Where We Stand on the Moon

Geology of the Moon. A Stratigraphic View. THOMAS A. MUTCH. Princeton University Press, Princeton, N.J., 1970. xii, 324 pp., illus. $17.50.

The last book I reviewed for *Science* was called *Lunar Geology* and was published in 1967 by the English selenologist G. Fielder. It was a book of the times. A central theme was the controversy over the importance of impact versus volcanic processes. The Rangers had sent back the first TV pictures, yet someone had said that the investigators saw in the pictures only mirrors to reflect their own theories.

There have been many rockets round the moon since then, and if our celebrated national lunar effort has produced any increased understanding, it ought to show up in the difference between 1967 lunar geology and the 1970 version. It does. There is a new tractability in the problems discussed. What has happened is not so much the cliche of "astonishing growth of the field," but rather the emergence of a healthy branch of science. Lunar science has begun to acquire what T. S. Kuhn called for in his *Structure of Scientific Revolutions* as a prerequisite for a new scientific subdiscipline: a paradigm, or substantial body of knowledge on which scholars can agree.

This is what has happened in the last few years and this is what makes Mutch's book mark a milestone in the development of our knowledge of the moon. Mutch has encapsulated much of the state of our science in those few months in the last half of 1969 when the first four men set foot on the moon.

It is unfortunate that the book does not go beyond the first Apollo landings, which are covered only in a final, appended chapter. Yet perhaps this makes the book more valuable as a unique standard for judging the success of our pre-Apollo analyses.

Specifically, the pre-Apollo analysis dealt with here is principally that of the United States Geological Survey. While most authors of "moon books" in the '60's addressed hundred-year-old questions about the origin of various classes of features, the USGS, in its heavily funded effort to prepare for Apollo, sidestepped this pitfall by using the tried-and-true principles of terrestrial stratigraphy. Of course, there were many arguments over whether their observers were detecting real stratigraphic units on the moon, but what the USGS achieved was an internally consistent set of maps establishing a reasonably reliable relative chronology without building on rickety foundations of assumptions about origins or absolute ages. In the process, the mappers soon became convinced by intimate experience that neither impacts nor volcanism offered an exclusive "key" to lunar understanding. Rather, they realized that they faced a chaotic mixture of the two.

Mutch describes himself as a stratigrapher and tells us that he chanced to write this book after spending time in the USGS mapping program. He takes a strictly stratigraphic view, though he advises us that he will also emphasize the historical development of lunar science.

Herein lie two criticisms. First, the book is too much limited to USGS stratigraphy. There are separate chapters on stratigraphies of the Imbrium basin, other basins, highlands, craters, and volcanics. Geophysical properties, internal structure, and structures such as the global "grid system" of lineaments are only briefly mentioned. The classic work of Shoemaker and Hackman in the early '60's is the takeoff point. From there on, there is a tendency to describe all advances as if they came from USGS personnel following the Shoemaker-Hackman footsteps and only occasionally influenced by "previous" nonstratigraphic work by non-USGS authors. (The reviewer admits his identification with the latter group.) The one good result of Mutch's approach is that it gives for the first time a complete synthesis of USGS work, much of it unpublished or available only in in-house publications (a result partly due to red tape of federal publication policies?).

The second criticism is that this approach, contrary to Mutch's stated purpose, does a disservice to the historical development of lunar theory. For example, in a two-page discussion of whether the surface evolved "uniformly with respect to time," Mutch refers to a 1969 paper by Urey, who mentioned early intense cratering, and a 1966 paper of mine mentioning early cratering by circumterrestrial planetesimals. He does not refer anywhere in the book to any of Urey's papers or book of the 1950's, where Urey's ideas were first presented, nor does he reference Kuiper's 1954 paper which suggested the circumterrestrial swarm, an idea which in turn dates back to Gilbert's unmentioned 1893 discussion of "moonlets." (Gilbert was a USGS founder. His paper *is* mentioned elsewhere in the book.)

In summary, Mutch has written *the* book on lunar stratigraphy, but the book on historical development of lunar theory remains to be written. Mutch explains stratigraphic and geological concepts clearly at an undergraduate level. The book is profusely illustrated with the best selection and reproduction of Orbiter photographs yet published, as well as one of the best photograph collections of terrestrial geologic analogs to lunar structures. Mutch spices the text with interesting comments on the philosophy of lunar science, the press reaction to Apollo results, and the like. His book would make a very good undergraduate or graduate text on lunar geology and on the remote-sensing approach to terrestrial planets—except that it is very high-priced. Have the publishers written off sales to individual students in order to make high-gain profits on their smaller number of sure-fire sales to institutional libraries?

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