Land and Sea Records

The Past Three Million Years. Evolution of Climatic Variability in the North Atlantic Region. N. J. SHACKLETON, R. G. WEST, and D. Q. BOWEN, Eds. The Royal Society, London, 1988. viii, 278 pp., illus. £53. First published as *Philosophical Transactions of the Royal Society*, vol. 318 (1988). From a meeting, London, Feb. 1987.

An understanding of the changing nature of climate variability through time is fundamental to determining linkages between various parts of the earth's global climate system. In this book, which contains 14 papers from a Royal Society "discussion meeting," the target is nothing less than the cause of the ice ages. The evolution of climatic sensitivity over the last three million years has been widely ignored until recently. As Shackleton states in the preface, "There has been a tendency for Quaternary specialists to distance themselves from phenomena that have characteristic times longer than a few tens of thousands of years, just as the rest of the geological community regard anybody investigating phenomena with characteristic times of less than a million years as a dangerous catastrophist. At this meeting we were forced to bridge that gap."

The bridge is being built by marine geologists, who in recent years have obtained continuous, high-resolution sedimentary sections from ocean drilling. With these detailed marine records, they have set the goals toward which terrestrial workers will strive. For example, in the lead paper in the volume Ruddiman and Raymo document the intensification of North Atlantic climate variability over the last three million years at a degree of resolution that would have been inconceivable a decade ago and then put forward an important hypothesis on the role of recent tectonism in modifying global climatic patterns. Sarnthein and Fenner focus on the role of oceanic productivity in controlling atmospheric carbon dioxide content and on potential climatic feedbacks.

In contrast, from my perspective as a marine geologist the land-based studies seem to bog down in questions of reliability of signal interpretation, correlation, and chronology of their fragmented records. For example, Catt reviews difficulties of interpreting climate change from soils, due to the complex interactions of local climate, exposure time, parent material, and postburial modification. The greatest potential appears to lie in loessial soils. Judging from a recently published study of Chinese loess deposits (Kukla *et al.*, *Geology* **16**, 811 [1988]), Catt's statement is already proving true. The climates within cold stages are addressed by West, who notes that evidence for past temperatures is reasonably good but reconstructions of precipitation and snowfall are more problematical. He emphasizes that our tendency to classify episodes as "glacial" or "interglacial" masks huge complexities within each regime, which are critical to interpreting mechanisms of change.

De Jong documents more than two million years of climate change in northwest Europe, using data assembled from pollen analyses of many sites, but notes that precise correlation to the deep-sea record is not yet possible. Cronin infers a 100,000-year climate cycle in his record of fossil ostracods from the eastern United States but emphasizes that the record is too fragmented and dating too uncertain to resolve shorter-period fluctuations in detail. In an account that is controversial when it conflicts with traditional stratigraphic interpretations, Bowen and Sykes review European land-sea correlations using amino acid stratigraphy. They assert that "traditional classifications of the continental Quaternary are inadequate and mostly oversimplified." In his study of the Canadian Arctic, Andrews states that "although it is tempting to correlate aminozones with the marine isotope record . . . [this] is only a hypothesis that requires rigorous testing." It is useful to have these complexities of interpretation, correlation, and chronology debated as they are here. A wide range of paleoclimatologists will become more aware of both the strengths and the limitations of data sets outside their expertise.

Noting the difficulties inherent in the land record, Shackleton, Imbrie, and Pisias ask boldly, "In areas where the prospect of reconstructing long records that are suitable for comparison with the deep-sea records is remote, is there any palaeoclimatic justification for continued Quaternary research?" Their answer, of course, is yes. The land-based record offers spatial detail and sensitivity that the deep-sea record will never achieve. Both areas give important, if distinctly different, information. Together they give insight that each alone would not provide.

In this combined land-sea approach lies the greatest strength of the book. This is a truly interdisciplinary offering, including micropaleontology, geochemistry, paleobotany, seismic profiling, and soil science as well as traditional Quaternary geology. Given the individual quirks of each field, the papers must emphasize a variety of spatial and temporal scales, and there is a vast range of specialized jargon represented, which may mean slow reading for the uninitiated. But fighting through the jargon is worth it. The book neatly summarizes the current state of the art in the study of climate variability over the designated time frame.

The Past Three Million Years focuses on the North Atlantic region, for it is only here that sufficient work has been done to attempt a broad summary. Studies of long-term climate variability will continue as more samples become available from the Ocean Drilling Project and other global studies, and this collection serves as a grand statement of strategy for such work. The volume is nicely edited and printed, and the Royal Society's practice of including the discussions that followed papers at the meeting is helpful, as it flags hidden assumptions and controversy that might otherwise be missed.

ALAN MIX
College of Oceanography,
Oregon State University,
Corvallis, OR 97331

Succulents and Their Ways

Environmental Biology of Agaves and Cacti. PARK S. NOBEL. Cambridge University Press, New York, 1988. x, 270 pp., illus. $59.50.

Agaves and cacti belong to unrelated plant families, yet they share ecological, physiological, and anatomical features. Both are succulent, although the agaves are leaf succulents whereas the cacti for the most part are stem succulents. Both are largely natives of the New World, occurring in arid, semiarid, and semitropical habitats, but they are cultivated throughout the world for food, fiber, and other uses. Importantly, both have the photosynthetic mechanism crassulacean acid metabolism (CAM), which imparts great resistance to drought. Nobel has developed from a biophysical point of view a comprehensive and excellent treatment of these two interesting groups of plants.

After an outline of the economic uses of the plants, the history of research on them, and their taxonomy and anatomy, there is a detailed development of the principles of plant gas exchange that provide a basis for understanding how these plants react to their environment. Subsequently, Nobel develops in biophysical terms concepts of water relations, temperature, photosynthetically active radiation (PAR), and soil nutrients as they relate to the ecophysiology of agaves and cacti. The final chapter brings the entire work together using an index referred to as EPI, the environmental productivity index. This index relates the actual CO_2 uptake over a 24-hour period to the maximal CO_2 uptake possible as affected by water, temperature, and PAR. Validation of the EPI