"Setting trawl on a fine evening, using a 'heaving stick.' " This picture, by M. J. Burns, "originally illustrated an account of a winter trip to Georges published in *Scribner's Magazine* in 1902." [From *Georges Bank*; photograph by Claire White Peterson; Mystic Seaport, Mystic, CT]

much net primary production on the basis of nitrogen fluxes) and to estimates of secondary production.

Possibly the greatest obstacle to explaining the high level of fish production on Georges Bank lies in the paradoxically low estimates of secondary production by zooplankton and benthos (chapters 25 and 37). To construct realistic trophic models requires the assumption of inordinately high transfer efficiencies of energy from intermediate to higher trophic levels. The problem is assumed to be due to losses of zooplankton from the system, a function of short residence times of zooplankton on the bank relative to their generation times, and perhaps to the as-yet-undefined role of microbes. It is clear that direct measurements of secondary production and microbial processes will be needed if the question is ever to be resolved; significant advances have been made in the second area since 1984.

The increase in fishing pressure brought about by the distant-water fleets in the 1960s and 1970s and the resulting decrease in biomass and production of the exploitable fish stocks have led to a much closer examination of recruitment processes and management strategies and underscored the role of humans in marine ecosystems (chapter 48). With the United States and Canada now jointly controlling the bank, an effective international management plan is still needed.

All those concerned about the future of Georges Bank are well advised to read this fascinating book, even though (with a page size of approximately 13½ by 15 inches) it may be too unwieldy to carry around in a briefcase. Backus recommends cautious development and suitable monitoring of Georges Bank, for which there should be time since further drilling depends on increases in the price of oil and gas. Whether the continuing uncertainty, frustration, and sense of crisis about future exploitation of the fisheries will "force a consensus on management purposes" (chapter 49) is far from clear, but new hypotheses about physical-biological interactions are already being tested.

Final thoughts must go to the fishermen who have perished on Georges Bank. During one storm in February 1879, 143 Gloucester fishermen drowned: "The hopless, terror striken faces of the crew we saw but a moment . . . . The doomed craft . . . struck one of the fleet, a short distance astern, and we saw the waters close over both vessels" (p. 99).

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Subterranean Systems

Paleokarst. N. P. JAMES and P. W. CHOQUETTE, Eds. Springer-Verlag, New York, 1987. xii, 416 pp., illus. $64. Based on a symposium, Golden, CO, 1985.

Caves have attracted humankind since time immemorial. In the Cretaceous reefs of Mount Carmel, Israel, caves were the refuge of humans when ice covered much of Europe. In biblical times the prophet Elijah hid in the same caves from the king of Israel. Paleolithic and later art is still preserved in the caves of France, where humans survived during the Ice Age. This book delves further into history: its chapters span the time between the Precambrian and Cretaceous. A good reason exists why paleokarst is of current interest. Caves form significant reservoirs of oil and gas. In a recent oil-exploration venture in the Park City Basin of Kansas, fluids and rods vanished in the Ordovician Arbuckle Formation. Several years earlier a similar event occurred in the correlative Ordovician Knox Group of Ohio and in a cave in Cretaceous strata 6 kilometers below Lake Maracaibo in Venezuela. Where caves are vast, exploration may be unsuccessful and fluid and drillrods vanish.

Caves are part of a karst system. The term "karst" derives from the Serbian province of what is now Yugoslavia, where limestone floors the type locality, known as Krš, a plateau in the Dinaric Alps. By extension karst is now a common term describing a topography formed on limestone or evaporite deposits, where extensive dissolution has created caves, solution-collapse, underground rivers, and sinkholes. Dissolution creates porosity, the basic condition for oil, gas, and water. But karst reflects megaporosity. As an example, commercial oil usually occurs in tiny pores in bedrock. By contrast the Golden Lane oil field in Mexico, where the karst is expressed as caves, comes closest to what a nonscientist thinks an "oil pool" should be, almost a cave of oil. Yet there is more to karst than oil, gas, and water. Karst hosts important mineral deposits, like lead and zinc.

This book presents a sequence of studies on buried karst, termed paleokarst. Its initial chapters relate to modern cave systems and their various precipitates, known as speleothems. Geochemical characteristics of carbonate cements derived through dissolution are described, and the application of geochemical patterns to studies of paleokarst is discussed. Most of the volume is devoted to case histories of ancient karst at scales ranging from local to regional and interregional. Economic examples include lead-zinc deposits in carbonate rocks and a subsurface case history from the San Andres Formation of the Permian Basin of West Texas. To appreciate the importance of the karst, note that the San Andres Formation holds 40% of the Permian Basin's oil reserves and the Permian Basin holds 20% of the total reserves of the conterminous United States. Among the examples of paleokarst terranes that are treated in separate papers are the Dismal Lakes Group in the Northwest Territories, Canada; the Leadville Formation in central Colorado; and the Subbetic Zone of southern Spain. Most of the papers are concerned with field exposures. Some of this material has been published before.

However, the significance of karst goes further than the authors and editors have shown. During much of geologic history, shallow seas, known as epeiric seas, covered the continents. Intervals of subaerial emergence during which karst developed are signals for globewide sea-level retreat. Why were the continents emergent? Did emergence reflect the freezing of polar ice or, during the Cretaceous when no ice occurred at the poles, was collapse of midocean spreading centers with consequent sea-level fall responsible? A key may be epeirogeny, the process by which broad vertical movements of the earth's crust take place unaccompanied by crumpling of strata. Large-scale vertical movements of the crust and lithosphere must be recognized in paleogeographic reconstruction. Such drastic changes represent isostatic unroofing, much of which results in the kinds of changes that generate karst.

The editors and authors have given us a splendid rendition of details, bringing together widely scattered information. Yet I missed the big picture. The editors should have shown how these case histories relate to global eustasy and regional epeirogency.

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Biography of Our Planet

Oasis in Space. Earth History from the Beginning. PRESTON CLOUD. Norton, New York, 1988. xviii, 508 pp., illus. $29.95. Commonwealth Book Fund Program.

Geologists are lucky people. They get to travel to all sorts of odd, beautiful spots, away from the urban miasma. They study that most wonderful, strange, and improbable of subjects, the earth. They can tell true tales of polar bears, hippos, and encounters with cannibals. They even get to go to committee meetings without wearing ties.

Preston Cloud is one of the luckiest of geologists: he saw the planet in the days before its ecological ruin; he has seen his discipline grow to a hard, if less amusing, science with a firm theory of the earth; he has seen innumerable rocks (the best geologist is often the one who has seen the most rocks) and much mud; and, mirabile dictu, he has had a chance to write it all down for us.

Oasis in Space is a paean to the glory of the earth. It is a fine exposition of the history of our planet, written in a chatty style that hides deep learning and wise judgment. The book is a biography of the planet, and it pays more than usual attention to the infancy, childhood, and youth of the earth. The first section recounts the beginnings of the planet and introduces the fundamental logical tools of geology, together with the concept of geological time. This is followed by an account of the next 3 billion years, or most of what is commonly (but not by Cloud) called the Precambrian. Woven into this history of the biosphere is a discussion of the more physical aspects of geology: plate tectonics, climatology, and so on. The final chapters recount the more familiar tale of a planet inhabited by metazoa: a biosphere dominated by plants and animals. Within this saga of trilobites, fish, dinosaurs, and humans, the author interleaves many other topics: mountain building and continental collision, evolution and extinction, oil and climate, forcing factors and the question whether a gale in a junkyard would ever assemble a B-29 bomber.

There is much meat in the book, and the material is eclectic and up-to-date; there is even mention of RNA enzymes, not normal matter for a geology text. There are many set-piece expositions of such varied subjects as the origin of ironstones and the history of the atmosphere, plate tectonics, the theory of evolution, and the nature of mass extinction. Throughout the book the argument is detailed and careful: there is little of the vacuity common in general geology texts. The book should appeal to hordes of students (though it may be too advanced for first-year students) and to scientists who are not geologists. It may even revitalize those professional earth scientists like myself who are so worn down by the interminable business of grant application and implementation that we forget the splendor of our home. Though one may disagree with some of Cloud's opinions and dispute some of his conclusions, this is a book worth reading well and well worth buying. And what a wonderful title!

Now, like most field geologists, I must end with a Cloud story and a moral. He visited us once, years ago, in the Zimbabwean bush. Our camp was by a pool occupied by bathing maidens at one end and a large hippo on a sandbank at the other. Cloud, being a geologist, went straight for the end with the hippo. Now large hippos are not safe—they kill many people, bite you in three, and stomp on the remains—but Preston was fearless. He advanced steadily onto the sandbank in his inexorable investigation of nature, while we watched, worried, and considered rescue. The hippo arose and angrily prepared to charge. Fortunately, at the very last moment it yielded and ran off with a great splash, and *Oasis in Space* could be written. The moral, inevitably, is that of Cloud's last chapter: mankind now rules the earth and nature is in retreat.

But hippos do not just sleep on sandbanks. Hippos have incongruously tiny tails, which do more than keep off flies. When a hippo defecates, which it does with great éclat, the co-evolutionary tail whirs around like a fan. The dung hits it, is spread far and wide, and nurtures the riverbank habitat. Here is the parting message of Cloud's book: when we remove the hippo we also leave the riverbank, the river, and the world much the worse. Our planet is in crisis. *Oasis in Space* is a summation of the insight gained by earth scientists in this century. Earth science has solved the problem of how the planet works in physical terms; our challenge now is to understand and manage the biosphere, our home, before it is destroyed.

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Sexual Reproduction

The Evolution of Sex. An Examination of Current Ideas. RICHARD E. MICHOD and BRUCE R. LEVIN, Eds. Sinauer, Sunderland, MA, 1987. x, 342 pp., illus. $55; paper, $29.95.

The near ubiquity of sexual reproduction has long attracted the attention of evolutionary biologists. Why should so many species engage in the complicated behavioral and physiological processes needed to bring together gametes from two distinct individuals, and possess the elaborate genetic machinery involved in producing recombination between the maternal and paternal genomes during the production of these gametes? It would seem much easier simply to engage in "some harmless mode of vegetation," as Edward Gibbon once put it. Since the development of the modern evolutionary synthesis in the 1930s and '40s, thinking about the evolutionary significance of sex and genetic recombination has been dominated by the idea that the long-term survival of the population or species is promoted by the ability of sexual reproduction to generate new combinations of alleles at different loci and thereby accelerate the rate of evolution. On this view, asexual taxa are more vulnerable to extinction in the face of a changing environment and so are poorly represented among extant species of higher plants and animals. During the past 15 years or so, this type of interpretation has come under increasing challenge, and considerable effort has been expended in developing models of selection on genes that modify the mode of reproduction or the frequency of genetic recombination, with the course of evolutionary change being determined by the changes in frequency of these genes within populations.

The early phases in the development of this viewpoint were reviewed by George Williams (*Sex and Evolution*, 1975) and John Maynard Smith (*The Evolution of Sex*, 1978). Since then, a number of significant further theoretical developments have occurred, and an ambitious attempt to test the earlier models against the evidence provided by the taxonomic distribution and ecological corre-