Book Reviews / Critique

Book Reviews

Rocks in My Head

By Celeste G. Engel
Vantage Press, New York
203 p., 1987; $10.95 US

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Since women geologists have not been numerous until today — if, indeed, they are to be considered numerous today! — it is scarcely surprising that extended biographical studies of them are few. The activities of one of the earliest, the Dorset fossil collector Mary Anning, have been documented in many pamphlets and papers, but the only extended treatment is a fictionalized biography for juvenile readers by Helen Bush (1967). The biographical account of Sarah K. Bolton by her son (1923) merits consideration but, though Sarah wrote on the history of the earth sciences, she was scarcely a geologist; and, while the several biographies of Marie C. Stopes (Maude, 1924, 1933; Briant, 1962; Box, 1967; Hall, 1977) all mention her palaeobotanical work, their stress is consistently on her social work, in particular as an advocate of birth control. In consequence, though Isabel Fothergill Smith's biography of Florence Bascom (1981) is brief — less than fifty pages — this life of the petrologist and mineralogist of Bryn Mawr College must be ranked as the most extensive biography of a woman geologist yet published! The only other work marginally to be considered is John McPhee's *In Suspect Terrain* (1983); but, though extensively featuring the opinions of US stratigrapher Anita Harris and telling something of that lady's life, it is not a biography.

If biographical works are few, autobiographical writings are fewer. Yes, there are a number of writings by wives concerning the travels, activities or lives of their geologist husbands — Mrs. Edgeworth David's account of her Australian geologist husband's work on Funafuti (1899), Lilian Brown's three entertaining reminiscences (1951a,b, 1958) of hunting fossil vertebrates with husband Barnum and Frances Bunbury's three earnest volumes on the life, work and letters of her late spouse Sir Charles (1894) are examples — these ladies were not themselves geologists. The reminiscences of Mary Somerville, carefully edited for publication by her daughter Martha (1873), are surely the earliest by a woman scientist to be published; but, though Mary contributed to the development of geomorphology, her most lastingly significant contributions were in astronomy and mathematics, not in geology. Emily Hahn's scathing recounting of her misadventures while striving to study geology at the University of Wisconsin (1970) proved the prelude to a career as a writer, not as a geologist. Marie Stopes' reminiscence of her scientific work in Japan (1910) is no more than an autobiographical fragment. The work here reviewed thus constitutes a marker stratum in scientific literature, for it is the first autobiography of a woman geologist yet to be published in English — or indeed, to my knowledge, in any language.

Its authoress graduated in geology from the University of Missouri where, like Emily Hahn, her sex occasioned for her many problems not faced by males. She comments succinctly (p. 5) that:

> Most professors in geology at the University were anti-women.

An honourable exception was Edwin Bayer Branson (1877–1950), "the first geologist I met who was kind to women students" (*idem*). When she was working as part-time cook at the geology camp, he took trouble to ensure she kept up her learning by conducting her on one-day field trips to significant outcrops and, in general, giving her all the extra help she needed to satisfy field training requirements. However, she remembers ruefully his enthusiasm for bridge — an enthusiasm that Celeste emphatically did not share!

Celeste married another geologist, Albert Engel. After their marriage, they worked together in their geological researches. Sometimes she merely accompanied him on field work, but much more often she was an active participant, perilously assisting him in wartime surveys of deteriorating talc mines in Vermont and New York and undertaking petrographic studies of mineral particles under the petrographic microscope which they took with them on their travels. Yet she comments bitterly (p. 29):

> My husband always apologized to everyone because I was along with him. Wives did not go into the field with their husbands... Some field parties considered women bad luck. Yes, it was the dark ages.

When this work was finished, Celeste and Al decided jointly to undertake postgraduate work in geology at the California Institute of Technology in Pasadena. Subsequently Al taught there, while Celeste worked for the United States Geological Survey from a base in that same city. Though her career was pleasantly interrupted by the birth of their two children, geology remained a major concern. Not only did it take her to many parts of the United States, but also to New Caledonia and the Mascarene Islands, as well as on a highly uncomfortable oceanographic cruise in the Indian Ocean. She worked with Harold Urey for a while, studying thin sections of the Orgueil meteorite — then considered to contain relics of extra-terrestrial life — and perceiving the drastically altered character of its minerals before the effects of subaerial alteration were generally admitted as invalidating the microfossil evidence (p. 3-4). She was one of the first to recognize the distinctive mineralogical character of oceanic basalts, with its implications for crustal structure, and to make petrological studies of volcanic rocks from the moon.

She is honest about her anxieties and — in a fashion likely to be considered reprehensible by feminists — prepared to admit that yes, there *are* differences in thought and attitude between men and women. For example (p. 119):

> Al was out dredging in the South Pacific, trying for basalts farther to the west, from both the ocean floor and from submarine volcanoes. While he was gone, I worked a lot at night. After I fed the grown sons, now in high school, I went back to work. A woman's work is never done. I am not complaining. I liked the work. Always, I was able to worry on several levels. Would the police call and tell me one or other of our sons was dead on the highway? What should we have for dinner? Did I turn off the stove when I left in the morning? Was the iron on? In the lab, I did most of my extra

> worrying while I was looking at thin sections of rock through the microscope. This is a sort of quiet time, and if you know the rocks, your mind can wander about. I noticed that Al could worry about, at most, one thing at a time and his worries were different from mine.

Al Engel's extreme enthusiasm for field geology meant that, when leading excursions, he wanted to "tell it all" and expected the undivided, critical attention of participants. Celeste recalls entertainingly how upset he was when, at one outcrop, the attractions of his rocks proved no match for the counter-attraction of wild strawberries! (p. 26-27). Nor was Al prepared to waste time on husbandly sympathy. When Celeste had fallen into a hole and injured her ankle (p. 50):

> We sat down for lunch and then I looked at my foot. It was huge, swollen to the size of an elephant foot.
>
> Al said, "Don't ruin the day. Take the car and go into the hospital for an Xray, but be sure to pick us up close to this spot at about 5:00 p.m."
>
> You see, he didn't spoil me.

She notes, and is disturbed by, the changing character of geologists (p. 109):

> I don't think Al minds being in a smelly bed or wearing dirty clothes, at least not when he has interesting rocks to look at. All field geologists were like that three generations back. Al and I began to notice, however, that the younger generation of field geologists were not like that. They found it difficult to work alone. They needed "noise" and people around them.

But maybe, in any case, theirs is a vanishing breed (p. 109-110):

> Field geologists may disappear, for several reasons. Fieldwork takes lots of time and is physically demanding. You could work years to get one good map and scientific paper. Then too, in a lot of areas in the world, millions of people have covered rock exposures with houses and moved rocks away to plant fields of food. The most barren deserts, highest mountains and coldest regions may be all that is left to study, and those areas will be too "lonely".

This is an entertaining chronicle, but it is markedly episodic and leaves unrecounted the events of many stages of Celeste Engel's career. We learn little about her parents and nothing concerning her life before entering University; no, not even her maiden name! These omissions can be frustrating. Yet this first autobiography by a woman geologist will be enjoyed by any reader who is not too serious-minded to be prepared to be entertained by her anecdotes. Moreover, these anecdotes are not only self-revealing but also illuminate attitudes within our science to her sex that, even now, are only slowly changing.

References

[Bolton, C.K.], 1923, Sarah K. Bolton. Pages from an intimate autobiography: Thomas Todd, Boston, Mass., for the Author, viii + 155 p.

Box, M., 1967, ed., The trial of Marie Stopes: Femina Books, London, 392 p.

Briant, K., 1962, Marie Stopes: a biography: Hogarth Press, London, 286 p.

Brown L., 1951a, I married a dinosaur: Harrap, London, 208 p.

Brown, L., 1951b, Cleopatra slept here: Dodd, Mead, New York, 248 p.

Brown, L., 1958, Bring 'em back petrified: Robert Hale, London, x + 224 p.

Bunbury, F.J., 1894, Life, letters and journals of Sir Charles J.F. Bunbury, Bart.: Privately published, London, 3 vols., 571 + 582 + c. 570 p.

Bush, H., 1967, Mary Anning's treasures: Gollancz, London, 128 p.

David, Mrs. E., 1899, Funafuti; or, three months on a coral island: an unscientific account of a scientific expedition: Murray, London, xv + 318 p.

Hahn, E., 1970, Times and places: Crowell, New York, 304 p. [Chapters published as articles under various titles in the *New Yorker* between 1937 and 1969].

Hall, R.H., 1977, Marie Stopes; a biography: Andre Deutsch, London, 351 p.

Maude, A., 1924, The authorized life of Marie C. Stopes: Williams & Norgate, London, 226 p.

Maude, A., 1933, Marie Stopes; her work and play: Peter Davies, London, and Putnam, New York, 299 p.

McPhee, J., 1983, In suspect terrain: Farrar Straus Giroux, New York and McGraw-Hill Ryerson, Toronto, 210 p. [Chapters published, as "Annals of the Former World in Suspect Terrain", in the *New Yorker* during 1982].

Smith, I. Fothergill, 1981, The stone lady. A memoir of Florence Bascom: Bryn Mawr College, Bryn Mawr, Penn., 49 p.

Somerville, Martha, 1873, ed., Personal recollections, from early life to old age, of Mary Somerville, with selections from her correspondence: Murray, London, iv + 377 p.

Stopes, M.C., 1910, A journal from Japan. A daily record of life as seen by a scientist: Blackie, London and Glasgow, xiv + 280 p.

The 1740 Description by Daniel Tilas of Stratigraphy and Petroleum Occurrence at Osmundsberg in the Siljan Region of Central Sweden

By Hollis D. Hedberg
American Association of Petroleum Geologists, Tulsa, Oklahoma
93 p., 1988; $18 US

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Hollis D. Hedberg is justly renowned among stratigraphers world-wide through his major contributions to the development of an international philosophy for the standardization of the nomenclature of zones, stages and other lesser or larger lithostratigraphic and chronostratigraphic units. He has been a revered and efficient member of many international geological commissions and an effective speaker at gatherings of geologists, public or private. He is indeed one of the handful among us who can truly claim to have altered the lineaments of our science, again and again trimming away fuzzinesses of terminology and concepts to produce clearer words and thoughts.

Daniel Tilas (1712–1772), in contrast, must nowadays be remembered by few geologists outside his native Sweden; yet he was a comparably major figure in the eyes of his contemporaries. He was a mining engineer and geologist in the employ of the Bergskollegium, Stockholm, a state organization having jurisdiction over the whole Swedish mining industry. The Sweden of his time incorporated what is now Finland; Tilas worked in both those countries, served on the commission defining the boundary between Sweden and Norway, and made professional visits to Lapland, Norway and Russia.

During most of his life, Tilas was engaged in geological mapping; and it was a tragedy for our science when the still-unpublished fruits of years of this labour were destroyed in a fire at his home in 1751. In his published addresses to the Swedish Academy of Sciences (notably *Stenrikets Historia*, 1742), the philosophies that are expressed accord with contemporary biblicist views of the generation of the Earth and its rocks; yet Tilas displays a considerable originality of perception and deduction that rank him among the foremost Earth-observers of his time.

The brief work, here translated and analysed, epitomizes Tilas' achievements, showing him to be a pioneer of lithostratigraphic correlation. Moreover, he was an early and careful observer of petroleum occurrences in a region now of particular interest because of the theory that its hydrocarbons are abiogenic, produced in shattered basement rock by the impact of a Devonian meteorite.

The book is readable and well illustrated. Tilas' original text is reproduced in facsimile, while his achievements are analysed and set into the perspective of earlier and subsequent geological studies of this area of Sweden. A useful geological map and section, plus a diagram illustrating the meteorite-impact hypothesis, embody present interpretations usefully; and full references are given.

This, then, is an admirable presentation of a significant work by a neglected figure in the history of geology. My only reservations are that I would have welcomed a somewhat fuller biography of Tilas and that I could find no justification for the awkward book shape chosen by the publishers — 25 cm [10 in.] wide by 21 cm [8 in.] high — a shape that makes this volume harder to handle and more difficult to shelve properly. For that, I am sure, the editors, and not the author, are to be blamed!

Coon Mountain Controversies. Meteor Crater and the Development of Impact Theory.

By William G. Hoyt
University of Arizona Press, Tucson
443 p., 1987; $40 US

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The brief descriptions of scientific discoveries that are embedded, like sultanas, amid the soggy suet pudding of school science textbooks give a highly romanticized picture of scientists and the advance of science; yet it is a picture that proves curiously difficult to discard. Even after adulthood and an advancing awareness of the realities of life have brought a reluctant recognition that one can rarely make a clear-cut choice between right and wrong or between truth and falsehood, one cherishes the idea that *scientists*, at least, can do just that — yes, even after one has become a scientist oneself! Similarly, one cherishes the concept that the true discoverers — the Lavoisiers, the Priestleys, the Darwins and the Wegeners — were gifted with crystal-clear intellects transcending those of normal humanity, permitting them to ascertain eternal verities known hitherto only to God and to present these lucidly, for detached consideration and swift, admiring acceptance by their somewhat less gifted (but nonetheless pure-minded) fellows in investigation and intellect.

Alas for such illusions! The truth is, of course, very different. New ideas have been very often based upon quite irrational prejudices or upon wrong readings of facts. They have been quite frequently introduced by persons only to be described as cranks, doggedly adhering to their theories despite the derision of their contemporaries. (Moreover, the derision has quite often continued even after the validity of those theories has been demonstrated.) Minor scientists have made great discoveries; great ones, great blunders. Important truths have been frequently attained, not in a single moment of scintillant vision, but by the patient accumulation of contributory data over many years. Yes, some theories — the phlogiston theory is an example — have been eventually discarded *in toto*, though their temporary acceptance may well have contributed, in itself, to the discovery of some scientific truth. Other theories, though contemptuously discarded for decades, turn out disconcertingly to be applicable under specific, if unusual, circumstances; Lamarckian evolution is an example. Science is not a linear progression from ignorance to knowledge; rather, it is like a heaping-up of stone blocks to try to climb a high wall, with some piles remaining stable and enabling an ascent, others crumbling under the climber so that he does not get there — and with some of the most promising-looking stone-heaps proving the most unstable!

As the distinguished US meteoriticist Eugene Shoemaker points out in his introduction to this work (p. xii):

> As an account of the growth and evolution of a scientific idea, it is...of great interest as a case history of how science actually works, as opposed to idealized and misleading concepts of how science "ought to work".

Since its first discovery, controversies have swirled about the elevated crater once called Coon Mountain, subsequently given several other appellations, and since 1946 officially named "Meteor Crater" (p. 334). These have been so vigorous, and in the last analysis so scientifically productive, as to make this little Arizona hill arguably the most significant geological feature on Earth in terms of its contribution to our understanding of planetary evolution.

This history shows how so truly distinguished a geologist as Grove Karl Gilbert could consider, and firmly reject, the true explanation of its origin, through evidence that misled him or that he misunderstood (p. 45, 50-51). It shows also, depressingly, how his successors in the US Geological Survey refused to admit the truth, simply because it might bring discredit upon their distinguished predecessor — even when, as George P. Merrill did, they fully perceived the significance of new evidence. It tells how a comparative amateur in geology, Daniel Moreau Barringer Sr., adhered doggedly to his basic thesis concerning the crater's origin, despite repeated revisions of interpretations and re-marshallings of evidence forced upon him by the discoveries of others. (Though Barringer did eventually secure acceptance for his long-cherished views, that came only after enormous cost to him in both monetary and personal terms.) It recounts also how Barringer's other cherished idea — that, buried in the crater, there was a multi-million-ton metallic meteorite — was either not correct or, if correct, is still awaiting substantiation sixty years after his death. (The geophysical evidence remains ambiguous, even now [see p. 327- 330]). It portrays a scientific community divided down the middle, with many welcoming the meteorite hypothesis — among them Herman LeRoy Fairchild, John C. Branner, Edmund Otis Hovey and the distinguished physicist Elihu Thomson — and as many defending the volcanic hypothesis — among them L.A. Fletcher of the British Museum (Natural History), F.N. Guild of the University of Arizona, Charles R. Keyes and Nelson Horatio Darton. No ready acceptance by disinterested peers, this!

It shows astronomers and physicists locked in combat on a whole series of questions — the entry speeds of meteorites into the atmosphere; the degree of atmospheric retardation; impact with or without explosion; liquefaction or volatilization of rocks impacted; the relation between crater shape and the angle of incidence of the meteorite; and the whole physical process of crater formation — which, even now, are far from being resolved. Indeed, neither the size of the meteorite — if it *was* a single meteorite and not a cluster of smaller ones — nor the date at which the event occurred, have yet been definitely resolved. Present estimates of the weight of meteoritic material fall far below Barringer's hypothesized value — probably less than 300,000 tons and perhaps much less — but they remain no more than vague approximations. The age of the crater appears much greater than he supposed, somewhere between 22,500 and 50,000 years; but that also is, even now, little better than speculation. The controversies over Coon Mountain are far from attaining any final resolution.

If so much remains uncertain, how can the study of this Arizona hill have contributed so significantly to science? Well, first of all, because it has demonstrated that there are indeed, on the surface of this our Earth, large scars produced by the impact of extra-terrestrial bodies. That the crater was formed in this fashion was, as I have noted above, long disputed. The idea that it was a topographic product of glacial action was early advanced, but speedily discarded (p. 44). Gilbert thought it to have been formed by an explosion of volcanic steam (p. 46) and many other geologists agreed with him. William P. Blake of Yale considered it a limestone sinkhole (p. 108). He was by no means unique in that odd belief, Eduard Brückner of Vienna and Eugene de Cholnocky of Hungary being among its other supporters (p. 148-150). Even those accepting that there had been meteorite impact could not agree how the crater was actually formed. Warren Upham suggested that rock pre-heated by vulcanism was caused to explode by a "falling star" (p. 52), while Herman L. Fairchild thought meteorite impact might have triggered the explosion of steam hypothsized by Gilbert (p. 114). Only slowly, over more than forty years, did it come to be accepted that the crater was a product of meteorite impact alone.

With a precedent thus established, other features elsewhere on Earth came to be recognized as having a similar genesis — the Odessa crater in Texas (p. 223), the craters on Ösel, an offshore island of Estonia (p. 250), the Tunguska phenomenon in Siberia (p. 250); and many more. The presence of the high-temperature mineral lechatelierite (p. 112) or the stress-generated mineral coesite (p. 343) in marine sediments or igneous rocks originally formed under low-tem-

perature, low-stress conditions, together with the discovery of shatter cones with apices directed upward (p. 351) or of concentrically arranged impact structures (p. 348-349), gave evidence of meteorite impacts in other regions. By 1963, some eighty large-scale astroblemes ("star scars") had been identified upon Earth; and more have been recognized since, with varying degrees of confidence. It has even come to be hypothesized that extra-terrestrial causes might account for that most famous of terrestrial non-events, the cataclysmic extinction of the dinosaurs! (p. 345).

From the outset, a parallel had been drawn between the structure of the Coon Mountain crater and the craters of the Moon. These had been long considered of volcanic origin, an idea first propounded by Robert Hooke as early as 1665 (p. 9). The alternative concept, that they might be the product of meteorite impact, was formulated in Germany before 1815 (p. 21) and was given strong support by English astronomer Richard A. Proctor in 1873. The absence of terrestrial analogies had, indeed, been the main obstacle to acceptance of that newer concept. Coon Mountain furnished the analogy and thus enabled a re-thinking, not only of the topography of the Moon but also of the mode in which the whole solar system originated. Yet, as the space probes and Moon landings have shown beyond argument, vulcanism has played a very major part in shaping the Moon and the other planetary bodies — volcanic eruptions have, for example, been directly observed on Jupiter's satellite Io (p. 366). Hooke and his successors were also right.

This meticulously prepared and lucidly written work will surely prove the definitive account of one of the most stimulating intellectual confrontations in the whole history of the earth and planetary sciences. I can recommend it without reservation.

Labrador Sea Basin Atlas

J.S. Bell, Co-ordinator
Geological Survey of Canada
Atlantic Geoscience Centre
Dartmouth, Nova Scotia
112 p., 1989; $135 (institutions & libraries), $65 (individuals)

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Established in 1984 by the Geological Survey of Canada (GSC), the Frontier Geoscience Program was designed to contribute to the knowledge of the frontier petroleum basins of Canada. A priority of the Program is the publication of results in a timely and useful way, with one of the most important outputs being the East Coast Atlas Series. The present Atlas of the Labrador Sea Basin is the first of the Series to be released. The Atlas is designed to provide a synthesis of the current geological knowledge in a format which is useful to a range of users.

The Labrador Sea Basin is defined by the coastlines of Labrador and Greenland and the lines of latitude at 50°N and 62°N. It is a simple rifted ocean basin.

Reconnaissance seismic surveys conducted by the Bedford Institute of Oceanography in 1965 and 1969 indicated the presence of a third marginal sedimentary wedge with the potential for petroleum accumulations. Petroleum exploration permits were awarded to industry in 1966, leading to increased exploratory activity by both industry and government. The first well was drilled in 1971 and between that date and 1985 some 30 wells were spudded with 28 reaching significant depths. Five gas pools were discovered and one well found a small quantity of oil. The harsh operating conditions on the Labrador Shelf and poor economics for gas located so far from major markets have led to the cessation of industry activity in the area.

While exploration over the past two decades has not yielded any commercial hydrocarbon developments, it has provided more than 80,000 linear kilometres of multichannel seismic surveys, as well as logs, cores and samples from 28 wells. In addition, there is a large database of regional potential field, single-channel seismic, side-scan sonar, bottom samples and drilling results from the DSDP and ODP holes in the Labrador Sea.

The compilation and synthesis of data for this Atlas were done over a 24-month period between April 1986 and March 1988 and involved many contributors from government, industry, academia and the consulting business. Co-ordination and stimulation of this effort were the responsibility of Sebastian Bell of the Bedford Institute.

The size of the intellectual effort represented by this Atlas is matched by its physical size. This is a large book measuring some 75 cm × 53 cm and consisting of 112 pages, most of which are double page-size fold-out maps, cross-sections, block-diagrams, stratigraphic tables and other illustrations. Accompanying text is often placed on the back of the relevant illustration making the correlation of words and pictures somewhat awkward.

The text is clearly written and to the point and the style is remarkably consistent, considering the large number of contributors. References are given at the end of each section of text as well as in a complete reference section at the end of the book. The text is in both French and English.

In organization, the Atlas starts with general illustrations of the seismic coverage and bathymetry, then works through the stratigraphy from the Quaternary to the bedrock geology. Thematic topics include lithostratigraphy, biostratigraphy, structure, isopach facies, paleogeography, geochemistry, geophysics and sea-floor spreading. The quality of the illustrations is high.

In producing this Atlas, the GSC states that it has made a conscious compromise between timely publication and extensive internal review. In my view, a good balance has been struck and a valuable contribution has been made to earth science. In terms of process, it is instructive and refreshing to see the very positive results of government, academia and the private sector working together for a better understanding of a large number of fundamental scientific factors. The price of the Atlas is $135 for institutions and libraries, and $65 for individuals. Map sheets are available at $5 each. At these prices this Atlas is excellent value.

I look forward to the publication of the other Atlases in this series, the schedule for which is:
Scotian Shelf Margin: February 1990
Grand Banks & Margin: August 1990
Hudson Bay & Gulf of St. Lawrence: 1991/92.

Short History of Vertebrate Palaeontology

By Eric Buffetaut
Croom Helm, London
222 p., 1987; $59.95 US, cloth

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In 1918 Richard Swann Lull attempted, in a paper of less than thirty pages, to epitomize the history of vertebrate palaeontology. Since that time, though Joseph T. Gregory has assayed the task for North America (1979) and though histories of research on dinosaurs and human origins have appeared, no one else has again attempted it on a global scale. This book thus fills a vacant niche in scientific literature. However, it should be stressed at the outset that, despite the all-embracing title, the period of coverage is essentially the same as in Lull's account, *i.e.*, from the beginnings to around 1914. Only a very brief last chapter surveys some subsequent developments.

Within this compass, Eric Buffetaut's survey must be rated very highly indeed for its readability, its lucidity of comprehension and, in particular, its freedom from national prejudices — a quality which, dare I say, is not evident in earlier works by other French authors on the history of the earth sciences! It is especially valuable for its account of the development of the less fashionable branches of vertebrate palaeontology — palaeoichthyology, the palaeoherpetology of marine reptiles and the smaller terrestrial amphibians and reptiles, and palaeomammalogy.

The coverage of vertebrate palaeoichnology is less satisfactory. Though the history of *Chirotherium* is discussed (p. 93-95) and Edward Hitchcock's work in the Connecticut valley gains mention (p. 125-126), nothing is said about the earlier and scientifically more crucial discoveries in Scotland (see Sarjeant, 1974, 1987). Moreover, the true significance of William Logan's discovery of Carboniferous footprints in Nova Scotia (p. 170) — providing, as it did, the first direct evidence for the existence of terrestrial vertebrates in the Palaeozoic — is allowed to pass unrecognized (see Sarjeant and Mossman, 1978).

In a work with so broad a canvas, any knowledgeable reader must inevitably find a few points to cavil at or perceive a few small gaps in the author's knowledge of relevant scientific literature, extremely sound though that is. Though quoting the Chinese name for the mammoth and their interpretation of the animal as a gigantic mole (p. 18), Buffetaut does not note that its name derived from the native Siberian name *Mamant*, for what was believed to be a giant rat capable of surfacing, and devouring unfortunate Tunguska families, when the night was sufficiently dark! (Digby, 1926, p. 17, 77, 79). In the account of the early descriptions of ichthyosaurs (p. 77-78), the influence of Cuvier and Joseph Pentland is ignored (see Delair and Sarjeant, 1976); nor does Pentland's early work on fossil bones from Australia, which amply predates that of Richard Owen (see Sarjeant and Delair, 1980), gain any mention. A textual ambiguity (p. 143) suggests that the term "coprolite" had a commercial origin, which is not the case (see Amstutz, 1958); the term is not defined and nothing is said about the information on the diet and anatomy of extinct animals that can be gained from study of fossil excreta. *Sivatherium*, though undoubtedly a giraffid, is surely too distinctive a creature, with its short neck and massive horns, to be dismissed (p. 70) as "a fossil giraffe." More importantly, the bibliography is not very fully presented, books often being given incomplete titles and lacking any citation of publisher's names or pagination.

However, this is a work which merits few such carpings and much praise. Any reader will surely learn much from it. It is salutory to be reminded that, though Johann Jakob Scheuchzer is remembered mostly as the victim of a cruel hoax, he was also a pioneer worker on fossil fishes and the first to report them from North America (p. 27). Buffon's early recognition of extinction (p. 41) — an idea that was anathema to his contemporaries — and Defay's more precise perception of the reality of that process (p. 46-47) gain proper stress, as do the conceptual refinements resulting from Johann Friedrich Blumenbach's categorization of fossil remains (p. 50-52). Louis Agassiz's studies of fossil fishes are well known, but his use of them in palaeoclimatic reconstruction (p. 87) has been unjustly forgotten. In contrast, Marcellin Boule's derogation of German palaeontologists (p. 193) perhaps might be better forgotten!

All in all, this is an admirable work which deserves to be on the shelves of anyone interested in the development of our concepts of the life of the past.

References

Amstutz, G.C., 1958, Coprolites; a review of the literature and a study of specimens from southern Washington: Journal of Sedimentary Petrology, v. 28, p. 498-508.

Delair, J.B. and Sarjeant, W.A.S., 1976, Joseph Pentland — a forgotten pioneer in the osteology of fossil marine reptiles: Dorset Natural History and Archaeological Society, Proceedings, v. 97, p. 12-16.

Digby, B., 1926, The mammoth and mammoth-hunting in North-East Siberia: Witherby, London, 224 p.

Gregory, J.T., 1979, North American vertebrate paleontology 1776–1976, *in* Schneer, C.J., ed., Two hundred years of geology in America: University Press of New England, Hanover, New Hampshire, p. 305-335.

Lull, R.S., 1918, The development of vertebrate palaeontology, American Journal of Science, v. 46, p. 193-221.

Sarjeant, W.A.S., 1974, A history and bibliography of the study of fossil vertebrate footprints in the British Isles: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 16, p. i-iii + 265-378.

Sarjeant, W.A.S., 1987, The study of fossil vertebrate footprints. A short history and selective bibliography, *in* Leonardi, G., ed., Glossary and Manual of tetrapod footprint palaeoichnology: Departamento Nacional da Producao Mineral, Brasilia, Brazil, p. 1-19.

Sarjeant, W.A.S. and Delair, J.B., 1980, A Irish naturalist in Cuvier's laboratory. The letters of Joseph Pentland 1820–1832: British Museum (Natural History), Bulletin, Historical Series, v. 6, p. 245-319.

Sarjeant, W.A.S. and Mossman, D.J., 1978, Vertebrate footprints from the Carboniferous sediments of Nova Scotia; a historical review and description of newly discovered forms: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 23, p. 279-306.

Dinosaur Plots and Other Intrigues In Natural History

By Leonard Krishtalka
Morrow, New York
316 p., 1989; $17.95 US

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There is a tendency for professional scientists to profess a disdain for the successful popular writers on their disciplines. This reaction has rather complex roots. In part it reflects a straightforward inability to appreciate such works; quite a few scientists nowadays read only the texts relevant to their teaching or research and do so little leisure reading that their minds become incapable of changing gear. In part also, it embodies the feeling that a good scientist involved in such writing is wasting his time and ought to be engaged instead in "serious research" — an attitude carried to an extreme when used as an argument that such writings should not be considered as qualifications for employment or promotion. Howver, there is also a component of envy — envy of colleagues able to write so easily and so lucidly, envy of the

reputation thus gained with a general public inexplicably (to the scientist) unable to appreciate his own, more weighty contributions or to give them the high regard that — unlike these trivia! — they surely deserve.

Yet such disdain is not merely discreditable to the scientist who expresses it, but also reflects a serious misassessment of the very real importance of such popular writings. All scientists depend, for the funding of their investigations, upon sources provided by non-scientists. In the last thirty years, we have seen a transformation in the fashion in which science is conceived, from an exuberant post-Second World War view that science provided the leading edge for the advancement of humanity from barbarism to higher things to the current, very widespread attitude of deep distrust of scientists — a feeling that they have been the cause of many of the World's present ills and are all too likely to precipitate future disasters. In such an essentially adverse climate of opinion, writers who can explain what is happening in science — and, in particular, writers who can transmit to the public at large a sense of the fascination and sheer excitement of scientific research — are more valuable than gold.

In the field of geology and palaeontology, yes, there *have* been a number of such writers, but never enough of them. Perhaps the first was Gideon Mantell, whose early nineteenth century writings — such as *The Medals of Creation* and *Thoughts on a Pebble* — revealed to his contemporaries worlds hitherto unknown. Another was Hugh Miller, a Scot who wrote so lucidly that he could make a book formidably titled *The Old Red Sandstone* into a best-seller of its mid-nineteenth-century time. In this century, one thinks of Haroun Tazieff's lively writings on volcanoes and earthquakes, mostly in French but several also in English translation; Willy Ley's elegant essays on aspects of palaeontology, in collections like *The Lungfish, the Dodo and the Unicorn* (1948) and *Dragons in Amber* (1951); and occasional writings by such other authors as Catherine and Sprague de Camp, Mildred and Carroll Fenton, Richard Carrington, Edwin Colbert and Björn Kurtén. Recently Stephen Jay Gould's columns in *The Smithsonian* (subsequently assembled into a series of attractively titled books) have, though not reaching out so far into the popular field as his predecessors, served to enlarge the intellectual horizons of many readers.

This reviewer must confess that he does not see *Carnegie Magazine* and has thus not had the pleasure of reading Leonard Krishtalka's column "Missing Links". *Dinosaur Plots* represents the first collecting of Krishtalka's essays into a book; and I trust there will be many others to come! It is a pleasure to discover that, though domiciled south of the border, he is a Canadian and thus able to incorporate cheerful references to Ontarian geology, the Montreal Expos and Montreal Canadiens into his entertainingly erudite and wide-ranging writings.

Articles in this collection review the creation of the calendar and its geochronological implications; the *raison d'être* of the Linnaean system of taxonomy; the growth of our knowledge of the mammoth; the art of Palaeolithic man and the much later art of the restoration of dinosaurs; the absurdities of creationism; the taxonomic problems presented by colugos, hyraxes and other "offbeat" mammals; the ridiculous allegation by Sir Fred Hoyle that *Archaeopteryx* was a scientific forgery; and a calm and reasonable assessment of the much-less-reasonable cluster of speculations concerning that outstanding geological non-event, the cataclysmic extinction of the dinosaurs. Krishtalka's literary allusions and mentions of personal experience enliven all these themes and are both entertaining and enlightening.

It is good, therefore, to add this new Canadian name to the all-too-brief roster of the popularisers of our science. We live in an age of increasing competition for funds and a dismaying tendency to view financial profit, when assessing whether such funds should be awarded, as the only criterion worthy of consideration. To counteract that attitude, writers like Krishtalka are of vital importance. Such writings as his enable readers to share in the pleasure and exhiliration of scientific investigation. Consequently, they serve as reminders of two facts that are forgotten nowadays — that a reaching-out of the mind is a pleasure transcending most others and that the pursuit of knowledge *for its own sake* should continue to be a prime aim, if humanity is to continue to advance.

Large conclusions, maybe, from such a light-hearted book — for indeed, the book is fun. Do read it and be captivated! And if you're *not* — well, I'm sorry for you.

Corridors of Time

By Aubrey Kerr
Privately published, Calgary, Alberta
(Available from S.A. Kerr, 912-80th Avenue S.W., Calgary, Alberta, T2V 0V3)
331 p., 1988; $28.95

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This work brings together a series of essays on the history of geology and petroleum exploitation in western Canada and Alaska, published originally in the *Journal of Canadian Petroleum Technology*. The series begins with a brief history of the pioneer work of the Geological Survey of Canada in the Western Canadian Oil Patch that sets a vigorous tone for the writings to follow (p. 2):

> All those hairy-chested free enterprisers who bitterly opposed Petro-Canada's entry (some say intrusion) into the oil patch should consider Ottawa's little-known, but significant, role in the very early history of frontier oil exploration. Men of determination and persistence, who were years ahead of their time, nearly catapulted the Northwest Territories into the embryonic oil world of the 1890's. These were *public servants*, officers of the Geological Survey of Canada (GSC), not entrepreneurs. Yet their collective prescience should be remembered and respected by today's harried oil finder.

Indeed, the liveliness of these writings throughout provides a pleasant sugar for the many valuable pills of history that are administered to the (soon) unreluctant reader. An assessment of the effect of the Petroleum Incentives Program between 1904 and 1925 leads to musings on the National Energy Program, so unbeloved of Albertans. A brief account of the boom at Oil City, down there on the U.S. border amid what is now Waterton Park, and a discussion of the influence of the Royalite company in the development of Alberta's Turner Valley field serve as prefaces to a series of short but always lively histories of petroleum exploration and production in different regions of that province, Saskatchewan and the North Slope of Alaska.

Several figures in these sagas gain extended consideration — S.E. Slipper, the pioneer petroleum engineer in western Canada; Theodore "Ted" Link, structural geologist and oil-finder; Arthur G. Spooner, who made his money by wasting his natural gas; and "rockhound" Frank Fournier. There are also some good-humoured excoriations of federal fumblings and a few firecrackers thrown at politicians and businessmen whose acquisitiveness outran their acumen.

Episodic, maybe; but entertaining and informative for all who find fascination in the history of the exploitation of one of this Earth's greatest resources — a history that, at times, makes the television series *Dallas* seem merely a heavily censored documentary!

Caravan Across China. An American Geologist Explores the Northwest.

By J. Marvin Weller. Edited by Harriet Weller
March Hare Publishing, San Francisco
394 p., 1984; $14.95 US, paper

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The past hundred years have, as we are all aware, seen more scientific and technological changes — some of them advances, some decidedly not! — than had occurred in all of human history prior to that time. The acceleration of pace in the development of the earth sciences has quite matched, perhaps even exceeded, that in the other sciences. When I was young, even the most up-to-date atlases and globes featured several blank white spots indicating regions not yet explored, while the maps of oceans showed many islands whose names were suffixed by the letters E.D. ("Existence Doubtful"). Nowadays, observation from space has allowed all coasts to be charted and has confirmed or denied whether such islands presently exist. Geological maps were then full of especially large blank areas; indeed, for many countries, there were no maps at all. Nowadays, virtually all the blanks have been filled in, at least in general terms. Even the submarine geology of the ocean floors, then virtually unknown, is now comprehended in such detail as to have changed our whole concepts of earth evolution.

Sometimes one must wonder whether, for geologists in particular, these changes have been wholly beneficial. Instead of being out in the field, examining rocks at outcrop, we see them mostly either in dusty core laboratories or merely as figures from automatic analyses or lines traced by geophysical instruments. The healthful outdoor life of our predecessors can seem very enviable to those spending their days in the sedentary contemplation of square charts and oblong screens: the obituary notices of the tough old "field men" have a wry quality for us, when printed alongside other obituaries of younger geologists who have succumbed to executive stresses well before reaching retirement age.

Yet — were those past times quite so much a "golden age" as they may sometimes seem to us? To read the book here reviewed is to be caused seriously to wonder. It has been carefully put together by his daughter from an inheritance of very detailed letters sent to his family by the US stratigrapher and invertebrate palaeontologist James Marvin Weller (1899–1976). These letters record a spell of field work in China that lasted a mere fifteen months, from February 1937 to April 1938. Within that short time, however, so many frustrations were encountered, so many discomforts endured, and so many perils survived as to make the present life of us geologists seem decidedly enviable!

Dr. Weller went to China under the auspices of the Standard Vacuum Company of New York, to quest for petroleum in an area of northwest China — Kansu, Tsinghai and Szechwan Provinces — where a group of wealthy Chinese businessmen had secured an oil concession. He was, at that time, employed by the Illinois Geological Survey, being given leave of absence to undertake this geological exploration. His principal companions were another American, Standard-Vacuum geologist Fred Sutton, and a Chinese official oddly named Irving Suez, with whom the two Americans were to develop a love-hate relationship during their journeys and whose disinterestedness they were given good reason to distrust.

The frustrations began early. They arrived in Shanghai on the thirteenth of March, but, because of delays in securing field assistance and necessary travel documentation in a country already torn by internal political conflicts, they were unable even to get on the road to their field area until early July. Thereafter they suffered from travelling conditions that were never easy and often appalling; much poor food, and at times a virtual lack of it; accommodation varying in quality from indifferent to awful — there are graphic accounts of the effects of lice and bed-bugs (p. 164, 177); the hardships imposed by a bitterly cold winter (p. 263, 267); the many frustrations caused by ignorant officials and petty bureaucracy; a recurrent uncertainty as to what particular warlord had authority in the region through which they were travelling, in a country where centralized authority had almost ceased to exist; and the menace, real or imagined, of robber bands (p. 165, 170). Moreover, throughout those months the Japanese menace was looming ever larger. The letters record the early attacks on China almost casually (p. 171-172, 183, 184-185). However, as air-raids become ever more frequent, the letters portray an increasing anxiety, not only about the prospect of returning home but about sheer survival (p. 210-211, 214-215, 233, 251, 277-278, 280, 282, 284-285, 289-291, 295-296, 308-309, 314, 318, 321, 323-327). All in all, though certainly an adventure, this was an experience that one cannot envy.

Yet there were compensations — the sight of the further reaches of the Great Wall of China (p. 191, 193, 226, 270-271); journeys to the Caves of the Thousand Buddhas (p. 247-250) and the sacred mountain of Omei Shan (p. 352-361); visits to Chinese theatres; and an occasional excellent meal, or comparatively comfortable hotel, whose pleasures were much enhanced by contrast with their customary grim experiences! Moreover, this was virtually a virgin area for geologists. Their identifications of Permian, Triassic, Jurassic and Tertiary strata and fossils helped to fill in a major gap in World geological knowledge. Again frustratingly, the maps and reports they produced were destined never to be published. However, their discovery of an oil seepage in the Shih Yu Ho anticline near Yu Men led, in February 1939, to the drilling of a first well that was soon producing twenty barrels a day — more than the entire annual Chinese production at that time — and presaged a later, vast expansion that made this China's first major oilfield.

The book is illustrated with clear maps and with photographs that are now of great historical value. Proof-checking could have been better — errors noted include "deisel" (p. 10); "Scharenhorst" (p. 27); "caligraphy" (p. 53); "innacurate" (p. 97); "Prophylitic granite" — surely "porphyritic"? (p. 181); "Sasson" — surely "Sassoon"? (p. 168); and "suprises" (p. 243) — but, in general, the transcription of the letters has been done very competently. The book's greatest weakness is its lack of an index; if a second edition is published, one should certainly be added to facilitate reference-tracing in a complex text.

All in all, this work is a fascinating and valuable historical document. Since the letters were written, China has changed beyond measure and the methodology of geology quite as much. Ms. Weller deserves great credit for her daughterly devotion, which has given us this intriguing depiction of a vanished epoch in the earth sciences — even if, at the same time, it has somewhat tarnished our image of that supposed geological "Golden Age"!

Digging Into the Past. An Autobiography.

By Edwin H. Colbert
Dembner Books, New York
456 p., 1989; $25.00 US

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Edwin Colbert is the Nestor of North American vertebrate palaeontologists. He is known to us affectionately as "Ned" and is, in admirable defiance of his years, still regularly encountered at gatherings of dinosaur experts or on field trips into the badlands that he has loved so well for so long. A few years back, he published a delightful *pot-pourri* of reminiscences entitled *A Fossil-Hunter's Notebook. My Life with Dinosaurs and Other Friends* (Dutton, New York, 1980). Tiresomely, this went out of print with such singular speed that, even though ordering a copy

immediately upon reading an early review, I could not obtain it; and I owe my copy entirely to the generosity of a former research assistant.

As it proves, the *Notebook* was but a prelude to the more substantial and satisfying autobiography here considered. There is some overlap between the two works, especially in their later chapters, but not enough to mean that the earlier book is rendered redundant reading by the later. There is perhaps a greater overlap of photographic illustrations than might have been desirable, but the quality of reproduction in the newer work is markedly better and lively drawings by Margaret Colbert serve to enhance its text.

The accounts of eminent contemporaries of earlier days are fascinating. Ned Colbert's relationship with the wealthy and arrogant, but highly talented and (in his fashion) generous Henry Fairfield Osborn, could cause frustrations:

> [My diary reads] "The day was spent at the Museum. Most of the time was spent with HFO, consequently little was accomplished. I did manage to get in some work on Siwalik pigs." "Little was accomplished." How true this was of so many of the hours that I spent with Professor Osborn — hours devoted to rehashing problems that already had been worked over to the point of exhaustion, hours spent in futile arguments, hours in which it seemed to me we were running, like the Red Queen, and staying in the same place.

However, Ned's account of Osborn (p. 142, 160 *et seq.*, 186, 217) is appreciative and generally quite kind.

He notes with incomprehension Arthur Smith Woodward's frustrated desire for the Directorship of the British Museum (Natural History). His comment thereon (p. 199) is endearingly self-revealing and deserves to be a matter for reflection by those with ambitions similar to Woodward's:

> Parenthetically, I have never been able to appreciate this lust for power and position. Yet it is a universal trait, going back to our Paleolithic ancestors and even beyond, as we know when we see the fight for dominance expressing itself throughout the animal world. Certainly being the director of a museum is no sinecure; from what I have seen over six decades of museum experience, it is one long, constant pain in the neck. And what does it avail the person who holds such a position? Within a few years he (or she) is forgotten; the people who are truly remembered are the scholars, the experts who seek out the truth and make the truth known through their activities, and especially through the things they write. It is the same in universities. Question: Who was Einstein? A question almost anyone can answer. Question: Who was the president of Princeton University during the years that Einstein was there?

Also endearing are Ned Colbert's awed admiration of George Gaylord Simpson, "scientifically speaking...up in the stratosphere" (p. 144); his respectful quotation of the inscription on Charles Lyell's grave (p. 184); and his amused descriptions of that brilliant scientist and unremitting woman-chaser, Robert Broom of South Africa (p. 191-192; 343-344) and his fellow worker on South African fossils, the "delightfully fuzzy" Guy Pilgrim (p. 202-203).

Many other personages are presented vividly to the reader. There are Friedrich von Huene of Tübingen, almost equally renowned as vertebrate palaeontologist and eccentric, with whom Ned had a memorable walk (p. 196-198); the artist Georgia O'Keefe, with her unexpected fondness for bones (p. 292-293); Walter Granger "who became a sort of surrogate father to me" (p. 143-144, 182-182, 244-245); Barnum Brown, almost as talented a showman as his namesake (p. 145, 179); and many, many more.

Most interesting of all, though is the description of Dr. Colbert's own evolution from country boy in humid Missouri to distinguished scientist with an especial love for arid badlands. His account of his entrancement with fossils struck a familiar chord in my own breast, but we differ in that I have no clear idea when or how mine began! I was therefore greatly intrigued by his discussion (p. 108-109) of the varied experiences that had motivated other palaeontologists to enter this particular field of scientific endeavour. Having done so, I'm sure that none of us have come to regret it; and certainly not Ned, whose rich and varied life is here remembered with such continuing gusto and delight.

Alaskan North Slope Geology

Edited by I.L. Tailleur and P. Weimer
Alaska Geological Society and
Pacific Section of the Society of
Economic Paleontologists and Mineralogists
874 p., 1987; $48 US, paper

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Alaskan North Slope Geology is a collection of papers and abstracts on a variety of aspects of the geology, geophysics and geochemistry of the northern half of Alaska including the Brooks Range and North Slope. It consists mainly of papers and abstracts from a three-day seminar held in Anchorage, Alaska in May, 1985. The papers are in two volumes, soft covered with simple glue bindings. Manuscripts were edited only to establish consistency within the volume.

Alaskan North Slope Geology is divided into eight sections with Appendices. These sections are as follows: *History* – a collection of early geological exploration and of North Slope Oil and Gas Exploration; *Reservoirs* – descriptions of various aspects of known hydrocarbon fields on the North Slope; *Geochemistry* – papers on oil-source correlation, crude oil chemistry and classification, and one on thermal alteration patterns; *Coal, Water and other Resources* – regional papers on coal and water resources and several papers on base metal and precious metal deposits in the area; *Stratigraphy* – a variety of papers on Lower Paleozoic to Quaternary stratigraphy, biostratigraphy, paleogeography, and composition; *Geophysics* – papers on geophysical surveys of permafrost and on paleomagnetism; *Structure* – a mixed bag of papers on structure, tectonics, plutonism, volcanism, geochronology, and correlation; *Synthesis* – two papers on Arctic reconstruction, one on evolution of hydrocarbon habitat and a set of abstracts on general themes. The *Appendices* includes the program of the original Anchorage meeting, senior author biographies, a short section of geographic names used in stratigraphic nomenclature, and Abstracts reproduced from a 1987 Geological Society of America Symposium on "Brooks Range Geology". The volume is full of inserts of historical material, including early maps of Alaska, drawings of early Alaskan scenes and people, and a preface by A.H. Brooks to a geological report of E. de K. Leffingwell on his 1906 exploration of the Canning River Region. The covers of the volumes are each the same — a reproduction of a painting by a well-known geologist M.D. Mangus showing a USGS 1924 Arctic Expedition in the Alatna river area.

Some of the papers which I found interesting were the historical papers, particularly the events leading up to the Prudhoe Bay discovery, a paper on oil-source rock correlations, new information on Lower Paleozoic stratigraphy and biostratigraphy, and papers on the geology of the Doonerak Window. Someone with different interests would cite just as lengthy a list of interesting papers, but they would choose a completely different set. There is a lot of new and important information in these volumes, with something for all geoscientists interested in Alaska and the Arctic.

The light editing has resulted in the relatively rapid publication and, because of this, it includes some papers which probably would have been withdrawn had greater demands been put on the authors. From a practical point of view, this is positive. On the negative side, however, is the fact that many of the papers could have been vastly improved and would be much more understandable and complete with more editing. Regardless of the quality of editing, this publication now stands as the latest word on northern Alaskan geology and it should be a standard reference for anyone interested in northern Alaska or the Arctic in general.