she is right, how personally important the topic is, and how much relevant information the person knows. These simple insights add immeasurably to the job of the survey researcher, because they suggest that it may be necessary to ask five or six questions to get what amounts to one answer. Dovidio and Fazio double the researcher's burden by noting that people give different answers when responding spontaneously and responding deliberatively.

Social and cultural change transforms the meaning of questions, and researchers must be prepared to reword or replace items that become obsolete. The GSS has long asked about the proper level of funding of various government projects, including the "space exploration program," and it has retained this wording for the sake of comparability over the years, even though the emphasis in the space program has shifted from exploration of the solar system to exploitation of near-Earth orbit. Recently, the GSS has debated whether attitudinal items about "communism" should be retained, because the collapse of hostile Marxist governments has rendered this term highly ambiguous in meaning and possibly no longer scientifically interesting.

Among the more influential psychological instruments of the 1960s was the 20-statement Mach scale (named after the Italian political theorist Machiavelli), which measured a person's tendency toward guile and deceit. One item said, "Barnum was probably right when he said there's a sucker born every minute." Extreme Machiavellians have always felt that once a minute is a gross underestimate, but many of today's respondents have trouble even figuring out what this statement means. They may never have heard of circus showman P. T. Barnum, and the term "sucker" may have dropped from the slang lexicon. Another Mach item simply said, "Most men are brave." Originally, disagreement reflected the low opinion of human nature held by Machiavellians, but today many respondents react to it as a sexist remark that ignores the bravery of women.

Sane paleontologists do not talk with their fossils. Social scientists, however, must generally enlist the willing assistance of their research subjects and cope with considerable waywardness on the part of these untrained helpers. There is nothing wrong about this, although more adequate funding would sometimes allow us to use more effective research methods such as direct observation of human behavior. What joy would reign among paleontologists if they could really make the mute stones speak and ask the dinosaurs about their social life! The problems of survey research are manageable, and methodological studies like those in Tanur's collection are essential contributions to rigorous social science.

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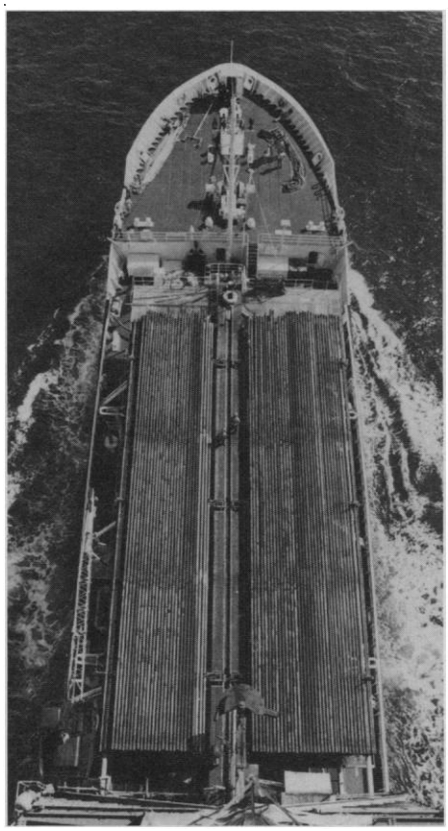
Opinions on Geology

Challenger at Sea. A Ship That Revolutionized Earth Science. KENNETH J. HSÜ. Princeton University Press, Princeton, NJ, 1992. xxxii, 417 pp., illus. $35.

Challenger at Sea: A Ship That Revolutionized Earth Science is rarely about a ship, and only sporadically about work at sea. It is about many revolutions in earth science, recent and long past, and how they happened, all strung together by the thread of the Deep Sea Drilling Project. Hsü preempts the critical reviewer by statements scattered through the preface—that the book "is not easy reading for general readers"; "it is not arranged in an orderly fashion"; "it is the story of a participant, and the partisanship is undisguised"; and, finally (appallingly), "I might as well accept the fact that my readers will only be those who want to learn something." This all makes the book sound awkward and difficult. It is not. It is written clearly, and if you have some small background in geology it is a quick and easy read. Hsü does get into some details and some complicated explanations—the listing of the 12 stages of the Cretaceous in a sentence; a complicated discussion of oxygen isotopes; an attempt to explain the measurement of the velocity structure of the earth, the petrography of the earth's interior, and the concepts of isostasy in a few short paragraphs—but if you are baffled by an item, keep going; these are isolated problems.



"Pipe rack on *Glomar Challenger*. Seven thousand meters of drill pipes are stored on [the ship]." [From *Challenger at Sea*]

As to the organization, since it is a chronological scramble and the chapters do not proceed logically from one topic to the next, it is an ideal book for browsing, so let me recommend a few of my favorite chapters.

Try chapter 15, "When the Mediterranean dried up." This is a great discussion of the stories that sediments can tell and how the key factors were discovered (by Hsü and others) to prove the dramatic concept that the Mediterranean had actually been walled off from the world ocean and dried up for a short period. The result was the deposition of salt 3000 meters below sea level and the cutting of great subaerial canyons around the basin.

Try chapter 8, "Swallowing up the ocean floor," where Hsü proves that this is not going to be a bland history of science by identifying heroes and villains in geology. On the assumption that every revolution is preceded by a tyrant, he nominates Sir Roderick Murchison for that position and suggests that Murchison's career in the mid-19th century led to the earth sciences revolution of the 1960s. Hsü demonstrates the influence of individual stubbornness and desire for self-aggrandizement in science in many short episodes. An ancient example is the history of the great controversy regarding glaciation in Europe that occurred in the latter half of the 17th and 18th centuries and resulted in the beginnings of scientific geology with Hutton and Lyell. Modern examples are the stories about how control of scientific drill sites was established by personal drive and persuasiveness.

Try the section of chapter 5 called "Isaac Newton was not Chinese." No doubt you were aware of that fact, but this section is a thought-provoking analysis by Hsü (a Chinese) of why the Chinese culture, as exemplified by the Chinese language, has not produced the sort of questioning science that the European and American culture has. The Confucian virtues of loyalty, constancy, and gratitude are great human attributes but may not lead to the develop-

ment of the best science, which requires the questioning of conventional wisdom.

Try chapter 20, "The great dying," about the development of ideas, based on evidence from all over the world, that a catastrophe at the end of Cretaceous time caused extinction of many species and how (p. 358) "the cores of *Glomar Challenger* are now being called as witness if a meteor has murdered the dinosaurs." Hsü avers that this shows that evolutionary changes are controlled to a considerable degree by accidental disasters, not by a continual competition between organisms as Darwin proposed, and he goes on to a criticism of the philosophy of social Darwinism.

This is a very individual, opinionated book, and you may end up arguing with it in places, but it is not dull. The book includes many personal stories. Some of them are trivial, regarding such matters as Dan Karig's ability to do minor home repairs or the instance when Hsü and Dan McKenzie did not recognize each other in an airport. Others represent tragedies, like the exclusion of a great scientist, Bruce Heezen, from his institution because of conflicting egos and a mistake he made, or such as the sad death of Seymour Schlanger.

"Taking a wire-line core on *Glomar Challenger*. The roughnecks have already unscrewed the drill string near its upper end, and secured the core barrel to a clamp on the rig floor. Then they had to unscrew the "overshot" (a hook-like device) at the end of the sandline, which had been sent down to fish out the core barrel from the bottom of the hole. After this was done, the core barrel could be taken out of the drill string, as shown here." [From *Challenger at Sea*]

Who should read this book? Any scientist or non-scientist with some familiarity with geology probably would enjoy it. Students in geology would see how modern concepts developed and observe a more personal side of their science; they also would be amazed at the freewheeling style of funding and planning in marine geology that prevailed in the late 1960s. Those were days of exploration, when we knew so little that we could be confident of new discoveries. Furthermore, support was easily available for field programs, unlike today, when proposals need to be tightly thought out, precisely planned, and carefully defended.

I started by indicating misgivings about the title. A more accurate (but, I suppose, much less rousing) one might be "A Personal View of the Development of Geology and the Significance of the Deep Sea Drilling Project." Two major technological systems that revolutionized our knowledge of marine geology were developed in the mid-to-late 1960s, the research submersible *Alvin* (1964) and the deep-sea drillship *Glomar Challenger* (1968). In some form they are still working (*Glomar Challenger* in a reincarnation as the *JOIDES Resolution*). This may be the time to write their history, and a fine history of *Alvin* was recently published (*Water Baby: The Story of Alvin*, by Victoria Kaharl, Oxford University Press, 1990). The history of the *Glomar Challenger* and the Deep Sea Drilling Project still needs to be written, perhaps by someone who was more closely and continuously involved than Hsü. However, *Challenger at Sea* is informative, interesting, and provocative, and, as a personal history of the workings of a science, it is superb.

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Earth's Early Life

The Proterozoic Biosphere. A Multidisciplinary Study. J. WILLIAM SCHOPF and CORNELIS KLEIN, Eds. Cambridge University Press, New York, 1992. xxiv, 1348 pp., illus. $195.

Oliver Morton, writing in *The Economist*, likened the study of Precambrian fossils to psychoanalysis, in which practitioners "seek . . . in ill-remembered childhood the forces that shape the adult mind." The simile is apt. Life was born in the Archean and matured during the Proterozoic, and so did the continents, oceans, and atmosphere. Earth's early memory is incomplete and colored by later tectonic and evolutionary events; yet present-day Earth is very much the product of its Precambrian development.

Fifteen years ago, J. William Schopf organized the Precambrian Paleobiology Research Group (PPRG) to study Earth's infancy as recorded in Archean rocks and bacterial physiology. The result was *Earth's Earliest Biosphere*, a splendid volume full of creative interdisciplinary effort. Now the PPRG is back with a gargantuan account of Earth's coming of age during the long (2500 to 540 million years before present) Proterozoic Eon. Data on Proterozoic life and geology far outweigh those available for the Archean. Whereas a handful of microfossils, two dozen stromatolite localities, and a smattering of isotopic analyses constitute the entire Archean paleontological record, Proterozoic evolution is documented by hundreds of microfossil assemblages, more than a thousand carbon isotopic determinations, a remarkable abundance of stromatolites, diverse biomarker organic molecules, and (near its end) animal remains. Additionally, the molecular, ultrastructural, and morphological variation found among living protists and animals greatly enriches the body of relevant biological data. The authors of this volume have worked hard to present a comprehensive overview of this mass of information.

The Proterozoic Biosphere has many merits. Without exception, the contributing authors are distinguished scientists whose interpretations warrant serious consideration. Annotated lists of published fossil occurrences and biogeochemical data, as well as an extensive bibliography, provide ready access to an extensive and often scattered literature. This information provides an important first line of attack for anyone interested in Precambrian life, though the compilations are current only to mid-1988. In the case of carbonaceous macrofossils and Ediacaran animals, the rate of new discovery is low enough that the treatment remains more or less current, but known occurrences of Proterozoic microfossils have increased by 25 percent over the past four years—with important consequences for some of the book's conclusions.

Many chapters in *The Proterozoic Biosphere* are tantalizingly, even frustratingly, brief. Brevity is a art not easily mastered, and too many of the chapters read like extended abstracts. The most successful miniatures are found in the sections on