Book Reviews / Critique

REVIEWS

Natural Stone, Weathering Phenomena, Conservation Strategies and Case Studies

Edited by S. Siegesmund, T. Weiss and A. Vollbrecht
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A book of review articles and case studies is by its very nature a useful quick introduction to what has been done and where to find it. However, by compiling papers of individuals or groups of individuals the style and use of language inevitably varies, and that is shown in this collection of papers. The deterioration of historic buildings and monuments built of stone and, as the editors point out, "man-made porous inorganic materials" is a cause of concern to all who wish to continue to view what societies have erected over the centuries. The editors state their aim with these studies and reports is to provide architects and those interested in the "safeguarding of our architectural heritage" with information that is hoped "will lead eventually to a means of achieving a sustainable long-term preservation" of historic buildings and monuments. Knowledge of the properties of geomaterials and their subsequent interaction with weathering processes allows understanding of the interrelated processes leading to deterioration - deterioration that threatens "the preservation of the current inventory of historically, artistically or culturally valuable buildings and materials."

The 30 papers, stemming from a series of international workshops held in Europe, are prefaced by an editorial introduction and introduce what is generally known about the forces and processes leading to deterioration in built structures. The papers, well illustrated with clear graphs, a few colour illustrations, and above average clarity in the photographs, are grouped under six headings: **Weathering of natural building stones** (3 papers), **Weathering processes** (4 papers), **Fabric dependence of physical properties** (5 papers), **Biodeterioration** (3 papers), **Quality assessment and conservation of stones** (7 papers), and **Environmental conditions** (8 papers).

The three papers under the heading, "Weathering of Natural Building Stones" discuss the effects of frost action, wetting-drying cycles, and the presence of soluble salts in respectively marble (3 types), sandstone (2 types), and limestone (2 types). The second set of four papers under the heading, "Weathering Processes" begins with a review of salt weathering. As a generalist without specialized knowledge in this field, I found the very comprehensive review of various salts, their behavior and effects, an excellent overview. Following this are papers on thermal expansion in 18 commercial marbles, a study on the variation of porosity in calcitic and dolomitic marble as a function of temperature, and microstructural simulations of thermal stresses in marbles. The third group of five papers, "Fabric dependence of physical properties" focuses on rock properties. First is an interesting study of the deposition and diagenesis of two German sandstones (braided river vs point bar – floodplain) and their consequent durability as building stone. Next are a study characterizing the mechanical anisotrophy of gneisses and granites, a study of itacolumites (flexible sandstones/quartzites), an assessment of marble using ultrasonic wave velocity measurements, and an investigation of gypsum-based mortars with suggestions for the development of a water-resistant mortar for restoration use. The three papers of the fourth set headed, "Biodeterioration" present the results of studies on the effect of biofilms on building stones and monuments. A series of seven papers under the heading, "Quality assessment and conservation of stones" includes: studies of monuments in Cairo, Egypt; granitic monuments in northern Portugal; a limestone palace in Spain; ancient sandstone building and monument stone in eastern Saxony, Germany; bowing of marble panels at the University of Goettingen, Germany; and a quality analysis study of the bending strength of eight varieties of untreated and impregnated 4, 7, and 10 mm thick dimension stone tiles. The final section is headed "Environmental conditions". The effects of urban pollution on calcareous facades and glass are well summarized in the first paper. This is followed by a study of sandstone deterioration due to gypsum and halite growths at the seaside. Other papers within this final section deal with deterioration of oolitic limestone in Budapest, Hungary; decay patterns on Venetian monuments; the possible affect of future climate change on building stone; the use of sulfur isotope ratio to determine the sources of sulphate salts

on monuments; an experimental procedure for the determination of cation exchange capacities in sandstones; and for those wanting to understand the effects of atmospheric pollution there is an excellent review article on acid deposition and stone deterioration. Having been inundated with mentions of "acid rain" over the years, finding that dry deposition of gaseous pollutants is the key in stone deterioration came as a surprise to me.

I personally find it unfortunate that, in summarizing their work, some researchers become so involved with process they make statements such as, "This improved understanding of decay dynamics has implications for decisions regarding conservation strategies when the application of inappropriate treatments may inadvertently act as a trigger for the decay sequence." If there is a practical application resulting from the research, let it be spelled out. For conservators and architects some suggestions regarding the "conservation strategies" and the sort of "treatments" thought inappropriate would have been welcomed. In summary, I feel that this volume is the creation of researchers looking to explain observed problems and directed toward an audience of their peers. While many papers stressed the need for an interdisciplinary focus, the papers are not written in a style easy to understand by all members of the target groups mentioned: architects, conservation specialists, art historians, geologists, mineralogists, chemists, physicists, biologists, and construction engineers. The two major review papers should be of interest to those seeking to understand salt weathering and atmospheric pollution as they affect stone and built structures. The text should particularly be of interest to scientifically trained members of the International Council on Monuments and Sites (ICOMOS). Photographic reproduction is excellent and sets a benchmark that I wish all geoscience publications would meet.

Mantle Plumes: Their Identification Through Time

Edited by Richard E. Ernst and Kenneth L. Buchans
Geological Society of America
Special Paper 352, 2001, 593 pages

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[An incomplete version of this review first appeared in the June 2003 issue of Geoscience Canada. We apologize to the author and present the full review below.]

As explained by the editors in their introduction, this volume is an outgrowth of a symposium titled "Locating Old Mantle Plumes" held at the Geological Society of America 1998 Annual Meeting in Toronto, Canada, and sponsored by the Geophysics and International Division of the Geological Society of America and the Geophysics Division of the Geological Association of Canada.

Nineteen papers, most of them presented at the symposium, but also some solicited by the editors, were grouped into six sections with the headings: I) **Overview**, II) **Lessons from Mesozoic and Cenozoic examples**, III) **Lessons from Venus and Mars**, IV) **Techniques to Locate Plumes**, V) **Early Precambrian Plumes**, and VI) **Compilations**. The overview by Ian H. Campbell is to the point and lays out the ground rules. It begins by noting that no single criterion exists that can be used to identify ancient mantle plumes. Plumes are "best identified by bringing as many criteria as possible to bear on the problem", keeping in mind that no physical characteristic, trace element plot, or isotope ratio may be taken in isolation to distinguish plume-related volcanic rocks from other types of mafic magmatism.

Section II consists of four papers dealing with Cenozoic and Mesozoic plume-related examples. Menzies et al. examine Oligocene-Miocene flood basalts of western Yemen, thought to be associated with the Afar plume, with the aim of deriving benchmark criteria for recognizing older, more eroded, plume-related flood basalt provinces. Wilson and Paterson look at the Tertiary-Quaternary volcanic province of western and central Europe, in particular the Massif Central, France, attributing these volcanic fields to diapiric upwelling of small-scale, finger-like, convective instabilities from the base of the upper mantle. Coffin and Eldholm present another edition of their large igneous provinces (LIPs) paper series, contrasting oceanic LIPs with "normal" ocean crust, and speculating that "more ophiolite fragments may be obducted sections of volcanic passive margins and oceanic plateaus than we now propose." Storey et al. review some of the main criteria for locating the original position of mantle plumes in large igneous provinces and apply them to the Middle Jurassic Karoo province in southern Africa, the Ferrar Province in Antarctica, and the Chon Aike province in Patagonia, all of which formed prior to, and are implicated in, the break-up of Gondwanaland. While links to a mantle plume center appear to be fairly clear for the Karoo province, they are far less certain for the other two provinces. All three provinces are thought to be related to a large thermal anomaly (superplume) in which several individual hotspots may have existed.

The four papers of Section III present details of well-preserved plume structures on Venus and Mars, emphasizing implications for identifying and understanding plume-related features on Earth. The topics covered are 'Large flow fields on Venus' (by Magee and Head), 'Contractional effects of mantle plumes on Earth, Mars and Venus' (by Mege and Ernst), 'Uniformitarian plume tectonics on the post-Archean Earth and Mars (by Mege), and 'Concentric dikes on the flanks of Pavonis Mons on Mars' (by Montesi). Especially useful to applications on Earth are the descriptions of 'wrinkle ridges' around domal uplifts on Mars and Venus by Mege and Ernst, which can be directly applied to plumes on Earth that are associated with giant radiating-dike

swarms. Similarly, the attempt to refine a comprehensive multiplanetary plume tectonics model by Mege should be beneficial to all those who study plumes on Earth. Curiously, the latter paper does not contain any references to papers by Kumazawa and others in the 100-Year Anniversary Volume of the Japanese Geological Society (1994), in which plume tectonics and the interaction between plume and plate tectonics are discussed within the framework of a whole-earth-tectonics model.

Five papers in Section IV deal directly with physical and chemical characteristics useful for identifying plumes and locating their centers. The strongest section of the book, it begins with an invited paper by Sengor identifying uplift as the one criterion that may be "uniquely reliable" in recognizing mantle plumes in the geological record. Sengor's discourse is highly entertaining, digressing in all directions, and full of semantic asides. Yet it is well researched and ultimately makes a very strong point by specifying just what type of uplift may be used and how to recognize it. Sengor's paper is followed by an equally informative discussion by Rainbow and Ernst about the sedimentary record resulting from mantle-plume-related uplift. Ernst and Buchans provide an update of their 1997 classic on the use of mafic dike swarms in identifying and locating mantle plumes. A very perceptive discussion by Bell on the question of distinguishing plume-related and non-plume-related carbonatites should be mandatory reading for all those attempting to relate all rocks of kimberlitic affinity to mantle-plume activity. Section IV ends with a wide-ranging discussion by Schissel and Smail on the relations between deep-mantle plumes and ore deposits that is remarkable for its use of PaleoGIS for paleogeographic reconstructions to test possible spatial associations between mineral deposits, including diamondiferous kimberlites, and plume-driven magmatism.

Section V consists of three papers discussing early Precambrian mantle-plume activity. Abbott and Isley discuss paleomagnetic tests of their model proposing a relationship between oceanic upwelling and mantle-plume activity for the formation of early Precambrian iron formations. Tomlinson and Condie make a case, based on geochemical arguments, that plume-related basalts and komatiites form a major component of Archean greenstone belts. Arndt et al. discuss the geochemistry of basalts and komatiites from the Pilbara Craton, Australia, and conclude that this craton preserves the record of some of the oldest oceanic and continental plateaus.

Section VI contains two global compilations, one of rifts of the world (by Sengor and Natal'in), the other of large magmatic events through time (by Ernst and Buchans). In both, an attempt is made to identify, using presently available data and well-defined criteria, those rifts and magmatic events that are most likely related to plumes. Such lengthy compilations are not normally published in journals, but they, and the references therein, are highly useful in the context of the present volume.

The editors of the volume are to be congratulated. The papers cover a wide range of topics pertinent to the aims of the volume, and all papers are informative and of high quality. The arrangement of chapters and the many cross-references to papers within the volume show that the editors have done their best to achieve coherency. Although it is a stated aim of the volume to identify plumes through time back into the Precambrian, a gap in understanding appears to persist between the Mesozoic to Cenozoic LIP community and those interested in applying plume models to Archean rocks. Thus the authors of Section II, chapter 4 propose that LIPs may be progenitors of some ophiolites with a brief reference to the effect that Archean greenstone belts may or may not represent the transfer of oceanic plateaus onto continental crust. Yet no reference is found to Section V, chapter 16, where this subject represents the main topic of discussion. The distinction between oceanic plateau (LIP) and mid-ocean-ridge basalts in Archean greenstone successions has been a topic of major debate, and both have long been considered as possible progenitors for the ophiolite-like fragments present in many greenstone belts.

It is the editors hope that this volume will stimulate research aimed at identifying and locating mantle plumes, especially in the pre-Mesozoic record. This reviewer agrees and thinks that the volume provides an excellent base from which to proceed. Plume or hotspot models should not be applied arbitrarily, as has been done all too often, especially in the mineral deposits literature. This volume should go a long way in putting such models on a more rigorous base.

Geology and Health: Closing the Gap

Edited by H. Catherine W. Skinner and Antony R. Berger
Oxford University Press,
2001 Evans Road, Cary NC 27513
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9 halftones and 41 line illus; 8.5 x 11;
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"Geology and Health: Closing the Gap" is a collection of 26 cross-disciplinary research papers, review articles, and essays that span the fields of geology, human and veterinary medicine, and dentistry. The book describes a remarkable range of human health problems around the world that are linked to geological and other environmental influences, set against the socio-economic backdrop of the different regions. Topics are grouped into threesections: physical and chemical geological hazards, anthropogenic impacts, and methods for identifying hazards. Introductory essays by the editors place these topics into the context of Medical Geology, a new and expanding field of research

succinctly defined by Berger as "public health impacts of geological materials and processes."

This book is a fascinating read. It leaps across scales of geochemical mapping that many of us have never imagined, from the visionary Global Geochemical Baseline Program (Plant and colleagues), to variations in the geochemical composition of the human skeleton (Skinner), the chemical stability of mineral deposits in human blood vessels (Pawlikowski), all the way down to elemental mapping of human cells using nuclear microscopy (Lindvall and colleagues).

The relevance of geological approaches to population health studies is described in an almost overwhelming number of examples from North America, the United Kingdom, Scandinavia, eastern Europe, East and South Africa, and Asia. Geochemical mapping techniques are used to delineate zones of overabundant hazardous elements such as arsenic, or zones of depletion of essential elements such as iodine. Arsenic receives a lot of attention in this book, and with good reason: there is no better example of the immediate benefit to be derived from an integration of geological and medical sciences. A case in point is the tragedy in Bangladesh and West Bengal where tens of thousands of people are clinically ill due to geogenic arsenic contamination of rural dug wells. The contribution by Naidu and Nadebaum tracks the speciation and transformations of geogenic arsenic as the element moves from parent material to soil to drinking water, discusses different (and sometimes conflicting) explanations for mechanisms of arsenic release, and includes a summary table of available drinking water treatment technologies (from 1978 to 2001).

Iodine also receives well-deserved attention as an element that is essential to human health, yet poorly understood due to the complexity of its biogeochemical cycling. Interestingly, two papers provide contrasting views on the significance of marine sources of iodine. Steinnes concludes that atmospheric transport of marine iodine is a significant source of iodine in the environment, based on Scandinavian soil surveys that show increasing iodine concentrations with proximity to the sea. In contrast, Fordyce and colleagues point out that, in the last 50 years, an estimated 10 million people in Sri Lanka have been diagnosed with goiter caused by iodine deficiency in their diet, despite the fact that no part of the island is more than 110 km from the sea.

This book reveals some of the obstacles – including disciplinary boundaries and organizational barriers – that are preventing the integrated, cross-disciplinary research effort that is needed to address existing or potential geological threats to human health. Some threats are immediate and obvious, such as arsenic contamination of groundwater. Another example, less publicized, is the relationship between natural windblown dust and lung disease in northwest China and the Ladakh region of northwest India, described by Derbyshire. During dust storms, villagers are exposed to outdoor and indoor dust concentrations of 4.2 mg/m^3 and 20 mg/m^3, respectively (total suspended particulates; containing up to 61% free silica). The number of people exposed to these conditions in the semi-arid region of northwest China is a staggering 24 million. Here the incidence of lung disease (silicosis) is comparable to uncontrolled industrial settings, yet Derbyshire indicates that there are few statistics and even fewer measures to reduce exposures. The contribution by Grattan and colleagues signals the inevitable impact of future volcanic eruptions on population health, as cities worldwide continue to expand toward volcanic centers. The authors present compelling evidence that atmospheric transport of volcanic gases from the 1783 Laki fissure eruption in Iceland led to a severe continent-scale air pollution event. This is a fascinating account of increased death rates in villages across England, France and the Netherlands in the summer of 1783, and co-incident observations of noxious sulphur fumes that caused difficulties in breathing, and high incidence of respiratory disease, which appear to be attributable to the Icelandic eruption.

In addition to natural hazard identification, geological approaches are being adapted for the purpose of identifying health risks arising from anthropogenic impacts. In an overview of the redistribution of lead (Pb) from mines to urban environments in the USA, Mielke describes childhood exposures to Pb in the city of New Orleans, and makes the case for urban geochemical mapping efforts. An introduction to the field of endocrine-disrupting chemicals by Plant and Davis indicates that geochemical mapping approaches also have much to contribute to understanding the environmental distribution of synthetic organic chemicals.

A couple of papers present preliminary results of clinical trace element research, such as treatments to alleviate symptoms of arsenic poisoning, or causes for trace element disorders such as "metal syndrome." Including examples of clinical research in a book on Medical Geology is a good method for stimulating cross-disciplinary collaborations. Research of this kind is commonly encountered in conference proceedings and publications of the "International Society for Trace Element Research in Humans" (ISTERH), but all too rarely in geological circles. However, it is not clear from the reference list or from the editorial commentary that the preliminary findings had been (or would be) accepted in peer-reviewed medical journals, making it somewhat difficult for geologists and geochemists to evaluate the merits of the work or to place the conclusions into context. These are the exceptions - in the majority of the articles, the authors are careful to distinguish which of their ideas are well-substantiated in the peer-reviewed literature, which need further testing, and which are novel hypotheses that ought to be tested.

Numerous examples of possible causal relationships between geological factors and human disease are cited throughout the book, pointing out intriguing research opportunities. An example is the possible link between kidney disease and lignite-derived organic compounds in drinking water in the Balkan countries (Tatu and colleagues). Similar hypotheses suitable for testing through cross-disciplinary

collaborative research will spark the interest of geologists from a wide range of subdisciplines. Altogether, "Geology and Health" is an inspiration and encouragement for earth scientists and medical researchers to work together toward understanding and ameliorating natural hazards to health in the geological environment.

Key issues in Earth Sciences: Vol. 1 – Mapping in Engineering Geology

by James S. Griffiths (compiler)
The Geological Society Publishing House
Unit 7 Brassmill Enterprise Centre
Brassmill Lane
Bath, Somerset
BA1 3JN UK
2002, 294 p., paperback $46.00 U.S.

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Some 200 years ago, William Smith was developing the technique of geological mapping and demonstrating its predictive and practical problem-solving power. In the first half of the 20th century, planners for tunnels, dams and other major engineering projects made use of existing geological maps and geological expertise, particularly in western Europe and Britain, where detailed geological mapping was underway. Mapping specifically aimed at the needs of the geotechnical engineer came into use in the 1960s and 1970s.

"Mapping in Engineering Geology" is a compilation of 13 classic papers on mapping for civil engineering and environmental purposes originally published in the Quarterly Journal of Engineering Geology and in the Geological Society Engineering Geology Special Publications. The volume also has a five-page introduction and a very useful five-page index at the end. The references are with each paper.

The stated purpose of the volume, given by Griffiths in his introduction, is to ensure that a new generation of engineers and engineering geologists do not lose sight of the heritage of mapping methods and approaches of the 1970s and 1980s that have proven so cost effective yet are now underused and at risk of being forgotten. Experience had shown in Britain that the cost per day of mapping a site is equivalent to only a few metres of cored borehole and that the usefulness and interpretation of that borehole is greatly enhanced if its place is established in a geological model based on mapping.

The 13 papers are placed in the order of their publication dates from 1972 to 1998 and they fall naturally into three periods of development. The first six papers represent the 1970s period of development of basic methods and include classic case studies.

The first is the report by the Working Party on the preparation of maps and plans in terms of engineering geology (Anon, 1972). In this report recommendations are made on mapping scales and practices, on description and classification of rocks and soils, and on symbols and legends.

This is followed by a review by Dearman and Fookes (1974) of engineering geological mapping in the UK, a paper by Brunsden et al. 1975 on large-scale geomorphological mapping for highway design and by Doornkamp et al. 1979 on rapid geomorphological assessment for engineering projects in arid regions of the Middle East. These first four papers constitute an excellent introduction to engineering geological mapping practice. The two remaining papers in this first section; Dearman et al. (1977) "Engineering Geological mapping of the Tyne and Wear Conurbation, North-East England" and Hawkins and Privett (1979), "Engineering geomorphological mapping as a technique to elucidate areas of superficial structures; with examples from the Bath area of the south Cotswolds" provide additional mapping ideas and well-illustrated examples. This first section takes up more than half the volume.

The second section, on the 1980s is 50 pages long and consists of four papers that concentrate on surface or "terrain" evaluation and environmental mapping. Dearman and Coffrey (1981) describe the preparation of an engineering zoning map in the region of Permian limestones in northeast England. Finlayson (1984) describes the application of the Australian Pattern-Unit Component Evolution (PUCE) system specifically for engineering planning and preliminary site evaluation. Dearman (1987) describes land evaluation and site assessment methods in mapping for planning purposes and Foster et al. 1987 discuss the preparation of environmental geology maps of Bath and the surrounding area for engineers and planners. This is a collection of concise, well-illustrated papers that present interesting ideas about mapping for planning purposes.

The last and briefest (35 pages) section consists of three papers included to illustrate "special purposes" maps of the 1990s; all three deal with hazard mapping. Hearn (1995) describes landslide and erosion hazard mapping at Ok Tedi open pit copper mine in Papua New Guinea to guide monitoring, detailed site investigation and remediation. Smith and Rosenbaum (1998) describe graphical methods for mapping and evaluating ground subsidence and collapse hazards above old chalk mines and Cross (1998) describes what he calls a Matrix Assessment Approach to map out landslide susceptibility domains in an area of Derbyshire.

There are few modern books on geological mapping and even fewer that discuss engineering geological mapping in any detail. "Mapping in Engineering Geology" will, therefore, at least partly fill the need for a modern text and should be on the reading list for advanced mapping courses, engineering geology and environmental geology courses. It should also be of great interest to surficial geologists and geomorphologists. This volume contains interesting ideas for all geological mappers.

The papers are well chosen to provide a real insight into mapping for engineering, environmental and planning purposes. My criticism is not of the papers included but of the

omission of some that Griffiths quotes as key papers in his introduction but then decided not to include. At a price of $46.00 U.S. ($37.00 for GSL and AAPG members) this is an excellent and highly recommended buy.

Key Issues in Earth Sciences, Volume 2: Extensional Tectonics - Regional-scale Processes (Part 1) Extensional Tectonics - Faulting and Related Processes (Part 2)

R.E. Holdsworth and J.P. Turner (compilers)
The Geological Society (London), 2002
Part 1, paperback, 352 pages, $46 US ($37 US GSL or AAPG member)
Part 2, paperback, 328 pages, $46 US ($37 US GSL or AAPG member)

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This two-part publication presents 34 papers (not 35, as stated on the back of each volume) on extensional tectonics, compiled from the Journal of the Geological Society (London) and various Special Publications of the Geological Society. The intent of the new "Key Issues" format is "to provide a coherent overview of a current issue in geoscience using a mixture of ground-breaking papers and synoptic views that hitherto have been widely scattered among [the Geological Society's] many publications". Each of the two parts of this compilation, which is published in two volumes (this term is used in two senses, since these two volumes comprise "Volume 2" of the "Key Issues" series), is accompanied by an excellent overview and summary by the compilers of each of the included papers. Importantly, they also make reference to numerous papers not reproduced in this compilation, but published both in the Journal and elsewhere.

Original publication dates of these papers span most of two decades, from 1982 to 1999. This period saw rapid growth in collaborations between research institutions, governments, and petroleum exploration companies. This marriage of largely curiosity-driven science and commercially oriented funding has resulted in numerous excellent publications, only a fraction of which are reproduced here. Nevertheless, this compendium of papers provides the user with a solid basis for subsequent exploration of the literature.

Part 1 (volume 1) focuses on the description and physics of regional-scale processes. Papers are grouped under three headings: 1) **Mechanical and thermal consequences of extensional basin formation** (six papers), 2) **Stratigraphic consequences of extensional tectonics** (three papers), and 3) **The uplift and erosion of sedimentary basins and the role of overpressure** (seven papers). Part 2 (volume 2) concentrates on faulting and related processes occurring on a sub-regional to local scale, with papers grouped under four headings: 1) **Geometry and spatial attributes of normal faults** (seven papers), 2) **Active normal faulting and seismicity** (three papers), 3) **Analogue modelling** (three papers), and 4) **Intra-reservoir faulting and fluid flow** (five papers). In all sections in both volumes, papers are reproduced in the order they were published.

Of course, all of these papers are available as Journal articles, so the real question is whether or not such a compilation provides sufficient "value added" to justify the cost. Holdsworth and Turner have taken the time to not only select those papers that have clearly made an impact, but this selection is specifically targeted toward structural geologists involved in petroleum geoscience, in both industry and academia. At a list price of $46.00 US for each volume (paperback), or $37.00 US for GSL or AAPG members, this compilation will certainly be attractive to many professionals and possibly students, and it will make a fine and inexpensive addition to any geoscience library.

The Early Earth: Physical, Chemical, and Biological Development

Edited by C.M.R. Fowler and C.J. Ebinger (Royal Holloway University of London), and C.J. Hawkesworth (University of Bristol)
Geological Society of London, Special Publication No 199, 2002; 360 p., ISBN:1-86239-109-2; 85UKP (~165 CAD)

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This is a volume of seventeen carefully reviewed and edited papers arising from a "Discussion Meeting" held in February, 2000, under sponsorship of the Geological Society and the Royal Astronomical Society. It is not an "easy read". The chapters are authoritative journal style papers by well-known scientists from a variety of countries. Most combine a comprehensive review with recent research results. The articles are printed in two-column journal format on 7" x 10" book format in very small type. High quality typesetting and illustrations (some in colour) combined with use of good paper offset the difficulty some readers might have with this.

As indicated in the volume title, the science discussed by the papers is diverse. Six deal with the nature of the upper mantle root under old cratons. Three deal primarily with atmospheric evolution, and two with the origin and evolution of life. The geographical focus of most of the solid earth papers is southern Africa although evidence from all continents is discussed.

It would take the rest of the review space to list the contents and authors more thoroughly, but this information is available at the publisher's website - http://bookshop.geolsoc.org.uk (search "early earth, and look under "more information".)

Unfortunately, the high price of the volume means that individuals are unlikely to order it just for personal reading. Nevertheless, I believe many Canadian earth scientists could find it very rewarding to spend some time with it. Especially as the two decades of Project Lithoprobe come to an end and Canadian Earth scientists must summarize what has been learned, the Early Earth should be a germane subject. In my view, we are beginning a decade where a lot of the fog about the Earth's beginnings will lift, although likely only after a period of turbulent argument.

Reading the papers of this volume is like getting deeply into the middle of a fascinating mystery novel to a point where much evidence has been unveiled, but where the denouement in which all is revealed has not been reached. The volume's virtue does not lie in providing final answers. Instead, it is in providing a compact update of important evidence and in revealing the diversity of the perspectives from which the subject can be approached.

Some of the authors are solid Earth scientists who are trying to fit their diverse observations with their Plate Tectonic understanding of how the Earth currently works, or to establish differences between modern and ancient regimes. A few approach the subject as planetologists, trying to fit the Earth in with the considerable new evidence about the formation and operation of the whole solar system. Others are system modellers who seem confident they have built the relevant set of equations, and that they then need only find the right parameter values in order to predict actual earth behaviour. Some papers are more concerned with the Earth's atmosphere and hydrosphere and why it is so different from that of the other terrestrial planets, and what role the evolution of life played in this.

A bit different in style from the rest is a 34 page paper by Ewan Nisbet on "The influence of life on the face of the Earth; garnets and moving continents" It was the 2000 invited Fermor lecture of the Geological Society, and it appears to have been addressed to a somewhat more general scientific audience. Active researchers in the field might perhaps consider it a bit of an oversimplification. But, being a physicist with negligible background in biology, I found it helped me understand the five environmental papers better, and to appreciate how important the findings of this field are to the overall subject.

What is scientifically significant and novel in these papers? I am sure every reader would give a different answer. The paper by D. G. Pearson et al., "The development of lithospheric keels beneath the earliest continents: time constraints using PGE and Re-Os systematics" was perhaps a key summary of the new results about the buoyant substrates of old continents. Although this evidence upsets a strict uniformitarian view of the earth, almost all participants tried hard to fit it into some version of the Plate Tectonic paradigm. Some, especially those taking a comparative planetological approach, felt less need to have the early Earth operate as it does now.

Personally, I found the papers dealing with atmospheric evolution eye-opening. They clearly demonstrate how paradoxical is the geological evidence of no large secular variation in the mean earth surface temperature since at least -3.5 Ga with the astronomical evidence for a gradual brightening of the sun of many percent. Nisbet's explanation is the evolution of life. Following the migration of bacterial life from deep hot springs to a shallow water and wetland surface environment on a temperate planet with a relatively large greenhouse effect, life continued its evolution there. By producing very large changes in atmospheric chemistry, it has brought down the greenhouse effect and maintained the planet's temperature. In another paper, by Grassineau et al. this interpretation is tied to Archean geological evidence (mainly light stable isotope studies) from the Belingwe greenstone belt in Zimbabwe.

My own favourite papers were two from France. B. Marty and N. Dauphas discussed, from a modern planetological and geochemical viewpoint, alternative views of how Earth likely got its hydrosphere and initial atmosphere through various accretionary processes that lingered on until about -4.2 Ga. I found it very enlightening. Also, I especially enjoyed a discussion paper by Nick Arndt, Eric Lewin and Francis Albarede; "Strange partners: formation and survival of continental crust and lithospheric mantle" because it tried to deal, from first principles, with the real difficulties of explaining how the buoyant, magnesian, upper mantle roots of the old cratons could have been formed. While it may be clear that this magnesian material is somehow a residuum of a higher degree of partial melting in the early, hotter mantle, it is not easy to see exactly how the separation process could have worked to produce what is now found. I liked this paper because it considered multiple hypotheses and seriously criticized each alternative vis-à-vis relevant basic processes.

Canadian readers may wonder about Canadian participation in the conference. There were two papers largely from Canada: W. Bleeker's "Archean tectonics: a review, with illustrations from the Slave craton", and Kendall et al.'s paper on deep seismic structure of the western Superior province. Older readers will remember when Nick Arndt, Ewan Nisbet and Mary Fowler were working in the Canadian earth science community.