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GEOLOGIC PROVINCES OF THE NEAR SIDE OF THE MOON

by

J. F. McCauley 1932
and
D. E. Wilhelms

U. S. Geological Survey
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2. Sketch map of the candidate Descartes Apollo 16 landing site, by C. A. Hodges. 5 p., 2 figs. USGS, 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

3. Geologic provinces of the near side of the Moon, by J. F. McCauley and D. E. Wilhelms. 5 p., 1 fig. USGS, 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

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7. Preliminary geologic results--Apollo 14 orbital photography, by D. H. Scott, M. N. West, B. K. Lucchitta, and J. F. McCauley. 17 p., 18 figs. USGS, 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

8. Two former faces of the Moon, by D. E. Wilhelms and D. E. Davis. 5 p., 3 figs. USGS, 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

9. Map showing structural features and dolomite occurrence in the Winchester quadrangle, Clark and Madison Counties, Kentucky, by Douglas F. B. Black. Map (1 sheet), scale 1:24,000. USGS, 710 West High St., Lexington, Ky. 40508; Kentucky Geol. Survey, 307 Mineral Industries Bldg., University of Kentucky, 120 Graham Ave., Lexington, Ky. 40506. [Material from which copy can be made at private expense is available in the office of the Kentucky Geological Survey.]

10. The vertical gradient of gravity in vertical and near-vertical boreholes, by L. A. Beyer. 229 p., 50 figs.; 14 tables.

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GEOLOGIC PROVINCES OF THE NEAR SIDE OF THE MOON

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J. F. McCauley

and

D. E. Wilhelms

> "On first examining a new district (planet) nothing can appear more hopeless than the chaos of rocks (the photographs); but by recording the stratification (various textural units) and nature of the rocks and fossils at many points (their distribution patterns), always reasoning and predicting what will be found elsewhere, light soon begins to dawn on the district (planet), and the structure of the whole becomes more or less intelligible."*

Systematic lunar geologic mapping, a program begun by the U.S. Geological Survey in 1961 (Shoemaker and Hackman, 1962; McCauley, 1967; Wilhelms, 1970) has determined the sequence in which most of the Moon's major surface features were formed. The data used were almost exclusively photographic starting with the best available telescopic photographs and later supplemented by the Ranger, Surveyor and Lunar Orbiter photographs. The most productive of these flights from the standpoint of an improved regional understanding of the Moon was Orbiter IV which provided nearly uniform eighty meter resolution coverage of most of the near side. The telescopic and unmanned probe data constitute the background which is basic to the study of photography from the past and future Apollo flights.

*From the Autobiography of Charles Darwin, by Nora Barlow, editor, 1958, p. 77, New York, Harcourt, Brace. Parenthetical inserts by McCauley. The authors believe the statement eloquently expresses the value of past and future orbital photographic experiments.

Preparation (late in 1967) of a synthesis of the geology of the near side at 1:5,000,000 scale commenced with acquisition of the Orbiter IV data. The map is built upon the results from the 44 quadrangles of the 1:1,000,000 scale systematic program (Wilhelms and McCauley, 1971). The map has been used to help select Apollo landing sites as well as photographic targets of particular interest from orbit including those of Apollo 14.

Synoptic maps of this type can be used for the preparation of various derivative products that depict certain aspects of the Moon's evolution. The first of these prepared to date is at the 1:10,000,000 scale and shows the twelve major geologic provinces of the near side (McCauley and Wilhelms, in preparation). It is reproduced in generalized form and reduced scale in figure 1. As in the case of terrestrial geologic province maps, the units consist of related rock assemblages. Each one of the different units is characterized by an inferred origin or history that distinguishes it from the others. The provinces differ markedly in relative age and their distribution patterns depict our current understanding of the evolution of the Moon's near side.

A brief interpretation and inferred geologic history for each province are given in the map explanation (fig. 1). These map units with similar regional geologic characteristics or distribution patterns are enclosed by brackets. These are from top to bottom: 1) mostly depression fillers except for the mare plateau and dark mantling units, 2) terra modifiers, 3) terra of nondescript

character or consisting mostly of closely spaced large very ancient craters.

Craters larger than 50 kilometers in diameter that formed after the Imbrium event show the Moon's impact cratering history after deposition of the Fra Mauro Formation. The depression filling units probably represent volcanic materials which, in the case of the mare, are now known to be of basaltic composition. The main pulse of depression filling by basaltic lavas occurred near the end of the Imbrian Period (Wilhelms and Davis, 1971) with progressive diminution of recognizable volcanic activity up through the Copernican. The units identified as terra modifiers are of significant geologic interest. One patch of the hilly and furrowed unit in the Descartes region is being considered for the Apollo 16 landing (Milton, 1971; Hodges, 1971). The presence of these deposits within the terrae suggests a distinct episode of lunar volcanism that pre-dated generation of the maria but which followed the formation of the large multi-ring basins. The magmas that produced these materials may be quite distinct in composition from the later mare magmas as suggested by their higher albedo and the nature of the landforms produced. Only three of the near side basins have recognizable surrounding ejecta blankets: Orientale, Imbrium, and Nectaris (in order of increasing state of degradation). The other, older basins, do show surrounding structurally elevated rings which together with their central depressions control the distribution of most of the

recognizable volcanic deposits on the near side (Wilhelms and McCauley, 1971). The undivided terra probably consists in great part of the erosionally degraded remnants of the ejecta blanket of pre-Nectaris basins. It is clearly of mixed origin and spans a considerable part of the Moon's early history. The densely cratered terra (sometimes referred to as the "macro-crater province") appears to be little modified by basin-forming events and later internal activity. It consists essentially of an almost shoulder-to-shoulder array of large pre-Imbrian craters, the frequency of which is greater than for any other part of the near side. The preservation of these ancient craters might be attributed to their occurrence outside the range of appreciable deposition and the structural dislocation associated with multi-ring basin formation. This province could then represent the most primitive and oldest part of the Moon's near side.

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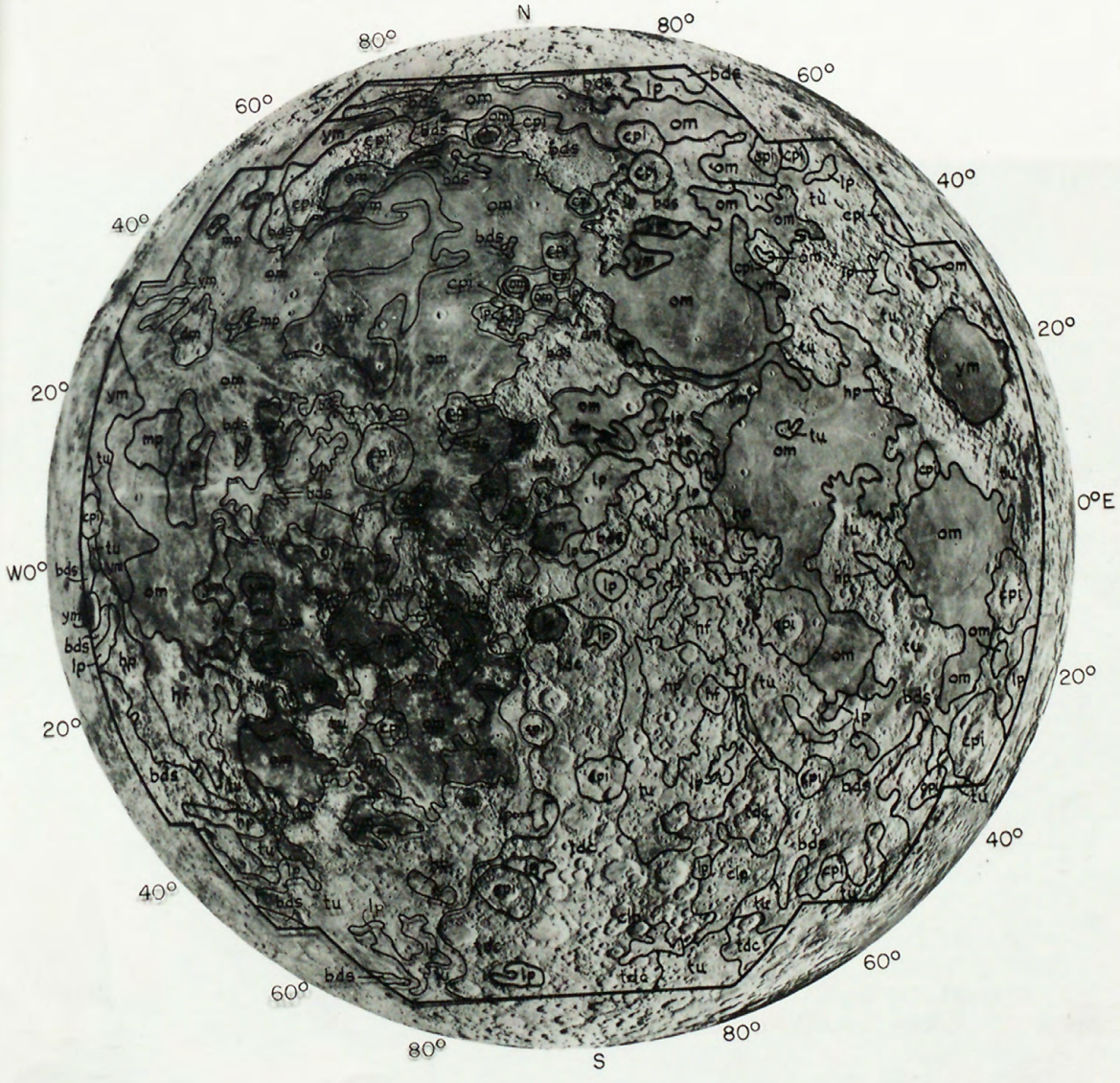
Figure 1. --Distribution and explanation of the major geological provinces on the near side of the Moon.

McCauley & Wilhelms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MAP UNIT		INTERPRETATION AND HISTORY
cpi Impact craters >50 km		Impact craters later than the Imbrium event and its associated blanket and structures. Age range from early Imbrian to Copernican.
mp Mare plateaus ym Younger mare om Older mare dm Dark mantles lp Light terra plains	(1)	Mostly depression fillers. Mare plateaus: Post mare aggregates of volcanic landforms; cones and domes predominate;pyroclastics and flows of same or possibly slightly different composition than maria. Younger mare: relatively thin flows, generally darker, less cratered than older mare; distribution patchy. Older mare: Flows of dark to intermediate albedo in near-side multi-ring basins and smaller basin related depressions or crater floors. Dark mantles: thin veneers of very dark pyroclastics; mostly covering lighter terra units near mare-terra contacts. Light-plains: more cratered than maria; fill basins and terra depressions; impact lightened old mare or compositionally distinct older volcanic fill unit. Imbrian to Copernican.
hf Hilly and furrowed terra hp Hilly and pitted terra	(2)	Terra modifiers. Hilly and furrowed: Mostly subdued closely spaced linear structures resembling fissure cones. Hilly and pitted: rolling plains and plateau unit; many closely spaced rimless pits on surface. Embays pre-Imbrian craters but transects Imbrium sculpture. Mostly Imbrian.
bds Basin deposits and structures		Recognizable ejecta blankets and parts of encompassing structural rings and radially lineated terrain of Orientale, Imbrium and Nectaris basins. Pre-Imbrian to middle Imbrian.
clp Cratered light terra plains		Heavily cratered plains filling local depressions in terra. Most superposed craters lower Imbrian in age including probable Imbrium secondaries. Pre-Imbrian equivalent of light terra plains.
tu Terra, undivided tdc Terra, densely cratered	(3)	Terra undivided: blocky hills, unevenly filled depressions, and segments of mantled craters. Of mixed origin; includes much interlayed ejecta and associated structural units of older basins. Terra, densely cratered: closely spaced 50-150 km craters of early pre-Imbrian age, possibly most primitive region of near side. Recognizable basin related units and probable volcanics very subordinate. Ages of both units from early to late pre-Imbrian.