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Books and Multimedia Reviews

Exploring the Moon: The Apollo Expeditions by David M. Harland. Springer-Praxis, Chichester, U.K., 1999, 411 pp., $39.95 paper (ISBN 1-85233-099-6).

This book was designed as a travelogue of the geological explorations carried out during the six Apollo missions that landed on the Moon. In an attempt to provide his readers with a sense of being present with the astronauts during their field excursions, the author, David Harland, makes liberal use of clips from their conversations with their back-up team in Houston. We hear moment-to-moment exchanges on the topography—steepness of slopes, configuration of craters, roughness of terrain—and the colors and textures of rocks and soils. We learn in "real time" about the difficulties they encounter with their equipment and their excitement about unanticipated discoveries. The illustrations include many pictures the astronauts took at each site.

The primary focus on field geology sets this book apart from others devoted to the Apollo missions. Harland outlines how the astrogeological mapping teams had interpreted lunar stratigraphy from images of the surface, and how their interpretations had influenced the selection of the landing sites and the investigations to be conducted at each one. Each traverse was traced out in advance for the astronauts and they were allowed so many minutes for instrumental measurements, so many for photography, and so many for sampling. Inevitably, since their total time for "Extra Vehicular Activity" was severely limited, they continually were faced with hard choices because extra minutes spent on one thing meant taking minutes away from another. Having "listened in" on these discussions, it is gratifying to read explanations by Harland of how the observations made by the astronauts and the analyses of their samples brought about significant changes in our ideas about the Moon.

This book can be easily read and understood by any students and general readers who have an interest in the Moon, and it will be enjoyed by many scientists who have advanced knowledge of it. The Table of Contents lists ten chapters with subheadings in each that serve as an easy guide to whatever topic a reader may wish to check-up on. One chapter is devoted to each of the six successful Apollo landings (with a short section on "Unlucky thirteen" at the beginning of the chapter on the Apollo 14 mission). The first chapter, titled "The robots" discusses the technical and political aspects of the decision to go to the Moon and the preliminary stages when engineers wrestled with the problems of landing spacecraft and men on an unfamiliar planet with a surface of unknown strength and consistency, which some scientists predicted would be solid and safe while others said it would be granular and yielding.

The time constraints imposed by President Kennedy in 1961 when he declared the national purpose of sending a man to the Moon and bringing him safely home within that decade, spawned a rapid succession of preliminary missions—the Lunar Rangers, Orbiters, and Surveyors—which tested the dynamical guidance systems and the crushing strength of the lunar surface. Despite the rush and many uncertainties, it all worked so astonishingly well that the Apollo 11 mission carried out its mission on time and on target when it landed two astronauts on the Moon on 1969 July 20 and brought them safely home four days later.

That voyage, the first manned flight to another planetary body, is discussed in Chapter 2, where Harland chronicles the "Eagle's Descent," "Moonwalk!," and "Moonrocks," and then places the mission in perspective. We follow the astronauts' activities as they emerge from the landing module, plant the flag, converse with President Nixon, deploy instruments, take photographs, and collect soil samples and rocks, one of which was described by Commander Neil Armstrong as "really vesicular." That remark sent a thrill through scientists who believed the dark maria must consist of basaltic lava flows. And, indeed, when the rock boxes were opened at the Lunar Receiving Laboratory in Houston, basalts were found in abundance.

Harland points out that by early January 1970, when the principal investigators from around the world gathered in Houston for the first Lunar Science Conference, it was obvious that those two hours the Apollo 11 astronauts devoted to lunar field work had upset all the entrenched theories about the Moon. The Moon was not the cold, primitive body championed by Harold Urey, but, although volcanism had produced the mare basalts it had not, as many believed, formed the craters. Impact processes and products predominated. The samples included the first glass-welded soil breccias ever observed as well as numerous shocked minerals. To everyone's surprise, all of the returned rocks and soils were utterly lacking in H_2O, H^+, and (OH), so the minerals and glasses had remained as fresh and unaltered as they were when they formed, billons of years ago. Isotopic dating showed that the Moon is as old as the Earth but some of its crustal rocks are significantly older than the oldest then known on the Earth (~3.5×10^9 years). The anorthositic character of the highlands, which many assumed would consist of rhyolite, was proposed on the basis of a few white grains of feldspathic rock in the dark soils of Mare Tranquillitatis.

Subsequent missions took more time and expanded the range of the explorations, so their chapters are longer. The longest is Chapter 5, which describes the Apollo 15 mission. Under the title, "The wonder of the unknown—Hadley—Apennine," the contents list 28 subheadings, including items such as "Spurr's treasure," "Tantalizing dune," or "The saga of the drill." Chapter 6, "Surprise at Descartes–Cayley," details the Apollo 16 mission

to the highlands, where the search for mountains and plains of siliceous volcanics yielded a landscape of impact breccias. Chapter 7 describes the final mission, Apollo 17, at "The beautiful valley of Taurus–Littrow." The contents list 25 subsections including one about a "Geologist-astronaut" (Jack Schmitt), and one called "Holy Grail?", which describes his totally unexpected discovery of orange soil. A later subsection titled, "So much for the fumerole," describes the dashing of Schmitt's initial hopes that the orange material might consist of volatile deposits from very recent volcanism. In fact, it proved to be an ancient accumulation of orange and black glassy spherules formed by mare-related fire-fountaining.

Chapter 8 treats the Soviet Union's robotic Luna sample-return missions and Lunakhod rovers. Chapter 9 places Apollo in a broad context, with some regrets about certain lost opportunities and the difficulties of starting over. Harland states: "Just as Apollo had come from nowhere, and held centre-stage for a decade, it disappeared from public consciousness virtually without comment, as if it had never happened; indeed, almost as if it was an anachronism." He adds: "In retrospect, it is clear that Apollo was an element of twenty-first-century exploration which was somehow drawn forward 50 years and, incredibly, implemented with early-1960s electronics technology—a fact which demonstrates the supreme mastery that the astronauts and their ground support team had over their remarkable vehicles."

The final chapter reports on the more recent missions: the Prospectors, Galileo, and Clementine and their cargoes of high-technology instruments. The text ends with a page remembering Gene Shoemaker, who played a crucial role in persuading NASA to conduct geological exploration of the Moon and whose ashes, carried aboard *Lunar Prospector*, were deposited on the Moon when it completed its mission with a crash-landing.

The narrative is not formally referenced but it is supplemented by a chronological bibliography of books and articles on the Moon that fills 28 pages of two columns each. A reader can use it as a guide to source materials on any topic in the text. There also is a 12-page glossary in which many of the technical terms not only are defined but explained in detail. The Appendix includes three tables listing: (1) the names, launch dates, and purposes of space flights that contributed to lunar exploration from the launch of Luna 1 on 1959 January 2, to that of *Prospector* on 1998 January 6; (2) the landing sites of all the robotic and manned lunar missions; and (3) data on all eleven of the Apollo missions, including the names and ranks of the crew members, the names of their Command/Service and Landing Modules, their launch and return dates, the purposes of the missions, and the timing of the activities astronauts spent on the surface. There follows a list of the numbers and weights all the lunar samples referred to in the text and a short Afterword by David R. Scott, Commander of the Apollo 15 Mission.

Many readers who followed the progress of the missions and watched the televised landings will read these chapters with fresh excitement (along with pangs of nostalgia) as they recall the hopes and anxieties they felt at each count-down to blast-off, their elation at viewing the astronauts walking on the Moon and collecting samples, and relief at the safe return to Earth of each crew. Readers who were indifferent at the time or are too young to remember the Apollo missions will find the book to be a clearly written and entertaining account of the geological field work supplemented with a greater wealth of background information than was publicly available at the time.

In his Preface, the author remarks that this book is *complementary* to all those that focus on the political, managerial, and engineering, aspects of Apollo or on the astronauts as people. With its emphasis on field geology it is a welcome addition to the literature of Apollo. Furthermore, it is fun to read.

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Perspectives in Amino Acid and Protein Geochemistry by G. Goodfriend, M. Collins, M. Fogel, S. Macko, and J. Wehmiller. Oxford University Press, New York, New York, USA, 2000, 384 pp., $85.00 hardcover (ISBN 0-19-513507-5).

The preface to this interesting book describes how it is a reexamination and update of a twenty-year-old book, *The Biogeochemistry of Amino Acids*. For those familiar with the earlier work, this is a fair description. For those who are not, the basic topic is what happens to amino acids and proteins in various geochemical settings. The single biggest part of the book, about 200 out of 355 pages of text, deals with the kinetics of amino acid racemization and application of this technique for dating of biologically derived material. Although there is a great deal of solid work discussed in this part of the book, for readers of *Meteoritics and Planetary Science* it is likely to be of less interest than the very first section of the book where three articles deal with extraterrestrial amino acids.

The first of these articles by Kvenvolden, Glavin, and Bada, in keeping with idea of a reexamination of the field, applies the very latest analytical techniques to essentially repeat the famous studies of the Murchison meteorite. This work, published back in 1970, found a number of "natural" and unnatural amino acids thought to be of extraterrestrial origin. A portion of the original samples, held for years in the dark, were extracted much as before and then their amino acid content and chiralities determined by HPLC. The modern results are compared to original results and, while the modern methods certainly improve the accuracy and precision, no major changes in what was originally published were found.

The second article is a review of the work that has gone into the determination of chirality of amino acids in meteorites.