U. S. Geological Survey.

REPORTS-OPEN FILE SERIES, no. 1581: 1971.

TWO FORMER FACES OF THE MOON

by

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and

D. E. Davis

U.S. Geological Survey
OPEN FILE REPORT

Work was performed by the U.S. Geological Survey on behalf of the National Aeronautics and Space Administration, largely under contract No. T-65253G.

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U.S. GEOLOGICAL SURVEY
WASHINGTON, D. C.
20242

For release JUNE 24, 1971:

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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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5. Geology of the region around the candidate Descartes Apollo landing site, by D. J. Milton. 4 p., 2 figs. USGS, 601 E. Cedar Ave., Flagstaff, Ariz.

6. Correlation of the zero phase brightness surge (Heiligenschein) with lunar surface roughness, by H. A. Pohn, R. L. Wildey, and T. W. Offield. 4 p. USGS, 601 E. Cedar Ave., Flagstaff, Ariz. 86001.

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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A two stage reconstruction of the visual appearance of the Moon at geologically significant points in its evolution was prepared by Wilhelms and Davis. Like the province map (McCauley and Wilhelms, 1971), these reconstructions are derivatives of the prior 1:5,000,000 regional mapping. Both geological and artistic interpretations have been combined to produce these geological visualizations. The artist, Davis, working principally under the guidance of Wilhelms, used the 1:5,000,000 geologic map to remove certain younger features from the Moon's present face shown as figure 1. Other features were enhanced according to their position in the relative time-stratigraphic sequence developed during the geologic mapping; inferred buried structures were added, particularly those showing the internal configuration of the multi-ring basins, from the studies of Orientale, the youngest of these structures (McCauley, 1968; Hartmann and Yale, 1969; Van Dorn, 1968). In these reconstructions, most of the older major craters are assumed to have had an initial morphology like that of the young craters Copernicus or Tycho and an erosional continuum is assumed to exist between craters of this type and vague circular structures now barely recognizable as craters (Pohn and Offield, 1970).

The first reconstruction (fig. 2) shows the Moon after deposition of most of the mare material but before the formation of the major post-mare deposits and craters--that is, at the end of the Imbrian Period. Dating of Apollo 11 and 12 rocks suggests that this time was about 3-1/2 billion years ago. The Moon's appearance in late Imbrian time is relatively easy to reconstruct because post-mare materials obscure only a small percentage of the surface. The underlying topography is partly visible through all but the innermost deposits of the Eratosthenian and Copernican craters, and these cover only about 2 percent of the near side. Post-mare deposits unrelated to craters are even rarer; the artist had to remove only the steep bright domes near Gruithuisen, the low mare domes, the dark deposits that thinly mantle the terra at the edges of some maria, and the younger mare plateaus such as the Marius and Rümker Hills. Craters such as Archimedes and Plato, formed just before the last pulse of mare flooding, were freshened so that the exposed parts of these late-Imbrian craters resemble Copernican craters. Everything on this reconstruction thus represents something now visible, but altered according to its relative age. The most telling feature of this reconstruction (fig. 2) is that in spite of the very ancient time represented (circa 3.5 b.y. ago) the Moon's surface looks much like the present Moon, and those unfamiliar with its surface details must look carefully to detect the differences.

The mare surfaces are shown darker and with sharper contacts than at the present time mainly because of the absence of overlying crater rays. Rays are not shown in figure 2 because it is assumed that all the late Imbrian mare material formed after all the late Imbrian craters, thereby covering the rays which these craters had when first formed. The peak of mare formation apparently occurred in late Imbrian time. However, pre-Apollo studies of crater frequencies and the somewhat divergent dates of the Apollo 11 and 12 samples (3.6-3.7 and 3.3 b.y. respectively) show that all mare material did not form exactly at the same time.

The second reconstruction (fig. 3) shows the Moon at a still earlier time in its history, before the present mare surface material was deposited and shortly after the youngest multi-ringed basin, Orientale, was formed. This is approximately in the middle of the Imbrian Period, probably more than four billion years ago. Accordingly, the artist removed most mare material and late Imbrian craters and freshened early Imbrian craters such as Arzachel and Piccolomini. Without the mare cover and other deposits, the dominance of the structures and blankets of the multi-ringed basins is strikingly revealed. Predominant among these is the Imbrium basin whose deposits, the Fra Mauro Formation, were probably sampled during the Apollo 14 mission. Although the artist necessarily had to add details for which there is no direct evidence, the pre-mare appearance of the Imbrium basin can be reconstructed from the present appearance of the relatively non-flooded Orientale basin. Those features of the Imbrium basin which are now exposed at the surface are considered degraded equivalents of similarly positioned features in the Orientale basin.

Craters shown in regions now covered by mare materials were reconstructed where a partial rim crest or ghost-ring structure is present. Incipient mare fill is shown where the greatest present concentrations exist--in the deepest depressions, especially those basins that contain "mascons." The amount of mare material is portrayed in figure 3 as dependent on the depth of the basin or depression because it is assumed that the formation of the maria spanned a relatively limited period of time. If, however, each basin started to fill soon after its formation, the shallower basins might also have contained some mare at the time depicted in figure 3. Some basins might have filled more quickly and more deeply than others depending on their location on the Moon--in which case even this very ancient lunar face would resemble more closely the present-day Moon.

Light plains, which appear to be mostly older than the maria, are shown at each locality where now present but in somewhat diminished amount. Some light plains are also shown in deep places now buried by mare material in the multi-ringed circular basins. The distribution and amount of light plains materials at the time depicted is quite uncertain because it is not known whether they were formed from an early different type of magma or are older mare materials similar in composition to younger mare materials, but which have been brightened by repeated meteorite bombardment.

Reconstructions farther back into the Moon's past are possible but would be increasingly speculative and have not yet been attempted. A reconstruction in pre-Imbrian time would show a Moon much like that of figure 3, but without the Imbrium basin and with the older basins appearing considerably fresher. Although prepared prior to Apollo 14, and for a different publication, the authors felt inclusion of these reconstructions in this post-Apollo 14 report would be of help in lunar sample analysis work and in the analyses of both the surface and orbital photographs.

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Figure 1. --The present Moon. Mosaic LEM-1, 3rd edition, 1966, made from telescopic photographs by U. S. Air Force, Aeronautical Chart and Information Center.

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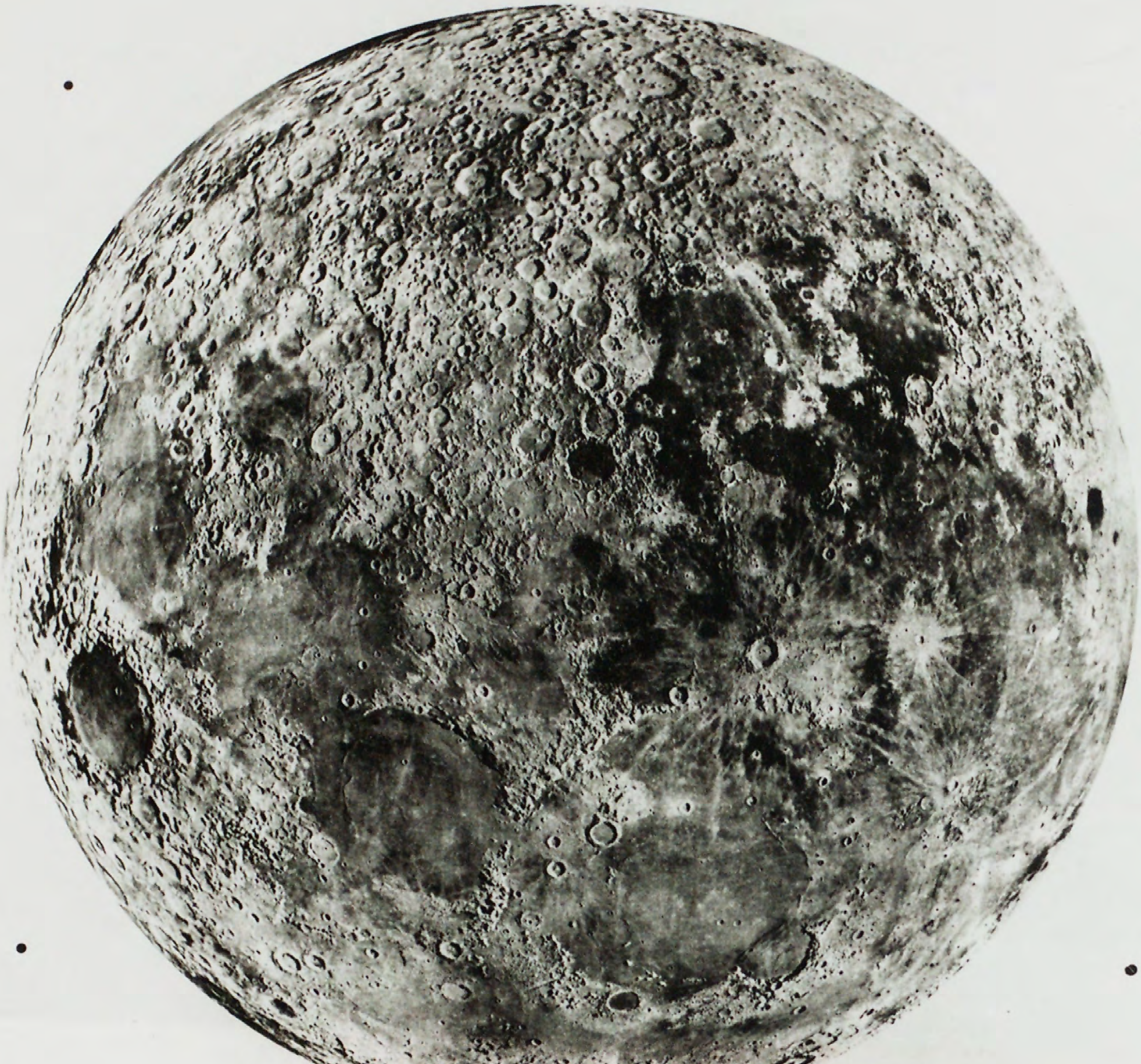

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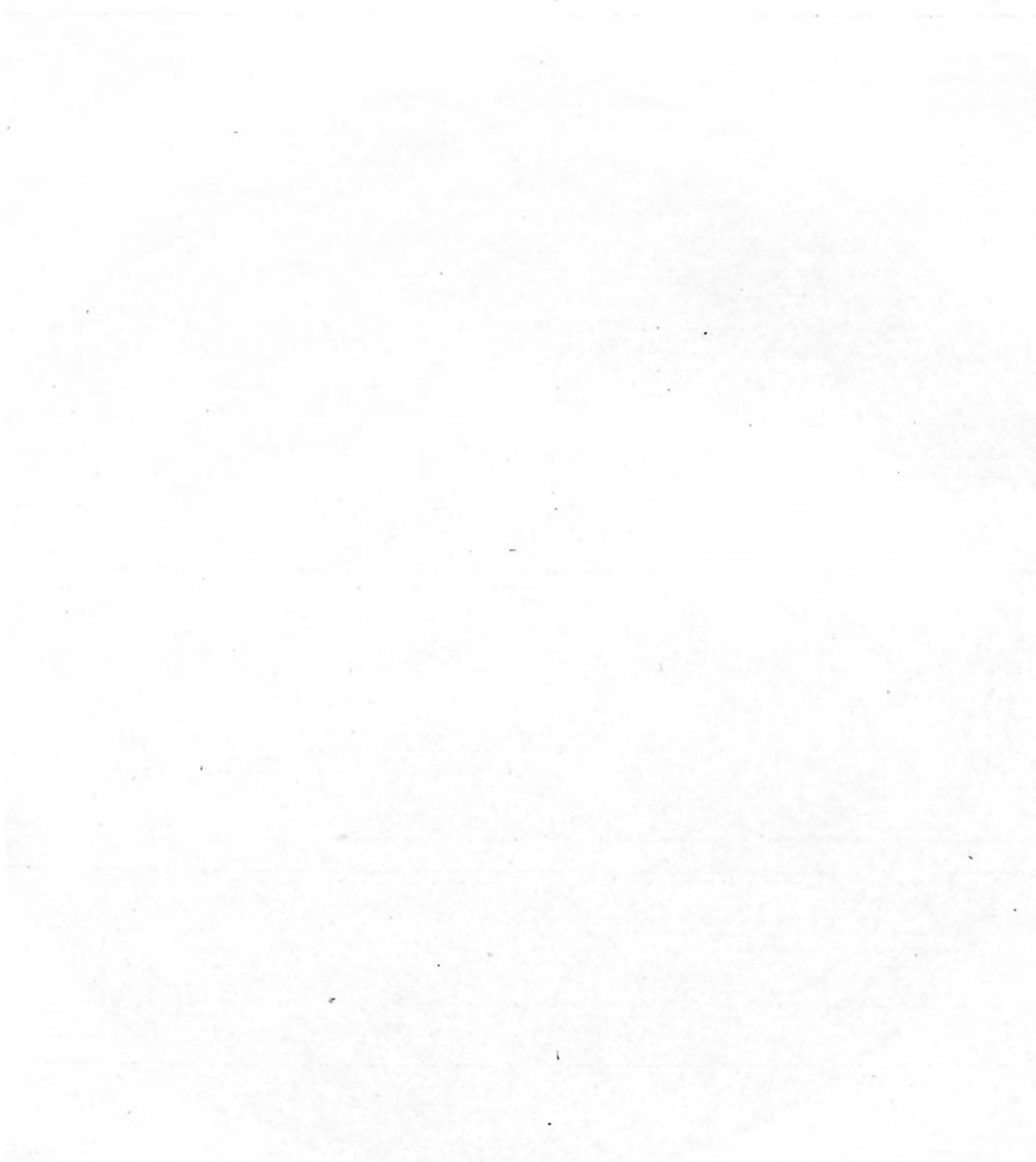

Figure 2. --The Moon at the end of the Imbrian Period, soon after the formation of most of the mare material approximately 3-1/2 billion years ago. Note the absence of such young craters as Tycho, Copernicus, and Eratosthenes from the otherwise not too unfamiliar scene.

Wilhelms and Davis

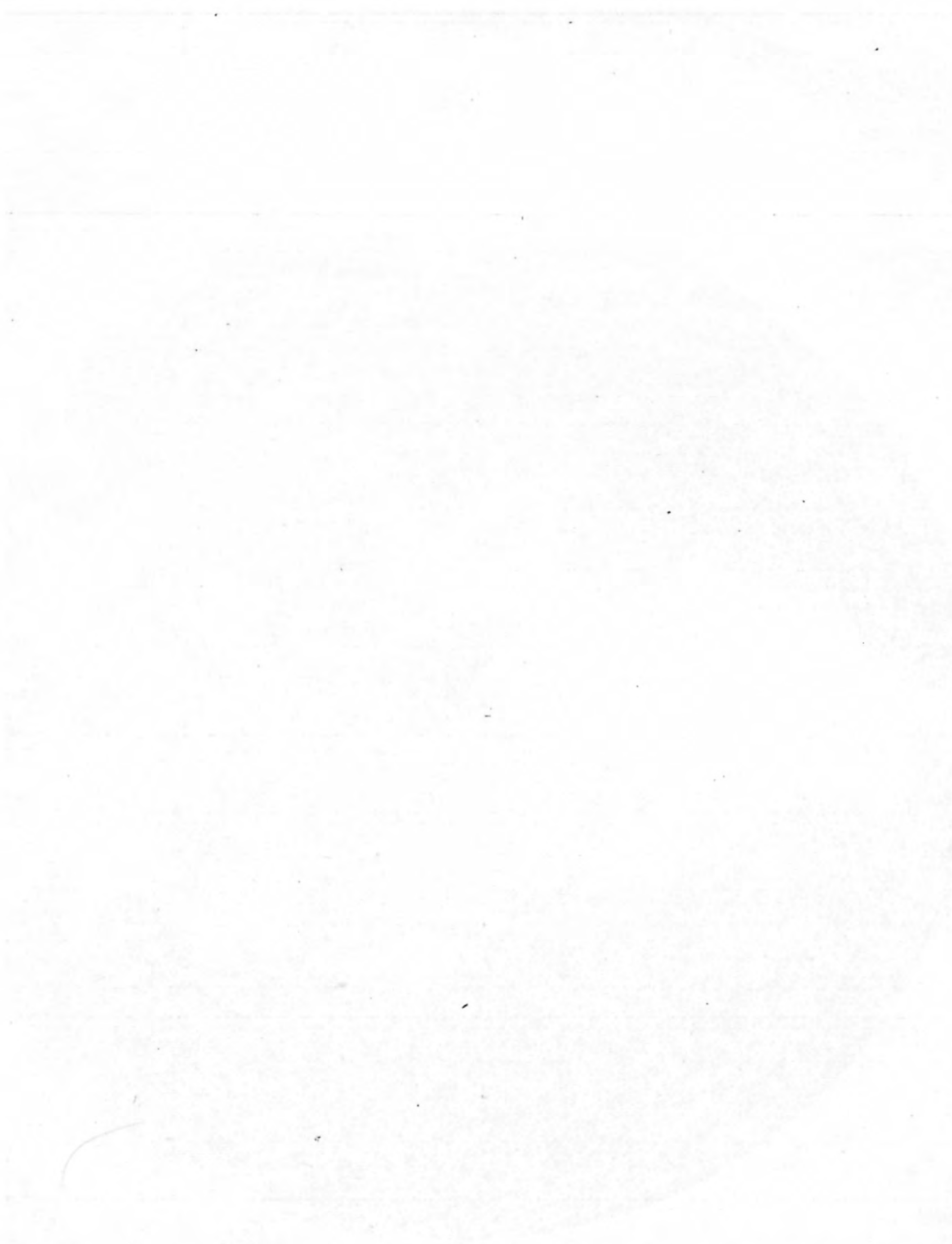

Figure 3. --The Moon in the middle of the Imbrian Period, before the formation of the present mare surface material and after the formation of the last of the mare basins, Orientale (partly in view on the west limb). Features exhumed by the artist include the fully developed yet-unburied Iridum crater, perched on one of the rings of the Imbrium basin.

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