BOOK REVIEWS

A World of Rock

To a Rocky Moon. A Geologist's History of Lunar Exploration. DON E. WILHELMS. University of Arizona Press, Tucson, 1993. xxii, 477 pp. + plates. $29.95.

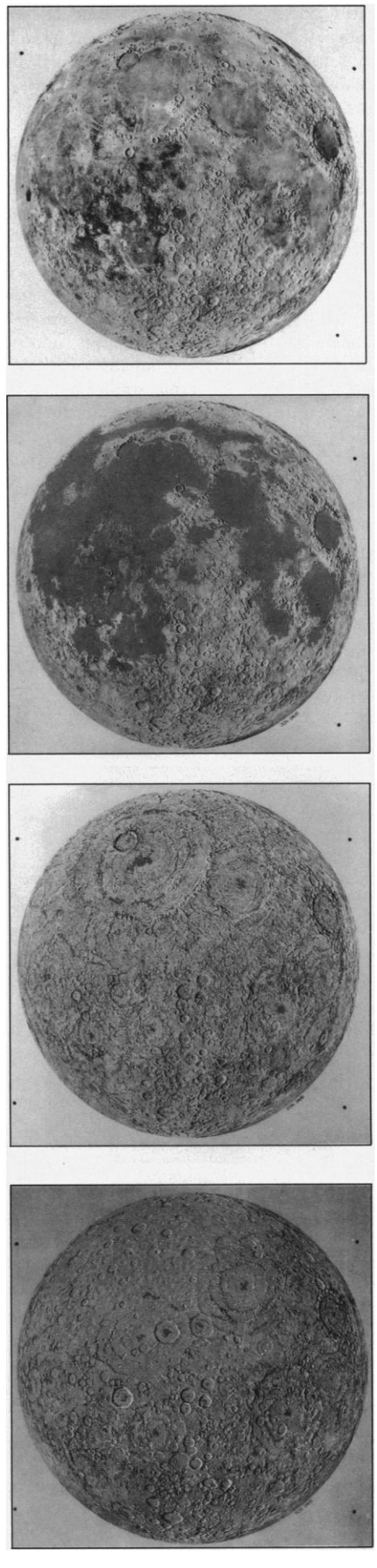
During the 1960s "lunar science increasingly became geological science. The later Apollo missions were elaborate geological field trips." So writes Don Wilhelms in the preface to this fascinating history of lunar exploration. His focus on the moon as a rocky world and the accumulation of geological knowledge about it sets this book apart from other accounts of Project Apollo. A magnificent work, it is scientifically rigorous yet clearly written in an anecdotal style and thus should attract a wide audience of general readers as well as scientists.

A geologist with a strong interest in astronomy, Wilhelms joined the new Astrogeologic Studies Group of the U.S. Geological Survey in 1962, three days after completing his doctoral dissertation. He remained in what became the Astrogeology Branch of the Survey until his early retirement in 1986. Wilhelms led efforts to apply principles of terrestrial geology to lunar mapping and to establish a relative time scale for lunar stratigraphic units. Over the years he appears to have gotten to know every person and every policy decision that influenced the scientific side of the Apollo program. In his book he provides trenchant (and not always complimentary) profiles of scientists, astronauts, and administrators, informing us of their ideas, their personalities, their disputes, and their accomplishments.

Originally intended as a historical chapter in Wilhelms's *Geologic History of the Moon*, a large (11 by 14½ inch), profusely illustrated *Professional Paper* of the Geological Survey published in 1987, his account expanded into this 477-page volume. In it Wilhelms traces geological studies of the moon from their beginnings in telescopic studies, recounts the early struggles to include geology and geophysics in the Apollo program, details the advances made by unmanned landers, and describes the geological findings of each of the six manned landings. Based on the author's intimate working knowledge and liberally spiced with his personal observations, *To a Rocky Moon* is the definitive work on this aspect of the Apollo program.

Wilhelms dates the beginning of modern investigation of the moon to August 1892, when Grove Karl Gilbert (1843–1918), chief geologist of the Geological Survey, began an 18-night period of observing the moon through the telescope at the U.S. Naval Observatory in Washington, D.C. Gilbert was the first person to perceive an overall uniformity in lunar craters, from the smallest to the largest. He concluded that virtually all the craters had been formed as a result of the impact of falling bodies. Wilhelms comments that Gilbert's sketches and descriptions (although not all of his interpretations) could be used in a modern textbook. At the time, however, most geologists took for granted a volcanic origin of lunar features and felt that Gilbert had wasted his time.

Similar attitudes prevailed 50 years later when Ralph B. Baldwin, a graduate student in astronomy, performed meticulous studies of telescopic photographs and concluded that the major crater- and basin-forming process on the moon was the explosive impact of meteorites. His senior professors warned him off lunar studies, and astronomical journals refused to print his early papers. Baldwin persevered, and in 1949 he published *The Face of the Moon*, in which he documented his case for explosive impact on a log-log plot showing a regular succession in depth-to-diameter ratios of bomb craters, lunar craters, and terrestrial meteorite craters. Wilhelms calls *The Face of the Moon* the most influential book on lunar science ever written, not because it sold well (it did not) but because it electrified two readers who would go on to play key roles in shaping strategy for lunar exploration. One of the two was Harold C. Urey (1893–1981), a Nobel Prize–winning chemist who pursued a second career in lunar science as a result of reading Bald-



Reconstructions of four stages in lunar history. *Top to bottom*: "Nectarian time about 3.86 aeons ago, after an impact created the Serenitatis basin (upper right) but before the Imbrium impact." "End of Early Imbrian time, about 3.8 aeons ago, after formation of both the Imbrium basin (upper left quadrant) and Orientale basin (lower left limb)." "End of Imbrian Period, about 3.2 aeons ago, after maria reached most of their present extent but at least 2 aeons before mare volcanism ceased." "Present Moon." [From *To a Rocky Moon*; prepared by Donald E. Davis]

win's book. The other was Eugene M. Shoemaker, a young geologist with dreams of going to the moon himself. In 1963 Baldwin published a second book, *The Measure of the Moon*, which presented an abundance of new observations and ideas, most of which were confirmed during the Apollo missions. Thus Wilhelms's own book is "dedicated to the amazing Ralph Baldwin, who got so much right so early." Perhaps Baldwin's accomplishments might not seem so amazing if he had been a full professor advising a succession of eager graduate students. But Ralph Baldwin never entered academia; his primary activity was running the family machinery company in Michigan. He pursued his lunar studies alone, as time permitted. (Now retired from the family business, he continues to study the moon.) Such achievements by this route must be well-nigh unique in the annals of contemporary science.

Wilhelms credits Eugene Shoemaker with being primarily responsible for persuading the National Aeronautics and Space Administration to incorporate geology and geophysics into the Apollo missions. Not only was Shoemaker himself an enormously persuasive advocate with a fine-tuned political sense, his cause received timely aid now and then from the successes of unmanned Soviet missions to the moon. One more scientist whom Wilhelms lists as a leader in the development of lunar science is Gerard P. Kuiper (1905–1973), who founded the Lunar and Planetary Laboratory at the University of Arizona. In addition to such key figures Wilhelms discusses the contributions of all the men and women who worked on lunar geology, down to the youngest recruits. In a final chapter, entitled "Debriefing," he reports where each of them is now. Twenty-one years after the flight of Apollo 17, all but a few are still living and active as lunar or planetary scientists; practically none have retired from scientific pursuits altogether.

"Apollo 15 prime and backup crews training at 3,700-m elevation in Silverton Caldera, San Juan Mountains, Colorado, July 1970. Lee Silver (with Tim Hait's hat) was showing them volcanic stratigraphy and deposits created by downslope movement of rubble (visible on mountains in background). From left to right, Dick Gordon, Jim Irwin (*front*), Jack Schmitt (*behind*), Dave Scott, Silver, Hait." [From *To a Rocky Moon*; photograph by Joe Allen, courtesy of L. Silver]

Once it became apparent that the manned spacecraft would have the capacity to carry scientific apparatus and sample boxes, there were strong clashes over who should go to the moon—test pilots or scientists. NASA favored test pilots. Scientists favored scientists. Wilhelms's own comments are

refreshing. He says that although many scientists regarded the test pilots as dumb fighter jocks incapable of learning science, that opinion definitely was not shared by those geologists, including himself, who led the pilots through their rigorous training for geological reconaissance and sampling. In the end, only one scientist-astronaut, geologist Harrison (Jack) Schmitt, flew to the moon, but Wilhelms reports that all of the pilot-astronauts performed well and some of them provided outstanding geological observations.

About half of the book is devoted to descriptions of the planning for each mission and reports of what the astronauts observed on the ground, what decisions they made in real time, what rocks and soils they collected, and what these samples added to our geological knowledge of the moon. Some sites of key geological importance could not be visited, much to Wilhelms's disappointment. Nevertheless, in an account of the geological evolution of the moon keyed to a radiometric time scale he shows that the missions yielded answers to most of our long-standing questions. For example, with regard to the fundamental questions of how the moon originated and why Earth is the only planet between the sun and Pluto possessing a single large satellite, he supports the widely accepted scenario promulgated at a conference at Kona, Hawaii, in 1984. After the separation of an iron core, the protoearth was struck a glancing blow by a passing body about the size of Mars; most of the iron from the impactor's core fell to Earth while a disk of vapor and debris from both the impactor and Earth's mantle spun out into space. Some of this hybrid material, which lost all of its water and most of its volatile elements in the event, coalesced to form the moon. Thus the odd pairing of Earth and moon arose by sheer happenstance.

Wilhelms points out that the Apollo program, which was launched by politics in the late 1950s and slowed by the Vietnam War in the late 1960s, was curtailed by economics in the 1970s. "By the time of Apollo 17 [in December 1972] a magnificent and sophisticated network of rocketry, flight operations, geologic and geophysical support, and geologic and laboratory analysis was functioning with smooth precision. Now it was time to shut it all down and turn out the lights," writes Wilhelms. Was it worth it? "Hell yes," he says, "it was worth it, and to pass up the opportunity to land people on the Moon when the once-in-a-lifetime opportunity arose would have been unconscionable." As one of the continuing benefits of the missions he points to the concept of Spaceship Earth and the urgency it instills in us to preserve the natural ecosystems of our planet. Unlike the prophets of space colonization, Wilhelms believes that the missions showed that Earth is the only viable abode for our species.

This book, which includes four highly informative appendixes, copious notes, a selected bibliography, and numerous illustrations, documents the history of a specific scientific enterprise. The author defines technical terms and explains geological principles so that the general reader can enjoy it for the grand adventure story that it is. At the same time, the volume is certain to find a place on reading lists of many undergraduate and graduate students in the earth and planetary sciences. With its wealth of anecdotes about personal relationships among those involved in lunar exploration and how policies were hammered out, it should also interest students of the social sciences. In the current controversy about who should write the history of science, scientists or historians,

Wilhelms is an unabashed insider—a scientist writing history. Historians must decide for themselves whether Wilhelms has properly placed Project Apollo in its social and political context. Among the book's most avid readers will be those hundreds of us who participated in the Apollo missions through geological mapping, sample analyses, and geophysical studies. My own friends and colleagues appear throughout its pages, and the chapters teem with fresh insights on the projects we engaged in. Those who pick up this huge and hugely entertaining book for browsing may find that they cannot put it down again in a hurry.

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The Spirit of the Gift

Inalienable Possessions. The Paradox of Keeping-While-Giving. ANNETTE B. WEINER. University of California Press, Berkeley, 1992. xiv, 234 pp., illus. $35 or £22.50; paper, $13 or £8.50.

The making of comparisons in anthropology has often been a matter of stretching concepts derived from the ethnography of particular groups in new directions. In Pacific ethnography such efforts have frequently been concerned with the old dichotomy between Polynesia and Melanesia, the former supposedly connected with hierarchical and the latter with egalitarian political forms.

Annette Weiner is an anthropologist who made her name by working in a society at the intersection of the Polynesia–Melanesia dichotomy, an intersection moreover already made famous through the work of Bronislaw Malinowski, namely the Trobriand society of Papua New Guinea. The strength of Weiner's contribution to the already rich ethnography of these people lay in her stress on the roles of women in the reproduction of the matrilineage and on the importance of their manufacture and exchange of decorated skirts and banana-leaf bundles in mortuary rituals. More recently she has extended her concern with the significance of material objects for gender relations among the Trobrianders to the broad theme of the importance of women's wealth throughout the Pacific. This in turn has led her to question the supposed overall preeminence of reciprocal exchange as the underlying principle in Pacific cultures and to develop instead a dialectical view that concentrates on what she calls, in one formulation, the "paradox of keeping-while-giving." One way of evaluating her argument is to see how well it applies to the different cases in Polynesia and Melanesia that it is intended to encompass.

The most unequivocally effective analysis Weiner provides relates to some of the classic themes in the earlier literature on Polynesia, for example her reconsideration of Marcel Mauss's work on "the spirit of the gift." The phrase is one Mauss took from an early Maori text, and it has exercised many commentators subsequently, including for example Marshall Sahlins. What none of the commentators, or Mauss himself, appears to have recognized is the association Weiner points out between the category of wealth goods cited, that is, the *taonga* (fine mats or cloaks), and the symbolism of female reproductive powers. "Here," Weiner writes, "is where we locate women's exclusive role: it is in the rituals surrounding human reproduction and cloth production where women gain control over *mana* [sacred power] which, in turn, gives them a domain of authority and power in their own right. And here also, we locate the source of the spirit of the gift" (p. 50).

It is at this point that Weiner pursues her argument in a new direction, stressing not that wealth goods are exchanged but rather that certain wealth goods are not exchanged but are kept within a particular lineage or group as a sign of that group's identity or "cosmological authentication" (p. 51). This she associates with her idea of inalienable possessions as expressed in the title of her book. The prime case of such possessions, represented in the book's cover illustration, is objects belonging to Polynesian dynasties and passed down in obligatory succession. With regard to such objects the argument is incontrovertible, since they undoubtedly could not be exchanged and were always passed down within a limited social group. They therefore can be described as systemically inalienable in contrast with objects that were produced for trade and exchange.

It is when Weiner extends her argument further, into Melanesia, that difficulties arise. In Melanesian social systems it is more difficult to find clear cases of valuable objects that were systemically kept out of exchanges (although such cases do exist). In the case of the famous *kula* exchange objects, first described by Malinowski, we can see that the whole purpose of these objects (mostly armshells or shell necklaces) was to be exchanged in certain limited circuits among persons of similar rank, thus conferring prestige on every participant who held them. *Kula* objects were thus strategically held on to and released by individuals according to their own aims, but they were not in themselves systemically inalienable possessions. Weiner explains the slow circulation of the most valued *kula* objects as a part of the strategy of individual men to increase their own prestige by attracting famous shells to themselves, and she argues that there is a "vertical movement from private ownership to an inalienable possession within *kula* to becoming an individual player's inalienable possession for many years [which] is the trajectory that the highest shells follow" (p. 135). It is doubtful, however, whether the term "inalienable" can strictly be applied to any of the circumstances involved here because, as Weiner herself notes, "eventually the shell must reenter *kula* exchange" (p. 133). Referring to the situation as one in which the shell is kept for several years "as if it were inalienable" raises the question whether the participants themselves ever have such a view or whether it is imported into the situation by the observer herself. In an earlier book, *The Trobrianders of Papua New Guinea* (1988), Weiner stresses the significance of giving rather than keeping and notes that "a *kula* man's fame is created through the circulation of his name in relation to the largest and the most valuable shells that he has obtained" (p. 143). Though the physical object, then, must in a sense be alienated

"At this mortuary distribution of fine mats, women carry the highest-ranking ones to the house where the relatives of the dead person are assembled." [From *Inalienable Possessions*]