

Book Reviews / Critiques

Volume 25, Number 1, March 1998

URI: https://id.erudit.org/iderudit/geocan25_1br01

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Publisher(s)

The Geological Association of Canada

ISSN

0315-0941 (print)

1911-4850 (digital)

[Explore this journal](#)

Cite this review

(1998). Review of [Book Reviews / Critiques]. *Geoscience Canada*, 25(1), 44–49.

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BOOK REVIEWS

A Geological Companion to Greece and the Aegean

By Michael Dennis Higgins and
Reynold Higgins
Cornell University Press
1996, 240 p., US\$55.00, hardcover

Reviewed by Alan V. Morgan
Department of Earth Sciences
University of Waterloo
Waterloo, Ontario N2L 3G1

Thirty-five years ago, I spent an incredibly uncomfortable night trying to sleep on bare rock of indeterminate age at the summit of Mt. Taygetus in the Outer Mani of southern Greece. Three decades later I co-led twenty Earth Sciences students for a two week field trip of central Greece and Thera. In both cases, and a number of times in-between, what I really needed was a copy of *A Geological Companion to Greece and the Aegean*. This text is an absolute must for anyone with an interest in understanding landscapes and stratigraphy in this portion of the eastern Mediterranean. I had considerable difficulty in gathering information on the geology of the regions that we planned to visit in 1994 because this was often in Greek, German or French, but rarely in English. The text resolves this problem since it covers not only the geology and geomorphology of selected regions in fair detail, but ties in the archeology and mining history and provides pertinent references to parts of Greece and the adjacent Greek islands.

The book is divided into 17 chapters and two appendices. Chapter 1 "The Geological Background" covers some basic geological concepts, useful both to the lay person and to fourth year students who

have forgotten the things covered in first year, such as origins of rocks, soils, karst, sea-level changes and elements of plate tectonism and associated activities! Chapter 2 provides a basic introduction to the "Geological History of the Mediterranean." Chapters 3 through 15 deal with regional aspects of the geology of mainland Greece and the smaller island groups of the Ionian and Aegean seas. Chapter 16 does the same thing for Crete. Chapter 17 covers "Future Geological Hazards." Appendix 1 provides information on marbles and related stones, and Appendix 2 presents a glossary of geological terms.

I have travelled moderately extensively in Greece on a number of visits over the past 35 years and I was curious to see just what the authors had described for some of the regions with which I am more familiar. One of these is Messenia in the western part of the Peloponnese, another is in Thessaly, and a third is the Cyclades. In each case I was intrigued with the text offerings. The different areas were described in moderate geological detail, often reinforced with interesting ties to the historical aspects of the region and usually with specific references to materials (marbles, ores) used in antiquity. For example the fault scarp near Yerolimena (Gerolimena in the text) in Deep Mani which I had noted as a second year student is mentioned (fig. 1). The caves of Diros Mani opened to tourists 35 years ago are covered in fair detail. The description of the eruptive stages of Minoan Thera are extremely clear, covering aspects that are difficult to ascertain. For example the growth of the Kameni islands is particularly well-documented, and is just the thing I could have used in our 1994 field trip. Elsewhere, in the section on Central Greece, I was pleased to see explanations of the stages and drainage of Lake Copais and the Lake Iliki system (important in the historical aspects of water use in Greece), and, in the section on Thessaly, a con-

cise description for the outstanding scenery at Meteora.

The photographs used in the book are all fascinating, although they suffer somewhat from over- and under-exposure, probably due to black and white conversion from color slides or prints. Diagrams generally are excellent. They are simple, which adds to the clarity, but they suffer from the age-old problem in Greece of placing yourself accurately in respect to modern communication routes. The book could have been made so much more useful by having modern roads superimposed on the base geology. I can cite one example in fig. 8.6. This is the location of the battle site at Thermopylae (familiar to many through Kirk Douglas and 300 Hollywood "Spartans" fighting off the Persian hordes). The main national highway from Athens north to Thessalonika passes the site. There is a huge memorial close by, and a major power line transects the area. Unfortunately these are not marked on the map and you end up wondering where you are with respect to the "West Gate," "the shoreline of 450 BC" or the "Middle gate." This is true of many of the other maps and it reduces the value of the text to the geologist, or tourist, travelling by car. This information can be easily gleaned from air photographs, but in fairness to the authors I do know how paranoid certain Greek government departments are in releasing any type of topographic or strategic information. It is to be hoped that the next generation of EOS satellites will release us from these constraints.

In summary the authors are to be congratulated in producing a book which, although expensive, (about Cdn\$80.00) is easily comprehensible and very readable. If you are planning on visiting this beautiful and interesting country with the object of learning more about its geological setting, you must have it. I plan on taking my copy with me to Greece this year!

Perspectives on the Eastern Margin of the Cretaceous Western Interior Basin

Edited by G.W. Shurr, G.A. Ludvisgon and R.H. Hammond
*Geological Society of America
 Special Paper 287
 1994, 264 p., US\$60.00*

Reviewed by Doug Cant
*Doug Cant Geological Consulting
 38 Redwood Meadows Drive
 Redwood Meadows, Alberta T3Z 1A3*

This volume contains 13 papers on the Cretaceous rocks on the eastern margin of the Western Interior Basin of North America. It reflects an attempt to balance the vast amount of published research work on the western, tectonically active margin of the basin with some relatively recent work on the less well-known margin. The cratonward-tapering eastern margin contrasts very strongly with the United States' western margin, which is deformed by Late Cretaceous-Tertiary high-angle reverse faults that created the so-called Laramide basins. Geographic coverage ranges from Manitoba through Minnesota, South Dakota, Kansas and Iowa. Stratigraphic range is from late Albian to Maastrichtian rocks.

Subjects include regional stratigraphy, sedimentology, paleobotany, geochemistry and structure. The opening paper presents a west-east transect from Montana to Minnesota, thus providing a descriptive review of the lithostratigraphy of the entire northeastern part of the basin. Another paper discusses the stratigraphy of equivalents in Alabama to provide a perspective to the studies of the eastern margin. Four papers provide more detailed stratigraphy and sedimentology of several of the units in the area of study. Several of these use some of the concepts of sequence stratigraphy and extend the large-scale (third order) sequences recognized farther west into this area. The common paleogeography known in the west is reversed, however, with fluvial input from the east, and marine conditions in the central part of the basin. Two papers on paleobiology discuss the ages of units as interpreted from plant and palynological collections and the stratigraphic

implications of these, particularly in recognition of unconformities in fluvial sections. Of the two geochemical papers included, one discusses sedimentology and isotope compositions of concretionary horizons in the Greenhorn Cycle. In this, the effects of sea-level fluctuations on the carbonate diagenesis (including oxygen isotopes) are documented. The other discusses a porcelanite in Manitoba in terms of mineralogy, chemical composition and paleontology, and interprets the depositional environment. These geochemical papers exemplify the differences with western sediments; these condensed sections show completely different mineralogies. The last three papers deal with tectonic features of this area in the middle of the stable craton. One is the Manson impact structure, a circular meteorite crater dated as terminal Cretaceous. Its possible relationship to the Chicxulub crater of Yucatan is not discussed. Several Upper Cretaceous stratigraphic units are preserved within the Manson structure that are eroded in the area, only preserved more than 300 km to the west. The other two tectonics papers deal with small faults and their relationships to basement structures reactivated by epeirogenic movements. These structures generate recognizable lineaments on air photographs, and are risk factors for construction projects.

This volume is a worthwhile contribution to the classic descriptive stratigraphy and sedimentology of the area. It contains data useful to all Cretaceous stratigraphers working on this vast basin. It complements several compilations in the western part of the basin, including the Canadian Society of Petroleum Geologists Mesozoic volume (CSPG Memoir 9, 1984) and the Geological Association of Canada's Manitoba Escarpment volume (GAC Special Paper 21, 1981). It is particularly useful to those of us who have tried to trace our favorite units in western Canada through the morass of stratigraphic nomenclature and Late Cretaceous Laramide deformation to their southern and eastern margins in the United States. Few of the papers within it break much new research ground; rather they review, describe or refine reports published previously. The price of the book (US\$60.00, Cdn\$87) is not unreasonable these days.

Low-grade Metamorphism of Mafic Rocks

Edited by Peter Schiffman and Howard W. Day
*Geological Society of America
 Special Paper 296
 1995, 181 p., US\$50.00*

Reviewed by Edward Ghent
*Department of Geology and Geophysics
 University of Calgary
 2500 University Drive NW
 Calgary, Alberta T2N 1N4*

This special paper was the "collective outgrowth" of a meeting under the auspices of IGCP project 294 (Very Low Grade Metamorphism). The meeting was entitled "The transition from basalt to metabasalt: environments, processes and petrogenesis." The 10 chapters in this special paper "attempt to do more than place the metabasalts into traditionally defined metamorphic facies but attempt to interpret the pressure-temperature-composition conditions of metamorphism and the processes attending low-grade metamorphism."

The recognition of the zeolite facies in the early 1950s was a breakthrough in the study of very low-grade metamorphic rocks. Subsequently, it has been recognized that low-grade metabasaltic rocks are very widespread, both on the continents and in the oceanic crust. Their association with many ore deposits is also noteworthy. A quick perusal of the metamorphic map of the Canadian Cordillera, for example, indicates the importance of these rocks in western Canada. They are also widespread in the Canadian Shield and in the Appalachians.

One of the major problems in the study of low-grade metamorphic rocks, including both metabasalts and metasediments, is that many of the reactions are thermodynamically irreversible. For example, the conversion of volcanic glass to zeolites, chlorite, etc. is clearly not a thermodynamically reversible process and consequently is rate dependent. Such reactions are not readily amenable to estimation of intensive variables of metamorphism, e.g., temperature, unless they can be carefully calibrated with respect to the rate of reaction in a natural setting. Another major problem is the timing of crystallization of

the low-grade minerals. "Relative time markers" such as foliations and microfolds which are present in metasedimentary rocks and rocks of higher metamorphic grade are generally lacking in low-grade metabasalts. Many of the papers in this collection acknowledge these problems and attempt to deal with them.

Most of the chapters refer to the low-grade metamorphism of specific metamorphic areas. The rocks studied range in age from Precambrian rocks in the Canadian Shield to late Mesozoic rocks in western North America and elsewhere. Several of the papers report metamorphism of ophiolites and compare their results with data obtained from the results of sampling of the oceanic crust. Two of the papers, which are of interest, do not seem to conform to the title of the volume. The paper on resetting of Rb-Sr ages in granitic rocks in Wales by Evans has little to say about low-grade metamorphism of mafic rocks. The paper by Bevins and Robinson on low-grade rocks from the Sierra Nevada foothills emphasizes a study of the mineralogy of micas in metasedimentary rocks. Beiersdorfer and Day review the mineral paragenesis of pumpellyite in low-grade metamorphism and also discuss the problem of the definition of low-grade metamorphic facies. It is likely that there has been more emphasis on this topic than is warranted. Many of the problems are due to the not unexpected overlap of some mineral assemblages in P-T space.

Many of the papers report analytical data, particularly electron microprobe analyses of low-grade metamorphic minerals. Other data reported include fluid inclusions, oxygen isotopes, whole rock analyses, illite crystallinity and lattice parameters. The treatment of ferrous-ferric iron in the analysis of pumpellyite, chlorite and actinolite is interesting. Some authors attempt to estimate the ferrous/ferric iron ratio in pumpellyite and treat the iron in chlorite and actinolite as ferrous iron only. Other authors have pointed out that this is an inconsistent approach and have treated the iron in these minerals as all ferrous.

There are a number of approaches to the interpretation of metamorphic conditions and metamorphic processes presented in these papers. Of particular interest are the use of single value decomposition (SVD) to test mass balance between prehnite-pumpellyite facies mineral assemblages and greenschist facies mineral assemblages (Digel and Gordon), the estimation of the effects of original poros-

ity and permeability on low-grade metamorphism (Manning and Bird), chemical and x-ray diffraction studies of chloritic minerals (Walker and Murphy), and the modeling of water-rock interaction to produce epidiosites in the sheeted dike section of the Trodos ophiolite (Bettison-Varga and Schiffman).

On the whole, the papers are representative of the present state of the study of low-grade metamorphism of basaltic rocks. The volume is essential reading for any worker interested in low-grade metamorphism. I would also include those workers whose emphasis is on the low-grade metamorphism of sedimentary rocks, because some of the techniques and interpretations presented in these papers are applicable to the study of meta-sedimentary rocks.

Reconstructing the History of Basin and Range Extension Using Sedimentology and Stratigraphy

Edited by K.K. Beretan
*Geological Society of America
Special Paper 303
1996, 212 p., US\$78.50*

Reviewed by Doug Cant
*Doug Cant Geological Consulting
38 Redwood Meadows Drive
Redwood Meadows, Alberta T3Z 1A3*

This volume is a collection of 10 papers from a symposium held at GSA section meetings in 1993. As implied in the title, the purpose of the volume was to report on progress in understanding the tectonic-sedimentary history of the extensional Basin and Range province of Arizona, Nevada and eastern California. As any geologist who has travelled through this area will know, the Basin and Range province consists of a series of linear basins and intervening uplands, clearly separated by almost straight normal faults. The basins are small half-grabens, generally on the order of 5-20 km wide and several tens to a hundred kilometres long. Because of the present-day climate, they are

being filled by alluvial fan, aeolian and ephemeral braided stream sands, but older sediments in them (generally Eocene and Miocene) show more variety, including lacustrine conglomerates and dolomites as well as abundant volcanoclastics.

A number of papers in this volume are similar in that they provide detailed stratigraphic data about specific units in the basins and use this data to infer the timing and type of structural deformation. They clearly fulfill the purposes of the volume. Several papers incorporate detailed structural and kinematic analysis of different basin types as well as data about the basin fills to provide a complete picture of the tectonic and sedimentary development. One paper uses advances in structural geology to discuss the three-dimensional aspects of half-grabens, *i.e.*, how subsidence changes from the midpoint to the ends of the fault, probably an important factor controlling basin fill. The papers in the volume cover the complete spectrum from those primarily concerned with the structural aspects of the basins to those primarily describing facies, evolution and paleoflow directions of the sedimentary fill. Besides classic field-based mapping, stratigraphic and sedimentologic analysis, other techniques which are used include high-precision radiometric dating of volcanics, seismic stratigraphy, computer modelling of basin geometries, and biostratigraphy.

As noted, most papers concentrate on the details of a particular unit. The data collected about a unit are used to infer the specific development of a particular basin in the area. The only exception is a paper by R.W. Schlische and M.H. Andrews which describes fault and basin models in a more general way, and incorporates examples from Triassic basins in eastern North America. This concentration on specific units and basins is the strength of the volume as the papers are all well grounded in data, unlike many modern publications which rely more on modelling and theory than observation. However, the extreme concentration is also a weakness for those not working in the Basin and Range province. The papers are not put in any context; there is no stratigraphic or structural overview of the province in any of the papers, not even an overall map of the basins. These additions would have made the volume much more usable for geologists not familiar with the area, but who are interested in non-marine rift-basin facies and evolution.

The volume is therefore useful to geologists interested in the Basin and Range province itself (probably including few Canadians) as well as those interested in the details of non-marine rift-basin morphology, fill and development. The latter group will be able to learn lessons from the well-understood examples noted here. For the rest of us, there are other sources of information available on the subject, perhaps slightly more generalized and more easily digested. At a price of US\$78.50 (approximately Cdn \$114), the price of this volume will ensure that only libraries in Canada will acquire it.

Silurian Encrinurine Trilobites from the Central Canadian Arctic

By J.M. Adrain and G.D. Edgecombe
Palaeontographica Canadiana 14
1997, ISBN 0-920230-63-6
Available from GAC:
Cdn\$44.50 (orders from within Canada)
US\$44.50 (orders from elsewhere)

Reviewed by Dave Rudkin
Department of Palaeobiology
Royal Ontario Museum
100 Queen's Park
Toronto, Ontario M5S 2C6

An encrinurine trilobite is a bizarre and improbable little bit of evolutionary engineering: a highly inflated and complex aggregate of tubercles, ribs, furrows, spines, and protruding eyes, all vaguely suggestive of a terminally carbunculate bug. Fortunately, under the discerning eyes of a small band of dedicated encrinurino- logists, such seemingly random assemblies of bumps and ridges resolve into patterns of characters that are a phylogenetic systematist's dream. When these same trilobites are exquisitely preserved (by silicification of the originally calcitic exoskeleton) AND when they occur within in a relatively complete and age-constrained sequence of Upper Silurian rocks, we have all the ingredients of a first-rate paleontological tale.

However, ingredients alone do not a successful story make. Patient and prac-

tised authors are required to first obtain the raw materials, then analyze and interpret their meaning, and finally pen an account that both pleases the eye and satisfies the mind. Adrain and Edgecombe have managed admirably in each respect, adding yet another volume to a growing body of work chronicling the diverse silicified Wenlock trilobite faunas of the Cape Phillips Formation, in the central Arctic Archipelago.

The current volume is both descriptive and interpretive. More than half of the text pages are devoted to detailed characterization of 28 species-level taxa allocated to four encrinurine genera. Eleven of 20 new species are named and, in keeping with a tradition established by the authors in earlier studies, new taxa are "...named after various contemporary minstrels and their spouses or associates." For some peculiar reason, this approach has offended at least one nomenclaturally sensitive referee; but where else could one find species named for the original Beatles drummer (*Struszia* [s.l.] *petebesti*) and for the entire complement of the Ramones? Thirty-five plates (including one of calcareous crack-out material from the upper Ludlow Douro Formation) and six text-figure reconstructions illustrate the described material. The photographs are excellent, as one has come to expect from this team, and depict in superb fashion all the exoskeletal eccentricities of this remarkable group of trilobites. One minor and insignificant quirk of some of the plates is the presence of unmasked edges on individual photos (plates 13 and 17, for example). I am apt to forgive such relatively trivial details, having myself faced the frustrations of producing pristine composite plates on revealing black backgrounds!

Prefacing the descriptive text are sections providing requisite background on faunal occurrence, preservation, localities and stratigraphy, biostratigraphy and paleobiogeography. The centrepiece of the monograph is a comprehensive phylogenetic analysis of the *Struszia* genus group, including a full elucidation of characters (illustrated on an accompanying text-figure), and a discussion of both systematic and paleobiogeographic implications of results. The genus group (of essentially northern Laurentian origin) is shown to include several well-supported clades, although *Struszia* itself is recognized as incorporating at least two distinctive lineages.

I end with a confession. When the re-

view copy of *Palaeontographica Canadiana 14* arrived on my desk just prior to Christmas, it wasn't the first time I'd laid eyes on the work. That occasion was some years ago when I had the pleasure of recommending the original manuscript for publication in a museum monograph series (better left unnamed) that unfortunately, and for totally unrelated reasons, went belly-up soon thereafter. I was impressed by Adrain and Edgecombe's work then, I remain impressed now, and I'm delighted that *Palaeontographica Canadiana* was able to leap to the rescue of this fine monograph.

The Nature of Diamonds

Edited by George E. Harlow
Cambridge University Press
in association with
American Museum of Natural History
1998, 278 p., US\$74.95, hardcover
US\$29.95, softcover

Reviewed by Walter W. Nassichuk
Geological Survey of Canada
3303 33rd Street NW
Calgary, Alberta T2L 2A7

The Nature of Diamonds is a companion volume to a special exhibition on diamonds created by the American Museum of Natural History to show the myriad of special linkages between the stone's historical, cultural and scientific value. In 13 chapters it contains a broad range of subjects including the composition, origin and natural occurrence of diamonds in the world, and other less scientific topics that deal with diamonds as coveted things of beauty as demonstrated in art, literature and indeed, the movies. Each chapter is a gem in itself, replete with magnificent illustrations, including color photographs of cut and uncut stones and exquisite pieces of jewelry contained in public and private collections around the world. The volume is a primer on diamonds, a small museum with a glimpse of interest for anyone who holds even the slightest interest in the natural sciences or in beautiful objects produced by nature.

The appearance of this volume in 1998 is fortuitous for Canadians because later

in the year Canada's first diamond mine, the DiaMet-BHP Ekati Mine at Lac de Gras, north of Yellowknife will begin to produce high-quality gemstones comparable to the best mined anywhere in the world. The economic potential for Canada is enormous and as other new mines open in the same general area early in the next millenium, the value of Canada's production should approximate 10% of the world's total. Since the discovery of diamonds at Lac de Gras in 1991, Canadians have been bombarded with data on diamonds, particularly scientific and economic data, and *The Nature of Diamonds* gives the discovery an historical perspective. Further, it clarifies why the diamond has come to symbolize wealth, greed and vanity on one end of a spectrum and purity, strength and never-ending love on the other.

The first four chapters and the last three are scientific in nature but are completely lucid, dedicted to the explanation of basic characteristics of diamonds, their occurrences and use. George Harlow explains what a diamond is from its atomic construction to its physical nature, and also explains the range of differences between Type I diamonds that contain nitrogen and Type II diamonds, that don't. In his chapter on the nature and color of diamonds, Emmanuel Fritsch suggests that colored diamonds, exceedingly rare even today, have been treasured since Roman times. In diamonds, colors are not related to metal impurities as in other gems, but rather to nitrogen impurities and to defects within the crystal structure. Blue diamonds, such as the Hope, one of the world's best-known diamonds, are generally devoid of nitrogen but contain traces of boron.

Diamonds occur mainly in the earth's upper mantle but Harlow, V.S. Shatsky and N.V. Sobolev explain that they are also formed, under peculiar circumstances, in the crust. They also occur in meteorites and in craters caused by meteorites hitting the earth. Melissa Kirkley reviews the mechanisms by which diamonds that formed within the upper mantle are transported to the Earth's surface in kimberlite and lamproite pipes. She also explains the possible sources for the carbon from which diamonds formed and how mineral inclusions within diamonds help to indicate the environment in which particular diamonds crystallized. Hartzburgite and eclogite are the main rock sources of diamonds within the mantle. Curiously, whereas hartzburgite-sourced diamonds

appear to have formed three billion years ago, eclogite-sourced diamonds appear to be slightly younger.

Alfred A. Levinson discusses the global distribution of diamond-bearing kimberlites and lamproites of commercial significance: kimberlites are contained in parts of stable cratons older than 2.5 billion years (Archons) whereas lamproites occur in parts of those cratons 1.6-2.5 billion years old (Protons). With magnificent maps and field photographs Levinson describes a fascinating historical journey of diamond discovery that begins in India 2000 years ago and ends with the most recent discoveries in northern Canada where the Ekati mine is under construction today. In a fascinating complementary chapter George Harlow traces the diamond through ancient literature with forays into the bible, Budhist text and mythology. Harlow's journey includes the earliest reference to diamonds in the Sanskrit text *Arthasastra* (?150-320 BC) and extends through the Middle Ages to the Renaissance.

A chapter entitled "Worlds Great Diamonds," presumably written by the editor and his associates, includes photographs and a brief description and history of the world's best-known stones including the Hope, Regent, Sancy, Tiffany, Cullinan and many others. The Premier Mine in South Africa has produced more diamonds greater than 400 carats than any other mine in the world, including the extraordinary Cullinan stone (3106 carats), which was discovered in 1905. The Cullinan was subsequently cut into 9 smaller stones ranging from 550.2 carats (The Great Star of Africa) down to 4.8 carats.

Diana Scarisbrick follows the evolution of diamond jewellery from the Middle Ages and the Renaissance through to the 19th century. She also traced the wedding ring as a symbol of love back to the second century (BC) but diamonds did not adorn wedding rings until the 13th century. During the second half of the 19th century, the engagement ring was born and the diamond became the gem-of-choice to adorn it.

In her chapter "The Value of Diamonds in English Literature," Carole Slade suggests that the diamond signifies wealth in Renaissance literature and that Shakespeare used it as a metaphor for the qualities required in an ideal woman; that is, virtue, beauty, wisdom, fidelity and chasity.

Several other delightful chapters deal with the ceremonial and decorative use of diamonds through history: "Diamond

Treasures of Russia" (Inna Kostina and George Harlow), "Diamond Jewelry for Everyone" (Janet Zapata) and "Hollywood Loves Diamonds" (Maura Spiegel). "Diamonds in the 20th Century" (George Harlow) shows how diamonds have evolved from baubles employed and displayed by royalty to ostentatious signs of wealth displayed by the "common man." Indoctrination of the main purchasers of engagement rings (males) to the belief that the diamond, the ultimate expression of love, is forever, certainly assisted de Beers in assembling considerable wealth.

Finally, some technical aspects of diamonds are reviewed succinctly and authoritatively. Editor George Harlow reviews the evolution of diamond mining and the processing of diamonds, James E. Shigley and Thomas Moses discuss the gemology of diamonds, and Alan T. Collins explains the industrial application of natural diamonds and the manufacture of synthetic diamonds.

The Nature of Diamonds, lucidly written by recognized international authorities and brilliantly edited, clearly achieves its principal objective, which is to link the scientific, historical, cultural and economic threads of diamonds. Certainly a fine fabric was woven from those threads. It is written for anyone with enough curiosity to enter a museum of natural history or indeed a museum of art. Many complex ideas, particularly those within the realm of science, are explained in an easily understood manner. Indeed, it is inevitable that the data presented will stimulate new insights into earth processes by geologists and other earth scientists. Of particular significance, scientists in this volume are reaching out not only to other scientists but to a much more vast and diversified cross-section of the population, that sector interested in and influenced by cultural history and the beauty of nature.

Plate Tectonics and Crustal Evolution (Fourth Edition)

By Kent C. Condie
Butterworth-Heinemann
1997, 282 p., US\$49.95

Reviewed by Glen S. Stockmal
Geological Survey of Canada
3303 33 Street NW
Calgary, Alberta T2L 2A7

This is the latest edition of Kent Condie's textbook, succeeding its popular predecessors. Similar to the three earlier versions, it covers an enormous amount of ground, but differs by being perhaps the best organized, and certainly the best formatted and illustrated (the fourth edition publisher is Butterworth-Heinemann, whereas Pergamon Press published the first three editions). Absent from this new edition is the large foldout tectonic map of the world familiar to owners/users of the first three editions, but illustrations in the body of the book more than compensate for the map's absence. The text is intended for advanced undergraduate and graduate students, and also for specialists in other fields for use as a reference book.

Chapters are more logically ordered than in previous editions, reflecting in part their extensive revision. The well-structured hierarchy of headings and sub-headings allows for ease of use and clarity of context. First occurrence of defined terms is in bold face, making reference easy. Each chapter begins with a concise but useful introduction, and ends with a summary consisting of numbered statements reiterating the most salient points. A limited number of references ("Suggestions for further reading") are provided at the end of each chapter, with the vast majority of references (ca. 700) listed at the back of the book. The Index is unfortunately brief.

Chapter 1, "Plate Tectonics," discusses the origins of the hypothesis, the physical nature of tectonic features arising from plate motion, observations of plate mo-

tions themselves, and a very brief section on plate driving forces. The chapter is completed with geomagnetism, hotspots and plumes, an introduction to plate tectonics and orogenesis, the creation and dismemberment of supercontinents, and reference to the concept of "Earth systems" and its rising importance in geological sciences.

Chapter 2, "The Earth's crust," focuses on crustal types, composition, physical properties, and processes related to crustal-scale deformation and petrological evolution. Sections include seismic structure, heat flow, the concept of "cratonization," and a discussion of the collage of crustal provinces and/or terranes that underlie the continents.

Chapter 3, "Tectonic settings," examines details of crustal-scale deformation within the context of plate tectonics. Oceanic as well as continental settings are discussed, including passive margins, continental rifts, arcs, and collisional and accretionary orogens. Sections on settings of uncertain affinity (anorogenic granites and Archean greenstone belts), and the linkages to mineral and energy deposits round out this chapter.

Chapter 4, "The Earth's mantle and core," presents geophysical and petrological observations constraining the structure, composition, and dynamics of the mantle, and to a lesser degree, the core. Seismic, potential field, thermal, and geochemical data are presented in a well-integrated fashion. In addition to summaries regarding mantle convection, plumes, and upwellings, the possible relationships between mantle dynamics and supercontinents are discussed also.

Chapter 5, "Crustal and mantle evolution," draws together information from the first four chapters to describe changes in the crust/mantle system through geological time. It includes the origin and subsequent growth of the Earth's crust and continents, the still-enigmatic episodic distribution of crustal isotopic ages, and secular compositional/chemical changes. The chapter ends with current thought on the nature of plate tectonics in the Archean, changes which occurred at the Archean-Proterozoic boundary, and speculative linkages between the episodic crustal

ages and mantle dynamics (specifically, catastrophic mantle overturn, or slab avalanches).

Chapter 6, "The atmosphere, oceans, climates, and life," is a welcome addition to this edition, which examines a number of "coupled" systems in a holistic, "Earth systems science" approach. Cross-disciplinary studies discussed include the evolution of the atmosphere, carbon and sulphur isotopic compositions through time, the growth of the oceans and chemical evolution, paleoclimates and their relationships to tectonic activity, and the evolution and episodic mass extinction of life.

Chapter 7, "Comparative planetary evolution," rounds out the book by placing the Earth's tectonic history in the context of that of the solar system. Being necessarily brief, the text provides an inventory of objects orbiting the Sun, considers models of planetary condensation and accretion, discusses the age of the Earth and solar system, and compares the evolution of terrestrial, Martian, and Venusian atmospheres. The Earth-Moon system is considered from the points of view of chemical composition, origin, and rotational history. A brief section on comparative evolution of the terrestrial planets completes the chapter.

In general, the book is very well illustrated, well organized, and well written. Typographical errors exist, but are rare. Errors also occur in the citations and references (misspellings and erroneous dates), but are infrequent. Some sections are extremely brief or cursory, but this is, I suppose, the nature of tackling such broad subject matter. One specific complaint I have is the conservative number of citations within the text. I realize this is a standard style for textbooks, but at this advanced level, and in consideration of the breadth of the subject matter, I believe more reference citations are warranted. Perhaps the best format would be numbered citations (fifth edition?), significantly reducing the length of the text, but providing students and/or professionals a way to more easily pursue details on their own.

The list price of US\$49.95 (softcover) seems pretty attractive in today's textbook market. This is a very good book at an equally good price.

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