DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MANNED SPACECRAFT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

GEOLOGIC SUMMARY

This map shows the geology in and around potential early Apollo landing site 5 in the lunar equatorial belt. The Maestlin G region is in Oceanus Procellarum, about midway between the crater Kepler to the northeast and Flamsteed to the southwest. Terra materials occur only in the northeast corner of the region. Dark mare covers the remainder, and the entire region is crossed by rays from Kepler. The general geology of the larger Kepler region was mapped at a scale of 1:1,000,000 from telescopic photography (Hackman, 1962), and a 1:25,000 geologic map has been prepared of the landing site in the central part of the region (Titley and Trask, 1969).

The oldest materials in the region occur in the northeast corner, where cratered terra plains-forming materials (Itp) abut a ridge of crater rim material (pIc). The ridge is a remnant of the rim of an old crater that predates development of both mare and terra plains units. The terra plains units (Itp and Etp) occupy the floor of the old crater and are slightly higher than the adjoining mare.

Mare material within the region is generally uniform in appearance, and the dominant mare type is designated "young mare" (Em). However, a small area of more heavily cratered mare in the southeast corner of the region is called "old mare" (Im). The young mare appears to be younger than typical mare of most other areas of the lunar equatorial belt. It has a slightly lower albedo, has fewer craters more than 200 m in diameter, and partly covers the flanks of two fresh-appearing craters in the west-central part of the region--Maestlin G and the 2 km crater directly to the northeast. The two craters are Eratosthenian in age; thus, the mare is no older than Eratosthenian.

In the southeast part of the region are two faint structural features: a north-south linear depression and a subdued east-west scarp. In several places these features separate mare materials with slightly different albedos. The linear depression may be the remnant of an old sinuous rille. Alternatively, both features may be related and may mark the edge of a flow front that has been largely destroyed by erosion.

Rays from Kepler cross the region from northeast to southwest and modify the preexisting terrain. The rays have been divided into two units: coarsely cratered Kepler ray (Crck) and finely cratered Kepler ray (Crfk). The coarsely cratered ray material has significantly more craters in the 100-600 m size range than the surrounding materials. Crater less than 100 m in diameter are much more numerous within the finely cratered ray unit than in surrounding materials. Both types of rays are characterized by linear depressions approximately radial to Kepler, but the linear pattern is more striking in the finely cratered ray. The lineations are mostly shallow grooves or lines of shallow craters and are generally less than 100 m wide. Some material from Kepler may be present along the rays, but the distinctive features of the rays probably result largely from reworking of preexisting surface materials.

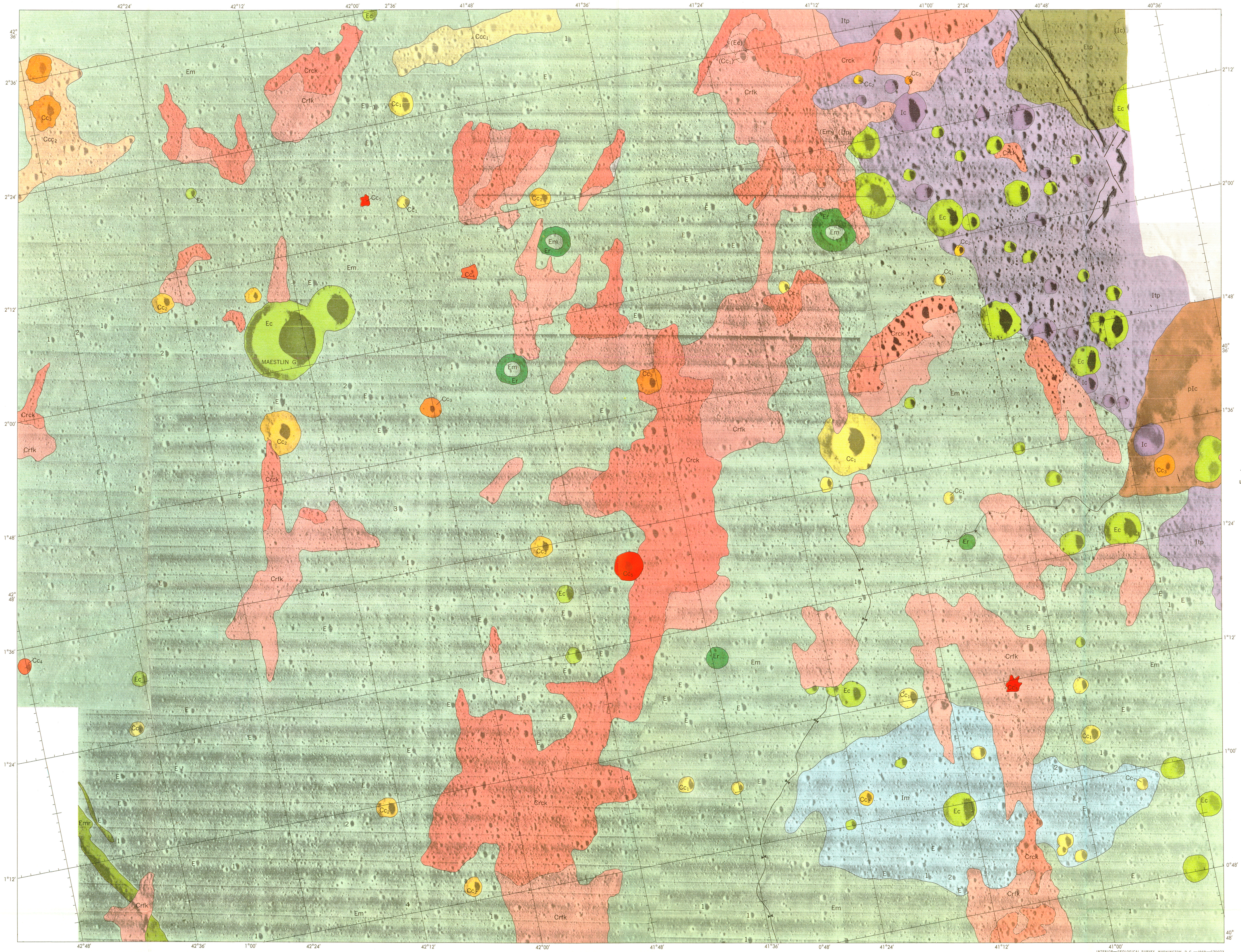
Several faint ring structures are of special interest. Each consists of a low circular ridge (unit Er) with gentle slopes enclosing an area that is commonly slightly lower than the surrounding mare. The rings may be pre-mare craters thinly covered by mare material, or they may be igneous intrusions similar to ring dikes.

Very few large scale linear structures are present in the region. In addition to those in the southeast part of the region, a northwest-trending mare ridge (unit Emr) occurs in the southwest corner. In the northeast corner the boundary between the mare and terra plains-forming unit also trends northwest and may coincide with a buried fault. Faint linear grooves trending northwest and northeast are visible in much of the mare; many of the northeast-trending grooves may be secondary craters from Kepler, but some although indistinguishable, are probably structurally controlled.

Several features of the region are of scientific interest. Because most of the mare material is young, the surface debris layer must be relatively thin and blocks should be plentiful around small fresh craters. It should be relatively easy, therefore, to sample bedrock underlying the debris layer. The mare scarp, the subdued linear trough, and the ring structures may all be volcanic features that formed by the same volcanic processes that deposited the mare material. The rays are of interest in that material from Kepler may be identifiable in the ray areas and would provide a sample of material from deep within the crust. Finally, comparision of the mare material and terra plains-forming material could demonstrate whether the differences between these units result from age, composition, or lithology.

REFERENCES

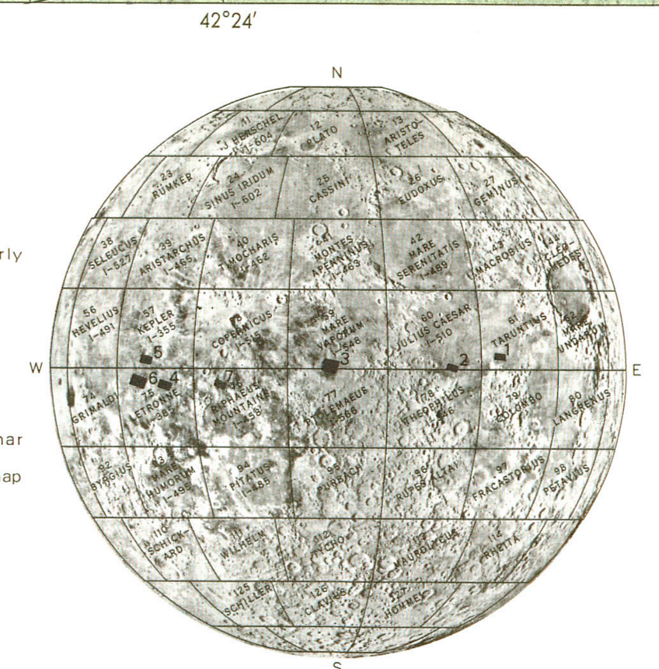
Hackman, R.H., 1962, Geologic map of the Kepler region of the Moon [scale 1:1,000,000]: U.S. Geol. Survey Misc. Geol. Inv. Map I-355.
Pohn, H.A., and Wildey, R.L., 1969, A photoelectric-photographic study of the normal albedo of the Moon: U.S. Geol. Survey Prof. Paper 599-E (in press).
Titley, S.R., and Trask, N.J., 1969, Geologic map of Apollo landing site 5 [scale 1:25,000]: U.S. Geol. Survey Misc. Geol. Inv. Map I-623



Controlled base is photomap Orb II-13 (100) prepared by Army Map Service, Corps of Engineers, U.S. Army, Washington, D.C. 20315

Large numbers 1-7 refer to regions that include early Apollo landing sites:
1. Maskelyne DA region - I-616
2. Sabine D region - I-618
3. Oppolzer A region - I-620
4. Wichmann CA region
5. Maestlin G region - this report
6. Flamsteed K region
7. Lansberg P region

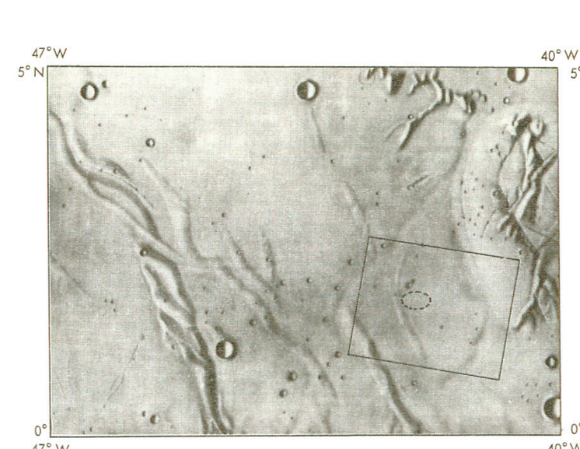
Small number above quadrangle name refers to lunar base chart (LAC series).
Small number below refers to published geologic map (scale 1:1,000,000)



INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON

SCALE 1:100 000
MERCATOR PROJECTION

1 ½ 0 1 2 3 4 5 6 NAUTICAL MILES
1 ½ 0 1 2 3 4 5 6 STATUTE MILES
1 .5 0 1 2 3 4 5 6 KILOMETERS



MAP OF PART OF THE MAESTLIN QUADRANGLE OF THE MOON (AIC SERIES)

Area of this report shown by solid line; dashed line indicates LM landing dispersion ellipse (99% landing probability). Approximate scale 1:3,100,000.

Principal sources of geologic information: Lunar Orbiter moderate-resolution photographs: II-M197-212; III-M161. Lunar Orbiter high-resolution photograph: IV-H144; albedo data from Pohn and Wildey (1969) and from full-Moon plates 5818 and 5819 taken at U.S. Naval Observatory, Flagstaff, Ariz.

Work performed on behalf of the National Aeronautics and Space Administration under contract No. T-66353 G

GEOLOGIC MAP OF THE MAESTLIN G REGION OF THE MOON
LUNAR ORBITER SITE II P-13, OCEANUS PROCELLARUM INCLUDING APOLLO LANDING SITE 5

By
M. H. Carr and S. R. Titley
1969

EXPLANATION

NOTE: A crater's materials are mapped and given symbols according to the size (rim-crest diameter) and interpreted relative age of the crater. The apparent freshness of the crater on Orbiter photographs is used to determine its age, and allowance is made for an inverse relation between the sizes and rates of degradation of craters (see enclosed pamphlet). The larger craters in each age group are mapped in color (mappable materials extend relatively farther from the rim crests of young craters than from the rim crests of old craters of comparable size). The map symbols that identify these materials consist of a capital letter to designate lunar time-stratigraphic division (system), lowercase letters to designate rock unit, and, in the Copernican System, a subscript number to designate relative age within that system. To keep the map from becoming crowded, materials of the smaller craters in each age group are not outlined; such craters are indicated by number or letter symbol only. For example, materials designated Cc_1, outlined and colored, are associated with a relatively old Copernican crater more than 600 m (meters) in diameter; materials designated simply 1 are the same age but are associated with craters from 400 to 600 m in diameter. The mapping is extended to smaller size craters for younger craters than for older craters; the smallest craters in all age groups are unmapped.

COPERNICAN SYSTEM

Cc_5 | 5

Crater material

Characteristics

Cc_5, material of rayed craters having block-strewn hummocky rims; abundant blocks and terraces on wall. Faint concentric ridges on rim. Crater rim crest sharp. Many secondary craters present

5, material of crater with well-developed rays. Abundant blocks on rim and within crater. Terraces on wall. Rim crest sharp

Cc_4 | 4

Crater material

Characteristics

Cc_4, material of rayed crater having block-strewn faintly hummocky rims. Abundant blocks and terraces on wall. Crater rim crest sharp

4, material of craters with bright halos and few or no rays. Abundant blocks on rim and within craters. Terraces on wall. Rim crest slightly subdued

Cc_3 | 3

Crater material

Characteristics

Cc_3, material of craters with limited rays and block-strewn rims. Abundant blocks and terraces on wall. Crater rim crest slightly subdued

3, material of rayless craters having smooth rims. Scattered blocks on rim and within craters. Rim crest moderately subdued

Crck | Crfk

Kepler ray materials

Characteristics

Materials in and around densely cratered areas of mare and terra. Faint to strong linear grooves occur approximately radial to Kepler. Albedo higher than that of surrounding terrain

Crck, material of coarsely cratered ray. More craters larger than 100 m in diameter compared to surrounding terrain. Many craters occur in chains radial to Kepler or overlap or form grooves. Some craters are elongate but many are circular and resemble nonrayed craters

Crfk, material of finely cratered ray. Surface almost completely saturated with craters smaller than 100 m but density of larger craters is comparable to nonrayed terrain. Craters occur in chains or overlap to form fine lineations on the surface. Albedo slightly lower than that of unit Crck. Commonly Crfk occurs adjacent to patches of Crck on southwest side away from Kepler

Interpretation

Mare and terra material modified by craters formed by objects ejected from Kepler. Surface materials mostly are reworked preexisting debris. Some exotic material from Kepler may be present. Age equivalent to Cc_2 craters

Ccc_2

Crater-cluster material

Characteristics

Material associated with cluster of Cc_2 craters. Cluster resembles cratered Kepler ray material but lacks the linear structures and numerous small craters that characterize the rays

Interpretation

Cluster of impact craters secondary to some crater approximately the same age as Kepler.

Cc_2 | 2

Crater material

Characteristics

Cc_2, material of rayless craters having block-strewn smooth rims. Blocks and subdued terraces on wall. Crater rim crest moderately subdued

2, material of rayless craters having smooth low rims. Scattered blocks on rim and within craters. Rim crest moderately to strongly subdued

Ccc_1

Crater-cluster material

Characteristics

Material associated with cluster of Cc_1 craters. Most craters are larger than 100 m. Unit occurs only at the northern boundary of the region

Interpretation

Secondary impact craters

Cc_1 | 1

Crater material

Characteristics

Cc_1, material of rayless craters having smooth rims. Scattered blocks on rim and wall. Faint terraces on wall. Crater rim crest moderately rounded

1, material of rayless craters having smooth rims. Scattered blocks on rim and wall. No terraces on wall. Crater rim crest strongly subdued and rounded

ERATOSTHENIAN SYSTEM

Emr

Mare ridge material

Characteristics

Material forming the mare ridges in the southwest corner of the region

Interpretation

Site of volcanic intrusion or extrusion. Position of ridge controlled by subsurface structure. May also be some form of pressure ridge

Em

Young mare material

Characteristics

Most extensive unit in the region. Forms level cratered surface. Distinctly darker on Earth-based full-Moon photographs than mare units surrounding the site

Interpretation

Probably composed of volcanic flows, the surfaces of which are covered by a fragmental layer. No bedrock is positively identifiable on the surface, although some may be present in the walls of young craters. The lack of Imbrian craters on the surface and the fact that the material covers the flanks of large Eratosthenian craters such as Maestlin G in the northcentral part of the region suggest an age at least as young as Eratosthenian and the presence of Eratosthenian craters on the surface restricts the age to Eratosthenian

Etp

Smooth terra plains-forming material

Characteristics

Occurs within an old large crater in the northeast part of the region. Forms generally level terrain having intermediate albedo. Fewer craters > 400 m than on Itp. Most craters are very subdued and flat floored. Fewer small (< 200 m) sharp craters than on the mare. Because of the high density of subdued craters, no age designation is given to craters too small to be outlined

Interpretation

Probably composed largely of fragmental debris of both volcanic and impact origin. Lack of small fresh-appearing craters and lack of blocks suggests that a much thicker surficial fragmental layer has developed on this unit than on the mare

Er

Ring material

Characteristics

Material associated with faint ring structures in the mare. Rings consist of low circular ridges enclosing material having a slightly lower elevation than the surrounding mare. Slopes covered with patterned ground (irregular anastomosing ridges and troughs approximately 10 m wide and several meters high). Albedo same as that of surrounding mare material

Interpretation

May be remnants of old craters thinly covered with mare material or may be volcanic ring structures that formed at the time of deposition of the mare material

Ec | E

Crater material

Characteristics

Ec, material of rayless craters having smooth rims. Scattered blocks present on rim and wall. No terraces on wall. Crater rim crests moderately to strongly subdued and rounded

E, material of shallow rayless craters having smooth low rim. No blocks in some craters; a few isolated blocks on rim or wall of others. Crater rim crest rounded and strongly subdued and barely stands above surrounding terrain

IMBRIAN SYSTEM

Im

Old mare material

Characteristics

Occurs in the southeast corner of the region. Resembles young mare material (Em) except that it is more densely cratered and has a slightly higher albedo

Interpretation

Probably volcanic flows similar to young mare material but has more craters and a thicker debris layer because of its older age. May be merely young mare material modified by ray material, but lacks lineaments typical of rays

Itp

Cratered terra plains-forming material

Characteristics

Forms highly cratered generally level terrain in floor of large old crater in northeast corner of region. Surface is saturated with subdued 200-500 m craters. Few fresh blocky craters present. Has slightly higher elevation than the mare. Albedo intermediate. Because of the high crater density, no age designation is given to craters too small to be outlined

Interpretation

Similar to unit Etp but older and more cratered. Probably composed largely of fragmental debris of both volcanic and impact origin. Lack of small fresh blocky craters suggests that a much thicker surficial fragmental layer has developed on this unit than on the mare

Ic

Crater material

Characteristics

Material of shallow bowl-shaped or pan-shaped craters having smooth low rims. No blocks in either rim or wall materials. Crater rim crest rounded

Interpretation of Crater Materials
Cc_5 - Ic; 5 - E

Materials of craters that are probably mostly of impact origin. A few may be of collapse origin and few of volcanic origin. Craters are assigned numbers or letters according to relative age. Numbered craters are the youngest and the higher the number the younger the crater. Interior slopes of youngest craters are probably fragmental and brecciated debris which may include blocks of highly shocked rock or, alternatively, volcanic fragments and pyroclastics. Highly shocked bedrock may also be exposed in youngest craters. Material around older craters is indistinguishable from surrounding materials

PRE-IMBRIAN

pIc

Crater rim material

Characteristics

Forms part of the rim of an old crater 40 km in diameter that lies mostly outside the map area. Rugged, sparsely cratered terrain covered with patterned ground

Interpretation

Rim and wall of a very old crater. Subdued by mass-wasting, faulting, and micrometeorite bombardment

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Contact

Dashed where two facies of same unit are separated

(Itp)
(Em)

Buried contact

Buried unit indicated by symbol in parentheses

Probable fault

Bar and ball on apparent downthrown side

Gentle sinuous scarp

Dotted where buried. Line marks base of slope and arrows point downslope. Probably a degraded flow front

Gentle linear depression

May be buried sinuous rille or may mark edge of flow front