The Canadian Mineralogist
Vol. 40, pp. 1235-1240 (2002)

BOOK REVIEWS

Murzinka: *Alabashka Pegmatite Field*. By V.I. Popova, V.A. Popov and A.A. Kanonerov. Mineralogical Almanac, Volume 5, Ocean Pictures Ltd., Moscow, Russia, 2002, 136 pages, softbound, US$45, including shipping and handling. Available from Terry Huizing, 5341 Thrasher Drive, Cincinnati, Ohio 45247, U.S.A. ISBN 5–900395–32–4.

This is the latest book published under the series title Mineralogical Almanac. Three volumes in the series have previously been reviewed in these pages (Gold: Nuggets of Russia: *Can. Mineral.* **38**, 772; Mineral Collections of Russia, Part I: *Can. Mineral.* **38**, 773-774; Dalnegorsk: Notes on Mineralogy: *Can. Mineral.* **39**, 217-218).

Murzinka (variously spelled as Mursinsk and Mursinka) in the Middle Ural Mountains of Russia is a famous, classic locality for fine, gem-quality crystals of topaz and beryl. As the title of the monograph *Murzinka*: *Alabashka Pegmatite Field* implies, the actual locality is a pegmatite field occupying an area of some 19 km^2. The pegmatite occurrences have been mined since the early 18^{th} century, and specimens grace mineral collections worldwide.

The book begins with a page of acknowledgements, followed by an introduction with maps locating the village of Murzinka and the principal pegmatites, and a table showing the distribution and abundance of mineral species in the pegmatites. The first chapter (20 pages) is a history of exploration and mining in the region from the earliest mention in the written record (1668) to the most recent mineralogical field work (2000). Descriptive excerpts from the literature, and a selection of photographs of historical and contemporary documents, mines, personalities and mineral specimens add interest to the chapter. One personality is the famous mineralogist A.E. Fersman, whose name seems to be associated with a great number of Russian mineral localities.

The second chapter (6 pages) summarizes the regional geology of the Murzinka massif and the Alabashka pegmatite field. It is illustrated by two simplified geological maps, both in color. Ample references to the literature are provided for further reading (in Russian), the most recent published in 1999.

The following chapter (28 pages) describes ten of the most important pegmatite systems that have been exposed by surface and underground mining. These systems are identified by the name of the mine or "vein", the latter designation reflecting the fact that most of the pegmatite bodies are vein-like. The external structures of the pegmatites and their relationship to the country rocks are well illustrated by colored plan views and vertical cross-sections. Unfortunately, there are only two (partial) sketches of internal structures. Whereas the internal structures and mineralization are described in considerable detail in the text, the descriptions are not always easy to follow, *e.g.*, "granite-like zone... [followed by] coarse graphic zone... [followed by] graphic pegmatite zone...with coarsening graphics from fine- to medium graphic structure." Strangely, the authors have chosen to present a table of the distribution and abundance of mineral species in the pegmatites described in the introduction to the book, and a discussion of the evolution of the pegmatite mineralization with a table showing the paragenesis of the minerals in one of the pegmatites and their estimated temperature and pH of formation, in the conclusions at the end of the book, rather than in this chapter. No attempt is made to classify the pegmatites other than that they belong to the "topaz–beryl type." Rounding out the chapter are 18 color photographs of mineral specimens from the pegmatites, as well as views of some of the mine openings and operations.

The main chapter (53 pages) in the book, on the mineralogy of the pegmatites, describes the 90 mineral species that have been reliably identified. In a refreshing departure from an all-too-common alphabetical listing, the presentation begins with the main rock-forming minerals, feldspars, quartz, and micas (7 species), continues with garnets (2), tourmalines (4), topaz, beryl, other beryllium minerals (5), phosphates (6), fluorite, calcite, oxides of niobium, tantalum, titanium, tungsten and tin (15), spinels (2), ilmenite, hematite, thorite, andalusite, cordierite, dumortierite, titanite, epidote group (2), zircon, zeolites (4), chlorite group (2), hisingerite, clay minerals (6), and sulfides (9), and concludes with late supergene oxides (7). The amount of information on each species varies, depending on its importance or occurrence as crystals, from a comprehensive description to a mere reference to the literature. Typically, the information includes morphology, color, mode of occurrence, associations and, for many of the major species, mineral chemistry. In total, there are 46 chemical compositions presented in nine tables, most of which appear to represent new data; additional analytical data, including some REE distributions, are given in the text. The crystal morphology of the major species is illustrated by 139 crystal drawings and sketches, some based on new goniometric measurements by the authors. A visual highlight of the chapter is the inclusion of 58 superb color photographs of mineral specimens from institutional and private collections.

The book ends with the previously mentioned conclusions, a whimsical color drawing of a topaz pocket, a glossary, references (73 citations), an index of the minerals described and illustrated, and eight pages of advertisements. Although they may be regarded as intrusive, advertisements help to underwrite the publication of the Mineralogical Almanac series.

The quality of the English in *Murzinka*, while still somewhat awkward, is much better than in some earlier volumes in the series. Typographical errors are few, but there are the usual inappropriately chosen English words (*e.g.*, "head" for crystal termination, "row" for a mineral series or group, "facet" for crystal faces, "scurfy" for scaly, "lumps" for crystal groups), and enigmatic literal translations of Russian words or terms, most of which, fortunately, are listed in the glossary provided. One word that will not be found in the glossary or an English language dictionary is "ichtyogliph." More properly spelled ichthyogliph, this is a translation of a Russian term for the graphic intergrowths of quartz in feldspar and alludes to their fish-like shape.

Printed on glossy paper, with a nice layout, excellent graphics and the liberal use of color, the book is a high-quality production. The text is on the right-hand two-thirds of the pages, leaving a wide marginal column for figure captions, crystal drawings, and smaller photographs.

Murzinka is a welcome addition to the rapidly growing number of topomineralogies. It can be recommended to anyone interested in classic mineral localities, or in granitic pegmatites and their minerals.

Peter Tarassoff
91 Lakeshore Road
Beaconsfield, Québec H9W 4H8

Structural Classification of Minerals. Volume 1: *Minerals with A, AmBn and ApBqCr General Chemical Formulas.* José Lima-de-Faria (2001). Kluwer Academic Publishers, 101 Philip Drive, Norwell, Massachusetts 02061, U.S.A. 146 pages. US$58 (hardcover). ISBN 0–7923–6892–4; 0–7923–6893–2 (set of three volumes).

This set of volumes is an extension of the earlier book by J. Lima-de-Faria entitled "Structural Mineralogy: An Introduction", which was reviewed in *Canadian Mineralogist* **33**, 699 (1995). Chapter 1 is an introduction, which includes a scheme of structural classification, symbols notation, and coordination polyhedra. Chapter 2.1 contains data tables with mineral name, chemical formula, structural formula, space group, unit-cell dimensions, equivalent positions, structure-type, and references (69 pages). Chapter 2.2 contains diagrams to show close-packed structures (17 pages). Chapter 2.3 lists the minerals under the headings of close-packed, group, chain, sheet, and framework structures (24 pages). The great strength of this book lies in the information in chapter 2.

The first mineral classification was based on useful properties, the second on physical properties, the third on chemical properties, and the fourth on crystal structure. Dana 8 (reviewed in *Canadian Mineralogist* **36**, 935, 1998) uses a chemical classification, whereas Strunz & Nickel (reviewed in *Canadian Mineralogist* **40**, 996, 2002) uses a chemical–structural classification. A comparison is drawn between the step forward from a physical properties classification to a chemical classification by Dana (1850), who, in the third edition, stated: "To change is always seeming fickleness. But not to change with the advance of science is worse; it is persistence in error..."

This classification is a structural–alphabetical one, because within each large group, which contains many structure-types, the minerals are listed alphabetically. What are the alternative structural classifications? Firstly, a Pearson Symbol minus hydrogen list, which appears to be a better listing than the structural–alphabetical; secondly, a group and family list, which brings together isostructural and related structures, and thirdly, a list based upon the reduced unit-cell, which is useful for identification on the basis of single-crystal data. The chemical classification is dead; however, a debate will continue whether to accept one of these structural classifications or the chemical–structural classification of Strunz & Nickel.

The book stresses the use of close-packed structures. For instance, pyrite is described as octahedral iron atoms in a cubic close-packed structure, with the two sulfur atoms taken as a unit like in the halite structure. The halite structure has a 6:6 coordination, whereas the pyrite structure has a 6:4 coordination.

There are few typographical errors. Mineral nomenclature follows Nickel & Nichols (1991), so that the book does not reflect the changes in Strunz & Nickel (2001). Compared to the earlier edition, the amount of white space has been reduced considerably. The book is printed on good-quality paper with clear type. Compared to other mineralogical books, the price is reasonable. Earth Science libraries will find a copy useful as a reference text, and the price may be low enough to justify a personal copy. I look forward to the production of volume two of this series.

Peter Bayliss
Australian Museum
6 College Street
Sydney, N.S.W. 2010, Australia

Industrial Mineralogy. By Luke L.Y. Chang. Prentice Hall, Upper Saddle River, New Jersey 07458, U.S.A. (available in Canada from Pearson Education Canada, 195 Harry Walker Parkway North, Newmarket, Ontario L3Y 7B4), 2002, viii + 472 pages. CDN $92.95. ISBN 0–13–917155–X.

Mineralogists and geologists in the academic realm are all too aware of the fundamental changes in the teaching of mineralogy and economic geology that have taken place over the past three decades. Shrinkage, compaction, and outright dumbing down have been the order of the day. On the other hand, whereas once one mineralogy covered all, we now have several: classical mineralogy (including crystallography and optical), environmental mineralogy, planetary mineralogy and, to judge by the title of the book here under review, industrial mineralogy. Is this really a new mineralogy? No, it is not. Luke Chang's *Industrial Mineralogy* (subtitled "Materials, processes, and uses") covers that which used to be labeled "Economic geology of the non-metals", or "Economic geology of industrial minerals and rocks". Mineralogy forms but a part of the book; its main strengths lie elsewhere.

Following seven pages of introductory materials (Preface, Acknowledgements, Introduction), *Industrial Mineralogy* is divided into 42 chapters that average 11 pages each (the shortest: Olivine at 5 pages; the longest: Zeolites at 23 pages), arranged alphabetically from asbestos to zircon. Some chapters treat individual minerals (barite, celestine, chromite...), others deal with mineral groups (beryllium minerals, feldspar, garnet...), or mixtures (bentonite, iron-oxide pigments, kaolinite and kaolinite-bearing clays...), or commodities (asbestos, silica, vermiculite...), or even (heaven forbid!), rocks (bauxite, diatomite, limestone...). Each chapter follows a uniform, user-friendly, four-fold division: Mineralogical properties; Geological occurrence and distribution of deposits; Industrial processes and uses; References. In all, the book is graced by more than a thousand useful references. It is interesting to see that over 25% of the citations are more than 30 years old. However, it is noteworthy that in a text published in 2002, only a half dozen references postdate 1997. The book includes 27 tables and 106 black-and-white figures. Many of the figures are processing flow-sheets. Unfortunately, a lot of the 40 or so geological maps and sections are hard to read because of confusing or unclear symbols and patterns. A five-page index of minerals concludes the volume.

In his Preface, Prof. Chang states that *Industrial Mineralogy* is intended to be a text "to introduce science and engineering students to the fundamentals of industrial minerals and mineral-based materials", and also to be a reference for professionals. In reading the book for this review, I found it difficult to envision it as a text; it is just too packed with data. Also, it would have been helpful to begin the book with a chapter outlining the principles of science and economics that underpin the subject. One must also ask if this book is distinct enough to be necessary. Seven books, each bearing "industrial minerals" in its title, and published between 1960 and 1996, are available. Four are titled "*Industrial minerals and rocks*" (J.L. Gillson, ed., 1960; S.J. Lefond, ed., 1983; M. Kuzvart, 1984; and D.D. Carr, ed., 1994). The others are *"Geology of the industrial rocks and minerals*" (R.L. Bates, 1969); *Industrial minerals, geology, and world deposits* (P.W. Harben and R.L. Bates, 1990); and "*Industrial minerals, a global geology*" (P.W. Harben and M. Kuzvart, 1996). I have not compared those volumes with *Industrial Mineralogy*; that task I leave to the professionals.

Although fundamentally clear, the writing would have been improved and made more fluid by professional editing. Poor choices of word order, split infinitives, sentences that begin with "There is" or "There are", incorrect uses of adverbs of time, sloppy syntax, and loose grammar abound. A disconcertingly large number of technical errors, too, have slipped in. Weight and density are confused in many places, beginning on page 3. To say that amosite (a banned name) is "biaxial negative with $2V$ between 90° and 96° leaves one scratching one's head (p. 7). I am not sure that my friend Bob Lamarche appreciates having his name changed to Lamarché (p. 10, 17). In the U.S., the average depth of oil wells over the past 40 years has not increased from 4800 to 6000 km (p. 23). It should be Al (not At) on Figure 8, and the patent number on p. 51 is wrong. Calling feldspars "aluminosilicate minerals" (p. 107) is wholly misleading and would cause S.J. Shand to turn in his grave, all while pyrophyllite, with nearly twice as much Al_2O_3 (p. 311), is not considered an aluminosilicate mineral. On page 115, we learn that "most fluorite is at least 99% CF_2", yet on the following page we are told that "fluorite from Coahuila has a 60 to 85% CaF_2 content", and English fluorite "has a 70 to 80% CaF_2 content". Presumably the author meant the CaF_2 contents of *ores* from the two districts, though this is not clear. The n_γ of gypsum is not 1.931 (p. 143), and the equations for the dehydration of the same mineral are wrong (p. 145). Permian salts in the Anadarko basin do not "make up an 8000 km sequence of gypsum, anhydrite, and rock salt" (p. 146). The formula for fluorapatite is in error (p. 150). Kimberlites in Canada are not restricted to the Grenville (p. 158), and the "Madgalen (sic) Islands" are not part of the "Quebec Maritime Provinces" (p. 301). In zircon, the Hf:Zr ratio is not 0.02:0.04 (p. 459).

Industrial Mineralogy is, nevertheless, filled with useful information, practically a printed databank. In reading the book for review, I learned, for example, that your wine and mine, as well as our beer and whiskey, probably have been filtered by diatomite (p. 99). β-eucryptite ($LiAlSiO_4$) possesses a highly negative coefficient of thermal expansion (p. 207). Were all the salts dissolved in the World ocean to be removed, their volume would be 50% greater than the volume of the North American continent now above sea level (p. 334). And finally, to help us through old age, wollastonite may be used as a bioactive bone substitute in humans (p. 434).

To sum up, *Industrial Mineralogy* is a fact-filled and well-organized reference on industrial minerals and rocks. Probably the book is unsuitable as a text. That aside, many of the references cited are to journals in ceramics, glass technology, metallurgy, and construction, fields not normally consulted by mineralogists or geologists. This alone should attract teachers and students.

Tomas Feininger
Département de géologie
Université Laval
Québec (Québec) G1K 7P4

Low-Grade Metamorphism. Edited by Martin Frey and Doug Robinson. Blackwell Science Ltd., Oxford, U.K. (Available in Canada from Login Brothers Book Co., 324 Saulteaux Crescent, Winnipeg, Manitoba R3J 3T2), 1999. 313 + x pages. US$89.95. ISBN 0–632–04756–9.

In the eyes of this reviewer, and probably of most practicing geologists, low-grade metamorphism is greenschist and lower amphibolite ("epidote-amphibolite" of yore) facies of regional metamorphism, and the albite–epidote facies of contact metamorphism. Such metamorphism produces thoroughly recrystallized rocks, mostly between 400 and 600°C, in which few of the protolith phases have survived intact. The subjects of the book here under review, *Low-Grade Metamorphism*, are, in fact, very low-grade rocks, those head-scratchers that commonly exhibit only feeble direct evidence of recrystallization: rocks of sub-greenschist and sub-blueschist (<400°C) facies (p. 1). Most of the rocks and assemblages discussed in *Low-Grade Metamorphism* developed at temperatures no higher than 300 or 350°C.

In the distant past, metamorphism covered a wide range, including weathering ("katamorphism" of C.K. Leith and W.J. Mead in their 1915 textbook *Metamorphic Geology*, and not to be confused with Grubenmann's "katametamorphixm"), diagenesis, and all types of metamorphism recognized today ("anametamorphism" of Leith and Mead). In about 1930, metamorphism was cut free from weathering and diagenesis. In short, a conceptual barrier was erected between the dominions of the metamorphic and sedimentary petrologist. This partitioning raised a new question: Where, at the low-T end of the scale, does metamorphism begin? The problem was first addressed seriously by D.S. Coombs in the 1950s with his pioneering studies of burial metamorphism and the erection of the zeolite facies. Later quantitative studies by B. Kübler, M. Frey, H.J. Kisch, J. Hower, and several Soviet and Japanese petrologists, further helped place the subject of very low-grade metamorphism on sound footing. (Thirty years ago, this reviewer directed a Master's thesis "The onset of metamorphism in the Tahuín Group, Ecuador". The literature was nearly devoid of references on the subject, and the student had to establish a variety of petrographic criteria which proved useful at least in the local context.)

Low-Grade Metamorphism is edited by Martin Frey and Doug Robinson, who also are co-authors of three of the eight chapters that comprise the book. The full list of the 11 contributors (with addresses) is given on p. viii. In a short preface (p. ix–x), Robinson stresses the growing importance of studying very low-grade metamorphism as "Earth science is increasingly concentrating on processes at shallower levels in the Earth's crust", with a focus on resource assessments, environmental impacts, and radwaste disposal.

The first chapter is an overview, indicating the well-known problems associated with the study of very low-grade rocks: sluggish reaction-rates, unachieved equilibria, and the fine grain-size of new phases. The roles of volatiles and size fractions are reviewed, as are low-T metamorphism in orogenic, nonorogenic, and postorogenic settings.

Chapter 2 discusses pelites. Whereas the simple disaggregation of samples may seriously compromise their usefulness for XRD, combined nondestructive TEM and AEM techniques offer new opportunities. Based on a variety of textural, mineralogical, and structural criteria, five zones are recognized (Fig. 2.1): early and late diagenetic; low and high anchizones; and epizone (lowermost traditional greenschist facies). The phyllosilicate reaction series is discussed in detail. The progressive development of mineralogical fabric through the stages of very low grade metamorphism is illustrated by a series of TEM images. Stressed is the necessity of separating neocrystallized from detrital phyllosilicates for crystallinity studies. The three modes of TEM techniques with their respective advantages are illustrated. "Retrograde diagenesis" (= diaphthoresis of very low-grade rocks) is discussed. The chapter closes with a review of five geothermobarometers and their pitfalls as applied to incompletely recrystallized pelites. Calibration is hampered by the absence of reversible clay-mineral reactions. Correlation with vitrinite reflectance is open to interpretation and may be skewed by heating rates, fluid compositions, and other factors.

Pelites are further explored in the third chapter, where it is pointed out that owing to their low clay content, sandstones and greywackes generally are unsuitable subjects. Following introductory pages on sampling and measurements to evaluate grade (including a useful summary diagram, Fig. 3.4), very low-grade pelites are placed in tectonic settings (extensional, Alpine collisional, accretionary, thermal aureoles) with examples. The utility of isocrysts (contours of equal Kübler indices) to unravel structural complexities (including inverted metamorphic gradients) is stressed. Cryptic aureoles around intrusions may extend far beyond the limits of aureoles defined by optical criteria alone.

Very low-grade metabasites are covered in the next two chapters. Chapter 4 opens with their mineral compositions and analytical techniques, including optical microscopy. This is illustrated by energy-dispersion spectroscopic spectra and BSE images. The difficulty of analyzing these fine-grained rocks and the hardships of analyzing and distinguishing zeolites is stressed. Given are projections that include pertinent phases (ACM from quartz + H_2O, from clinochlore, and others), as well as algebraic methods. The chapter closes with notes on geothermobarometry and the statement: "We can be cautiously optimistic ... to understanding low-grade assemblages down to perhaps as low as 200°C" (p. 141).

Chapter 5 documents numerous examples of regional very low-grade metabasites in extensional and convergent settings, as well as subaerial flood-basalt sequences. Oceanic crust covers 60% of the Earth and is largely composed of hydrothermally altered and metamorphosed basaltic rocks, which constitute the focus of Chapter 6. Treated herein are the upper volcanic section, the underlying sheeted dyke complex, volcanic islands, ophiolites, and back-arc basins. Geothermal systems are touched upon (p. 197-198), as are seafloor sulfide deposits (p. 189-190). The scarcity of pumpellyite in oceanic systems may reflect the low pressure of the environment. Zeolites tend to be late, and may be associated with the normal aging of the crust.

The seventh chapter deals with isotopic dating. A pivotal problem is the wholesale survival of protolith minerals; these may share a common grain-size, density, and magnetic susceptibility with newly formed (metamorphic) minerals and may thus be inseparable phases. Disaggregation by freeze–thaw techniques may obviate this dilemma in part. Also knotty is to distinguish detrital micas in microlithons from metamorphic phyllosilicates on bounding cleavage planes. Treated next is the geochronology of very low-grade rocks, with a discussion of the applicability of K/Ar, $^{40}Ar/^{39}Ar$, Sm–Nd, and U–Th–Pb systematics, as well as fission-track dating. The chapter ends with an extensive discussion on isotopic homogenization (or lack thereof!), which results in flat, bench-type, or inclined spectra on age *versus* size-fraction diagrams. Conclusion? Each sample must be treated individually and carefully.

The final chapter covers the field of stable-isotope geochemistry and its use in geothermometry and to document fluid–rock reactions. Application to very-low grade rocks has so far been limited. Although the author of the chapter waxes the potential strength of the geochemical approach, your reviewer wanes, citing the small (and erratic) trends on diagrams that portray delta *versus* metamorphic grade.

All references (about 1000!) are gathered at the end of the text (p. 261-301). They are up-to-date [the earliest is attributed to Charles Darwin (1846), and less than 10% predate 1970] and together they constitute a veritable gold mine for the serious researcher. The book closes with a thorough general index (p. 303-313).

Low-Grade Metamorphism could have been enhanced by the choice of a title that better reflects the content of the book, and by a summary introduction. Although the chapters are sound and replete with useful information, they don't hang together well. This inconvenience is at least in part offset by the excellent general index. Then, in a global work of this nature, it is surprising that the chapters have no abstracts. In short, the editors should have been more demanding. Finally, chapters on fluid inclusions (key tools in the study of very low-grade rocks), and on research in geothermal fields, would have greatly enriched coverage of the subject.

Errors and misprints are scarce, and most and confined to the references and of little consequence. Some figure captions are incomplete and depart from the illustrations: "chl" and "phen" for Fig. 2.7; and what is "L" on Fig. 3.17? The Pacific plate does not override the Atlantic plate, but rather the Indian–Australian plate at New Zealand (p. 91).

To summarize, *Low-Grade Metamorphism* is not a textbook. It is a loosely organized reference work on very low-grade rocks that spans the range from diagenesis to the beginnings of metamorphism.

Your reviewer must end on a sad note. Martin Frey, a pioneer in the study of very low-grade metamorphism and an outstanding petrologist, lost his life in a climbing accident in the Alps on September 10, 2000. Dr. Frey was a personal friend of many Canadian petrologists, having spent a sabbatical year at Carleton University, Ottawa, in 1981. He is missed.

Tomas Feininger
Département de géologie
Université Laval
Québec (Québec) G1K 7P4

Crustal Heat Flow: A Guide to Measurement and Modelling. By G.R. Beardsmore and J.P. Cull. Cambridge University Press, Cambridge, U.K., 2001, 324 pages, paperback, US $37.95 (ISBN 0–521–79703–9), hardback, US $100.00 (ISBN 0–521–79289–4).

The aim of this book is to be a "handbook for geologists and geophysicists who manipulate thermal data, particularly for petroleum exploration." The book is meant to be a long-term reference source for earth scientists and engineers, particularly those working in the oil-exploration industry, but also a basis for advanced undergraduate and graduate courses in geology and geophysics. For this purpose, the book is divided into three parts. Part one covers the thermal state of the earth, Part two, measurement techniques, and Part three, modelling techniques.

Part one, on the thermal state of the earth, comprises Chapter 1 (Terrestrial Heat) and Chapter 2 (Heat Generation). These chapters cover basic topics such as the origin of the Earth and its present thermal state, basic heat-flow terms and units, radiogenic heat, frictional heat along faults, and metamorphic reactions.

Part two, on measurement techniques, consists of Chapter 3 (Thermal Gradient), Chapter 4 (Thermal Conductivity), and Chapter 5 (Thermal Maturity). In these chapters, the authors discuss topics such as techniques and indicators for estimating the thermal gradient, surface temperature offshore and onshore, the heat-transfer theory, measurements of thermal conductivities of rocks, the generation of hydrocarbons from organic matter, geochemical indicators of paleotemperatures, and fission-track thermochronology.

Part three, on modelling techniques, covers many topics and comprises Chapter 6 (Heat Flow), Chapter 7 (Lithostatic Models), Chapter 8 (Numerical Modelling), and Chapter 9 (Unravelling the Thermal History of Sedimentary Basins). In Chapter 6, the authors discuss Bullard plots, non-vertical heat flow, and heat flow in relation to heat production, continental age, oceanic age, seismic data and electrical conductivity. In Chapter 7, there is a discussion of oceanic and continental lithospheres, hot spots, subduction zones, and the various models of crustal extension (instantaneous pure shear, constant pure shear, simple shear, *etc.*). The final two chapters, 8 and 9, deal with standard modelling topics such as finite-difference models, the relaxation technique, associated boundary-conditions and errors, determination of the present heat-flow distribution, the tectonic history of sedimentary basins (and associated stretching factors), heat-flow anomalies, and the temperature distribution in the crust.

Since the book is meant to be a reference source, one criticism is that the references in several of its sections are not really up to date. This criticism does not apply to the many "historic references", which are most welcome, particularly because the foundation of much of the basic theory in the text is quite old. But this criticism certainly applies to the sections on hot spots, where most of the references are to papers from the 1990s. Given the intense research on hot spots and mantle plumes in the past decade, many more recent papers should have been cited. The same applies to the sections on subduction zones; most references are old, and the general treatment is not quite up to date. Fortunately, there exist many recent books that provide a modern treatment of these topics; for example, *Dynamic Earth: Plates, Plumes and Mantle Convection* (G.F. Davis, 1999). Most other sections, however, are more up to date, and in the text as a whole, about 25% of the cited books and papers are from the 1990s.

The book is well written, well organized, and has good illustrations. SI units are used throughout the text. Among the most appealing aspects of the book are the sections entitled Questions and Answers. Most of these are solved problems (worked examples), where the equations are applied to realistic problems. The Question-and-Answer sections serve to illustrate and amplify the theory, and to bring into focus the basic theoretical ideas, data-reduction techniques and data interpretation, so as to help the student in effective learning of the principles of measurement and modelling of crustal heat-flow. Most of the answers are given in considerable detail. This will be very helpful to many readers, particularly those who are not familiar with the quantitative treatment and equations used in the text. Although there are many formulas presented in the book, the general mathematical level is not too high for interested geologists with a relatively modest background in mathematics.

Crustal Heat Flow: A Guide to Measurement and Modelling is a book that will be of interest to a broad range of earth scientists. It is suitable as a complementary text for many advanced undergraduate and graduate courses in geology, geophysics, and related fields. The text is also likely to be very helpful to those earth scientists and engineers working in the petroleum industry who need a review of the basic principles of crustal heat-flow applied to sedimentary basins. In this context, the numerous worked examples should be most helpful. In summary, this fine text on crustal heat-flow, useful both as a handbook for researchers and as a textbook for students in geology and geophysics, is thoroughly recommended.

Agust Gudmundsson
Geological Institute
University of Bergen
Allegt. 41
N–5007 Bergen, Norway