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Book Reviews / Critique

Book Reviews

The Burgess Shale

By Harry B. Whittington
Yale University Press (in association with the Geological Survey of Canada), New Haven 151 p., 1985; $25.00 US, cloth

Reviewed by Rolf Ludvigsen
4062 Wren Road
Denman Island
British Columbia V0R 1T0

Fossils interest virtually everyone. Kids love them; most adults find them fascinating; few can remain indifferent to the paradox of the once-living stone. But despite the abundant supply of curiosity, it is often difficult for amateur naturalists to move beyond the "gee whiz" stage and start to understand the sum and the substance of fossils. A number of books are designed for identification of major fossil groups, but few treat the full meaning of fossils as biologic, ecologic and geologic objects of historic and scientific significance. A good part of the blame must rest with academic paleontologists, many of whom view books on popular paleontology with the kind of bemused scorn that literary critics reserve for books by Harold Robbins.

Popular paleontology has been concerned largely with advanced animals from the Cenozoic and Mesozoic. Human paleontology has been dealt with in lively and informative books by Richard Leakey and Don Johanson. John Reader's well-crafted *Missing Links* is probably the best of the lot. Everybody's favourite fossil group, the dinosaurs, has recently been the subject of a spate of fine books by Adrian Desmond, Chris McGowan, Alan Charig and, particularly, Robert Bakker (his *Dinosaur Heresies* is a must read!). With the exception of Riccardo Levi-Setti's coffee-table book on trilobites, none has dealt specifically with any of the invertebrates that crowd the basement and the first floor of the Phanerozoic. But now that Harry Whittington has written this slender book on the fauna of the Burgess Shale, these extraordinary Cambrian fossils from Yoho National Park are revealed to the general reader in their entirety for the first time.

Many Canadian geologists probably have a nodding acquaintance with the Burgess Shale and its fossils; possibly from a distant paleontology course, or from David Suzuki's CBC program *The Nature of Things*, or from one of the review papers on the fauna by Whittington or his colleague Simon Conway Morris. But few will be prepared for the variety, complexity and preservation of the fossils represented in this half billion year old faunal assemblage. As Whittington shows, here are species of polychaete and priapulid worms, dozens of crustaceans and unassigned arthropods, various echinoderms, a chordate, possibly a barnacle and a ctenophore, in addtion to crowds of trilobites, sponges, brachiopods and mollusks. In many specimens, the guts, gills and appendages are replicated as reflective films of muscovite; so precisely that detailed paleodissections are possible for some of the fossils.

The Burgess Shale is a distillation of things discovered about this unit and its fossils by Whittington and a small coterie of coworkers. The fossil locality above Emerald Lake was discovered in 1909 by Charles D. Walcott, industrious boss of the Smithsonian and past Director of the United States Geological Survey; who, by 1917, had removed 65,000 specimens to Washington and, by 1924, had described almost the entire biota. The Canadians finally got involved in 1966 when a Geological Survey of Canada party under J.D. Aitken re-opened and enlarged Walcott's Quarry and started systematic collection for a new investigation of these fossils. Whittington took charge of the paleontology of the Burgess animals and Jim Aitken and Bill Fritz the regional stratigraphy and trilobite biostratigraphy. Delineation of the dramatic depositional setting of the Burgess Shale at the base of the vertical Cathedral Escarpment, which has been repeated in all subsequent papers, is the most visible result of the efforts of Fritz and Aitken. Whittington and his group have been remarkably active — producing some 50 papers and monographs on the Burgess fauna over the past 15 years. This body of work deals not only with the paleobiology of the animals, but also with their ecology, taphonomy and evolutionary significance; the last being of immense importance because the mid-Cambrian Burgess Shale fauna is a sharply focussed snapshot of the products of the first great metazoan radiation in the lower Phanerozoic.

Even though the book is much more than a Burgess bestiary, about half is taken up by description/explanation and photographs/reconstructions of representatives of various fossil groups of the Burgess Shale assemblage. This section is clearly written and devoid of jargon; it needs no previous knowledge of paleontology in order to be understood, only a healthy interest. The small size of the photographs and the rather soft paper are unfortunate editorial choices for a book such as this which depends heavily on visual impact. Geological Survey of Canada Miscellaneous Report 43, printed on glossy paper, gives a much better idea of the spectacular preservation of a smaller selection of these fossils.

Harry Whittington has succeeded in writing a much-needed book of popular paleontology on, what may well be, the most important fossil fauna ever described. The book is designed for students, amateur naturalists and non-specialists (the last group includes many geologists), but those paleontologists who deal with broad patterns of faunal diversification would do well to ponder some of the implications of the results of this re-investigation of the fauna — the Burgess Shale can no longer be considered unique, it could well represent a normal Cambrian outer-shelf assemblage from Laurentia; it can no longer be considered primitive, either in terms of morphology of the animals or in their ecologic organization; and some of the Burgess species cannot now be forced into any of the thirty or so metazoan phyla currently recognized.

The Great Dying. Cosmic Catastrophe, Dinosaurs, and the Theory of Evolution

By Ken Hsü
Harcourt, Brace, Jovanovich, New York
292 p., 1986; $17.95 US, paper

Reviewed by A.R. Berger
Geological Survey of Canada
601 Booth Street
Ottawa, Ontario K1A 0E8

Ken Hsü spins a good yarn, like this masterful tale of how the impact theory for the Cretaceous-Tertiary boundary extinctions developed. With a minimum of technical jargon, the author traces ideas on the disappearance of fossil taxa back to Linnaeus and Cuvier, but he concentrates on the work of the last ten years, drawing it together as in a detective novel in which the actual order of events is filtered and re-arranged to suit the story line. Like other books in this increasingly popular genre, *The Great Dying* portrays well the excitement and vitality of frontier research.

No one could accuse Hsü of sitting on the fence. The subtitle of his book and its cover painting of dinosaurs startled by a white-hot explosion, presumably due to an extra-terrestrial impact, indicate clearly where the author stands in the debate over the K-T boundary, and he castigates those who doubt the impact scenario. "Today's paleontologists," he claims, "whitewash the matter of mass extinction by choosing units higher up in the taxonomic hierarchy in compiling casualty lists."

Despite his philosophical and cultural roots in the Orient, which are often mentioned in the book, Hsü's language is partisan and he gives short shrift — or none at all — to arguments against extra-terrestrial impacts. Those in the know can read Hsü with pleasure, but the non-specialist will find no reason here to suspect flaws in, or alternatives to, the bolide scenario. There is no hint, for example, of recent studies that dinosaurs were able to survive readily in Alaska and Arctic Canada through the long polar winter darkness. The presence of iridium and other geochemical anomalies in volcanic rocks is ignored, as is evidence of ultra-high pressures in some pyroclastic eruptions resulting in shocked crystals, or the unusually voluminous volcanism during the K-T interval, as in the Deccan Plateau.

Hsü is at his best in his very clear explanations of the "Strangelove Ocean" that would have existed after a cometary impact and of the subsequent acid rain and ozone depletion that would have reduced the natural immunity of organisms to disease. There are obvious lessons here for those who contemplate nuclear winters and other global changes. Hsü is nothing if not imaginative, as he muses whether Sodom and Gomorrah were not destroyed by a Tunguska-like impact. The climatic effects of a comet hitting the ocean remind him of the 40 days' rain of Noah. And he happily relates somewhat equivocal Chinese reports of Ir spikes and negative carbon isotope anomalies at the Precambrian-Cambrian and Permian-Triassic boundaries, as evidence of "a very big visitor from outer space".

His writing is clear, succinct and peppered with colourful phrases: "the browsing foraminifera and the browsed-on nannoplankton", "the standard product code of remnant magnetism" (*i.e.*, magnetic reversal time scale). To describe Cretaceous-Tertiary extinctions, the central theme of his book, Hsü turns military spokesman, referring to "body counts", and stating that "Maastrichtian brachiopods were simply massacred". The book is quite free of minor errors, so that the author can be forgiven perhaps by Richard Grieve who becomes Robert, for "ceosite", and for the "Wollastan" medal. That the Wollaston is "geology's most prestigious award" according to the dust jacket, will not please many North American geologists and may even set some teeth on edge at the Geological Society of London which awards it and some other medals. The author cannot, however, be excused his surprising gaffe that the atmosphere is a mere 7.1 kilometres deep.

Toward the end of this fine book, the author returns to the attack on Darwinism in a chapter entitled "The Race is Not to the Swift". "It is time," he says, "to awaken to the absurdity of the idea of natural selection." Survival of those organisms most fit to do so makes little sense to Hsü when the crisis is extra-terrestrial and cannot be foreseen. Hsü emphasizes earlier views that Darwinism owes its enduring popularity to the human preference for competition and to political ideologies that encourage one group or race of our species to exploit and even exterminate another. He ends with the thought-provoking notion that we should not judge who or what is fit and not fit, but rather should take a Taoist view and "embrace the diversity of forms and ways that nourish life itself". There is much to reflect upon in *The Great Dying*: those who consider ecological relationships and who ponder the evolution of life should find it of considerable interest.

Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation

By Suzanne Zeller
University of Toronto Press, Toronto, Ontario
376 p., 15 plates, 1987; $35.00 cloth;
$15.95 paper

Reviewed by William A.S. Sarjeant
Department of Geological Sciences
University of Saskatchewan
Saskatchewan, Saskatoon S7N 0W0

The principal title of a book can have, as we all know, a considerable effect — positive or negative — on its sales. This book's title is quite apposite but has, I feel, been unfortunately chosen. Many geologists and naturalists, reading only the spine title or the main title on the front cover, will pass it over, failing to notice the much more informative subtitle and thinking it to be a history of Canadian inventions and thus of small relevance to their concerns.

That is regrettable, for this work deserves to be read by all interested in the history of what the author styles the "inventory sciences" — a very convenient designation defined thus:

> A common inventorial purpose linked early Victorian scientific pursuits in British North America, and they are here collectively called 'inventory science' to highlight the mapping and cataloguing of resources and other natural phenomena which preoccupied the colonists. Inventory science in early Victorian Canada included geology, terrestrial magnetism, meteorology, botany, and to a lesser extent entomology, zoology, and anthropology. (p. 4)

It is with these sciences that the author is principally concerned; and it is her exposition of the interrelation of discoveries in geology and geophysics with education in Canada and the ideas of westward territorial expansion that should interest readers of this journal. Indeed, the greatest strength of this work is its meticulous documentation of the political repercussions of early Canadian scientific discovery.

A prominent figure in this story, very properly, is Sir William Edmond Logan, whose combination of scientific knowledge with political percipience made him the ideal occupant of the position of first Director of the Geological Survey of Canada. The controversy over Logan's appointment (p. 46-48) is now almost forgotten, but it was sufficiently bitter to have lastingly undermined the authority of any person with lesser acumen. Logan's sensitivity to the political breezes of his day enabled him to trim his sails effectively and to maintain his direction without ever losing way. As the author comments, for example, in dealing with the prevalent belief that there must be coal in central Canada,

Logan's "performance was a *tour-de-force* which was indispensable for the future survival" of the Survey (p. 56). We Canadians are still benefitting from Logan's lifelong dedication to the service of our country.

Yet it is salutary to be reminded that, though brought into being in the heyday of the British Empire, the Survey received very little help from Britain. Instead, Logan received the greatest aid from geologists in the United States (p. 57-58). The praises lavished upon the displays of Canadian minerals that Logan organized for the Great Exhibition, held in London in 1851, undoubtedly caused him particular pleasure (p. 81-84). Equally undoubtedly, this very visible success strengthened Logan's hand when dealing with politicians back in Ottawa.

The story of the Survey will be well known to most geological readers, though they should gain many new insights from this account. The early history of the Toronto Magnetic Laboratory — the first important centre in Canada for geophysical investigations — is much less well known. In particular, the figure of Lieutenant (later Sir) John Henry Lefroy is here deservedly brought forth from the shadows. The brief account of his early magnetic survey in what were then the territories of the Hudson's Bay Company is succinctly told, but would have benefitted from illustration on a sketch map. His later activities — the setting-up of the Toronto laboratory, as associate of Sir Edward Sabine; his involvement with social and educational circles in Ontario; and his contribution to meteorology — are all lucidly recounted. Lefroy's recall to England in 1853 ended his work here. Had the money for continued support of the laboratory been forthcoming a little earlier, perhaps he might have stayed and made even greater contributions to Canadian geophysics.

This account, then, is concerned with the interplay of geology with politics: it is not a history of the evolution of Canadian geological thought. This aim is, in general, very well fulfilled; however, there is perhaps too much emphasis on happenings in Ontario and Quebec, too little on the even earlier, if transient, geological explorations in the Maritime Provinces and Newfoundland (Gesner's surveys in New Brunswick gain only passing mention and their political setting receives no attention).

The contribution of the publishers to the presentation of this work cannot be wholly praised. The paragraphs and lines are rather too closely spaced, the typeface rather too small, giving a "too solid" effect to the text which is not prepossessing. Like the grouping of plates all together at the front (at least in the paperback copy), this was no doubt "justified" in terms of production costs; but both decisions make the reader's work harder. The illustrations were well chosen — I was fascinated, for example, to see the pictures at Logan's collecting basket and his buggy and wheel odometers — but the quality of reproduction is no better than moderate — and why was that specimen of *Eozoon* shown split and reproduced so small?

Yet I must not end on a low note. Whatever the ineptitudes of the University of Toronto Press in its production, the quality of scholarship cannot be seriously faulted. This work deserves to be on the shelves of all who are interested in the history, not just of the earth sciences but of science and education in general, and not just of Canada, but of the whole of North America.

The Curious Incident of the Missing Link, Arthur Conan Doyle and Piltdown Man

By Douglas Elliott
Bootmakers of Toronto,
Occasional Papers No. 2
(Available from the Bootmakers of Toronto, 47 Manor Rd. W., Toronto, Ontario M5P 1E6)
36 p., 1988; $5.50, paper

Reviewed by William A.S. Sarjeant
Department of Geological Sciences
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0

The discovery of human remains from the Quaternary deposits of Piltdown in Sussex was announced to the World on December 18th, 1912, jointly by an English solicitor and antiquarian (Charles Dawson) and a respected vertebrate paleontologist and museologist (Arthur Smith Woodward). Nine fragments of a skull, thick but unquestionably human in character, and a fragment of a jaw of quite remarkably ape-like nature, had been found in association with fossil remains of an array of other mammalian bones — of mastodon, rhinoceros, beaver, deer, horse and hippopotamus. Two years later, a carved fragment of an elephant femur was found also, seemingly indicating that this primitive humanoid — by then christened *Eoanthropus*, "man of the dawn" — had not been merely a maker, but also a user, of tools.

The impact of the discovery is well summarized by Elliott:

> The Piltdown find was exciting to British scientists for a number of reasons. It fulfilled the prediction of many Darwinians that primitive man developed first an advanced brain, while retaining an ape-like jaw that sported large canines (eye teeth) which could still be used as weapons. It also provided a major boost to the national ego, since primitive human remains had until then been found only in continental Europe and Southeast Asia: the birthplace of Shakespeare and Newton could hardly be without earlier evidence of human cultural advances. (p. 3)

For Arthur Smith Woodward, this discovery marked the acme of his distinguished career. His book *The Earliest Englishman*, published by his widow in 1948 four years after her husband's death, reflects the warm glow of excitement which the memory of the discovery still caused. Indeed, he was not alone in his assessment of the importance of this find. Such other distinguished anatomists as Grafton Elliott Smith (1931, p. 23-27 and earlier works) and Arthur Keith (1948, p. 228-229, and earlier works) were staunch in their defence of the significance of *Eoanthropus*, claiming that the Piltdown finds provided pivotal evidence in determining the phylogeny of man. Keith's defence, indeed, stimulated the English humorist, "Beachcomber" into a verse parody (1931, p. 114):

> Reconstructed Eaonthropoi
> When twilight was falling
> "Keith, Keith, Keith, Keith"
> They were crying and calling.

Yet, from the outset, there were others who viewed the discovery with extreme suspicion. Frank Weidenreich, for example, wrote (1943, p. 273):

> Eoanthropus should be erased from the list of human fossils. It is the artificial combination of a modern-human braincase with orang-utang-like mandible and teeth.

Moreover, Woodward had been somewhat puzzled that, though he, Elliott Smith and others had sought energetically for further finds, they had done so without success:

> After Mr. Dawson's death, in 1916, I was able to open a series of pits along the other side of the hedge in a field adjacent to the original pit... We began close to the spot where the skull was found, and worked in both direction from this place... Our efforts, however, were in vain. We found nothing of interest in the gravel, and it was evident that we were outside the range of the eddy which brought the scientific treasure to its resting-place. (1948, p. 13).

Even so, the demonstration in 1963 by three British Museum scientists — J.S. Weiner, Kenneth Oakley and Wilfrid le Gros Clark — that "Piltdown man" was a flagrant forgery, burst like a bombshell upon the scientific world.

By then most of the principal protagonists in the discovery and defence of "Piltdown man" were gone from the scientific scene. Charles Dawson died in 1916, only a year after reporting further finds of *Eoanthropus* at a second location two miles away from Piltdown. The three principal scientific defenders of the skull's importance had all attained knighthoods. Sir Grafton Elliott Smith died in 1937 and Sir Arthur Smith Woodward in 1944. Yet Sir Arthur Keith was still alive and, though by then approaching

90, he took the demonstration of the forgery in good part:

> "I think you are probably right, but it will take some time to adjust myself to the new view." (Quoted in Millar, 1972, p. 210).

From the outset, Charles Dawson was viewed as the most likely forger of Piltdown man — as the creator of Woodward's "eddy": and indeed, though a Scottish jury might adjudge the case against him as "not proven", he continues to seem the most likely candidate. Yet, as the years have gone by, other possible culprits have been adduced. Father Pierre Teilhard de Chardin, S.J., unquestionably helped with the excavations. Though coming later to be almost buried under the laurel wreaths bestowed upon him as a Christian defender of evolution, he was a lively young man with a mischievous sense of humour: yet the evidence against him is too tenuous for ready belief. William Johnson Sollas of Oxford University was accused by his colleague, J.A. Douglas, in a tape-recording relased posthumously, of involvement in the fraud. Yet while there can be no question that Sollas, in his later years, became very odd indeed (see Sarjeant, 1980, p. 7-8), the evidence against him is equally tenuous. No doubt, as the years pass, the number of suspected culprits will grow, just as have the identifications of "Jack the Ripper"!

Sir Arthur Conan Doyle was, I suppose, destined inevitably to be drawn into this waxing whirlpool of suspicion. Not only was his home quite close — though not very close — to Piltdown, but also he corresponded with Dawson and unquestionably visited the site of the "discovery", even aiding in the search for artifacts and bones. Yet, amusingly, it was his creation Sherlock Holmes who was first accused of fabricating the find, in a humorous article by Rolfe Boswell (1963) — an accusation refuted, equally humorously, by his fellow Sherlockian Paul Durrenberger (1965).

The first serious claim that Conan Doyle himself was "the perpetrator at Piltdown" did not come until 1983. It was made by two other Americans, John Winslow and Alfred Meyer, in the popular journal *Science 83*. Refutations were published in that same journal only two months later, while in the very balanced overview of the whole Piltdown controversy by Charles Blinderman (1986), the accusation is taken very lightly and dismissed in a chapter "The Adventure of Queer Street", written as a Sherlockian parody.

Nevertheless, the storm of newspaper publicity generated by the accusation has not entirely died away. It was in response to its continuing rumblings that Douglas Elliott wrote the entertaining short work here reviewed. It is based on a personal investigation, undertaken without initial prejudice, yet its conclusions are unequivocal. The evidence adduced by Winslow and Meyers is presented very fully; but then, point by point, their thesis is demolished. As Elliott demonstrates, Conan Doyle was a man too much in the public eye to have been able unobtrusively to plant the bogus fossils and artifacts. Whereas Charles Dawson may have had a desire for fame and an urge to attain it by any means he might, Conan Doyle was already more famous than he would have wished:

> He could no more have made frequent visits to the pit without being spotted than could Robert Redford drop in for a pint with the lads at the local pub today. (p. 20)

This little book, the first on the Piltdown theme to be written by a Canadian, is not only entertaining and inexpensive; it is also decisive. Who was the culprit in the Piltdown forgery, we may never know; but it was not Sir Arthur Conan Doyle.

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Pioneers of Geology

By Douglas A. Robson
Special Publication of the Natural History Society of Northumbria Hancock Museum, Newcastle-on-Tyne, England
73 p., 1988

Reviewed by William A.S. Sarjeant
Department of Geological Sciences
University of Saskatchewan
Saskatoon, Saskatchewan S7N 0W0

To attempt to write a comprehensive history of any science is a courageous undertaking; to attempt to do so in such small compass as the work here reviewed is a formidably difficult task. Most historians have preferred instead to examine a particular subdiscipline, a particular period or theme, a particular geographic region or the achievements of one or more individuals and one can scarcely blame them!

To my knowledge, only four persons have yet attempted to epitomize the history of our science in books shorter than 200 pages. The first was Horace B. Woodward, whose *History of Geology* (Watts, London, 1911) occupied only 154 small pages and yet ranks as a fundamental contribution to the understanding of our discipline. It was long ere the attempt was made again. Carl Christian Beringer's *Geschichte der Geologie und des Geologischen Weltbildes* (Ferdinand Enke, Stuttgart, Germany, 1954) is a solidly factual summary, but rather dry and paying small regard to palaeontology; it occupies 158 pages. André Cailloux's *Histoire de la Géologie*, written for the famous "Que Sais-Je?" series of paperbacks (Presses Universitaires de France, Paris, 1961) occupies 126 small pages and was a remarkable feat of compression without forfeiture either of accuracy or readability. Most recently Bruno Accordi, in his *Storia della Geologia* (Zanichelli, Bologna, Italy, 1984), has written an attractive book of 114 pages in which, for the first time, a proper emphasis is given to the achievements of his compatriots.

How does Robson's work compare with these? In terms of presentation, very favourably. It is a large-format paperback (24.5 × 17.5 cm), having a handsome colour portrait of William Smith as English worthy on cover and as frontispiece, a series of colour photographs of places of importance in the history of our discipline and numerous portraits of the eminent scientists named in the text. (Most of these portraits have been trimmed to show the head only; the strong jaw-lines of our predecessors are impressive indeed!). The typography is attractive, with the names and birth and death dates of the principal protagonists mostly — though, oddly, not consistently — set into bold type upon first mention. On appearance alone, then, this little book certainly surpasses its predecessors.

Though Mr. Robson occupies sixteen pages in summarizing the earlier history of geology and just over a page in treating with subsequent developments, his prime concern is explicitly with the period between 1775 and 1875; that is, with the "heroic age" (1775-1825) and "golden age" (1825-1875) of geology:

> Thereafter, there dawned the age of the professional, when periodicals and surveys multiplied and when the numbers of scientific papers, on every aspect of the subject, greatly increased — a trend that has continued to this day. (p. 7)

His intended audiences are senior school students, university students taking foundation courses in geology, and laymen interested in natural history subjects, though he notes optimistically:

> It might also attract the attention of the professional geologist from whose memory there may have faded the realisation of the debt owed to the great pioneers. (idem)

These, then, are his aims; and they are very largely fulfilled. The text is quite readable and its organization by subheadings satisfactorily coherent.

The selection of what to include, and what to exclude, in so short a work must be the author's own decision; and his selection is unlikely to correspond *in toto* with one made by any other historian of geology. Even so, there are some contributions to our discipline's development that surely deserved, but did not receive, mention. Though a brief account is given of concepts of Greek and Roman thinkers concerning the earth sciences — mostly, be it said, rather incoherent concepts, rarely founded upon accurate observation — the equally early and often sounder ideas of the ancient Chinese are not even mentioned. Though the importance of the Arabs as transmitters of classical scientific knowledge is noted (p. 9), the original ideas of Ibn Sina (Avicenna) are not discussed. Though Agricola's ideas on rock genesis are mentioned (p. 9), the immense and lasting importance of his *De Re Metallica*, as a standard text on mineral veins and mining procedures over many centuries, gains no mention. Robert Plot's ideas on the origin of fossils are recounted (p. 199) but those of Edward Lhuyd, his successor at the Ashmolean Museum, are not. Jean Étienne Guettard's work on volcanoes is described (p. 13-14) but there is no mention of his observations on the processes of erosion, of his recognition that plant communities characterize particular rock types and can be used in mapping, or even of his geological maps, among the first ever to be produced. Nicolaus Steno's work on "glossopetrae" is mentioned (p. 10) but not his advanced concepts of stratal succession and the geological history of Tuscany. Sir Archibald Geikie's assessment of the work of Abraham Gottlob Werner is echoed uncritically (p. 18), even though comprehensively refuted, in a succession of recent papers, by Alexander Ospovat. Despite the fact that microfossils are nowadays so fundamental a tool in stratigraphy, nothing whatever is said of the origins of micropaleontology and such pioneers as Christian Gottfried Ehrenberg (1795-1876) gain no mention. Similarly, though Henry Clifton Sorby's work on sediments is properly noted (p. 55), his studies of rock deformation and the origin of slaty cleavage and his development of etching techniques to study the crystalline structure of metallic meteorites are not.

Yet after all, however one may view them, these omissions mostly reflect decisions of inclusion or exclusion. Errors are relatively few. Two very familiar mistakes are repeated: Archibishop James Usher did indeed calculate the year of the Creation from biblical sources (p. 12) but it was John Lightfoot, not he, who worked out the month and the day. The legend that Gideon Mantell was the first scientific discoverer of a dinosaur is retold (p. 58); yet William Buckland discovered *Megalosaurus* several years before Mantell found his *Iguanodon* bones and, morever, described that carnivorous saurian well before Mantell described his massive herbivore. (Incidentally, Othniel March would chuckle to find a mention of his own work (p. 58), but none at all of the studies of his rival Edward Drinker Cope!).

The passage on the journals available for the publication of geological articles "up to the first decade of the nineteenth century" (p. 36) is rather unclear, but appears to imply that the *Memoirs of the Wernerian Natural History Society* and the *American Journal of Science* were already being published by 1800. They were not; the former first appeared in 1810, the latter in 1818. The Dublin Society had been in existence since 1731; though unmentioned here, it was more important than the Royal Irish Academy to the development of Irish geology, indeed sponsoring that country's first geological maps and organizing its first museum displays of rocks and minerals.

In the account of the establishment of early geological societies, the Royal Geological Society of Cornwall (founded in 1814) gains no mention. The listing of the dates of establishment of geological surveys "abroad" (p. 38) includes Ireland: but of course, in 1845, Ireland was still part of the United Kingdom, *not* a foreign place as is implied. I am also puzzled as to why the mention of Robert Chambers' anonymously published *Vestiges of the Natural History of Creation* (p. 43) comes after, rather than before, the account of Charles Darwin's evolutionary studies, when it was the hostility evoked by Chambers' ideas that deterred Darwin for so long from publishing his own.

The book's worst feature, however, is the extreme editorial carelessness which has afflicted the spelling of so many personal names. Examples are embarrassingly numerous — Niels Stensen (p. 10); René? Descartes (p. 12); Horace Bénédict de Saussure (p. 14); Torbern Bergman (p. 17); Reliquiae Diluvianae (p. 30); Philippe Eduard Poulletier de Verneuil (p. 35); [John] **Thackray** (p. 35); Vicomte, not Viscomte, d'Archiac (p. 36); Thomas Oldham (p. 38); Ignaz Venetz (p. 39); Helvé?tique (p. 39); Bernhard Studer (p. 45); Baron Ferdinand von Richthofen (p. 47, twice; that would have upset the Red Baron!); [Wilfrid] Hudleston (p. 50); Joseph Paxson Iddings (p. 56); Evgraf Stepanovich Federov (p. 56); Tyrrell (p. 57); Merrill (p. 58); Rütlmeyer (p. 58); Duklnfield Henry Scott (p. 59); William T. Blanford (p. 59); and E. von Rebeur Paschwitz (p. 60). Guy Sylvain Tancréde de Dolomieu was most often called "Déodat", a point not mentioned. Worst of all, Karl Harry Ferdinand Rosenbusch is misnamed "Heinrich" (p. 56) and Clarence Edward Dutton miscalled "Charles" (p. 61)!

This account is, of course, primarily intended for a British readership. Its tendency to undervalue the labours of non-British geologists is thus explicable; yet I must regret that nothing is said about the contributions of Joachim Barrande and of Czechoslovak and Polish geologists to our knowledge of Paleozoic rocks and fossils; of the numerous conceptual innovations in stratigraphy, paleontology and structural geology of Italians subsequent to Arduino; and of the whole concept of the Gothlandian, as an alternative to the Silurian.

How, then, to assess this little book overall? I think, on balance, one must do so favourably. The errors can — and should — be eliminated from subsequent printings; the omissions, however much I might personally regret them, are an expression of the author's choices. This remains a handy and attractive little book, which should attain the author's aims by acquainting students, laymen and even some of we professionals with the lively history of this, our business and delight of studying the earth.

Volcanic Successions: Modern and Ancient

By R.A.F. Cas and J.V. Wright
Allen & Unwin, London
528 p., 1987; $39.95 US, paper

Reviewed by John Stix
Department of Geology
University of Toronto
Toronto, Ontario M5S 1A1

Ray Cas and John Wright have taken on a vast undertaking in dealing with the enormous amount of recent work in physical volcanology. They have met the challenge admirably and have produced an up-to-date, comprehensive synthesis of the field. While covering a wide range of topics, the book remains quite detailed in its description of theory and application. It complements and extends Fisher and Schmincke's (1984) treatment of pyroclastic rocks by examining these subjects in greater detail and by taking a facies analysis approach in studying both modern and ancient volcanic deposits. The authors' philosophy is that modern and ancient volcanic systems can best be studied concurrently.

Chapters 1-3 cover basic aspects of facies analysis, properties of magmas, and fragmentation mechanisms. Chapter 4 discusses lava flows, while Chapter 5 provides an introduction to the following three chapters on subaerial pyroclastic fall, flow, and surge deposits.

Chapter 6 covers subaerial fallout tephra deposits and their eruptions. Plots of dispersal (D) versus fragmentation index (F) form the basis for classifying different types of fallout deposits in terms of the eruption column height and degree of fragmentation of the magma. Abundant grain size data are plotted, and numerous photographs illustrate the details of, and distinctions among, the various deposits. The authors also discuss potential pitfalls associated with D-F diagrams, such as rain flushing, premature deposition of fine ash, and secondary thickening of fallout deposits.

Chapter 7 examines subaerial pyroclastic flows and surges. The authors state that a spectrum of pyroclastic flow types exist, with different support and transport mechanisms such as laminar and plug flow, turbulence, and fluidization. They discuss theoretical and experimental aspects of fluidization in some detail because of its importance in the movement of pyroclastic flows. They also discuss vertical and lateral grading of fragments within a pyroclastic flow and relate these observations to the dynamics within the head, body, and tail of the flow during movement. Many of the ideas concerning the structure of the flow stem directly from Middleton's observations of turbidites in an experimental flume. The discussion concerning grading is particularly relevant to the Archean where grading relations are used to infer stratigraphic tops. Pyroclastic surges also are examined, and the problems in distinguishing deposits of violent high concentration pyroclastic flows from those of low concentration surges are discussed. This chapter is very detailed and is an excellent reference for these types of deposits.

Chapter 8 covers ignimbrites and their eruptions. The authors discuss the two-stage single vent and ring fissure vent model with numerous examples and emphasize the importance of co-ignimbrite breccias. They develop depositional facies models for specific ignimbrite deposits and suggest that magma discharge rate is the main control upon the resultant facies. Welding also is discussed, as well as epiclastic deposits which may be mistaken for ignimbrite sequences.

Chapter 9 deals with subaqueous pyroclastic flows and ash layers. The authors stress the differences between pyroclastic and epiclastic deposits and show that the roles of reworking and slumping in the subaqueous environment are very important. They find little evidence for subaqueously welded ignimbrites. They emphasize that hot, subaqueously emplaced ignimbrite deposits must be documented by (1) facies associations indicating a subaqueous paleoenvironment and (2) macroscopic and microscopic evidence of welding.

Chapters 10 and 11 cover epiclastic processes in volcanic terranes. Chapter 11 is particularly valuable in discussing the origin of crystal-rich volcaniclastic deposits. The authors show that both pyroclastic and epiclastic processes concentrate crystals. This is relevant to Archean intermediate to felsic supracrustal sequences in which crystal-rich deposits are abundant. The authors also provide criteria with which to distinguish volcanic from plutonic sources of crystals.

Chapter 12 outlines a succinct classification scheme for pyroclastic and epiclastic rocks from modern and ancient settings. Chapter 13 examines different types of modern volcanic centers; this discussion ties in nicely with that of Chapter 14 which covers facies associations in ancient volcanic sequences. The authors relate these various facies to the different volcanic centers discussed in Chapter 13. They also outline the types of ore deposits expected in each facies association. The book closes with a general discussion of volcanism with respect to tectonic setting.

In summary, this is an admirable book which lies somewhere between a reference work and a text for graduate students and advanced undergraduates. I would suggest that a person unfamiliar with volcanic regimes first read the relevant sections of Fisher and Schmincke (1984), then proceed to Volcanic Successions for the gory details.

My complaints are few and far between. The photographs are uniformly grey and lack sufficient contrast. Some of the photomicrographs are unclear and lack scale bars. The writing style is rather formal; one can get lost in the detail of the various subdivisions. On a more substantive note, the authors do not address the theoretical basis and problems of grain size measurements. With so much of modern physical volcanology based on relatively few grain size parameters, a reassessment of the physical basis for these parameters would have been welcome. The book essentially ignores magmatic geochemistry; clearly, its strengths lie in physical volcanology and facies analysis.

I strongly recommend this book to anyone working in modern or ancient volcanic terranes. With a price of $40 for the paperbound edition, this book is excellent value.

Reference

Fisher, R.V. and Schmincke, H.-U., 1984, Pyroclastic Rocks: Springer-Verlag, Berlin, 472 p.