to the original isotopic measurements and recalculate the ages of samples using 1976 decay constants. Whole-rock isochrons and concordant ages are classified as ages, the remaining ages are classified as apparent ages. Isochrons are distinguished from less reliable regression lines by mean square of weighted deviates values.

Each of the following 20 chapters deals with a particular area. Each starts with an adequate geologic description and neatly drawn maps generally too small to show much geology or even all the places named in the text. The geochronology of each area is described by means of selected age data, whose reliability is assessed.

The authors compiled 502 isochron and concordia age clusters. Only 21 cover the 800 million years before 3000 million years ago, after which a virtually continuous Precambrian record is preserved in three long durations: 3000 to 2450 million years ago, 2275 to 1750 million years ago, and 1425 to 425 million years ago. Only the 3786-million-year-old Sand River gneisses in the Limpopo domain are definitely older than 3500 million years, but samples from southern Africa, central Sahara, northern Zaire, and Madagascar date to around 3500 million years ago. A truism of plate tectonics (which is favored by the authors for the Archean) is that no pre-Jurassic oceanic crust survives owing to Benioff subduction. Yet rocks composed of oceanic crust (greenstone belts) and of continental crust (granitoid gneisses) have coexisted in Africa since 3550 million years ago, becoming widespread between 3300 and 2500 million years ago. At least three ages for greenstone belts are recorded in Zimbabwe and Zaire.

Four major periods of Archean cratonization are recognized. Precambrian cratonic cover includes the 2700 million-year-old Francevillian of Gabon and the many southern African sequences displaying an almost unbroken record from the Pongola (3000 million years ago) to the Mulden (580 million years ago).

High-grade gneiss terranes (mobile belts), representing deeply eroded sections through orogenic belts, crisscross the continent. Supposedly discrete and widespread tectonic cycles were proposed by earlier workers on the basis of age clusters that we now know are not discrete or representative. Only the youngest cycle survives, and then only if the original 1964 definition of it is enlarged; the Pan-African cycle affected two-thirds of Africa in six ubiquitous pulses from 900 to 550 million years ago.

The last three chapters deal with Phanerozoic igneous activity and the succession of tectono-thermal events and present the authors' conclusions. The remarkable Phanerozoic stability of Africa is shown by the restriction of orogeny to narrow fringes in the north and south. There was extensive anorogenic igneous activity in the rest of Africa during the Phanerozoic. The authors' theme is that continuity was imposed on the development and movement of magma by older tectonic provinces, especially during the breakup of Gondwana.

Field geologists will doubtless scrutinize the sections of the book that deal with their areas of interest for errors of commission or omission. But this would be petty given the wide sweep of this authoritative and objective synthesis of about 1450 references, some of the most important of which are in French. The formerly dark continent and its radiometric clocks provide an illuminated showcase for most of our planetary history.

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Climate Dynamics

Ice Sheets and Climate. J. OERLEMANS and C. J. VAN DER VEEN. Reidel, Boston, 1984 (distributor, Kluwer Boston, Hingham, Mass.). xii, 217 pp., illus. $34.50.

In the past few decades considerable progress has been made in understanding the present and past climate of the earth. With this increased knowledge has come an awareness of the remarkably wide range of processes that play vital roles in climate and changes of climate.

In the book under review Oerlemans and van der Veen are concerned with the role of the cryosphere as a component of the climate system, acting on a time scale of 10^3 to 10^6 years. Their stated objective is to write a short book suitable for graduate students that bridges the gap between glaciology and climate research. This is a challenging task, not only because of the number of disciplines directly involved but because research is advancing rapidly on many fronts; in addition, in spite of advances, a number of fundamental questions remain open and practical numerical methods are not yet available to deal with some topics, such as the coupling of the thermodynamics to the flow field of an ice sheet.

The book is logically organized. After a brief chapter reviewing the traditional components of the climate system, the atmosphere and the oceans, the authors devote a chapter to a preliminary survey of the role of ice sheets in climate. This is followed by four chapters on the physics of ice sheets and modeling procedures, first leaving out thermodynamics and then including it. After a brief chapter on the physics of the response of the earth to varying ice loads, the authors devote two chapters to the response of continental ice sheets to the atmosphere-ocean environment.

After briefly reviewing the observational evidence of the Pleistocene glaciations, the authors discuss simulation modeling of the ice volume record and the stability of ice-age ice sheets. They then return to the present ice sheets, Greenland and Antarctica, drawing conclusions about each from the results of their modeling studies. In the final chapter they touch on "the carbon-dioxide problem" and difficulties of detecting long-term climate changes from brief time series of observations.

To a considerable extent, the book is, as the authors admit, an exposition of their (extensive) work on ice sheet modeling. The additional material included is apparently intended to provide the necessary background and supplementary knowledge to make their work reasonably comprehensible to the reader with some background in the natural sciences and mathematics. They have succeeded in bringing together considerable information about the physics of the cryosphere; the discussion is heavily, but not exclusively, slanted toward the point of view of the climate modeler. The method of presentation is quantitative and makes extensive use of very simple numerical models of one or more of the components of the climate system. Modeling is used both for purposes of demonstration of specific processes and as an investigatory tool.

The book gives some appearance of being hastily written; there are a number of typographical and grammatical errors. There are some confusions; for example, the authors refer to the crust as being separate from the lithosphere rather than part of it. More important, in view of their conclusion that bedrock adjustment to the varying ice load is one of the important processes involved in the Pleistocene glaciations, the chapter on bedrock adjustment is an inadequate presentation of the present knowledge of the subject. On the other hand, the material on the coupling of ice flow and thermodynamics and its possible role in the late Pleistocene ice sheet oscillations is new and a substantial contribution. I found the chapters on this subject the most interesting.

In view of the difficulties of writing a book on this subject, the authors' presentation of their important and substantial research on the vital role of the cryosphere in the earth's climate is reasonably successful. I suspect that it is more likely to be of use to a climate modeler in understanding ice sheets than to a glaciologist in understanding the earth's climate, so in a sense it is a one-way bridge. For the student of modeling it could indeed provide a useful source for an advanced graduate or seminar course.

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Astrophysical Plasmas

Magnetic Reconnection in Space and Laboratory Plasmas. EDWARD W. HONES, JR., Ed. American Geophysical Union, Washington, D.C., 1984. xii, 386 pp., illus. $33. Geophysical Monograph Series, 30. From a conference, Los Alamos, N.M., Oct. 1983.

It has been over 30 years since magnetic reconnection was first proposed as the acceleration mechanism responsible for plasma energization in both the solar flare and the terrestrial aurora. Initially reconnection was greeted by some members of the scientific community with a great deal of skepticism. However, in the intervening years it has come to occupy a preeminent position in our understanding of the dynamical behavior of astrophysical plasmas. It has also been discovered to be one of the major sources of plasma instability in magnetic containment devices such as the tokamak.

This volume is an impressive collection of more than 50 papers presented at a Chapman Conference. The book provides both a good review of the basics of magnetic reconnection and a broad survey of some of the more exciting and recent observations and developments.

Basically, reconnection involves the flow of plasma in topologically complex magnetic field configurations that usually involve magnetic null regions. It is the breakdown of ideal magnetohydrodynamics at these null regions (or their topological equivalents) that allows the vast amounts of magnetic energy typically stored in an astrophysical plasma to be efficiently converted into kinetic and thermal energy.

Unfortunately, the mathematical theory of the reconnection process is extremely difficult to formulate, and analytical solutions are available only in highly idealized cases. It is this inherent mathematical intractability that has been, and continues to be to some extent, the source of much controversy.

In many ways the history of magnetic reconnection parallels that of plate tectonics. Both concepts were treated with much suspicion when they were first proposed, primarily because simple theoretical arguments were quickly expounded to show why the concepts were not viable. In the case of magnetic reconnection it was thought that astrophysical plasmas lacked the electrical resistivity necessary to provide the diffusion of the magnetic field that produces reconnection. However, the accumulation of observational evidence eventually forced a reevaluation of the theoretical objections to both concepts.

As with plate tectonics, part of the appeal of magnetic reconnection is its ability to account for a very wide range of phenomena with a single, unifying principle. The book shows just how diverse these phenomena can be, for it contains in-depth discussions of magnetic reconnection in solar flares, coronal heating, comet tails, the terrestrial dayside magnetosphere, the geomagnetic tail, the Jovian magnetosphere, laboratory fusion machines, and various assorted galactic and extra-galactic objects. In addition there are sections on basic theory, recent computational results, and future directions and unanswered questions.

Transcripts of the question-and-answer periods following each presentation have been edited and have had references added where appropriate to make them comprehensible to those who did not attend the meeting. The inclusion of the transcripts is valuable, for they give the reader an idea of the major controversies existing at the present time.

Although one usually thinks of conference proceedings as being of interest only to specialists, I think this volume deserves to be considered by a wider audience. The papers (which have been refereed) are well written and articulate, and they are intended to be understandable to nonspecialists.

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