commodating Plowshare-type projects under the provisions of a comprehensive test ban, however.

In addition, there is at present no proposal for peaceful applications for U.S. purposes that appears attractive. The Rio Blanco gas stimulation experiment (p. 189) seems to have been a failure as far as commercial development is concerned. The American excavation projects that have been proposed all involve environmental hazards that appear to be unacceptable, if not illegal. The control of earthquakes by relieving tectonic strain with explosion-generated motion (p. 209) should no longer be considered as a serious suggestion in view of the great uncertainties of the interaction of the dynamic stress field from the explosion with the ambient stress field and geologic structures. Fluid injection and withdrawal offer a much more promising approach, based on principles we understand better. It seems unfair to suggest (as the author does on p. 246) that some proponents of an extended treaty want to end Plowshare programs. Another interpretation is that they see these as incompatible with a test ban and choose to forgo them in the interest of achieving an end to nuclear weapons development.

The text is almost free of editorial and technical errors, and the few I noticed will be of concern more to the seismologist than to the general reader. More information on Soviet seismic arrays is available, in a RAND report published in June 1975, than the author suggests on p. 146. The problem of determining the depth of a shallow seismic source, discussed briefly on p. 151, is more difficult than the author implies, and recent results using techniques not discussed are promising. The statement, on p. 170, that "shallow-focus earthquakes are always followed by a sequence of aftershocks" is not true, as seismologists who have worked with earthquakes in the central United States are well aware.

The publication of this book is especially timely in view of the treaty between the United States and the Soviet Union limiting underground tests to yields smaller than 150 kilotons that was to have gone into effect on 31 March and that is being honored even though the negotiations are incomplete. The background provided by this book will be most useful to the reader who wants to consider the problems of test bans on the basis of the facts.

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Forecasting

Earthquake Prediction. TSUNEJI RIKITAKE. Elsevier, New York, 1976. xvi, 358 pp., illus. $37.95. Developments in Solid Earth Geophysics, 9.

Twenty years ago one would have kept a book on earthquake prediction on the same shelf with texts on astrology, ESP, and dowsing. Because of limited and sketchy data, lack of good understanding of earthquake mechanics, and relatively poor detection equipment, scientific prediction of earthquakes was impossible. All that has drastically changed. The seismic and other geophysical data available today are voluminous and quite accurate, the equipment to obtain the data is versatile and sensitive, and the mechanics of faults is much better understood.

The near accomplishment of earthquake prediction raises new challenges. It is now necessary to specify more precisely what is required of an earthquake prediction. If we characterize an earthquake by its location, time, and magnitude, it is necessary to predict all three with a certain accuracy. If uncertainties in predicted time, location, or magnitude are large, the significance of prediction is greatly reduced. The prospect of earthquake prediction raises also social, political, and economic questions. How can and how should society respond to an earthquake warning? How can we deal with the uncertainties of prediction? What degree of prediction accuracy is necessary to justify the evacuation of an area at risk?

Rikitake's book is therefore timely. It opens with a brief collection of legends about harbingers of earthquakes, a resume of historical developments in earthquake research, and a description of the Japanese, Soviet, U.S., and other national programs. These are followed by an extensive collection of examples of crustal motion and deformation, seismic activity, and geomagnetic and electrical variations detected in association with earthquakes. Special attention is paid to variations in seismic wave velocity preceding earthquakes and to their possible relation to dilatancy and fluid flow in the earth's crust. It is interesting to point out here that the work that led to the development of the dilatancy-diffusion hypothesis was international. In the 1920's, Bridgman at Harvard University discovered that the elastic moduli of rocks increase significantly with pressure, owing to crack closure. In 1948 M. Hayakawa in Japan suggested that the change of stress in the earth's crust should cause small changes in wave velocities, which he observed. Fifteen years later a Russian team repeatedly detected velocity changes preceding local earthquakes. This was followed by similar observations in the United States. At the same time laboratory studies of velocities in rocks and dilatancy at the Massachusetts Institute of Technology provided the basis for the explanation for the velocity changes.

The dilatancy-diffusion hypothesis highlights the otherwise empirical approach that has been taken to earthquake prediction. The final section of the book contains a prediction theory developed by the author that is almost entirely statistical in nature and makes no use of physical models for earthquakes or their precursors. In fact, the lack of physical models is probably the greatest weakness of the book. Reid's notion of elastic rebound, which opened the way in 1906 to an understanding of strain accumulation and release, is mentioned only once. There is no mention of work on faulting mechanics, such as that by Burridge, Walsh, Haskell, and many others. Friction, which is probably the most important physical quantity in earthquake faulting, is not even listed in the index. The lack of concern with these aspects of earthquakes is also reflected by inaccuracies in references to original work on, for example, velocities in dry and saturated rock.

The book falls short of putting earthquake prediction into a strong scientific framework with working hypotheses. It is, however, an invaluable collection and summary of past and current work on the prediction of earthquakes around the world. As such, it will be an important reference for earthquake students.

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Experimental Petrology

Composition and Petrology of the Earth's Mantle. A. E. RINGWOOD. McGraw-Hill, New York, 1975. xviii, 618 pp., illus. $29.95. McGraw-Hill International Series in the Earth and Planetary Sciences.

Experimental petrology addresses problems related to the origin of magmas and the evolution of the crust and upper mantle. High pressure petrology is a subdiscipline that concerns itself with phase assemblages that occur deeper in the mantle. Geologists and geophysicists