DISCUSSION

The Essentials of Formations

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One of the most important questions that I addressed in my book, *From mineralogy to geology: the foundations of a science 1650-1830* (1987, Chicago: Chicago University Press) was how the study of the earth shifted from a mineralogical to a geological emphasis around the beginning of the nineteenth century. In the mining schools of Germany and Sweden that played such a central role in eighteenth-century studies of the earth, most of the effort went into mineralogy in the broad sense of the term then current, that is into describing the chemistry and lithology of the rocks of the earth's crust. By the second decade of the nineteenth century all that had changed; attention had shifted to deciphering the order of the rocks as a key to the sequence in which they had been formed. Like many other historians of geology, I regard this transition from mineralogy to chronology and history as a key factor in the making of modern geology.

I suggested that this transformation was brought about by Abraham Gottlob Werner and his pupils and their introduction of the concept of the 'formation.' In his *Kurze Klassifikation und Beschreibung verschiedenen Gebirgsarten* (1786), Werner announced that the 'essential differences' between rock masses consisted of their 'mode and time of formation,' thus thrusting the temporal order of the rocks into prominence. He dubbed rocks of the same mode and age of formation *'Gebirgsformations'* ('formations' in English and French') creating a new taxonomic unit based on time not on lithology; his followers, finding a modified form of this concept very fruitful, fanned out across Europe to sort out and correlate the sequence of formations and construct the geological column. With a new historical unit defined, the earth sciences took a historical turn.

Professor Carozzi has recently published a review of my book in this journal in which he takes me to task on a number of issues, the most important of which are:

(1) that since Werner's definition of a 'formation' as a historical unit differs from our modern definition of formation as a purely lithological unit, I am 'anachronistic' in using formation in the Wernerian sense and

(2) that I have 'truncated' Werner's definition of formation 'in an unscholarly manner' that obscures its real meaning.

These are strong claims. Professor Carozzi is not merely disputing my interpretation of the evidence. That I would expect and welcome because history, like science, progresses through controversy that clarifies issues. Instead he suggests to the reader that my book can be dismissed out of hand. Hence I feel compelled to respond.

On the first point, provided that usage is clearly defined as it was in my book, it is not anachronism but perfectly common and correct historical practice to employ terms in the sense in which they were used in the past. Indeed it is often only by reconstructing earlier usage that we can see what was at stake in earlier historical periods, in this case in the transition from mineralogy to geology. The fact that 'formation' later acquired a different meaning is interesting (and it would be an interesting historical exercise to study how this came about) but it is no part of the task that I set myself.

On the second point, provided that the quoted authors' intentions are fairly represented, as they were in my book, it is not unscholarly but perfectly common and correct historical practice to pick out key words for quotation. Prior to discussing Werner's definition of formation, I spent the better part of two chapters setting up the eighteenth-century terminology for classification, identification, and description of the rocks, including the terms 'essential' and 'accidental' characters or properties, and showing that Werner was fully conversant with this technical vocabulary. To recap briefly, Werner, like other natural historians, thought that objects, including rocks, should be classified according to their 'essential' properties, that is, the property or properties that made them what they were and that could not be altered without alteration of the kind of rock itself. All the other properties were 'accidental' in the sense that they could be present or absent without altering the identity of the object. Hence when Werner specified 'time and mode of formation' of the rocks as their 'essential differences,' he meant that rocks should be classified according to these properties. All agreed that the term 'formation' was Wernerian and that a formation was defined by the period of origin. To give just a couple of examples, Alexander von Humboldt (one of Werner's most prominent pupils) defined a formation as "an assemblage of mineral masses so intimately connected, that it is supposed they were formed at the same epoch" and Cuvier and Brongniart defined it as "a group of beds of the same or different nature, but formed at the same epoch."

However, Werner was painfully aware from his mineralogical work that essential characters were often observable only with difficulty if at all; he believed that minerals should be classified by their essential character, their chemical composition, but lamented that the inadequacy of chemical analysis meant that taxonomists had to resort to the indirect method of identifying accidental properties (external features) that they hoped bore some steady relationship to the essential properties. The same was true of rock classification: time and mode of formation could not be directly observed, but lithology (an accidental property) could and it would have to serve. Therefore Werner continued that where rock masses were concerned he had also concentrated "on the classification and characterization of these [essential] differences [of time and mode of formation] according to the nature [lithology] of the rock masses." So far from ignoring lithology, Werner necessarily relied on it heavily in his *Kurze Klassifikation*. Of course, Werner's followers were not zealots blinded by their master's aura. They quickly recognized that lithology was not invariably a reliable guide to time of formation since rocks laid down in different locations at the same time might have different lithologies. This generated a debate about the best way to identify time of formation, and particularly about the reliability of fossils as indicators, that persisted through the 1810s and 1820s in Germany, France and England. But the Wernerian idea that time of formation was the essential character of rocks for the geologist interested in reconstructing the earth's history persisted throughout these debates.

My book addresses many other themes, including the methodologies employed by geologists, the classification of minerals in the seventeenth and eighteenth centuries, the influence of chemistry on the development of geology, the various approaches to the problem of consolidation, the role of mining schools, the development of a Wernerian causal geology and its relationship to the causal geologies of Hutton and Werner, and Lyell's adaptation of methodologies commonly employed in the physical sciences. I would hate to think that Professor Carozzi's review dissuaded readers of this journal from assessing my treatment of those themes for themselves.

Earth Sciences History, v. 8, no. 2, 1989, p. 192

BOOK REVIEWS

Gretchen Luepke, Book Review Editor

DRIFTING CONTINENTS AND SHIFTING THEORIES. *Harry E. LeGrand. 1988. Cambridge University Press, New York. 313 p. Hardcover, $52.50; softcover, $16.95.*

As LeGrand points out, his is an unfinished study in two senses. First, his broad coverage amounts sometimes almost to a catalog and brief description of who held what position when. There is very little detailed reconstruction of arguments or developments, but the book certainly does provide a necessary foundation for such work. Second, LeGrand believes that the "historical task is inseparable from the task of constructing and evaluating frameworks for analyzing and understanding scientific change" (p. 276). And in this, LeGrand contributes far more than do most historians of science. In commentaries at the end of each chapter, he discusses the material he has covered so far in terms of basic rationalist, cognitive, and social models of the development of science. In particular he both casts his treatment in terms of models proposed by Kuhn, Laudan, Lakatos, and Feyerabend, and also provides critiques of those models on the basis of his analysis of the history he has written.

LeGrand considers the hypothesis of drifting continents in its developing versions from "Wegener to Holmes to Hess to Vine-Matthews to Vine-Wilson to McKenzie, Morgan, and others" (p. 255). He concludes that "plate tectonics is the most recent version of a succession of Drift theories and that it is clearly related to those theories" (p. 155), which does not support the view that it involves a radical, discontinuous, irrational Kuhnian paradigm shift. And while he agrees that there is a sense in which cognitive and social interests and struggles are intertwined (he says indistinguishably in a rhetorical flourish a the end of the book, but he demonstrates their distinguishability in his analyses), his own approach depends on his belief that science is, and is best understood historically as, "a problem- or puzzle-solving activity" (p. 269).

What LeGrand adds to previous models of historical understanding of science is a stress on the role of localism, specialization, restricted data-bases, limited interests, modest goals, and the general position of most working geologists outside the concerns of global theory. He shows how, toward the late 1960's, work by geophysicists and marine geologists that supported the Drift hypothesis gradually (and then rapidly) became pertinent to more and more specializations in geology, until a change was made in which the field of Geology based on a pluralism of general programs and global theories was replaced by the field of Earth Science structured around plate tectonics.

One of LeGrand's most striking observations is that the move from a descriptive to a theoretical science--from inductivism to hypothetico-deductivism--is illustrated by the difference between a 1944 textbook that contains "24 full-page and 173 half-page photographs of actual landforms and geological features" as contrasted to a 1976 textbook "filled with symbolic maps, symbolized theories, graphs, and charts...[and] not a single photograph of an actual landform...[showing] the increasing emphasis on geology as an explanatory rather than a descriptive science" (p. 262).

LeGrand's approach is practical in that although he shows how "Partisans of different theories appealed to different facts, interpreted the same data in different ways, argued for different geological methods, and put forward distinctively different views of the history and current state of the earth" (p. 1), and although he acknowledges the logical point that "for any given set of data, there is an infinite or at least indefinitely large set of possible theories compatible with it [a predicament known as the empirical underdetermination of theory]" (p. 221), he says that "in the 'real world' of scientific practice that we are examining, underdetermination in its purest form does not seem applicable. Geologists did not have to have all possible theories to account for ocean-floor data. They had a restricted set of three or four programs and a dozen or so versions of those programs from which to select or on which to build" (p. 222). In a similar vein, when considering the claim that scientific theories might merely be social constructs, he remarks that, after all, "Trenches, ridges, magnetic anomalies, and so forth were not social artifacts" (p. 185). There is a certain tension in his text about this realism, however, as indicated when he remarks about palaeomagnetism that "It was neither the 'raw' specimens nor the 'raw' data which found their way into the literature, but rather specimens and data adjusted according to various theoretical beliefs and expectations. Consider the famous *Eltanin-19* profile. The data from which it was constructed were gathered using a complex network of theories and methodological presuppositions and equipment which itself was a concrete manifestation of theory" (p. 220).

Thus, while insisting that we keep in mind that theories are fact-laden and that facts are theory-laden, LeGrand is obviously confident that both he and the scientists he is studying have in their grips a "real" world about which they can come to agreement about results on rational, cognitive, objective grounds, which results can be distinguished from those imposed by wishful thinking or arbitrary authority. *Drifting Continents and Shifting Theories* goes some distance toward confirming this belief, in that it shows how a theory that many giants in the field believed to be crazy eventually became dominant because adherence to it led to the slow accumulation of more and more comprehensive solutions to global problems than did work in any other guiding research tradition.

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THEORIES OF THE EARTH AND UNIVERSE: A HISTORY OF DOGMA IN THE EARTH SCIENCES. *S. Warren Carey. 1988. Stanford University Press. 413 p. Hardcover. $45.00.*

This book is so diametrically opposed to the central prevailing views on tectonics in the Earth Sciences that it will immediately provoke many readers to either enthusiasm or outrage. It is written by one of the best known gadflies of geology in this century, one who rejects the subduction aspects of plate tectonics and the "Big Bang" theory of cosmology in favor of a universe in self-cancelling equilibrium. Carey is Professor Emeritus of Geology at the University of Tasmania and Honorary Life Fellow of the Geological Societies of America, London, and Australia. His reputation is solidly based on a lifetime of energetic questing and innovative hypothesizing. In a subject that does not often allow time for its practitioners to ruminate on the sources and history of its competing theories, it is fortunate that Professor Carey has taken the time to produce this book. It is passionately written, clearly draws lines of debate, and is copiously illustrated.

The book is at once a history of the development of the main tectonic ideas during this century, a memoir on Carey's evolving geological views, and a sharp protest concerning dogma in science. In his epilogue, Carey writes "the more radical the advance from current orthodoxy, the more certain will it be scorned and rejected. Prestige is the canker of the great because it has been the innovators like Werner, Newton, Kelvin, Jeffreys, Bailey Willis, Gaylord Simpson, and Tuzo Wilson who have led lesser lights into withering rejection of new wisdom."

Carey has been a tender of "the flickering flame" of continental drift long before what he sees as the Kuhnian shift to plate tectonics. For him, however, the tectonics revolution has only gone halfway because it is filtered by "the English-language dogma...(of) the subduction myth." Carey warns the emergent generation of scientists not to expect to be heralded as heroes when they make discoveries but rather to be ready to be treated as "ratbags." He has contempt for the struggle for publication priority and "for the publish-or-perish rat race that rules American science." Such colorful judgments make lively reading but help little towards understanding the underlying epistemological problems.

The contents of the book include retrospective sections which deal with the early philosophical approaches to geology involving the Neptunism of Werner and the uniformitarianism of Hutton and controversy on the age of the Earth between Kelvin and the geologists. There is an interesting account of the development of the continental drift model. Paleomagnetism is credited as the modern seed of the revolution which led to plate tectonics, aided by what Carey calls "American evangelism." He then passes to a detailed description of the expanding Earth hypothesis, which has been central to his tectonic model since a 1956 international symposium at the University of Tasmania in Hobart, when he came to the conclusion that Pangaea required a smaller Earth for its reconstruction.

He then deals with the significant effect of gravity on Earth tectonics and discusses diapirs and orogens. He treats Alpine foreshortening and subduction as myths. The Benioff zone is the boundary of an "upward-thrusting diapir which flows into a bell shape as it rises a hundred or so kilometers" and not, as in the subduction model, the consequence of thrusting of the oceanic plate down beneath the orogen for thousands of kilometers. Global tectonics are explained in terms of global expansion requiring differential angular velocities between polar and equatorial continental blocks and hence torsion on a global scale. In this section, many examples of reconstruction are described. Finally, Carey broadens his palette to cosmology and philosophical speculation concerning a proposed new Newton-Hubble law, gravity waves, and much else.

In summary, the book represents a discussion on an extraordinary range of different subjects; some, such as the expanding earth hypothesis, are set out at depth, some in only a limited way. The major difficulty in critiquing this stimulating string of ideas, in being convinced by the arguments, is the selectivity of the presentation and the unevenness of the analysis. For example, a profound subject such as acceptable models for an expanding universe is discussed in terms of a brief mention of a few sample published experiments. Argument by intuition and analogy is common, with the defense that complex analysis is often less satisfactory than "the simple and naive."

The foundation of Professor Carey's passion is an expanding Earth consisting of eight primary polygonal prisms extending to the core-mantle interface. The boundaries are the tectonically active zones. He appears to believe that the main cause of this expansion is related to time dependence of the value of the gravitational constant G. He gives twelve explicit places of evidence for the expansion concept which together he finds "compelling." In reaction, the judgements of a reader are hindered by sparse and unsystematic references.

It is of special interest to read such an iconoclastic book, with its cry for relief from the orthodox with their fixed beliefs, in the year in which Sir Harold Jeffreys died. For Carey, Jeffreys is a prime example of "a truly great thinker" who, in later years, refused to acknowledge "new discoveries" that would overturn his entrenched dogma. Not surprisingly, the full circumstances require a wider and more analytic treatment than given in this book, as may be demonstrated from internal propositions. Jeffreys could not grant large-scale mantle convection, and favored the Earth contraction hypothesis, because the time-dependent viscous behavior he adopted (satisfying both the simplicity criterion and a fit to crucial direct observations) damped out such motion. Yet Carey agrees with Jeffrey's objection to horizontally sliding plates and sees his error as the same as that of the supporters of "new global tectonics," i.e. unacceptance of expansion of the Earth. Indeed, Carey gives as a benefit of his own work its curtailment of convective circulation. What is ironic here is that several major parts of Jeffrey's work were initially treated by the orthodox as unacceptably radical but later adopted such as the variation in internal terrestrial gravity field, Baysian methods, and the damping effect on Earth eigenvibrations. Like Jeffreys, Carey has had the determination to develop unpopular ideas in the face of opposition or indifference.

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HISTORIA DEL INTERES ANGLOSAJÓN POR LA GEOLOGIA DE ESPAÑA (History of the Anglo-Saxon interest in the geology of Spain). *Estanislao Ribera i Faig. 1988. Consejo Superior de Investagaciones Cientificas, Madrid. 522 p. Hardcover. 4,000 pesetas. (Available from Servicio de Publicaciones, Vitruvio 8, 23006 Madrid, Spain).*

When Estanislao Ribera went to Harvard toward the end of 1947 to work with Professor Kirk Bryan, he was surprised at the apparent lack of interest of English-speaking geologists in the geology of Spain. To verify if this initial impression was indeed correct, he began a search of the literature for publications on the geology of Spain by British, American, and Canadian geologists. His search extended to contributions by scientists of other nationalities, including Spaniards, that had been translated into English.

The product of Ribera's inquiry, the subject of the book under review, is a careful and thorough bibliographic compilation of English publications concerned with the geology of Spain and related subjects. It covers the period between the 17th century and 1950. The selection of 1950 as the limit of the bibliographic search is not entirely arbitrary; it marks, according to the author, the beginning not only of renewal of Anglo-Saxon interest but also a marked increase in cooperation between these interests and Spanish scientific institutions.

The book includes five sections. In the introduction, the author discusses the background, methodology and scope of the study. The second section, almost a third of the book, is a listing of 875 publications by subject in chronologic order. Part Four includes a summary and conclusions; section five is a bibliographic list of publications related to the book's main theme. The appendices include brief biographies of the English-speaking geologists who wrote about Spain; lists of libraries and journals used during the project; and sources for the book's many fascinating illustrations.

The third section, undoubtedly the most informative, contains brief comments on the principal publications and, in some cases, about their authors. The earliest publications are by British travelers, naturalists, priests, physicians, and military personnel; these are mostly descriptions of the Canary Islands and their volcanoes. The first, by an Edmund Skory, is dated 1610. The Irish naturalist William Bowles lived in Spain for 25 years and published in 1775 his *Introduccion a la Historia Natural y la Geografiá Fisica de España*, the first truly scientific work on the mines and general geology of Spain.

By the beginning of the 19th century, however, British geologists and mining engineers became the main contributors to the English geologic literature on Spain, much of which was devoted to Gibraltar and the Pyrenees. Sir Charles Lyell was probably the first British scientist to write in 1830 about the Pyrenees; in the many editions of *Principles of Geology*, he also discussed the Canary Islands and the volcanoes of Cataluna, among other Spanish regions. It was, however, a Scottish geologist, P.W. Stuart-Monteath, who most thoroughly studied the Pyrenees, publishing copiously on the subject in British, French, and Spanish journals for 70 years. Both British and North Americans studied Spanish mining districts, most attention being given to the mercury mine at Almaden and the pyritic copper deposits at Rio Tinto, both the largest of their kind and mined since antiquity.

North American earth scientists did not consistently direct their interest to Spain until late in the 19th century; during the early part of the 20th century, the American contributions equaled those of their British colleagues. Both groups reduced their activities in Spain in the 1930's and 1940's during the Spanish Civil War and World War II.

Estanislao Ribera's book is a true bibliographic tour de force, but could have been improved with the inclusion of somewhat more extensive accounts of the lives, motives, and experiences of the English-speaking scientists while they were in Spain, particularly Bowles, Lyell, and Stuart-Monteath.

It was the author's intention to cover next the contributions of English-speaking geologists from 1950 to the present, which represents about two-thirds of the total contributions to date. Regrettably, this will not be possible, because Estanislao Ribera i Faig died in June 1989, a few weeks before he planned to present a summary of his research at the 28th International Geological Congress in Washington, D.C.

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APPROPRIATING THE WEATHER: VILHELM BJERKNES AND THE CONSTRUCTION OF A MODERN METEOROLOGY. *Robert Marc Friedman. 1989. Cornell University Press, Ithaca and London. 251 p. Hardcover. $34.95.*

In the first half of the 20th century, meteorology became established as both an academic discipline and a major government science. Besides an increase of an order of magnitude in the number of practitioners, there was a fundamental change in both theory and practice. It is arguable that the most important figure in this development was the Norwegian physicist-turned-meteorologist Vilhelm Bjerknes.

Bjerknes importance resulted from two almost separate contributions: the promulgation of a program of calculating the weather on the basis of physical laws, and the initiation of a new form of practical meteorology based on the concept of warm and cold fronts, the polar front, and air masses. Friedman's book *Appropriating the Weather* focuses on the second of the two contributions. The concepts introduced by what became known as the Bergen School--that is, by Bjerknes and a number of younger meteorologists including his son Jacob, Halvor Solberg, and Tor Bergerson--are clearly explained, often with the help of original diagrams. The greatest strength, however, of Friedman's book is its explication of the social setting of the scientific development, which illuminated enormously Bjerknes's shift in the first decade of the century from physics to meteorology, his moves to Leipzig in 1913 and to Bergen in 1917, and his turn toward practical meteorology shortly after his return to Norway. (Indeed, *Appropriating the Weather* does more than any other historical work to make clear the effect on meteorology generally of World War I and the advent of commercial aviation).

Though Friedman presents what is basically a descriptive, narrative account, he does so from a particular viewpoint that certain readers will find irritating--an effect, I suspect, that Friedman intends. He seems to see a scientific discipline primarily as an arena in which scientists compete for authority and Bjerknes's actions as primarily aimed at achieving dominance in international meteorology. Bjerknes's turn to practical meteorology is described as a strategic move to increase his standing and access to resources and as "exploiting" the wartime situation. Some readers might object to the implied cynicism of the title phrase "appropriating the weather," others to the lexical strain (since Friedman surely means appropriating meteorology rather than the weather itself).

These cavils notwithstanding, we have here an excellent history--carefully documented from primary sources and interestingly recounted--of one of the most important episodes in the history of meteorology.

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INTERNATIONAL RESEARCH IN THE ANTARCTIC. *Richard Fifield. 1988. Oxford University Press, New York. 146 p. Hardcover, $45.00.*

The United States Antarctic Research Program (USARP) was founded in 1958 to continue IGY programs in fluid and solid-earth geoscience. The present short book is a general-audience review of the primary research programs and results of experiments conducted in the Antarctic under the auspices of the concurrent International Council of Scientific Union's (ICSU) Scientific Committee on Antarctic Research (SCAR).

As noted by the author-editor (currently managing editor of *New Scientist**), the 16 chapters are closely based on topical reports from SCAR's working groups in biological, geological, oceanographic, climatologic, and ecologic sciences. A brief historical and organizational background to SCAR and its 30+ years in polar science is given in the introduction by prior SCAR president James Zumberge. Specific chapters on Geodesy and Cartography, Geology and Geophysics, Glaciology, and Paleoecology comprise the major earth science and related history focus. Unfortunately for HESS readers, the historical perspective, provided principally as background and not as theme, is dispersed throughout the book's review discussions. [Other detailed reportage on Antarctic science with greater specifically-historical discussion can be found in Walton (1987) and Moss (1988)].

The author gives an accurate account of SCAR's programmatic aims, carefully defining the predominantly scientific and advisory role of SCAR's efforts within the context of international environmental and exploration agreements. In the SCAR viewpoint as presented here, a sufficiently-informed program of treaty legislation on the future use of Antarctica necessitates an adequately funded ongoing research foundation across all the "environmental" sciences. In view of the perennial difficulties in achieving effective international cooperation in circumpolar regions on issues of global impact such as ozone depletion, fossil fuel exploitation, and whale species extinction, the author and topical editors stress the effective mechanisms for technical information exchange, cooperative planning, and consensus achieved through SCAR. Although individual scientists, scientific commissions, and environmental research agencies have praised these endeavors in the past, given the difficulties in understanding complex ecosystems like the Antarctic, and the tendency of treaty parties to pit scientists of different persuasions against each other, it will be interesting at the very least to read any subsequent volume documenting ICSU's forthcoming Geosphere-Biosphere, scheduled for the 1990's.

In the Antarctic as perhaps nowhere else is the term "geophysics" used in as wide an interdisciplinary fashion. Earlier texts on South Polar science [e.g., Porter (1971) and McWhinnie (1978)] largely presented atmospheric fluid dynamics, meteorology, oceanography, and solid-earth geoscience as parallel but generally non-interacting endeavors. An interdisciplinary leitmotif in the present volume, because of its criticality to almost all aspects of polar research, are the problems of obtaining accurate and consistent relief and thickness estimates for the Antarctic ice sheet. In addition to reconciling diverse geodetic, photographic, and cartographic data formats and tolerances over several generations of instruments, the questions of resolving smaller-scale ice/basement topography are highlighted. Antarctic geodesy and geocartography represents an important (and as yet only barely outlined) chapter in the early history of regional-scale thematic mapping. From the geomorphologic viewpoint, many occurrences of the ice sheet have frequently proven to be what is probably one of the very few natural surfaces which can be accurately modelled over most spatial scales by a linearized power spectral slope or fractal dimension [see Barnbery (1988) and Mandelbrot's classic volumes].

A compressed and general treatment such as this cannot exhaust all issues. Several gaps in the discussion include roles of other (e.g., military) agencies in underwriting and undertaking many aspects of Antarctic sciences. Although cited, the status and impact of future oil and mineral exploration is inadequately discussed in view of its currency (albeit with largely pseudoscientific accuracy) in the popular press. The bibliographic selection is exclusively SCAR program element reports and might have been usefully supplemented with additional citations to provide a larger objective overview.

The book is attractively produced and well bound and printed, and includes a larger number of high-quality maps and photographs than usually seen in books of this type. Although perhaps overpriced in view of its brevity, this book will serve needs of beginning students of polar science and its history, as well as browsers.

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*Fifield became executive editor of *New Scientist* in April 1988.--Ed.

CATASTROPHIC EPISODES IN EARTH HISTORY. *Claude C. Albritton, Jr., 1989. Chapman and Hall, London, New York. 221 p. $29.95 (also available as paperback).*

This is the second book in a series called *Topics in the Earth Sciences* edited by T.H. van Andel and Peter J. Smith. In their foreword the series editors point out that "The rising flood of research reports has drastically cut the time we have available for free reading." It is the purpose of this series to publish books on selected topics in an easily readable format. The avalanche of publications during the last 20 years on "extinctions" as documented in the paleontological record make this field a particularly attractive choice for such a book. In fact, Michael J. Benton (*Nature* 17 August 1989) has spoken of a "mass extinction industry" that is turning out hundreds of publications per year, and Pete Palmer and Art Boucot (in written communications) have taken the "extinctionists" to task. Since many of these papers are short, in the format of letters and reports to *Nature* and *Science*, it is often difficult to condense them still further.

Approximately the first third of the book is devoted to historical views from the Noachian flood to the Darwin-Kelvin controversy and the discovery of radioactivity. These stories cover familiar ground; they are well-told and can be recommended as part of introductory readings on these subjects.

To me, the most interesting and informative chapters were those on meteorite craters and cryptoexplosion structures. As a young man, I had opportunities to study four geological features now interpreted as impact craters: First, the Ries and the Steinheim Basin in southern Germany, then interpreted as volcanic features; second, a crater then called "Krater von Sall" (now known as Kaalijarv [misspelt Kaalijaarv in this book] crater on the island of Saare, or Saaremaa, in Estonia), then interpreted as caused by a gas explosion, due to the decay of organic-rich sediments known to occur in the subsurface; finally, the celebrated Meteor Crater of northern Arizona, then (1930) as now believed to be caused by a meteor impact. All these features are now interpreted as impact structures of one kind or another, regardless of whether or not meteoritic materials are found in their vicinity. It is always attractive and satisfying to the human mind to reduce the number of causative factors in the explanation of similar geologic phenomena. The author distinguishes impact, explosion, and cryptoexplosion craters and gives clear and informative descriptions of examples for all of them. Cryptoexplosion craters are believed to have been caused by impacts of objects at especially violent speeds or of more than usual sizes. Here belong some well-known structures such as the Ries in southern Germany and the Vredefort Dome in South Africa.

Among other things, we learn that much effort is being spent on efforts to link major extinction periods to contemporary impact craters, but many of such efforts are less than convincing. For example, the 40 km wide Charlevoix crater in Canada has been cited as one of the prime candidates linked with the extinctions at the Frasnian-Famennian boundary (intra-Upper Devonian). Its age is stated to be 360±25 m.y. The Frasnian-Famennian boundary falls somewhere between 356 and 368 m.y. ago. Sample calculations show that the Charlevoix bolide may have hit the earth at any time between 29 m.y. before and 33 m.y. after the passage from the Frasnian to the Famennian. To connect the Charlevoix bolide with the terminal Frasnian extinction is, therefore, a purely speculative exercise. And this is not the worst case.

The last half of the book (Pages 94-181) is given to discussions of various aspects of mass extinctions, beginning with a very brief characterization of the five mass extinctions which the author suggests are recognized by "most paleontologists" and which he calls: Late Ordovician, Late Devonian, terminal or Late Permian, Late Triassic, and terminal Cretaceous. Characteristically, fossils are barely mentioned in these discussions, and if at all, only to the level of phyla or classes. This is not surprising, because the extinction industry whose products Albritton reviews is not concerned with such a mundane fact as that it is only species that can become extinct and that, if a species disappears from the published record at a point in time, it might not have become extinct at all, but just developed into another species, a process certainly not indicative of a catastrophic event. What is true for species, is, of course, true for such derived concepts as genera and families. For cephalopods, examples have been given in publications by this reviewer. I am convinced that after thorough reviews by competent specialists, dozens, perhaps hundreds, of families, and hundreds, perhaps thousands, of genera would disappear from the extinction lists. These basic flaws in the current extinction literature are accurately reflected in Albritton's book.

The author devotes considerable space to the discussion of possible causes of "mass extinctions" other than by extraterrestrial impact. The arguments pro and con for the role of volcanism, worldwide climatic changes, and sea-level fluctuations are clearly and accurately discussed. Again, fossils are rarely mentioned, other than in the broadest taxonomic categories, with the exception, of course, of the dinosaurs to which Albritton devotes a special chapter.

Future science historians may well wonder, why De Laubenfels' proposal of 1956, that an asteroid or meteorite impact was the ultimate cause of dinosaur extinctions was ignored in contemporary discussions, while an identical proposal by Luis Alvarez and associates, published in 1980, is rated by Albritton as one of the "few papers published in this century [that] have generated so much controversy ... into the history of life on Earth." The modern extinction debate had started in the early 1950's with the bench mark Paleontological Society debate in 1951 and with Schindewolf's expedition to the Salt Range in Pakistan 1952. In the late 1950's, dinosaurs were popular toys, available in supermarkets (we kept a basketful of them at home for the kids to play with), but no dinosaurmania (Albritton's term) developed). Gould (in *Natural History*, August 1989) has spoken of the "dinosaur craze" and "dinosaur rip-off" that started a decade ago. The dinosaur craze and the "extinction industry", triggered off mainly by several Alvarez *et al.* publications, are concurrent events, both still going strong, but the cause-and-effect relationship between the two remains to be determined.

Almost without exception, extinction papers written by nonpaleontologists are not based on the study of fossils, but on the interpretation of curves, showing the abundance of taxonomic families in the geologic record, most of which were published in a number of well-researched papers by John Sepkoski, Jr. Many nonpaleontologists do not realize that evolution proceeds on the species level and that genera and higher taxonomic categories are derived concepts that embody varying amounts of subjectivity. The abundance, "origination", and "disappearance" of families in the fossil record do not provide a sound data base for evolutionary theory, because they almost certainly include an indeterminate number of artifacts (see Teichert, *Palaios*, 2, 411. 1987).

The book leaves the reader with the impression that the extinction debate of the last 30 years is essentially an anglophone phenomenon. No publication in any language other than English from this period is included in the very extensive reference list. However, while it is true that English-language publications have dominated the field to a large extent, very important contributions are found in papers presented in French, German, and Russian. Schindewolf is one of the few non-Anglophone authors mentioned, but his seminal 1954 paper on the Salt Range is not cited.

The book reflects fairly accurately the state-of-the-art of the contemporary mass extinction literature published in the English language and can, therefore, be recommended to anybody who wants to inform himself on this aspect of the extinction problems. It is well-written and well-documented, within the self-imposed limits set by the author.

Curt Teichert, Department of Geological Sciences, University of Rochester, Rochester, New York 14627.

INTERESTING PUBLICATIONS

Since the start of this journal, Editor Gerald M. Friedman has prepared this column. Contributors wishing to list recent books and papers of interest to our membership are requested to send them to the Editor.

Ager, Derek, 1989, Lyell's pillars and uniformitarianism: Journal of the Geological Society of London, v. 146, pt. 4, p. 603-605.

Armstrong, Patrick, 1984, Charles Darwin and the development of geography in the 19th century: Hist. Geogr. Newslett., v. 4, p. 1-10.

Atanasijevic, Ivan, 1987, Milankovicéva astronomska teorija klimatskih promena (The Milankovic astronomical theory of climatic variations): Dijalektika, v. 22, p. 41-73.

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Barrett, P.H., Gautrey, P.J., Herbert, S., Kohn, D., and Smith, S., (eds.), 1987, Charles Darwin's notebooks, 1836-1844: geology, transmutation of species, metaphysical enquiries. Cambridge University Press and British Museum (Natural History), Cambridge, 747 p. £65.

Berg-Madsen, Vivianne, 1989, Origin and usage of the geological terms orsten, stinkstone and anthraconite: Archives of Natural History, v. 16, p. 191-208.

Blei, Wolfgang, 1987, Seit wann wird die Wandelbarkeit des Antlitzes der Erde angenommen?: Petermanns Geogr. Mitt, v. 1312, p. 255-258.

Bork, K.B., 1989, Kirtley Fletcher Mather as geologist and political activist: Jour. Geological Education, v. 37, 190-193.

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Eagan, W.E., 1989, The debate over the Canadian Shield, 1880-1905: Isis, v. 80, No. 302, p. 232-253.

(Editorial staff), 1988, V.A. Obruchev and the geology of Siberia: Geologiya i Geofizika (Soviet Geology & Geophysics), v. 29, n. 10, p. 1-4. (A commemoration of the 125th anniversary of the birth of Academician Vladimir Afanas'evich Obruchev)

Engelmann, Gerhard, 1986, Albrecht Penck in Wein: Ein Freundschaftsbericht von Joseph Partsch *in* Hamann, Günther, ed., Aufsätze zur Geschichte der Naturwissenschaften und Geographie. Vienna, Österreichische Akademie der Naturwissenschaften, p. 163-181.

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Fisher, W.L., 1989, From gushers to reserve growth: a brief history of Texas oil: Amer. Assoc. Petroleum Geologists, v. 73, No. 9, p. 1143.

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Goodman, Edward J., 1986, The exploration and mapping of the Arctic coast of North America: Terra Incog., v. 18, p. 55-72.

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Landa, Edward R. and Ince, Simon, (eds.), 1987, The history of hydrology. With a forward by William Back. History of geophysics, v. 3. Washington, D.C., American Geophysical Union. xi + 122 p.

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Rosenbaum, M.S., 1989, Geological influence on tunnelling under the Western Front at Vimy Ridge: Proceedings Geol. Association, v. 100, pt. 1, p. 135-1240.

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Symons, M.V., 1989, Growth of geological knowledge of the Llanelli coalfield: Archives of Natural History, v. 16, p. 59-80.

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Tesmer, Irving H., 1989, History of Geology of Westernmost New York State. Buffalo Museum of Science, Humbolt Parkway, Buffalo NY 14211-1293, 214 p. $19.95.

Thompson, Susan J., 1988, A chronology of geological thinking from antiquity to 1899: Scarecrow Press, Metuchen, New Jersey. 320 p. $29.50.

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Wolff, Hans, 1986, Goethes Kenntnisse der Alpen im Lichte der modernen Geologie: Sudhoffs Arch., v. 70, p. 143-152.

ANNOUNCEMENTS

British Geological Survey--Archive Collections

The British Geological Survey Archives contain manuscript, graphic, photographic and printed material (some 30,000 items) relating to the history of the geological sciences, not only in Britain but also in many other parts of the world. There is naturally particular emphasis on the records of the British Geological Survey and its forerunners, the Institute of Geological Sciences, the Geological Survey of Great Britain, the Museum of Practical Geology and Overseas Geological Surveys.

This display for the 28th International Geological Congress, 1989, provides examples of the wealth of documentation contained in the collections. It shows the results of survey work carried out in various countries often, covering vast tracts of difficult terrain. As the personality of the individual geologists is often reflected in their work, the background archival material accompanying the maps adds an extra dimension to the completed maps.

Researchers are able to consult the archive collections in the Survey's new Library at Keyworth, which is now designated as a place of deposit under the Public Records Act. Enquiries relating to the contents of the collections and access to the material should be addressed in the first instance to the Chief Librarian and Archivist, British Geological Survey, Keyworth, Nottingham, NG12 5GG, UK.

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**STRATIGRAPHY'S GOLDEN AGE:
MURCHISON AND HIS SILURIAN SYSTEM**

Smithsonian Institution Libraries
Special Collections Branch
The Dibner Library of the History of
Science and Technology
located in the National Museum of Natural History
Twelfth Street and Constitution Avenue, NW,
Washington, D.C. 20560

July 3-31, 1989

INTERNATIONAL GEOGRAPHICAL CONGRESS
HISTORICAL - GEOLOGICAL MAPS OF AUSTRALIA

Robert Brough Smyth, (1830-1889), Secretary of Mines in Victoria, was responsible for publication of the first reasonably complete geological map of Australia which appeared on November 1, 1875, 87 years after the first European settlement.

In 1873 Brough Smyth sent a formal request to the various colonies (the present states of Australia) for information about their geology, and received in reply a considerable amount of printed and manuscript material which he compiled and edited.

The sources of Brough Smyth's map are clear for some regions as published maps of Victoria and Western Australia had appeared before 1873 and detailed maps of much of New South Wales, Queensland and Tasmania were available. However Brough Smyth clearly interpreted the data and modified the printed maps in some regions for reasons which are not clear, although he probably relied on more recent work and some personal communication with workers in the field.

It is not clear who was responsible for providing the data on Cape York (the north-eastern most tip of Australia) but some work was possibly done there by Christopher D'Oyby Aplin, who was Police Magistrate at Somerset, then a calling point for vessels traveling to Europe via the Barrier Reef and Torres Strait (between Australia and New Guinea), from September 1874 to September 1875. Aplin had previously been Government Geologist of Southern Queensland (1867 1869) after a period in the Victorian Survey under A.R.C. Selwyn.

The display shows some of the earlier geological maps of parts of Australia, including a map by John Lhotsky (1836) of the Port Arthur region of Tasmania, and one of Wellington Caves (in NSW) by T.L. Mitchell, published in 1838. Lhotsky was a talented but eccentric European who made an early journey to the Australian Alps, and who is believed by some to have reached the highest country some years before it was visited by Paul Strzelecki who named Mount Kosciusko. Thomas Mitchell was Surveyor-General of the colony of NSW from 1828 to 1855.

An important precursor of Brough Smyth's map was that published by J.B. Jukes in 1850 following his visit to Australia on board HMS "Fly". Jukes was later on the geological survey of Ireland.

Another important forerunner of Jukes' map was that prepared by P.E. Strzelecki, published in 1845 in his *Physical Description of Australia and Van Dieman's Land.* A half size copy of Strzelecki's original map and sections which measure some 8m x 1.6m when put together, is displayed. Strzelecki's original contains considerably more information than appears on his published map. Other important local maps by S. Stutchbury and A. Selwyn are shown.

Since Brough Smyth's map was published only 10 significantly different geological maps have appeared. These include Edgeworth David's map of 1932.

D.F. BRANAGAN
Department of Geology and Geophysics

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CALENDAR

1990

Oct. 25-28 - History of Science Society Annual Meeting, Seattle, Washington U.S.A. Contact Peter Galison or Timothy Lenoir, Program in the History of Science, Building 200-33, Stanford University, Stanford, California U.S.A. 94305. Telephone: 415/725-0714.

October 25-31 - INHIGEO Symposium - meeting in conjunction with the Seventh Symposium of the Committee of the History of Geology, Geological Society of China, Beijing, People's Republic of China. The general topic is the interaction of geological thought between East and West. Four of the main components of the scientific program are; 1) history of interchange of geoscience ideas among China, Europe and America; 2) important events which promoted communication of geologic thought between East and West; 3) history of interchange of ideas in the main branches of geology, including seismogeology, stratigraphy, tectonics, petroleum geology, etc; 4) biographical notes of geologists who made great contributions to the interaction of geological sciences and geological undertakings between East and West. To obtain a copy of the second circular write: Prof. Tao Shilong, China University of Geosciences, 29 Xueyuan Road, Beijing 100083, People's Republic of China.

Oct. 29-Nov. 1 - Geological Society of America Annual Meeting, Dallas, Texas U.S.A.

1991

Apr. 7-10 - American Association of Petroleum Geologists Annual Meeting, Dallas, Texas, U.S.A.

Apr. 7-12 - 5th International Symposium on Fossil Algae, Capri, Italy. Organized by the Department of Paleontology of the University of Naples Federico II: Prof. Filippo Barattolo, Head of Committee. Activities include geo-turistic visit of Capri, scientific sessions and post-symposium excursions to classic algal localities in the surroundings of Naples. Official Language: English, French and Italian. Contact Dr. Maria Carmela del Re, Dipartimento di Paleontologia, Largo S. Marcellino, 10, 80138 NAPOLI, Italy.

Apr. 15-19 - International Association of Hydrogeologists - Spanish Chapter: XXIII International Congress, Aquifer Overexploitation, Puerto de la Cruz, Tenerife (Canary Islands, Spain). Activities include oral and poster sessions and post-Congress technical visits. Official Language: Spanish and English. Contact Dr. Fermin Villarroya, Chairman, Congress Organizing Committee, Departamento de Geodinamica, Facultad de Ciencias Geologicas, Universidad Complutense, 28040 MADRID Spain. Telephone: (34-1)449-73-91; Telex: 41798 UCGEO; Telefax: (34-1)243-91-62.

September - INHIGEO Symposium - "Museums and collections in the history of mineralogy, geology, and paleontology." Dresden, German Democratic Republic. Associated field trips. For additional information write: Sekretariat der GGW, INHIGEO 1991, Invalidenstrasse 43, 1040 Berlin, DDR.

1992

June 28-July 1 - 5th North American Paleontological Convention, Chicago, IL.

August 24-September 3 - 29th International Geological Congress, Kyoto, Japan.

MISCELLANEA

We have established a format for the heading of all book reviews. This will ensure that all necessary information is included. All reviewers are asked to head their reviews in the following format: TITLE (primary title in all capitals; any subtitle may be in lower case letters), author, date, publisher, number of pages, hard or softcover, price. Any further information as to how to order the book may be included in parenthesis.

Example: HISTORICAL WRITING ON AMERICAN SCIENCE. Sally Gregory Kohlstedt and Margaret W. Rossiter, eds. 1986. Johns Hopkins University Press, Baltimore and London. 321 p, softcover. $15.00

When preparing your review, remember that the optical character reader (scanner) used to produce *Earth Sciences History* best reads manuscripts typed on an ordinary typewriter or a good-quality dot-matrix printer. Make sure the printing is dark; use a new ribbon if necessary. The scanner cannot read "fancy" type (such as helvetica, italics, or script) and printing that is either too large or too small. (It reads 10-pitch Courier best.) It also has problems with type that is proportionally spaced. Deadlines for submission of reviews are April 1 and October 1.

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* Note from Prof. Dan YAALON (The Hebrew University, Jerusalem, ISRAEL):

The Working Group on the History, Philosophy and Sociology of Soil Science of the Intl. Soil Sci. Society is organizing a Symposium on "Historical, Philosophical and Sociological Aspects of Development in Soil Science" for the 14th ISSS Congress in Kyoto, Japan (August 1990).

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KUDOS

Cecil Schneer of the University of New Hampshire is the 1989 Hawley Medallist of the Mineralogical Association of Canada.

Gerald M. Friedman of Brooklyn College, the City University of New York Graduate School, and the Northeastern Science Foundation, editor of *Earth Sciences History* was awarded Honorary Membership in the American Association of Petroleum Geologists.

The Graduate Alumni of Columbia University
Awards for Excellence
DIVERSITY AND EXCELLENCE --
Awards for Excellence Medal:
Stephen J. Gould

SOCIETY FOR THE HISTORY OF NATURAL HISTORY:

LANDMARKS IN NATURAL HISTORY

7th International Conference. 25-27 April, 1990, at the British Museum (Natural History):

Exploration - The discovery of the natural world and its resources including collectors and collections.

Structure and Function - To include palaeontological and mineralogical studies as well as on living plants and animals.

Concepts and Theories - The great organizing principles of pioneers such as Darwin, Wegener and Weissman.

Registration: members-£25, nonmembers £35
Conference Secretary: Gina Douglas
Linnean Society of London, Burlington House
Piccadilly, London W1V OLQ UK.

*****

In conjunction with the 28th International Geological Congress, held in Washington, D.C., the Library of Congress has had a display of geological maps. The exhibit of more than 70 items was arranged in three sections. The first traces the development of tectonic ideas concerning the earth, the second illustrates the evolution of geologic maps from both the view of cartography and the changing printing methods, and the third considers the development of geologic mapping in the United States.

A summary catalogue giving the captions which accompany these maps has been prepared and is being distributed gratis. To obtain a copy write: Ralph E. Ehrenberg, Geography and Map Division, Library of Congress, Washington, DC 20540, U.S.A.

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IN MEMORIAM

For the first issue of *Earth Sciences History* I carefully selected an editorial board who would provide the drive to make this journal a reality. The original fifteen-member board included John Haller of Harvard University and George W. White of the University of Illinois. Both of these distinguished scientists and historians of geology died several years ago. Now a third member of the original board has joined their fate. John G. Dennis, whom I recruited at the International Geological Congress in Paris, France, died on September 23, 1989. A professor of geology at California State University Dennis, who was born into a liberal publishing family in Berlin, Germany in 1920, moved with his family to France and then England after Hitler's takeover. He fought in the British military before completing his undergraduate studies at Imperial College in London. After a stint as a mining geologist, Dennis resumed his studies and earned a doctorate from Columbia University in New York. Before coming to Long Beach, he taught at Texas Tech in Lubbock. His work included two books, a geological dictionary, and many articles, as well as service on the editorial boards of several scholarly journals. Dennis' work also included travel throughout Europe and Africa, with lectures at universities in France, Sweden and Germany.

Gerald M. Friedman
Editor

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