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Book Reviews / Critique

REVIEWS

Climate Change 2001: Impacts, Adaptation and Vulnerability

Edited by J.J.McCarthy, O.F.Canziani, N.A. Leary, D.J. Dokken and K.S. White
Cambridge University Press
40 West 20 Street
New York, NY 10011-4211 USA
2001, 1032 p. US$130.00 hardcover
ISBN 0-521-80768-9
US$49.95 paperback
ISBN 0-521-01500-6

Reviewed by Antony R. Berger
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This massive volume is the contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Together, this and its three companion volumes (science of climate change, mitigation, and synthesis) constitute perhaps the most comprehensive and authoritative global review of climate change science and its societal and environmental implications. Unlike most UN reports, it is not an anonymous work, for its 143 lead authors, 243 contributing authors, 440 reviewers, and 33 review editors are named, the total including 39 from Canada. The book is laid out in a hierarchical manner, with its base a series of detailed reviews of key topics, including methods and tools, climate scenarios, water, ecosystems, coastal and marine zones, settlements, human health, small island states, Africa, Asia, and so on. The major findings of these 19 chapters are brought together in a lengthy (56 pages) Technical Summary, which is further boiled down to a short (18 pages) Summary for Policymakers.

Despite the earlier claim that climate change is caused directly or indirectly by human action, natural variability is now firmly incorporated in IPCC thinking. This clears up a misconception that has bothered many who know the Earth archive, with its abundant evidence of long- and short-term climatic fluctuations. Recognizing the interacting contributions of humans and (non-human) nature does not make climate change issues easier to deal with, but ignoring natural inputs can lead to woefully inadequate models and forecasts.

Some of the conclusions of the report seem rather obvious: developing countries have less capacity to adapt to climate change; urban heat deaths are most likely among the elderly, the very young, the sick, and the poor; and tens of millions of people are at risk from flooding due to increased precipitation and sea level rise. The report contains much invaluable information on the biological, hydrological, and atmospheric changes to be expected as climate varies. Oddly enough, the section on physical indicators of climate change deals only with the cryosphere (and even here omits mention of ice and snow phenology). Indeed, the report says little about such important abiotic parameters as ground temperature regimes, dune formation and transport, dust storms, karstification, lake and groundwater levels, and other well-known geoindicators (see www.lgt.lt/geoin).

The chapter on North America brings together a vast array of data and data sets, and there is much on the kind of landscape and ecosystem changes already being seen in Canada's far north. Human systems and their interaction with abiotic and biotic forces are immensely complex, and a particularly valuable component of this report is its assessment of many social and economic issues, including societal vulnerability to climate change, food security, energy, and financial services such as private and public insurance.

The IPCC assessment presents a clear and coherent scientific world-view of climate change and its potentially disruptive effects on people everywhere. Despite this powerful account, most governments still do not "get it." The Canadian Government argues about whether or not to accept the Kyoto Accord, while our northern people are already feeling the pinch. Our geological agencies struggle with budgets determined by economic thinking that ignores biophysical realities. Some national and international efforts to foster climate change research are thriving, chief among them the International Geosphere-Biosphere Programme. Others, including Canada's Climate Change Impact and Adaptation Research Network, which should be actively developing ways to respond to the coming changes, appear to be doing little. If this inaction reflects a lack of public support, what does it say about the capability of science — and especially geoscience — to dispel public apathy on issues that sooner or later will affect us all?

Climate change may be the biggest challenge facing people and the biosphere, although it is not the only one, as constrictions in natural resources, and human impacts on climate, air, land, and water combine to form a barrier to our survival as a species. The dimensions and challenges of the approaching "bottleneck"(in E.O. Wilson terms) through which society must pass if we are to survive are fairly clear. The work of the IPCC is probably the most comprehensive, interdisciplinary and societally important research effort ever undertaken. And the paperback version no more than the price of a good dinner out!

Drift Exploration in Glaciated Terrain

Edited by M.B. McClenaghan, P.T. Bobrowsky, G.E.M. Hall and S.J. Cook
Geological Society, London
Special Publication 185
2001, 350 p.
£70, US$103 hardcover
(discount available to GS, GSA, AAPG, SEPM members)

Reviewed by B.E. Broster
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As the title implies, this volume is intended for exploration companies and prospectors working in glaciated terrain. The book presents a collection of 15 papers nicely grouped into topical sections. The introductory paper by R. Klassen covers the principles of glaciation and dispersal and provides a review of many of the current theories relating to the development of dispersal trains. The sections immediately following provide an excellent review of sampling techniques in the Canadian Shield (I. McMartin and M. McClenaghan), a discussion of geochemical anomaly evaluation in the Canadian Cordillera (V. Levson), and papers on the evaluation of heavy minerals separates for specific mineralized targets (S. Averill) and diamond exploration (M. McClenaghan and B. Kjarsgaard). The latter paper contains two valuable contributions that I should mention here: 1) a list of published provincial and federal government indicator mineral surveys and case studies around known kimberlites in Canada, and 2) a discussion of pathfinder elements related to the indicator-mineral assemblages within specific kimberlite facies (hypabyssal, diatreme, and volcaniclastic), or indicative of other ultramafic lithologies that can also be diamond bearing.

The next two topics summarize the use of lake sediment geochemistry (S. Cook and J. McConnell) and biogeochemistry (C. Dunn), which although not specifically "drift" are often viewed as "glacial" albeit first to fourth derivatives (*cf.*, Shilts, 1976) and which, when undertaken, can provide important considerations for the broader exploration of glaciated terrains. Dunn's paper on biogeochemistry contains an enlightening discussion on selective elemental concentration due to variation in species and tissue samples. It points out some strengths and weaknesses with biogeochemical surveys, and complements the following paper by J. Harris, L. Wilkinson and M. Bernier on GIS and statistical data analysis for humus, soil, and till geochemical data. Both papers should be read as a matter of course by prospectors concerned with biogeochemical interaction with soil and till, and the interpretation of these data.

The remaining papers deal with case studies of geochemical exploration in distinctive physiographic regions across Canada, representing the three main styles of glaciation: shield, alpine, and subalpine. M. McClenaghan provides an overview of gold exploration in the Abitibi Greenstone Belt, with specific attention to gold grain and geochemical dispersal patterns, and an effective comparison of these data across nine known occurrences of mineralization. An example of drift prospecting for uranium in northern Saskatchewan is given in the a paper by S. Earl, who presents the clast lithology and lithogeochemical data for a prodigious 20,000 composite boulder samples that had been archived in government assessment files from collections across the eastern part of the Athabaska Basin. The major element data from composite boulder sample sites are then used to estimate clay mineral proportions and distribution at a 500 m x 500 m grid across an area of about 15,000 km^2.

Two papers deal with drift exploration in Atlantic Canada. R. Stea and P. Fink illustrate the difficulties with modelling glaciation and applying mathematical solutions to dispersal analysis of hybrid tills and palimpsest dispersal patterns; a function of the complex terrain and succession of small ice caps that were indigenous to the genesis of till in the Maritimes. M. Batterson and D. Liverman discuss contrasts between the glaciation by small ice caps, for the Island of Newfoundland, with the glaciation of Labrador, as dominated by the effects of the Laurentide Ice Sheet. Both papers include discussions on mathematical assessments of glacially dispersed component concentrations and their relationship to distance of glacial travel.

The last three papers discuss geochemical exploration in the Cordillera, and complement the earlier paper by Levson. A. Plouffe discusses his studies on mercury and gold partitioning in till of central British Columbia. This is followed by R. Lett's presentation of geochemical signatures collected around known massive sulphide deposits in southern British Columbia, and R. Paulen's investigations of secondary hydromorphic metal mobilization at seven sites of differing mineralization and physiographic terrain. While the study area for this last paper was the southern interior of British Columbia, the conclusion that one must consider the effects of secondary mobility on the spatial patterns of dispersal for mobile elements, is applicable to any terrain, and more so where the geomorphology favours either the ponding of surface water or down-slope movement of near-surface soil-water. Paulen's paper should be viewed as a companion discussion with the earlier paper by Harris *et al.* that includes information on the effects of geochemical scavenging on spatial dispersal patterns and its recognition using ratios of Cu with Fe, Mn, or LOI.

Overall, the book represents a further contribution to the growing collection of material on drift prospecting. Papers are surprisingly sparse in the noticeable errors that are customary with paper-collections, which indicates that they were subjected to a reasonably competent review and editorial process. Commonly, such collected works vary widely in writing style but this work holds together well, as the major theme is maintained throughout. The strength of the volume is that the papers are well grounded in data, unlike other publications that rely more on modelling and theory than on actual observations. The data mainly represent a cross section of work undertaken for or by members of the Geological Survey of Canada and three provincial geological surveys, none of whom are encumbered by proprietary

rights, as is much of the exploration data collected by private companies. As a result, many of the individual studies in the volume represent large collections of data and ideas that will serve as a valuable resource for future exploration activities in glaciated terrains.

This volume has the look and feel of a high-quality publication. The papers are well written and nicely illustrated with appropriate visuals and the sporadic use of colour.

The collection is representative of the current level of study in the field across Canada but is particularly valuable for the accumulation of referenced data sources. Many of the papers contain references to government releases or open file reports that will enable explorationists to identify archival information sources on target areas, thus reducing some of the time needed for the usual long and tedious search of background information. The value of this material alone is worth much more than the price of the book.

I would recommend to those interested in comprehensive review of drift prospecting activities that they should also read Kujansuu and Saarnistro (1990), which includes case-study examples from the United States and northern Europe as well as from areas across Canada. Themes are similar between these two books (McClenaghan *et al.*, 2001; Kujansuu and Saarnistro, 1990) and together they are supplementary to the acquisition of a fundamental introduction to the science of drift prospecting. For an excellent collection of papers focussed on drift prospecting in the alpine terrain of the Canadian Cordillera, see the volume by Bobrowsky *et al.* (1995).

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Kujansuu, R. and Saarnistro, M., 1990, editors, Glacial Indicator Tracing: A.A. Balkema Publishers, Rotterdam, Netherlands, 252 p.

Shilts, W.W., 1976, Glacial Till and mineral exploration *in*, Legett, R.F., editor, Glacial Till: Royal Society of Canada, Special Publication 12, p. 205-233.

Mantle Plumes and Their Record in Earth's History

By Kent C. Condie
Cambridge University Press
40 West 20 Street
New York, NY 10011-4211 USA
2001, US$110.00 hardcover
ISBN 0-521-80604-6
US$39.95 paperback
ISBN 0-521-01472-7

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Mantle Plumes and Their Record in Earth's History by Kent Condie joins the ranks of recent valuable reviews of mantle plumes (see reference list below). However until Condie's book there was none suitable as a graduate-level textbook. Condie's book is an admirable and up-to-date summary of virtually all aspects of this rapidly evolving field. His book covers hotspots and mantle upwellings, large igneous provinces, kimberlites, magmatism on Venus and Mars, models and mechanisms of plume generation and ascent, geochemical characteristics, plumes and continental growth, Archean greenstone belts, superplume events, and links with Earth System evolution.

The large igneous province (LIP) sections are comprehensive, and include not only the young continental flood basalts, but also oceanic plateaus, layered intrusions, giant dyke swarms (particularly important in the Proterozoic), and the Archean greenstone belts that can be interpreted in a plume context. Particularly impressive is his assessment of the evidence that komatiite-bearing greenstone belts have a plume origin. Arguably the best sections of the book relate to the geochemistry of plumes where the reader is treated to a comprehensive and orderly treatment of the isotopic, major and trace element characteristics of LIPs and inferences regarding the nature and distribution of mantle source areas.

However, there are a few problems in an otherwise admirable book: Condie has adopted a definition of superplume to refer to all plumes originating from the deep mantle. This is unfortunate because most LIP events probably originate in the deep mantle and each would reflect a superplume according to Condie's terminology. Recent compilations suggest that LIPs occur at an average rate of about one plume every 20 million years, and there is nothing "super" about an geological event happening with such frequency.

In the final two chapters on Superplume Events and Mantle Plumes and Earth Systems, Condie attempts to fit a diverse set of extreme phenomena into a "superplume event" and "supercontinent" context. These phenomena are episodes of major mafic magmatism, supercontinent breakup, rises in sea level, periods of increased juvenile crust production, major anoxia events, excursions in seawater composition preserved in marine carbonates, and magnetic superchrons. Unfortunately each "superplume event" (at 120, 280, 480, 1900, and 2700 Ma) is identified using different criteria, and one is left wondering whether a single label is appropriate for such an apparent range of phenomena. In fairness I should say that the subject is extremely complicated and that Condie has bravely attempted to integrate a wealth of recent literature on this fast-evolving field.

The text is exceptionally clear and the figures are well done. While the referencing is abundant and up-to-date, there are also some errors in the reference list (and some cited references are missing); these should be corrected in subsequent editions.

The publisher is to be commended for releasing a paperback edition that is very affordable. Condie's book is the obvious choice for the textbook in a graduate course on mantle plumes, and would be equally useful for the general scientist.

As discussed above, there are additional key volumes on mantle plumes such as:

- special issue of Journal of the Geological Society of Japan (1994, v. 100)
- Mafic Magmatism Through Time (edited by Ludden, Arndt and Francis, 1996, Special Issue of Lithos, v. 37)
- Large Igneous Provinces: Continental, Oceanic, and Planetary Flood Volcanism (edited by Mahoney and Coffin, 1997, AGU Geophysical Monograph 100)
- The Earth's Mantle: Composition,

Structure and Evolution (edited by Jackson, 1998, Cambridge University Press);
- Dynamic Earth: Plates, Plumes and Mantle Convection (by Davies, 1999, Cambridge University Press);
- Oceanic Plateaus and Hotspot Islands (edited by Condie and Abbott, 1999, special issue of Lithos, v. 46)
- Mantle Plumes and Ore Deposits (by Pirajno, 2000, Kluwer Academic Publishers);
- Mantle Plumes: Their Identification Through Time (edited by Ernst and Buchan, 2001, Geological Society of America, Special Paper 352)
- Mantle Convection in the Earth and Planets (by Schubert, Turcotte and Olson, 2001, Cambridge University Press).

Tsunami: The Underrated Hazard

By Edward Bryant
Cambridge University Press
Cambridge, UK and New York, USA
2001, 350 p., US$74.95 hardcover
ISBN 0-521-77244-3
US$27.95 paperback
ISBN 0-521-77799-X

Reviewed by Ian Hutchison
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The publication of Ted Bryant's book follows hot-on -the-heels of several Hollywood blockbusters ("Deep Impact", Armageddon") and several made-for-TV videos and news flashes that aimed at raising public awareness of the hazards of "killer" waves. Their focus was the potential threat represented by the unstable flanks of oceanic volcanoes (particularly Kilauea and Las Palmas), the fracturing of the United States eastern continental margin, or an asteroid in near-earth orbit. The resultant submarine landslides or oceanic impacts generated gigantic tsunami waves travelling at jet-plane speed across the world's oceans. The culmination of several of these productions was a graphic simulation of towering tsunami waves that completely inundated coastal cities such as Los Angeles or New York, stopping only when they reached the base of the San Bernadino Mountains or the Appalachians. Movie producers are an easy target when it comes to accusations of hyperbole, but the truth is that we know very little about the incidence of such mega-tsunami, or their potential impacts. Bryant's book attempts to fill this vacancy.

The entry to the book is guarded by a dedication that must give pause to any reviewer: "To the Memory of J Harlen Bretz." The Introduction continues this implicit challenge to conventional wisdom. Rather than recounting anecdotes of the sufferings of the inhabitants of Lisbon after the tsunami of 1755, or of Hilo following the 1960 Chile and 1964 Alaska earthquakes, Bryant illustrates the effects of tsunami by recounting ancient native oral traditions from Australia and Washington State, and the more recent experiences of the residents of Sissano lagoon in Papua New Guinea and the shores of the islands adjacent to Krakatua. His purpose is to illustrate the variety of mechanisms that generate tsunamis, and to stress that non-seismic causes, while accounting for less than 20% of cases and fatalities in the historic period, may still pose a substantial risk on seismically passive coastal margins.

Chapter 2 outlines the basics of tsunami wave theory. For the layman or the mathematically timid geoscientist this may well be the best introduction to the topic in the literature; arcane topics such as edge wave development and resonance effects are succinctly explained and illustrated by real-world examples.

It is in Chapters 3 and 4, however, that the reason for Bryant's dedication to Bretz becomes clear. These sections of the book summarize the last decade of Bryant's field research on coastal landforms, primarily in southeastern Australia. It is his belief that many of the depositional and erosional landforms on this coastline are the result of recurrent mega-tsunamis, rather than the normative processes of coastal evolution. The widespread nature of this evidence, particularly in areas that are commonly regarded as free of tsunami risk, is the basis for Bryant's contention that mega-tsunamis are an underrated hazard.

What's the evidence for this contention? Bryant begins by tabulating the suites of landforms that he and others have recognized as marking tsunami activity. These include such commonly cited features as anomalous, landward-thinning and fining sand sheets in coastal marshes and lakes. Examples of these are known from virtually every convergent plate margin. Admixed marine microfossils confirm the offshore origin of these deposits, and evidence of coeval coastal deformation supports the inference that these deposits are the products of coseismic tsunamis. Bryant, however, argues for a tsunamigenic origin for assemblages of more enigmatic coastal deposits. These have commonly been overlooked, or ascribed to other causes. They include supratidal "dump" and "smear" deposits of chaotically mixed materials (sometimes sculptured into isolated ridges and mounds), megaripple bedforms on coastal headlands, and piles of imbricated boulders in ramps at the base of cliffs or in revetments. Still more contentious is his suggestion that turbidites indicate recurrent tsunami activity. This presumes that turbidites predominantly originate as coherent block slides, only disintegrating during the runout phase.

The various coastal erosional features that Bryant notes as potential tsunami signatures range from small-scale flutes, S-forms, and impact marks (bearing a striking similarity to the microforms that have been ascribed to subglacial paleofloods in Canada) to large-scale whirlpools on exposed areas of bedrock above coastal headlands.

In the following chapter Bryant examines several cases of tsunami-generated landscapes, with examples from Australia, the Bahamas, and Chile. These all involve juxtaposed assemblages of the deposits and erosional forms outlined in the previous chapter. To get a sense of Bryant's vision of the magnitude of the tsunamis that generated these coastal landscapes in southern Australia, consider his analysis of one example: Flagstaff Point, near Wollongong. Here, a headland 20 m above sea level has been overridden and planed by a paleo-tsunami, leaving piles of imbricated boulders, a landward-thinning smear deposit, and a sand sheet that extends some 500 m inland.

These interpretations are obviously idiosyncratic. I think this is clearly a case where you've got to poke your fingers into the inferred tsunami stigmata before becoming a disciple. Not knowing any of the sites he describes I found myself still fence sitting at the end of this section, largely because the chronologies that are presented for the development of these assemblages are piecemeal, and seem to vary locally. Clearly, tsunami with run-ups to 30 m or 40 m above present sea level in southeastern Australia should leave more than local evidence. The other question that remained at the back of my mind was the apparent lack of a tsunami-generating mechanism in the region.

Bryant addresses the potential causes of tsunamis, both large and small, in the following section. A chapter on earthquake tsunamis, outlining measurement of magnitudes and the impacts of large historic events, covers ground that has been examined in other books on the subject. Bryant's treatment, however, is succinct, thorough, up-to-date, and very nicely illustrated. It is easily the best introduction to the subject for general audiences in the scientific literature. This high standard is maintained in his sections on landslide, volcanic, and tsunamis. With the exception of tsunamis generated in small basins such as Lituya Bay, however, the run-ups associated with even the largest of these events rarely exceed 5 m away from their source areas. They are therefore unlikely to be the source of the enigmatic features that Bryant describes along the southeast Australian coastline. Even major collapses of volcanic edifices appear to be unlikely to generate the monster waves that Bryant requires. For instance, Mader (2001) simulated the "worst-case" collapse of Cumbre Vieja volcano in the Canary Islands, and generated a maximum wave height of 1-3 m on the east coast of the United States.

Bryant introduces one other possible cause of this phenomenon by discussing the probability of cosmogenic tsunamis, those caused by meteor or cometary impacts. After discussing the case that has gripped the public imagination in the last decade (the Chicxulub impact), he then catalogues other impact events, some of which may lie in the realm of geo-fantasy. Two examples of the latter are an inferred impact of seven cometary fragments about 8200 years ago, causing a nuclear winter and widespread tsunamis (the former more likely the last of the late glacial "cold snaps"), and a possible airburst over New Zealand at the beginning of the 15th century. The latter was reconstructed from Maori oral traditions, and coincides with the occurrence of one inferred mega-tsunami in southeastern Australia. Two further possible examples of potential cosmogenic mega-tsunami in northwestern Australia in the protohistoric period are described, based upon the unusual situation of shipwrecks. There is obviously a paradox here, and it is one that Bryant recognizes. The recurrence interval of mega-tsunamis in southeastern Australia based on geomorphic and similar evidence is about 350 years (fig. 8.3). Astronomical data, however, predict recurrence intervals on the order of several million years (p.244).

This book left me with a mixed set of responses. The author is obviously a courageous and visionary geomorphologist, not afraid to tackle complex problems, and his campaign to have mega-tsunamis recognized as a potential coastal hazard in non-seismic areas is one that should receive widespread support. I suspect, however, that this campaign may have blinded him to an alternative explanation for the features that he describes, and one that doesn't require cosmic interventions. Not only was the 20th century in Australia devoid of mega-tsunamis, it was also devoid of Category 5 cyclones. The latter apparently have a recurrence interval of about 200-300 years in northern Australia over the course of the late Holocene (Nott and Hayne, 2001). What happens at Flagstaff Point when one of these monster storms swings southward, and impacts the southeastern Australian coastline?

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Fossils, Phylogeny, and Form: An Analytical Approach

Topics in Geobiology, Volume 19

Edited by Jonathan M. Adrain, Gregory D. Edgecombe and Bruce S. Lieberman
Kluwer Academic/Plenum Publishers
New York, NY USA
2001, 402 p., US$130.00

Reviewed by M. J. Melchin
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The past half-century has witnessed the growth and development of a number of new, increasingly quantitative approaches to the study of fossil and recent organisms. The focus of morphometric methods is on the quantitative analysis of form. Phylogenetic systematics deals with analysis of the patterns of evolutionary branching of taxa through study of the distribution of characters among those taxa. Both of these fields have been the subjects of a wealth of recent papers, many of which are in biological journals. Paleontologists, in general, have not adopted these methodologies as quickly as systematic biologists, and one of the purposes of this book is to bring some of these approaches to the attention of paleontologists, by presenting examples and discussing some of the controversies that surround the methods.

The introductory chapter by the editors outlines the basic themes of this book, which are the study of form in fossil taxa, how form can be used to elucidate phylogenetic relationships and taxa, and how the results of studies of form and phylogeny can be used to address interesting paleobiological questions. The second chapter, by D.A. McLennan and D.R. Brooks, provides the readers with a step-by-step introduction to the logical processes involved in conducting a phylogenetic analysis. It clearly outlines the assumptions involved in the various steps and how the outcome of a phylogenetic analysis leads to a testable hypothesis of phylogenetic relationships. I would especially recommend this chapter to any reader who has

not embraced phylogenetic systematics, particularly through lack of understanding of its methodologies.

In Chapter 3, by N.C. Hughes and R.E. Chapman, a landmark-based morphometric analysis is conducted on a large number of specimens of six species of trilobites from a single Silurian locality in the Czech Republic. This analysis is then used to address several different paleobiological questions. The first set of questions deals with intraspecific variability in form of the taxa, and the degree to which the outcome analysis depends on sample size. The other set of questions relates to ecological *versus* genetic control on variation in form, particularly the question of developmental canalization in trilobite evolutionary history. Both morphometric and phylogenetic data are used, resulting in interesting insights into these problems. Chapter 4 by M.A. Wills deals with morphological disparity. This long and ambitious chapter covers, to varying degrees of depth, a wide range of topics dealing with morphometric approaches to the understanding of the history of range of variation in form. It examines cladistic *versus* phenetic concepts of disparity, the methods of acquisition and analysis of discrete character, landmark-based, and outline-based morphometric data, and the problems of how morphometric data can be used to measure disparity and define morphospace. These are followed by discussions of examples of the applications of studies of disparity to such problems as change through time and constraints of the evolution of form.

Chapters 5 and 6, by M.L. Zelditch, D.L. Swiderski and W.L. Fink, and N. MacLeod, respectively, deal with some of the methods and controversies surrounding the use of the results of morphometric analyses in phylogenetic studies. Whereas both papers strongly support the idea that morphometric methods are important means of discovering characters that may be useful for phylogenetic analyses, their authors disagree about the degree to which results of certain quantitative morphometric variables can directly represent homologous characters in such analyses. Chapter 7 by M.C. Ebach and G.D. Edgecombe introduces some the methods of cladistic biogeogeography. Through paleontological examples, the strengths and weaknesses of various approaches are outlined in this relatively undeveloped field of investigation. Chapter 8 is a critique, by J.M. Adrain and S.R. Westrop, of the various methods that some authors have used to incorporate stratigraphic distribution data into phylogenetic analyses. The authors strongly argue such methods have serious logical and/or methodological flaws in their approaches. In addition, they present a detailed example to show that, even in well-studied fossil groups and regions, stratigraphic data are unlikely to be complete enough to meet their intended purpose in these methods. Chapter 9, by B.S. Lieberman, examines a number of approaches to the analysis of speciation rates in a phylogenetic context. Although a range of methods is introduced, the main focus of the paper is a comparison of stochastic approaches to analysis of within-clade speciation rates.

The final two chapters consider larger-scale issues in paleontology. Chapter 10, by N. Eldredge, discusses genealogical and ecological hierarchies and examines, by reference to phylogenetic and morphometric studies, the relationships between varying scales of ecological disruption and patterns of macroevolution and extinction. Chapter 11, by R.L. Kaesler, J.W. Krebs, and D.L. Miller, discusses the design and role of databases in paleontology, particularly that of PaleoBase, which is being developed to accompany the Treatise of Invertebrate Paleontology.

I found a few of papers in the volume lacking in clarity, particularly in those areas in which I was least familiar with some of the concepts and methods described. However, the book, as a whole, is more than worthwhile reading for anyone interested in pursuing quantitative aspects of the study of fossil faunas, and the lists of references for each chapter provide all of the information needed for further exploration of each topic.

Climate Change 2001: Mitigation

Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change

Edited by Bert Metz, Ogunlade Davidson, Rob Swart and Jiahua Pan
Cambridge University Press
The Pitt Building, Trumpington Street
Cambridge, UK
www.cambridge.org
2001, 752 p.
ISBN 0-521-80769-7, hardcover
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This two-kilogram tome on mitigation of climate change reminds me of my mother's bread pudding: solid, heavy, full of good things, and rather hard to digest. Perhaps this is not too surprising in a volume written by nearly 150 leading and co-ordinating authors, a further 80 contributing authors, and another 18 review editors! The book summarizes no less than 10 meetings of "Expert Meetings and Workshops" held over an 18-month period from 1998 to 2000. The volume consists of 10 chapters that explore various biological and technological options to mitigate climate change.

A number of assumptions are made. That climate change is basically a human-induced problem, and in this context the mitigation strategies build on the first and second reports of the Intergovernmental Panels on Climate Change and several other technical reports. That climate change and necessary mitigation strategies are a "long-term" problem (not in a geological context), but certainly in the term of politicians' life spans and governments' mandates. Projections are usually for several centuries into the future. That decision making will be fraught with risks and uncertainties, some of which may be non-linear and some may be irreversible. That changes have national and international significance and will affect the goals of equity and

sustainable development. Finally, that the various mitigation strategies depend upon better understanding the environmental, economic, political, social and technological changes that are regularly modified by human interference.

So just what is in the book? There is a short, (10 pages) easily readable (it has to be) summary for policy makers. This is followed by a lengthy (52 pages) technical summary that synthesizes the following 10 chapters. These comprise Climate Change and Sustainable Development; Greenhouse Gas Emission Mitigation Scenarios and Implications; Technological and Economic Potential of Greenhouse Gas Emissions Reduction; and Technological and Economic Potential of Options to Enhance, Maintain, and Manage Biological Carbon Reservoirs and Geoengineering. The remaining chapters are Barriers, Opportunities and Market Potential of Technologies and Practices; Policies, Measurements and Instruments; Global, Regional and National Costs and Ancillary Benefits of Mitigation, and, finally, Decision-making Frameworks. All 10 chapters involve 618 pages of text with innumerable graphs and diagrams in full colour that depict the various scenarios described in the body of the text. The remaining pages comprise seven appendices: Authors; Glossary; Acronyms, Abbreviations and Chemical Compounds; Units, Conversion Factors and GDP Deflators; List of Annex Countries; List of Major IPCC Reports; and the Index.

Who should read this book? Firstly, it is not a "readable" text. The book is almost like trying to digest a specialized encyclopedia, but it does contain an incredible amount of factual data aimed toward governments, policy makers (especially those with interests in social and economic decisions), and the scientist who has to interface with these decision makers. This is especially true for those involved in climate change policies and sustainable development. For example, it illustrates the problems, barriers, and mitigation scenarios for those involved in the social implications of implementing the Kyoto protocol. In this respect, earth scientists interested in greenhouse gases and the policies that might be applied for their future reduction certainly should read it. Others might want to refer to it since there are large quantities of interesting information contained within, but extracting it is a difficult matter. This book does serve to illustrate the difficulties of resolving some of the complexities in our natural world that are purely the result of human interaction with various planetary systems.

Health Effects of Chrysotile Asbestos: Contribution of Science to Risk-Management Decisions

Edited by R.P. Nolan, A.M. Langer, M. Ross, F.J. Wicks and R.F. Martin
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Mineralogical Association of Canada
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An international workshop entitled "Health Effects of Chrysotile Asbestos: Contribution of Science to Risk-Management Decisions" was held in Montreal in September 1997, sponsored by the Mineralogical Association of Canada. The purpose of the workshop was to review the biological data available for the various types of asbestos fibre, to compare the health effects of chrysotile asbestos with other types of asbestos, and to calculate the risks associated with current levels of exposure to chrysotile.

The workshop proceedings were published in 2001 as a five-part monograph, with each part containing three to eight peer-reviewed articles, a Discussion, and a Rapporteur's Report. In a single volume, *Health Effects of Chrysotile Asbestos* provides the perspectives of a wide range of experts, including epidemiologists, toxicologists, occupational hygienists, medical researchers, clinicians, mineralogists, economic geologists, environmental chemists, and engineers. The proceedings are framed with an Introduction by Dr. Robert Nolan, a General Discussion facilitated by Drs. Robert Murray and Kevin Browne, and a Summary of the Symposium by Dr. Arthur Langer. The Preamble by Dr. Robert Martin, Editor of *The Canadian Mineralogist*, is followed by an obituary to Dr. Murray, who was a leading expert on the health effects of asbestos and an active participant in the Montreal workshop.

Advancing science beyond traditional barriers requires, as a first step, grasping the foreign terminology of other disciplines. Biologists need help with the language of geology, geoscientists need help with the language of the medical community, and researchers everywhere need help with the language of the regulators. The editors and authors of *Health Effects of Chrysotile Asbestos* deserve a lot of credit for getting this right. The articles are clearly written with concise and interesting explanations of the basic concepts underlying each discipline, using minimal specialized jargon. The short but excellent Glossary of Terms serves as a bridge linking the many health sciences and earth sciences disciplines covered in the proceedings.

A significant glitch in communication arises from the nomenclature of the asbestos minerals. Current regulations are based on the generic term "asbestos." Most dictionaries define "asbestos" simply as a fibrous mineral that doesn't burn, which is what it meant in the original Greek. In the regulatory world, the fibres of six minerals are defined as "asbestos": chrysotile, amosite, crocidolite, actinolite, tremolite, and anthophyllite. These are also the terms used in commerce, although chrysotile is the only asbestos mineral still of commercial importance. Health scientists and clinicians who study asbestos-related diseases define the asbestos minerals in terms of their varying potencies, the most potent being the amphibole minerals (amosite, crocidolite, actinolite, tremolite, and anthophyllite) and the least potent being the serpentine mineral chrysotile.

In 1978 the Commission on New Minerals and Mineral Names (CNMMN) examined these mineral names with the aim of "eliminating redundancies and cleaning up the nomenclature" and determined that the terms crocidolite and amosite were no longer valid. In his Preamble, Dr. Martin explains that the CNMMN does not approve of the use of special names to refer to the habit of a mineral. It was ruled that riebeckite and grunerite (respectively) are the correct names and must be used exclusively. Thus, even before the fibrous minerals crocidolite and amosite were banned from the world market, their commercial names were banned from the pages of *The Canadian Mineralogist.*

The epidemiologists and toxicologists tasked with reviewing a century of complex lung disease and exposure data for this book either missed or ignored the 1978 CNMMN ban, and continued to refer to crocidolite and amosite in their manuscripts. In his Summary of the Symposium, Dr. Langer presents compelling arguments in their defense. After all, these are the names that evoke the key physical property of asbestos minerals: their fibrous habit. It is this property that allows asbestos fibres to be woven into fireproof textiles, to become airborne and remain airborne, and to penetrate deeply into the lungs and stay there until they do serious damage. Crocidolite and amosite are terms with historical meaning and significance: they have an important place in medical literature and regulatory documents spanning a hundred years.

Apparently these arguments do not wash with the CNMMN. Just as the Canada Post cannot accept two names for a street, we are told the CNMMN cannot accept separate names for the fibrous *versus* chunky forms of the same mineral. To accommodate the biologists' preference and still abide by the rules of mineral nomenclature, the editors fashioned a compromise. Throughout the book, the mineral formerly known as crocidolite is termed riebeckite-asbestos ("crocidolite"). The mineral formerly known as amosite is termed grunerite-asbestos ("amosite"). Some readers may find these bulky constructions of hyphenated words, brackets, and quotation marks a bit daunting, like trying to keep track of the characters' names in a 19th century Russian novel. It is well worth the effort: understanding the nomenclature is key to understanding the discussions and debates about the data sources underlying asbestos epidemiology and risk assessments.

In Part 1, Exposure to Amphibole-Asbestos and Mixed Fibers, a collection of six papers provides an overview of the health hazards associated with the inhalation of asbestos minerals, and introduces the methodologies used for exposure assessments, epidemiological studies, and risk assessments. The first paper by Dr. Langer examines the approach used for risk assessments carried out in the United States, which are based primarily on the experience of insulation workers in the New York-New Jersey area in the mid- to late-1900s. These data are considered reliable for risk assessments because the fates of all the workers are known and their exposure histories are known. Excess lung disease in the insulation workers was caused by chronic exposures to high levels of potent amphibole fibres (amosite and crocidolite) or to mixtures of amphibole and chrysotile fibres. Dr. Langer clarifies that these workers do not represent a single population exposed to a single substance. He concludes that the group consists of multiple subpopulations, each having different exposure histories and exposures to different types of fibres, and that the controlling risk factors are type of fibre and intensity of exposure. Existing regulations are based on past experiences with amphibole-asbestos and mixed asbestos fibres and do not differentiate between more and less biologically active asbestos minerals. In short, the asbestos minerals vary widely in their potency, and current regulations were designed to protect against the worst of them. These observations set the stage for much discussion throughout the remainder of the book.

Part 2, Exposure to Commercial Chrysotile – Mineralogy, Modern Products and Exposures, consists of six papers describing the major deposits of chrysotile around the world, production and consumption trends, regulations to control occupational exposures currently in place worldwide, successes and limitations of workplace monitoring techniques, and exposures of the general population. Of particular interest is the paper by Dr. Anthony Williams-Jones and colleagues from McGill University, which examines the distribution of tremolite in the vicinity of chrysotile ore of the Jeffrey mine in Asbestos, Quebec. Studies of chrysotile mine and mill workers in Quebec have determined that the amphibole mineral tremolite is the principal fibre in their lung tissues, rather than chrysotile as might be expected. The chrysotile ores in the Jeffrey mine are essentially amphibole free. However, if mining staff are unaware of the distribution of the tremolite-bearing zones, there is a high probability that tremolite-bearing rock will be included in the ore and find its way to the mill, leading to exposures of people in the mill environment. To ensure that the chrysotile ores are produced with minimal tremolite contamination, the authors recommend a lithogeochemical screening method to identify and avoid potential amphibole-rich zones.

In Part 3, Mechanisms of Mesothelioma and Lung Cancer, Drs. Neil Johnson and Brooke Mossman review current knowledge of factors influencing dose-effect relationships for chrysotile, including level of exposure, physical dimensions of the fibres, and biopersistence of the retained fibres in the lung. Chrysotile is considered the least potent of the asbestos minerals for the reason that chrysotile fibres are cleared from the lungs more rapidly than amphibole fibres. Studies of biopersistence are made through examination of fibres in autopsy lung samples, and measurement of fibre levels in broncho-alveolar fluid. Chronic exposure to high levels of airborne fibres of any type of asbestos, including chrysotile, causes the extensive scarring of the lung tissue called asbestosis. Among those with asbestosis, the risk of developing lung cancer is greatest for people who also smoke cigarettes. Mesothelioma is another type of asbestos-related tumor, which usually develops 30-40 years after exposure, and is most commonly associated with past exposures to crocidolite and amosite. Chrysotile on its own may or may not cause human mesotheliomas (the evidence is uncertain), but chrysotile is commonly contaminated with tremolite which does cause them. The two other articles in Part 3 describe emerging

information about a possible viral agent that may be contributing to the increase in incidence of mesothelioma in a number of industrialized countries.

The eight articles in Part 4, Exposure to Commercial Chrysotile – Historical Perspectives of the Health Effects, document a wide range of international perspectives, experiences, and regulatory trends. The topics include occupational and environmental exposures to asbestos in mining and milling operations in Canada, Italy, and Russia, and in the asbestos-cement industry in India. An article by Drs. Toshiaki Hagashi and Ken Takahashi provides an overview of commercial use, exposures, health effects, and regulatory trends in Japan, and describes the release of asbestos fibre during demolition of buildings following the 1995 Kobe earthquake. Canadian epidemiologist Dr. Michel Camus emphasizes the need for risk assessments of the fibrous materials proposed as substitutes for asbestos, which include ceramics, glass, and rockwool products. A key paper by Dr. Stanislav Domnin and colleagues examines effects of exposure to low concentrations of asbestos-containing dust on children's health. The authors report a relationship between the concentration of asbestos in ambient air in Asbest City, a chrysotile mining and milling area in the Urals, and peak figures of bronchitis, acute respiratory infection and inflammatory diseases in children. The exposures of these children are low compared to the occupational setting, but high compared to other non-occupational settings such as inside buildings containing asbestos. Their study departs from the traditional focus of the literature, which is mainly on the carcinogenic properties of chrysotile at high levels of exposure, and represents an important new direction of research into the potential for non-malignant respiratory disease among children.

Part 5, Exposure to Commercial Chrysotile – Modern Perspectives of the Health Effects, describes the difficulties in identifying health hazards associated with the current low levels of exposure to chrysotile experienced by modern workers and by the general population. In the first article Dr. John Hoskins provides perspectives on the toxicological data and its interpretation. In the second article Dr. Bernard Gee describes problems with the clinical diagnosis of early signs of pulmonary disease. In the final paper Drs. Richard Wilson and Bertram Price continue to examine the assumptions underlying USA risk assessments, in keeping with themes introduced in Part 1, and outline areas where the science conflicts with the regulations. In contrast with the large body of evidence for disease potential at high levels of exposure, there is a lack of evidence for health effects at current levels of urban exposure. This lack of evidence forces regulators to make assumptions about cause and effect at low levels of exposure. The result is a debate about the key assumption: that is, whether it should be assumed that there is a linear dose-response relationship or whether it should be assumed that there is a threshold effect. We recognize this as the place where the science has reached its limits, and where there is a clear need for further research, because it is the place where the experts start to disagree.

Apart from the clumsy mineral names — grunerite-asbestos ("amosite") is as distracting as an ant carting its dead companion across the page — my only complaint is that the table of contents is buried inside the back cover. Nothing at the front or on the cover indicates that there are five parts to this book. Someone in the habit of reading books from back to front might be quite satisfied to find the full table of contents on pages 303 and 304. The rest of us are likely to flip to the first table of contents that we encounter, which is on page 7 and covers Part 1 only, and mistakenly believe it to represent the contents of the whole book.

A highlight of the book is the remarkably candid nature of the discussion sections. The participating scientists, who are leaders in their respective fields, openly discuss the strengths and weaknesses of their methods, problems caused by historical changes in diagnostic and analytical techniques, the inevitable disagreements in interpretation, and their concerns with the limitations of current knowledge. These informal exchanges nicely complement the formal peer-reviewed contributions, and provide useful insights into areas of controversy and data gaps.

Although this was a scientific workshop, not a policy workshop, the contributors often express opinions on social and ethical aspects of the asbestos issue. The workshop participants all appear to agree that current regulations are protective, but there is general acknowledgment that these regulations are not applied equally everywhere around the world. The participants speak of the moral obligation on the part of exporting nations to provide training in the handling and use of chrysotile products and implementation of good work practices, and endorse the view that export of control technologies should accompany any export of chrysotile asbestos to consumer nations. It is on this appropriate note that Arthur Langer closes the final chapter.

The History and Sedimentology of Ancient Reef Systems

Topics in Geobiology, Volume 17

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Reefs have been with us, in one form or another, for much of planet Earth's existence. Reefs constructed by prokaryotes first occurred in the mid- Archean, more than 3 billion years ago. Those constructed by metazoans first occurred in the Cambrian, more than 500 million years ago. It is not surprising, therefore, that reefs have been the topic of geological inquiry for more than150 years, since Charles Lyell published the *Principles of Geology* (1831) and Charles Darwin summarized his research, and that of his contemporaries, in *The Structure and Distribution of Coral Reefs* (1842). *The History and Sedimentology of Ancient Reef*

Systems (2001), edited by George D. Stanley Jr., provides an excellent, up-to-date synthesis of current knowledge of the geology and ecology of ancient and modern reef systems. This book is both an exceptional reference for reef researchers as well as a friendly introduction for the newcomer. The chapters, outlined below, are authored by an international group of specialists and are, as a whole, well written and organized in a clear, consistent manner.

The first two chapters of *The History and Sedimentology of Ancient Reef Systems* provide the framework for the rest of the volume. Chapter 1, written by the editor, provides an overview and an introduction to reef ecosystems and their evolution through time. Chapter 2, written by Wolfgang Kiessling, summarizes the findings of the Paleoreef database, a collection of data from more than 3000 pre-Quaternary reef localities worldwide. This project provides quantification on trends in reef attributes through time, clarifying cycles in reef composition and complexity, and provides a basis for assessing the relationship between reef composition and global climatic fluctuations.

The remainder of the book provides an overview on reefs through time in rough chronological order. Chapter 3, written by Paul Copper, provides an overview of the first 2.5 billion years of reef evolution, from the mid-Archean through the Frasnian-Fammenian mass extinction near the end of the Devonian. Chapter 4, written by Andrey Yu-Zhuravlev, discusses the evolution and paleoecology of Cambrian reef ecosystems. This interval is particularly important because it documents the development of the first Metazoan reef components. This transition, from microbial to metazoan reefs, is a recurrent theme throughout the history of reefs occuring first in the Cambrian, and again after several global extinction events.

Chapter 5, by Gregory Webb, provides a brief aside, discussing biologically induced carbonate precipitation through time. This chapter emphasizes the contributions of nonskeletal (nonenzymatic) reef constructors to the development of reefs. Chapter 6, by Norman Newell, discusses the Permian reef complex in the Guadalupe Mountains of western Texas and southeastern New Mexico. This synthesis, by one of the original researchers, provides a brief summary on past and current research on the Guadalupian complex.

Chapter 7, by Erik Flügel and Baba Senowbari-Daryan, discusses Triassic reefs of the Tethys region. The authors concentrate on the distinct biotic composition and community structures of reefs at different points in the Triassic. Triassic reefs can be separated into three distinct groupings (Lower Triassic to Anisian, Anisian through Carnian, and Norian-Rhaetian). These groupings are related to three major extinction events, (end-Permian, Carnian, and end-Triassic), which severely effected reef biotas. Chapter 8, by Reinhold Leinfelder, concentrates on Jurassic reef ecosystems, comparing and contrasting them with modern reefs. Although scleractinian corals originate earlier, Jurassic coral reefs exhibit amazing diversity and extent, representing one of the acmes in reef evolution. Chapter 9, by Claudia Johnson and Erle Kauffman, summarizes Cretaceous reef ecosystems of the Carribean tropics.

The final two chapters concentrate on different aspects of modern reefs. Chapter 10, by Dennis Hubbard, Ivan Gill, and Randolph Burke deals with the role of framework in modern and ancient reef ecosystems. Their thesis is that, although reef biota have evolved, the processes responsible for reef building have remained consistent through geologic time. This is an important chapter and, although it deals with modern reef systems, provides important perspective and should perhaps be read prior to some of the other chapters, particularly by reef neophytes. Chapter 11, by Pamela Hallock concentrates on the impacts of nutrient input, global climatic perturbations, and anthropogenic factors on modern coral reefs.

Overall the book is physically well produced, although many of the photographs are too dark to be easily discerned. Omissions include the absence of separate chapters dealing with Carboniferous and Tertiary reef systems. However it must be stated that, as it stands, this book contains an amazing amount of information on ancient and modern reef systems. One of the joys of this book is its excellent organization. Each chapter is arranged in a clear, logical manner, and although the chapters were written by a diverse group of authors, they are consistent in organization and style. A solid effort was made by all contributors to the volume to place their respective chapters into global context and relate their topics to the overall theme. The table of contents is comprehensive, providing chapter titles as well as chapter subdivisions, a useful feature for educators looking for support material or for researchers comparing and contrasting reefs from different intervals. This, and the thorough glossary of pertinent reef-related terms included at the back of the book, are particularly useful features.

In summary, this book is an excellent reference source for any researcher involved in the study of reefs. As well, it constitutes an excellent resource for undergraduate and graduate level courses in carbonate sedimentology or reef evolution.

Smithsonian Institution Secretary, Charles Doolittle Walcott

By Ellis L Yochelson
Kent State University Press
Kent, Ohio and London, England
2001, 589 p., US$55.00

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This second volume completes the authoritative biography of an amazing man. Charles Doolittle Walcott was a brilliant scientist and spectacularly successful as a leader of major scientific organizations. Prominent in Washington society, he was a confidant of influential businessmen, prominent philanthropists, leading politicians, and ambassadors of foreign countries. He had ready access to six Presidents, Roosevelt, Taft, Wilson, Harding, Coolidge and Hoover (but for Hoover prior to his election), who valued his assessment and advice on scientific

and industrial topics.

Without formal training in geology, Walcott learnt scientific methods by reading widely, by his personal investigations and by apprenticeships with prominent geologists. He became a world famous scientist receiving prestigious medals and awards and 11 honorary degrees from universities that included Yale, Harvard, Cambridge, and the Sorbonne.

The earlier volume (Yochelson, 1998) covered Walcott's career up to his appointment as the head of the Smithsonian Institution as its fourth Secretary in 1907 and until he died in office in 1927. The Smithsonian was and is a remarkable institution, privately endowed for scientific and cultural activities but with connections and responsibilities to the most senior levels of the United States Government. But Walcott's influence went far beyond the responsibilities of the Smithsonian Institution. An awesomely effective leader of committees and back-room negotiator, he was influential in the development of many national activities, including military and naval affairs, the aircraft industry, national parks, forestry, water supply and resources, and the establishment of the National Gallery of Art. He was a key figure in virtually every scientific society in Washington. Duty and responsibility were ingrained in his soul and he found it extremely difficult to decline invitations to serve and to be a key component of any committee or organization for the betterment of science or society. Of course he managed his time superbly, moving from one task to another with progresses and plans neatly recorded and actions delegated.

Despite his many and demanding responsibilities, Walcott continued his beloved scientific research whenever days or hours were available. Throughout his life, Walcott battled bouts of ill health and he suffered the tragic losses of two wives and two sons. No doubt his ability to submerge himself in the challenges and pleasures of science provided an antidote to the stresses and adversities of his other activities and to the despairs of grief.

His biographer, Ellis Yochelson, is an accomplished scientist with great familiarity with the history of the prominent scientific institutions that Walcott headed and also knowledge of the personalities of many of Walcott's contemporary scientists. Throughout his life, Walcott recorded his activities in a daily journal. Yochelson has mined this hoard of information and put Walcott's career into perspective with the national and global events of the times.

Walcott's research received global scientific recognition for three outstanding achievements. Firstly, for the application of the evolutionary paleontology of trilobites to the dating and correlation of Cambrian and Ordovician rocks. Secondly, for his remarkable studies of the detailed morphology of the trilobite animal. Thirdly and pre-eminently, by the discovery and detailed descriptions of the fauna of the Burgess Shale of Middle Cambrian age, which is the most important known assemblage of fossil animals. Because of a fortunate freak of burial with preservation from scavengers and by serendipitous protection from deformation of the host rocks, the Burgess Shale Fauna provides a glimpse of a great diversity of soft-bodied animals alive some 505 million years ago and otherwise essentially absent from the fossil record. Bizarre creatures record many evolutionary experiments as well as early ancestral stages in the development of most of the major groups of animals alive today. All theories of evolution have been influenced by the remarkable diversity of the Burgess Shale Fauna.

Every book has its own particular audience, but this book seems to have been aimed at several audiences with disparate interests. Firstly, an audience interested in the evolution of stratigraphic paleontology and geology in the United States. Secondly, an audience for the machinations of national scientific and cultural institutions and their relationships to political leaders and to influential business people. Walcott became an outstandingly effective leader and advisor who recognized the need for regular and open communication at every level, and for creative forward planning to provide for needs and for future opportunities. He excelled in the patient building of consensus. The reader will recognize situations that have their parallels in the present, and will appreciate that Walcottt's methods and skills are just as appropriate today. Thirdly, an audience interested in the year-by-year and month-by-month details of political, cultural, and scientific events in Washington, the capital city, at a time when the United States was beginning to take a major role in world affairs.

Together with the first volume, Yochelson has produced 1099 detailed pages to describe Walcott's career and his achievements. A dedicated service to document the life of a remarkable man. The book is not relaxing reading, although from time to time Yochelson's wry humour relieves one's concentration and also explains for the lay reader some of the geological scenarios. Yochelson has provided a valuable and elegant chapter, Epilogues, that summarizes and elucidates aspects of Walcott's life and the organizations with which he was involved.

There was a strong Canadian component to Walcott's work, especially his studies of the Burgess Shale Fauna of British Columbia and on the Cambrian and Ordovician rocks of the Rocky Mountains. Among the illustrations in front of page 367, there is a photograph of Walcott still at work at 74 years old, leading laden packhorses on the route from the Burgess Shale Quarry. Recently named in his honour, the photograph shows Walcott Peak standing at the north end of Mount Burgess, overlooking the quarry where Walcott and his colleagues laboured long dedicated hours, mostly in cold and inclement weather.

The biography provides a fascinating description of the life of a very talented scientist who also had remarkable influence on many developments in the United States in the early part of the past century. It belongs on the bookshelves of research organization and academies and will be prized highly in the personal libraries of scientists concerned with research on Cambrian rocks and faunas and with the history of the evolution of life.

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