonomagmatic setting. This is the foundation from which a detailed understanding of the compositional diversity in the ores can be explained.

The world demand for Ni continues to grow at a formidable rate, with China representing a very important stimulus for supply, demand, commodity price, and exploration strategy. Although it appears increasingly likely that future demand for Ni and Co will be met by increasing contributions from laterite deposits, the major camps in Canada, Russia, and Australia are poised to continue production well into the 21st century. Increased demand for PGE will not be met from laterite sources, and there is every indication that exploration and development of magmatic sulfides as a source of Ni, Cu, and PGE will continue. An important contribution to maintaining this supply of metals will be the education of undergraduate and graduate students who will be the next generation of exploration geologists. Without these trained individuals, the minerals industry will be in a sad state. The enormous effort required to produce a text that is so thorough and detailed (727 pages), yet eminently readable, is a challenge that Naldrett has met. The extent to which explorationists will succeed in finding new deposits is proportional to their understanding of the geological environments that contain the known deposits, and their appreciation of empirical geological associations, new geophysical technologies, and better geochemical prospecting tools. If the Canadian mining industry is to continue to thrive, there is a clear and present requirement to provide motivation through understanding and success through a logical strategy. This book raises the bar against which other books in Economic Geology will be compared, and it should be standard issue to those involved in the base-metals exploration industry.

References

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The Dynamic Structure of the Deep Earth (*An Interdisciplinary Approach*). By Shun-ichiro Karato. Princeton University Press, Princeton, New Jersey, U.S.A., 2003, ix + 241 pages, US $35. ISBN 0–691–09511–6.

We are coming to realize that the whole Earth, from top to bottom (atmosphere to inner core) has an incidence, in one way or another, on geological and mineralogical processes and products that we observe routinely. In the mid-20th century (when this reviewer was an undergraduate), geological processes were considered to be limited exclusively to the crust. With the recognition of plate tectonics some two decades later, it became clear that the mantle, at least the upper mantle, had an important role in diastrophism, plutonism, and volcanism. In the last 20 years, owing chiefly to important technological advances in seismology, high-P mineral physics, and the building of adumbrations by digital simulation, geophysicists, mineralogists and theoreticians have peered yet deeper into the Earth and made some surprising discoveries.

The Dynamic Structure of the Deep Earth is a journey along this path of discovery. The book is not a text, but rather a structured expository ramble. Beware, though, the book is scientifically rigorous and with enough mathematics perhaps to dissuade the more casual reader. Mercifully, some of the more daunting math has been segregated into boxes that can be skimmed without losing the thread of exposition. The author's goals are set out in a three-page preface (p. vii-ix). The book is an excellent translation of a text written originally in Japanese. It reads smoothly and easily holds one's attention.

In the first of the book's six chapters, the author examines basic observations that bear on the chemistry and physics of the whole Earth. Chapter two treats the upper mantle; the lithosphere–asthenosphere distinction, where the author points out that this boundary, fundamental in plate tectonic constructions, is based on H_2O content rather than on any degree of partial melting. In

fact, partial melting leads to the *hardening* of olivine-rich mantle rock.

Chapter three covers seismic tomography and high-resolution seismography and what these interesting new techniques reveal about mantle convection and the ultimate fate of subducted slabs. Featured is an extensive discussion of the fundamentals of mineral physics (velocity anomalies of thermal or chemical origins) and the effects of anisotropy. The fourth chapter offers a concise analysis of convection in the Earth's mantle. Intermittently layered or hybrid convection with cold, dense material may accumulate above the 660-km boundary, then to sink suddenly into the lower mantle. Rheological effects, only recently taken into consideration, are of great importance. The 660-km boundary may, in fact, act as a rheological filter for mantle convection and possibly explain the geochemical differences between ocean-island basalt and MORB (p. 145). Juggling of phase changes with depth in the mantle *versus* density changes in the downgoing slab and changes of strength caused by reduction of grain size from deformation and recrystallization greatly complicate the picture. In brief, the combined evidence suggests that whole-mantle convection takes place.

Chapter 5, dealing with deep earthquakes, is where we learn (p. 158) how Benioff zones came to be called Wadati–Benioff zones. Deep earthquakes are enigmatic to this day. Like shallow quakes, they appear to be the result of shearing motion on faults. The problem remains that at depth, normal stress is so great that a tectonically unrealistic differential stress is required to cause slippage (faulting). No first-motion records offer evidence that deep quakes are the result of phase change (*i.e.*, collapse). A variant, "transformation faulting" (p. 169) may be the cause, although the author is skeptical. The currently preferred mechanism is "thermal runaway instability" (box 5–2). Major progress toward the resolution of this conundrum may be forthcoming soon. The closing chapter treats the deepest of the deep: Earth's core. The liquid outer core may result from the solidification of the inner core by the progressive outward expulsion of light elements that cannot be taken up in solid solution. The solid core makes up about 4% of the entire core (~0.7% of the whole Earth). The author discusses the many theories of core formation and how that may be tied to Earth history, particularly the Archean–Proterozoic boundary. Also discussed are the problem of the geomagnetic field, core anisotropy, and the possible super-rotation of the inner core.

The book concludes with nearly 300 references (pp. 215-230), and a detailed 11-page index.

The Dynamic Structure of the Deep Earth is nearly free of typographical errors. Birth (p. 19) should be Birch, and the citation to Fig. 1–8a (p. 31) should read Fig. 1–10a. "Wood alloy" (p. 53) must refer to Wood's metal, an alloy of Bi, Pb, Sn, and Cd. "Heavier" is mistakenly used for denser in a few places (*e.g.*, p. 119, 147). The sole systematic grammatical error is the use of split infinitives; to quantitatively test, to experimentally measure, and so on. Annoying, but not debilitating enough to detract from a mainly flowing text.

Nearly four decades ago, three Japanese geoscientists teamed up to write an engaging and remarkably cogent book that forcefully introduced the then new topic of plate tectonics [H. Takeuchi, S. Uyeda, and H. Kanamori (1967): *Debate about the Earth,* Freeman, Cooper, and Co.]. Their book took the reader from Earth's surface to the upper mantle. Now, with an emerging realization that so many geological processes involve the whole Earth, Shun-ichiro Karato has followed his countrymen's footsteps to take us to deeper levels, a journey to the very center of the Earth's inner core. Although *The Dynamic Structure of the Deep Earth* will be easier going for physicists than for geologists, for Earth scientists in general it is a fine introduction to what goes on thousands of kilometers beneath our feet.

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Evidence from the Earth (*Forensic Geology and Criminal Investigation*). By Raymond C. Murray. Mountain Press Publishing Company, P.O. Box 2399, Missoula, Montana 59806, U.S.A., 2004. xi + 226 pages, US$20 (softcover). ISBN 0–87842–498–9.

Why do we study mineralogy? Certainly the net cast by the subject has reached far beyond its traditional realm. We now have experimental mineralogy and phase petrology, materials science, biomineralogy, lunar and planetary mineralogy, meteorites, environmental mineralogy...and, *voilá*, mineralogy applied to forensic geology. The branch of mineralogy is an important (but far from exclusive) component of the book here under review. *Evidence from the Earth* is a gentle overview of the subject, and may be anchored to Prof. Murray's two earlier texts, *Forensic Geology,* coauthored J.C.F. Tedrow and published in 1975 and 1991. Neither of these two books was available to the present reviewer in his university library.

Evidence from the Earth is divided into ten chapters. The first concentrates on a series of crimes in which geological evidence was pivotal. This is a fine introduction that draws the reader's attention and urges him on. The ensuing nine chapters are a bit of a potpourri. Nearly

all are interspersed with snippets of crimes and case histories where geoforensics (this reviewer's term) played an important or crucial role. This is a dramatic technique that will stimulate the reader. Respectively, these nine chapters deal with the following topics. (2) The development of geoforensics from its earliest days in the 19th century, to its modern underpinnings. Yes, Sir Arthur Conan Doyle is in the picture. (3) Types and legal validity of geoforensic evidence. (4) Earth Materials with tables (minerals) and charts (igneous rocks, grade scales, Mohs' scale...). A fundamentally sound but hyperdistilled "Geology 101" on 34 pages. (5) Artificial and commercial Earth materials (glass, insulation, building materials, cleaning and face powders, abrasives, sands and soils). (6) Geological maps are introduced in this chapter on evidence collection. (7) Examination methods: color, particle-size distribution, cathodoluminescence, SEM, XRD, various chemical techniques, and density. A well-illustrated chapter, but quite a plateful to cover in a mere 36 pages. (8) Geophysical methods and instruments: location finding, magnetometry, seismography, GPR, radiometry, fluorescence, and remote sensing. (9) Frauds: mining (a brief discussion of Bre-X is given on pp. 177-179), gems, works of art and Leonardo's "third painting". (10) A summary and look into the future. The author laments that "many geology departments no longer teach use of the petrographic microscope for mineral identification" (p. 197), and warns that "expert witnesses must rise to the highest standards...if they don't, the advocates may find ways to remove the privilege, returning us to a legal world populated only by human witnesses reciting their stories from studied memory" (p. 198).

The book concludes with a glossary of ~140 terms, not all of which are pertinent to the subject, and a half-dozen pages of references and supporting materials (from Sherlock Holmes to texts as recent as 2004), and an eight-page index. A terse single-page biography of the author follows the index.

The text is somewhat scattered and could have been tightened and made less repetitious by a firm dose of professional editing. Also, some errors are worth noting (aside from minor typos such as "intriquing" on p. 33). For example, cristobalite is not "a beautiful pink glass" (p. 33), and "over two thousand individual minerals on Earth (*sic*) have been identified" (p. 65). Isn't is more than 4000 by now? The formula of zoisite is erroneous (p. 69), and the photomicrographs on pages 87 and 97 lack scales. Really, can indices of refraction be measured *reliably* to 0.00007? Even should it be so, would it be meaningful for a manufactured product such as glass? Then, what is "corrugated asbestos" (p. 103)? Stressing the already overblown hazard of asbestos (p. 106, as insulation in safes; where could the material be more isolated?!) adds fuel to an already senseless firestorm on the asbestos issue. The mixture of units, tubes 10 mm in diameter and 12 to 18 inches in length (p. 155), is an unfortunate oversight. Finally, gamma rays have wavelengths, not cosmic rays (p. 169).

To conclude, who is this book for? In this reviewer's opinion, practising mineralogists would learn little from it. Bedtime reading? No, that time would be better spent with the primary source: *The Complete Sherlock Holmes.* Earth scientists who wish to learn more about the field perhaps would be advised to turn to the last edition of Prof. Murray and John Tedrow's earlier *Forensic Geology. Evidence from the Earth* is for the general reader and there well serves its purpose. Within our fields of mineralogy and geology, I would unhesitatingly recommend this book to our sons and daughters of secondary-school age. It will give them a taste of the excitement available in one field of the vast realm of the Earth sciences.

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A Practical Guide to Rock Microstructure. By Ron H. Vernon, Cambridge University Press, Cambridge, U.K., 2004, 594 p.US$130 Hard cover, $70 Soft cover (ISBN 0–521–89133–7).

Ron Vernon has managed to put together an excellent book illustrating microstructures seen in thin section coupled with a basic discussion on their description and interpretation. It is not a textbook on the origin of these features but rather an intermediate guide for senior students and professionals who wish to go further into the study of microstructures encountered in (mainly) igneous and metamorphic rocks. It has clear, succinct text with copious references and keyed illustrations. The brevity of the discussion in the text keeps the book to a respectable size (and cost) and in no way takes away from its value.

The book starts with a brief 11-page introduction, where the author explains the goal of the book as a guide to the interpretation of microstructures seen under the transmission light microscope. He also states that his basic pedagogical approach is one of evidence and skepticism. With the copious illustrations throughout the book, he certainly succeeds in the first of these endeavors. The skeptical aspect comes across in his non-pedantic style and the occasional voicing of alternative hypotheses. After a few definitions both here and in a glossary, he starts right in.

The chapter on sedimentary and pyroclastic rocks is brief. This chapter is provided only as a background for what follows. He covers the basic features such as size, shape, and sorting of clasts and maturity in siliciclastic

sedimentary rock, and gives an overview of pyroclastic, biogenetic and chemical sedimentary rocks without getting too bogged down in diagenetic effects.

The next three lengthy chapters are where Vernon excels. Chapter 3 on "Microstructures of Igneous Rocks" begins with the description of glass and then crystal size in volcanic and plutonic rocks. The accompanying text delves into the current theories of crystal formation and size through the interplay of nucleation and growth rate. Grain shape is very well explained without going too far into geochemistry (the reader is encouraged to go to the references for more information, but more on this later). These basic features of igneous rocks are followed by sections on mineral distribution within igneous rocks, mineral intergrowths, flow, compositional zoning and twinning, dissolution and boiling-related microstructures.

Chapter 4 is on the "Microstructures of Metamorphic Rocks" and begins with descriptions of crystal shape and size of porphyroblasts. This is followed by various sections on fluid effects, solid-state transformations, twinning, exsolution, symplectitic intergrowths, compositional zoning, evidence for metamorphic reactions, mineral distribution, and residual microstructures. Opaque minerals are mentioned throughout, but the main minerals shown are silicates.

Chapter 5, on deformation microstructures (179 p.), begins with a brief review of deformation mechanisms from experimental evidence to what is seen in rocks, and then gets into recovery and recystallization processes. The author follows this with numerous sections ranging from foliation development, to fluids, and to microstructures seen in partially melted rocks. This chapter is extensive, with a great number of illustrations, ideas and caveats. It is more like a work in progress, and the reader is constantly reminded of this through the extensive listing of references.

The references in the book cover 83 pages, including some from original work in the 19th century to modern review papers, many published in 2004. Vernon, at the beginning of the book, encourages readers to be skeptical, and is up front in stating that he does not have all the answers. Delving into some of these references shows how true this is, and in this way we are encouraged to look for new ideas and theories.

I first approached this book with skepticism because a cursory read got me muddled for two reasons. First was the copious referencing that made for difficult reading and, as a result, got in the way of understanding what the author was describing. Second, the illustrations and their descriptions are not always on the same page, and I found myself flipping pages much of the time. On a second reading, however, I came to appreciate the references; with a better understanding of how the book is set up, I could see their value as a guide on where to go for further study. With respect to the second problem, a single photomicrograph shows many features, and so may be referenced many times, all of which makes for page turning.

I'm a sucker for well-illustrated books, and geoscience books in particular. The photos are superb. They are of a consistent size and are not cluttered with bar scales, overprinted line drawings, or labels. This is all taken care of in the captions or text, a method that works well. Their placement on the pages is balanced with respect to the text so that visually the book is easy on the eyes. I often found myself just looking at the photos; in some I recognized microstructures I have seen under the microscope and wished I had taken that shot.

To use this book effectively you have to have knowledge of igneous and metamorphic petrology as well as a proficiency with the petrographic microscope, skills usually found in senior undergraduates and researchers. Many geoscientists do not readily believe in the value of the microscope, a fact which Vernon also questions, but which is borne out when one conducts surveys into how many use them once they graduate. This book can go a long way in helping students and researchers to appreciate and understand rock microstructures. It will make an excellent companion to any course using petrographic techniques. Ideally, it will stimulate graduates into describing and eventually understanding similar microstructural features beyond academia. Who knows, it might even promote wider use of the optical petrographic microscope.

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