A Supercontinent

Gondwana Five. Papers from a symposium, Wellington, New Zealand, Feb. 1980. M. M. CRESSWELL and P. VELLA, Eds. Balkema, Rotterdam, 1981 (U.S. distributor, MBS, Salem, N.H.). x, 340 pp., illus. $48.

An organic chemist residing on one of the fragments of the former supercontinent of Laurasia could readily be forgiven for thinking that *Gondwana Five* might be the most recent episode in the *Star Wars* saga. Indeed, there was a time when the vast majority of Northern Hemisphere geologists believed that the Gondwana supercontinent, like its Northern Hemisphere counterpart, belonged in the realm of science fiction. The main proponents of continental drift during the 1930's, 1940's, and 1950's were geologists such as Alexander du Toit, Arthur Holmes, and Lester King with experience of the present southern continents. *Gondwana Five* reflects the marriage of classical Gondwana stratigraphy with sea-floor spreading and plate tectonics. Three of the four previous Gondwana symposiums concentrated on the type Gondwana sedimentary sequences and their correlation. Only at Canberra in 1973 did the symposium participants get their feet wet and devote significant time to marine sequences. Hence the fifth Gondwana symposium was a milestone in the development of thought concerning the supercontinent.

It is appropriate that Wellington should have been the site of this meeting because, as the editors of the book point out, the New Zealand microcontinent has tended to be neglected in reconstructions of Gondwana, ironically even in the one forming the frontispiece of the book. Central to the new view of Gondwana that emerges from the volume is the recognition that much of New Zealand and West (Lesser) Antarctica, as well as the Pacific margin of South America, is not merely a late Mesozoic and Cenozoic "Andean" orogen as shown on many tectonic maps but constitutes the Paleozoic and early Mesozoic Pacific (or Panthallassic) convergent margin of the Gondwana supercontinent. Understanding of this margin is crucial not only to the jigsaw puzzle of Gondwana reconstruction in the complex area between South America and eastern Australia, but also to important problems involving paleocirculation, paleoclimate, and paleobiogeography. Another significant departure taken in the book is the acknowledgement that the Gondwana supercontinent existed from late Precambrian or early Paleozoic time and that several portions of southern Asia from Turkey to Indochina, not just India, were probably parts of Gondwana rifted away during the Paleozoic before ultimate fragmentation. Thus two papers on the geology of China are included with contributions on Australia, India, South America, Africa, Antarctica, and New Zealand. Together with general papers these amount to a total of 47 papers, in addition to which there are 13 abstracts in the volume.

The book was prepared from author-supervised camera-ready typescripts, and the length of the contributions had to be severely limited. It is understandably, therefore, not a "handsome" volume and does not contain any lengthy papers rich in new data. It can, however, be recommended strongly as an overview of the state of the art in Gondwana geology sensu lato. It is particularly valuable because it has been published while the meeting is still fresh in the minds of even the participants.

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Planets and Satellites

The New Solar System. J. KELLY BEATTY, BRIAN O'LEARY, and ANDREW CHAIKIN, Eds. Cambridge University Press, New York, and Sky Publishing Corporation, Cambridge, Mass., 1981. viii, 224 pp., illus. $19.95.

In the 12 years that have elapsed since the first man walked on the moon, our knowledge about the solar system we inhabit has grown dramatically. Objects that were once little more than points of light in the sky are now familiar worlds. Though some of this new wisdom is highly technical, much of it is accessible to anyone curious enough to examine a picture. And what sights the effort will reveal! We have now surveyed every planet known to the ancients, finding phenomena as diverse as sulfurous volcanoes on Io, cratered terrains on Mercury, and frozen carbon dioxide polar caps on Mars. As this is being written, the second Voyager spacecraft is moving steadily closer to Saturn, where its sister craft has already discovered intricate structures beyond expectation in the planet's famous rings and new moons with unusual orbits that help to keep these rings in place.

All of these discoveries, the technical and the pictorial, are discussed in a pleasing way in this handsome new book. With studies of the solar system proceeding at a breakneck pace, it is impossible for any book to be truly current. This one takes us through the highlights of the November 1980 Voyager encounter with Saturn.

The range of topics covered is very comprehensive. The book begins with a historical introduction by Noel Hinners that describes how the NASA programs developed. John Eddy's chapter on the sun is the first of 19 scientific chapters, which end with a general review of current theories on solar system origin by John Lewis. Along the way, there are chapters on some individual planets and other chapters that group objects to discuss surfaces, atmospheres, or phenomena such as collisions and magnetospheres. This necessarily leads to some redundancy. But, given the level of controversy surrounding many of these new discoveries and interpretations, more than one point of view is often desirable. There is even an engaging on-the-scene account by Bradford Smith of the activities of the Voyager imaging team during the high points of the Jupiter and Saturn encounters. The sense of intimacy with the process of scientific exploration is sustained in many of the other chapters by the authors' use of the first person in describing their own work.

The book most resembles a kind of encyclopedia, in which an interested reader can delve for current information about a particular subject. But because it is so comprehensive and so fresh, it is also a pleasure simply to read right through it. The illustrations are of high quality and are often new or unusual, and there is a pleasing blend of results from spacecraft, telescopes, laboratories, and even fieldwork on earth.

A difficulty in a book of this type is that there is no narrative thread that carries the reader along; the bits and pieces aren't always stitched together to form a pattern, as they are in a conventional account. Thus the reader must struggle to relate James Pollack's review of atmospheric evolution to Harold Masursky's description of the history of water on Mars and Gerald Soffen's discussion of the search for life on that enigmatic planet. Similarly, there are ten chapters devoted to moons, craters, asteroids, meteorites, and comets, and each is more or less independent of the others. The editors have helped by adding cross-references, and the diligent reader will want to peruse these related chapters more than once before trying to

weigh and sift their separate conclusions.

Despite—or possibly even because of—these difficulties, the book is an excellent compendium of our current knowledge about the solar system. Among other insights, it shows how our increasing knowledge about the separate members of the solar family illuminates our understanding of the whole system. One cannot help but endorse the stated wish of many of the authors that spacecraft will continue to be sent out on their missions of exploration. The riches in this book give eloquent testimony to the power of such machines to gather wonderful information about our solar system.

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Ancient Mining

Prehistoric Mining and Allied Industries. R. SHEPHERD. Academic Press, New York, 1980. xii, 272 pp., illus. $37. Studies in Archaeological Science.

During the last decade renewed interest in prehistoric technology has generated numerous studies of the processes by which both stone and metal artifacts were made. In lithic analysis, studies of the mechanical aspects of production and of microwear predominate, whereas archeometallurgical investigations comprise elemental and metallographic analyses of copper, bronze, and iron artifacts. End products—that is, finished artifacts—generally have been the focus of research, and little attention has been given to the initial process in their production, in which raw materials are extracted from the earth's crust.

Shepherd aims to fill the need for a survey of prehistoric mining directed especially to archeologists. He devotes approximately half his book (four chapters) to European flint mining, which started perhaps as early as the fourth millennium B.C. In these discussions the author's expertise as a mining engineer is best demonstrated. Through description of the two largest excavated flint-mining areas (Grimes Graves, Norfolk, England, and Spiennes, Belgium) and of other flint mines in Europe, one sees the extent and sophistication of this early mining. The mining of flint is perhaps better understood in archeological terms than the mining of metals, and levels of preservation not only of the mines themselves but of artifacts found in them make it clear that reconstruction of not only the technological but also the social aspects of this activity warrants more attention from scholars. In chapter 6 the author does turn to brief overviews of the cultural background of the flint-mining sites to try to place them in proper context.

Shepherd's treatment of prehistoric ore mining and related issues in archeometallurgy, to which he devotes two chapters, is not as thorough as the evidence permits. For example, the Bronze and Iron Age mining center at Timna in the Wadi Arabah in the Negev desert, Israel, receives little attention although it is one of the most extensively investigated of all mining sites. Also, the site of Laurion in Attica, Greece, which is perhaps the most important source of lead and silver for the entire eastern Mediterranean world and undoubtedly was exploited in prehistory, is not discussed.

The attempt by the author to review basic concepts in archeometallurgy that concern the development of the technology runs into difficulty. Archeometallurgical research has become sharply focused in a number of areas of Europe and elsewhere in the Old World, and one can no longer easily describe a developmental sequence that is applicable to all areas. Though the archeology of mining is adequately surveyed, the bibliography on archeometallurgy is neither current nor sufficient. Glaring omissions such as the more recent articles of Theodore A. Wertime (*Science* **159**, 927 [1968] and **182**, 875 [1973]) and James D. Muhly's *Copper and Tin* (1973) reflect on the nature of the research. In addition, the book is marred by the acceptance of several hypotheses that have been vitiated by more recent research or that represent only one of several possible explanations. None of these dicta can be considered as accepted fact: that the collapse of the Hittite Empire around 1200 B.C. allowed the dissemination of iron-working technology (p. 203), that the increased use of iron that marks the Iron Age occurred as a result of the disruption in the tin trade (p. 203), and that in prehistory arsenical copper artifacts were produced by mixing arsenic with copper (p. 240). All are currently the subject of considerable speculation and debate.

A pervasive problem is caused by the uncritical presentation of the ideas of a wide variety of scholars, both past and present, which makes the text rather erratic and disjointed; this book could have been the vehicle for the synthesis of current and relevant data into a useful, comprehensive body of information. In addition, editing should have ensured consistency in style, spelling, and content, and here the fault lies partly with the publisher.

This volume stands, nonetheless, as the only modern survey of prehistoric mining. Future users may find that flaws in the reporting of certain basic information as well as in format and style render it less valuable as a reference volume than one might have hoped.

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Biological Records

Skeletal Growth of Aquatic Organisms. Biological Records of Environmental Change. DONALD C. RHOADS and RICHARD A. LUTZ, Eds. Plenum, New York, 1980. xiv, 750 pp., illus. $47.50. Topics in Geobiology, vol. 1.

This book reviews current understanding of the sorts of information stored in animal skeletons, how it is stored, and how it can be recovered. Examples given in the book show that such information can be used not only to reconstruct aspects of the environments in which skeletons grew but also to determine population features such as growth rate, recruitment, and survivorship.

Analysis of past environments from the structure and morphology of skeletal materials was given a new twist by J. W. Wells in the early 1960's. Wells brought together the annual banding long recognized in the morphology of rugose corals and the tiny surface ridges that give this fossil group its name. He suggested that the ridges in these fossil corals (and in their modern relatives) represent daily growth increments. Since there are about 400 ridges to an annual band in Devonian fossils, the length of the Devonian day must have been about 22 hours. A geophysicist, S. K. Runcorn, saw the potential of this information. He stimulated further research and was rewarded with an estimate of 30.6 days for the length of the Devonian lunar month. This was obtained from repeated patterns of daily growth ridges within each annual band. These values were used with Kepler's second and third laws to calculate the loss of angular momentum from the earth to the moon. The transfer of energy occurs because tides raised by the moon