DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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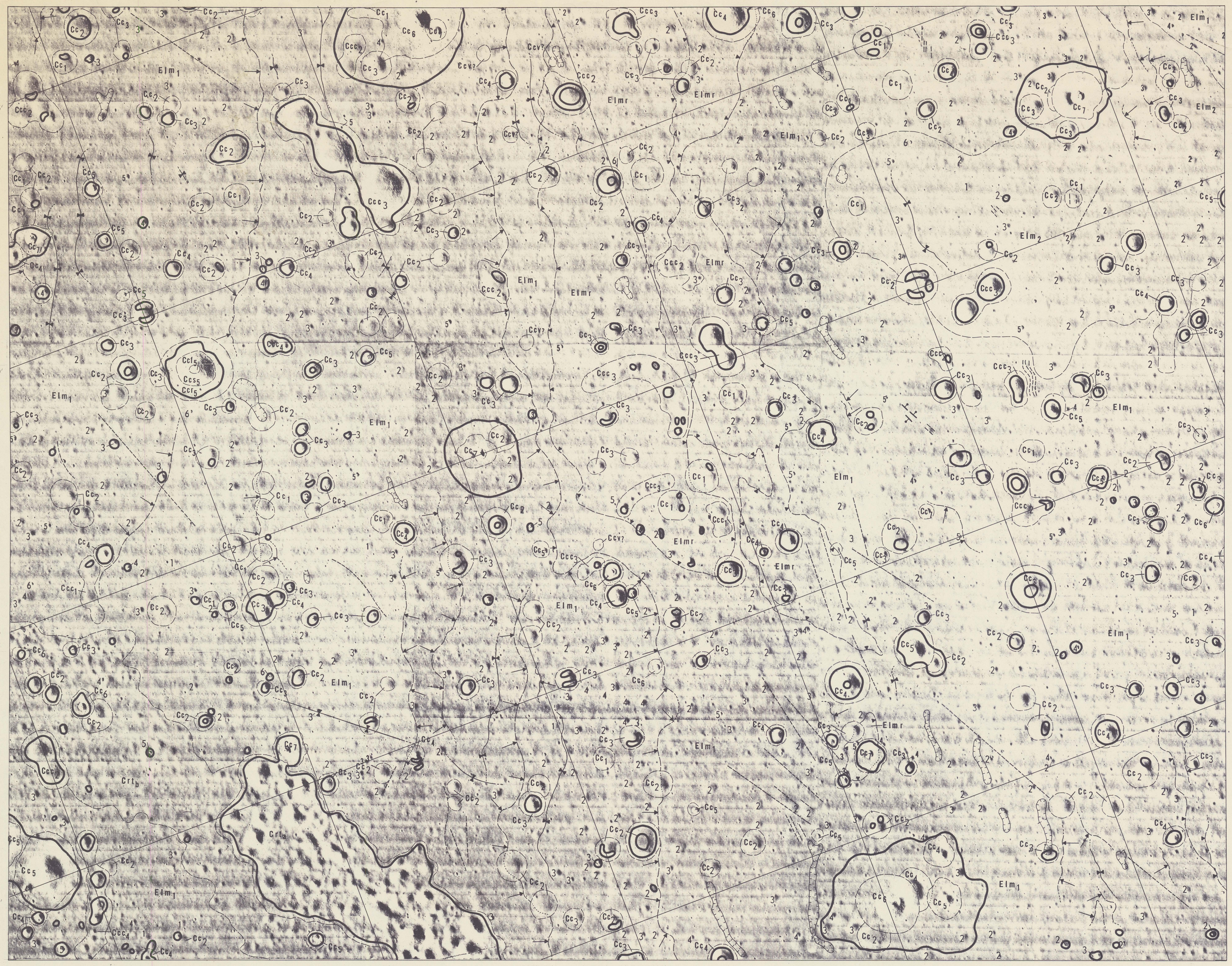
Manned Spacecraft Center,
National Aeronautics and Space Administration

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.

ORB III-11-8

DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
OPEN FILE REPORT



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SCALE 1:25,000 (APPROXIMATE)

KILOMETERS

NAUTICAL MILES

Principal sources of geologic information: Lunar Orbiter III and V photographs (Langley Research Center, NASA, 1966, 1967); albedo data from Pohn and Wildey (1966) and from full-Moon plates 5818 and 5819 taken at U.S. Naval Observatory, Flagstaff, Ariz.

PRELIMINARY GEOLOGIC MAP OF ELLIPSE III-11-8 AND VICINITY

By
Mareta West and P. Jan Cannon
1967

Mercator Projection

Ellipse III-11-8 is in southeast Oceanus Procellarum, south of the craters Kepler and Encke. The center of the ellipse is at lat 3°37'30" S., long 36°42'30" W.

Regional Geologic Setting

The topography of this area of fairly dark (albedo, 0.060-0.075) mare is moderately smooth. Rays from Tycho cross the region. Crater morphologies suggest that mare units are covered with a thin layer of fragmental material, interpreted as fresh, poorly sorted debris derived from bedrock by impact.

General Geology and Stratigraphy

Crater studies suggest that mare materials of this region are younger than mare materials elsewhere. The texture of the mare, relatively random swales and swells, may reflect the presence of near-surface bedrock.

The regional stratigraphy consists of a mare ridge unit and two mare units. The swath of craters mapped as unit Crta in southern part of the ellipse may contain Tycho ray material.

Superposition relations indicate that craters are degraded with time. On the assumption that round craters were originally sharp and fresh appearing, they are assigned numbers indicating their relative ages according to their degree of apparent degradation. Higher numbers indicate younger craters. Small craters are degraded faster than large ones so that a small subdued crater may be of the same age as a large sharper one. Figure 1 shows, in graph form, the general morphologic criteria used in assigning relative ages.

Engineering Geology

Fresh craters with secondary craters formed by ejected blocks and 2 possible tracks of rolled boulders in Orbiter site III P-11 indicate a surficial layer of fragmental material (regolith) which behaves in a manner similar to terrestrial soils. Ellipse II-11-8 is 200 km east of the Surveyor I site, where the static bearing capacity of the fragmental layer on the mare surface was determined to be about 3×10^5 dynes per cm^2 (5 psi), assuming homogeneity to a depth of about 30 cm (Natl. Aeronautics and Space Adm., 1966, p. 20).

The Soil Mechanics Surface Sampler aboard Surveyor III, 400 km east of ellipse III-11-8, tested properties of the lunar regolith to a depth of about 7.5 cm. A static bearing capacity of 2×10^5 dynes per cm^2 (3 psi) was determined for a homogeneous fragmental layer to a depth of 5 to 7.5 cm (Natl. Aeronautics and Space Adm., 1967, p. 85). A maximum static bearing capacity of 5.5×10^5 dynes per cm^2 (8 psi) was estimated from footpad imprints.

Ellipse III-11-8 and the two Surveyor sites are each covered by the extensive mare material of Oceanus Procellarum. The relatively smooth mare surface appears to be continuous from the two Surveyor sites to ellipse III-11-8, which more closely resembles the Surveyor I site, especially in thickness of fragmental layer.

Ejecta blocks occur around fresh craters more than 21 meters in diameter. The size and areal distribution of the blocks increase with crater diameter. Blocks around Cc_6-Cc_8 craters are angular to subangular and appear to rest on the mare surface. Blocks around Cc_2-Cc_5 craters are partly buried and appear to be subrounded. The presence of blocks indicates that a hard substrate occurs not far below the fragmental layer. The blocks are distributed from one to three crater diameters around Cc_6-Cc_8 craters and should be representative of bedrock excavated from these craters.

The morphology of 188 "fresh" craters from 14 to 110 meters in diameter was studied. Three morphologic types were distinguished: normal, flat bottom, and concentric, as classified by Oberbeck and Quaide (1967).

Craters situated on the rims of other craters were not included in this analysis. Crater rims are covered with ejecta and underlain by disturbed bedrock; therefore craters formed on crater rims would be morphologically anomalous.

Craters 14 to 24 meters in diameter were recorded for each meter increase in diameter on a frequency polygon. Craters more than 24 meters in diameter were recorded on the frequency polygon at 5-meter intervals starting with 25 meters. Using the data from the frequency polygon, percentages of morphologic crater types were plotted to diameter (Fig. 2).

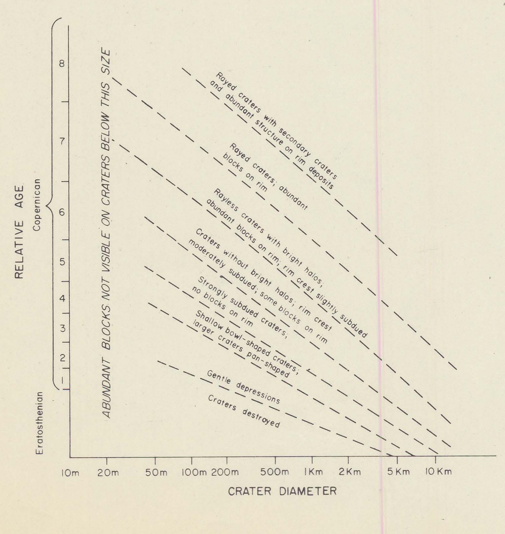

Figure 1.--Graph showing relation between crater diameter (rim crest to rim crest), crater morphology, and crater age.

According to experimental work of Oberbeck and Quaide (1967) the crater structure can be related to the value of a parameter R, defined as the ratio of the crater rim diameter to the thickness of the fragmental layer. Values for R of 6.5 and 11.0 were used to determine the depth of the fragmental lunar surface layer.

From the graph of percentages of morphologic types versus crater diameter (Fig. 2), the minimum diameter of flat-bottom craters (16 meters) was used to calculate the thickness of the fragmental layer where R = 6.5. The minimum diameter of the concentric craters (21 meters) was used to calculate the thickness of the fragmental layer where R = 11.0. The calculations made with these values indicate the fragmental layer in ellipse III-11-8 is between 2.0 and 2.5 meters (Fig. 2).

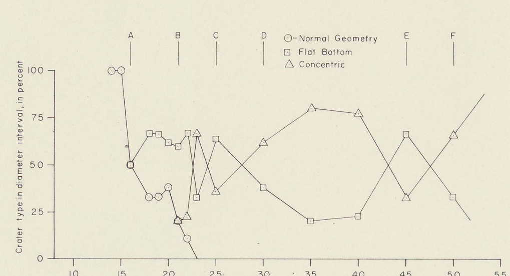

Figure 2.--Percentages of normal, flat-bottomed, and concentric craters of diameter D. Method described by Oberbeck and Quaide (1967). A, crater D = 16 meters. Point near bottom of fragmental layer. Maximum depth would be where R = 6.5; depth = 2.5 meters. B, crater D = 22 meters. Point where uppermost substrate begins to be penetrated. Minimum depth would be where R = 11.0; depth = 2.0 meters. C, crater D = 25 meters. Point where uppermost substrate is completely penetrated and top of second substrate is reached. Maximum depth from surface would be where R = 6.5; depth = 3.8 meters. D, crater D = 30 meters. Near point where second substrate becomes penetrated. Minimum depth to top of second substrate would be for R = 11.0; depth = 2.8 meters. E, crater D = 45 meters. Near discontinuity between second and third substrate. Maximum depth to discontinuity would be where R = 6.5; depth = 6.9 meters. F, crater D = 50 meters. Point where third substrate becomes penetrated. Minimum depth would be for R = 11.0; depth = 4.5 meters.

The site is entirely mare covered and only mare-type features are present; no terra is present. Much of the surface has a faintly perceptible texture of gentle swales and swells, differing from typical patterned ground in that topographic elements are more randomly arranged. This texture and the presence of numerous small blocks may present landing hazards.

Scientific Interest

Samples from the mare ridge and the two mare units could be used to ascertain the age and origin of the mare. Ground observation would aid in the interpretation of mare ridges and provide information as to the relationships between ridges and mare structure.

The apparent shallow depth to bedrock (less than 3 meters) would afford ease of sampling rocks in situ. The numerous blocks associated with the impact craters would provide samples of bedrock which could give insight to the mechanics of crater formation. Blocks associated with Cc_6-Cc_8 type craters are angular in shape whereas those associated with Cc_3-Cc_5 type craters are subangular to subrounded; therefore, the process or processes which are degrading and subduing the craters are also rounding the blocks. Specific sampling of the blocks will give information as to the process or processes involved in the modification of lunar surface materials.

This ellipse contains a variety of crater morphologies. Craters less than 16 meters in diameter have normal geometry, those between 16 meters and 21 meters in diameter have a flat bottom, and those greater than 21 meters but less than 90 meters in diameter have either flat bottoms or concentric terraces around the lower part of their interiors. All craters greater than 90 meters in diameter exhibit a rough normal geometry.

Summary

Ellipse III-11-8 is a relatively smooth mare surface. The upper layer appears to be gently undulating, thin, and youthful. Good possibilities of sampling bedrock in the ejecta or walls of relatively small craters give the site high scientific importance.

References

National Aeronautics and Space Administration, 1966, Surveyor I--A preliminary report: NASA Spec. Pub. 126, 39 p.

_________ 1967, Surveyor III--A preliminary report: NASA Spec. Pub. 146, 159 p.

Oberbeck, V. R., and Quaide, W. L., 1967, Estimated thickness of a fragmental surface layer of Oceanus Procellarum: Jour. Geophys. Research, v. 72, p. 4697-4704.

Contact

Long dashed where approximately located.

Buried contact

Lineament

Gentle narrow trough or scarp. Interpretation: May be fault, joint, or depositional feature.

Fault

Solid line at base of scarp; bar and ball on downthrown side.

Scarp

Long dashed line at base of scarp; short dashed where approximately located; dotted where concealed. Barb points downslope.

Flow front

Long dashed line at base of gentle scarp; arrows point down the face of the scarp; short dashed where approximately located; dotted where concealed. Interpretation: May be the front of a lava flow or debris flow.

Symmetrical linear depression

Narrow troughs which are 5 to 10 meters wide and 2 to 3 meters deep; dashed where inferred. Interpretation: May be surface expression of tension fracture.

Irregular depression

Depressions having fairly steep walls and fairly flat bottoms. Interpretation: May be collapse feature.

Block field

Angular to subangular fragments associated with craters; size range of fragments is 3 to 10 meters. Interpretation: Fragments of bedrock excavated by impact.

COPERNICAN SYSTEM

Crater materials

NOTE: Crater materials occupying larger areas are outlined by geologic contacts; materials occupying smaller areas are assigned numbers only.

Cc_8

Crater materials, undivided. Rim crest diameter less than 400 meters. Includes very bright ray material and satellitic crater material; abundant blocks present; pronounced structure occurs in floor; crater density on rim material very low; crater rim crest sharply raised.

7	Cc_7

7, crater materials, undivided. Rim crest diameter less than 100 meters. Includes ray material; moderately abundant blocks present; floor material is hummocky and has arcuate terraces; crater density on rim lower than that of surroundings; crater rim crest very slightly subdued.
Cc_7, crater materials, undivided. Rim crest diameter less than 400 meters. Includes bright ray material; abundant blocks present; moderately pronounced structure occurs in floor material; crater density on rim material lower than that of surroundings; crater rim crest slightly subdued.

6	Cc_6

6, crater materials, undivided. Rim crest diameter less than 100 meters. Unit is bright; scattered blocks in rim material; terraces present in wall material; crater density on rim material less than that of surroundings; crater rim crest slightly subdued.
Cc_6, crater materials, undivided. Rim crest diameter less than 400 meters. Unit is bright; moderately abundant blocks present; relatively strong structure occurs in floor material which has arcuate terraces; crater density on rim material lower than that of surroundings; crater rim crest slightly subdued.

5	Cc_5	Ccr_5	Ccs_5	Ccf_5

5, crater materials, undivided. Rim crest diameter less than 100 meters. Unit is not bright; scattered blocks occur in rim material, and abundant blocks occur inside crater; subdued hummocks or terraces occur in floor material; crater density on rim material same as that of surroundings; crater rim crest subdued.
Cc_5, crater materials, undivided. Rim crest diameter less than 400 meters. Unit is not bright; scattered blocks occur in rim material and abundant blocks occur inside crater; slightly subdued structure present in floor material; subdued remains of terraces line the lower parts of the wall material; crater density on rim material slightly lower than that of surroundings; crater rim crest raised and well defined.
Ccr_5, rim material. Strong concentric pattern present in rim material; scattered blocks occur; crater density on unit same as that of surroundings.
Ccs_5, bright slope material. Occurs on steep slopes; abundant blocks present.
Ccf_5, floor material. Patterned ground present; occurs on gentle slopes.

4	Cc_4

4, crater materials, undivided. Rim crest diameter less than 100 meters. Unit is not bright; scattered blocks occur in wall material; crater density on rim material same as that of surroundings; associated crater has shape of shallow bowl and has slightly raised rim crest.
Cc_4, crater materials, undivided. Rim crest diameter less than 400 meters. Unit is not bright; sparse blocks occur in rim material, scattered blocks in wall material, and no blocks in floor material; very subdued structure present in floor material and concentric structure present in rim material; crater rim crest strongly subdued.

3	Cc_3

3, crater materials, undivided. Rim crest diameter less than 100 meters. Scattered patches of blocks occur in wall material; associated crater is gentle pan-shaped depression.
Cc_3, crater materials, undivided. Rim crest diameter less than 400 meters. Scattered patches of blocks occur in wall material; slight concentric structure present in rim and wall materials; crater density on rim material same as that of surroundings; associated crater is shallow-bowl shaped and has very slightly raised rim crest.

2	Cc_2

2, crater materials, undivided. Rim crest diameter less than 150 meters. Associated crater is very gentle depression.
Cc_2, crater materials, undivided. Rim crest diameter less than 400 meters. Sparse patches of blocks occur in wall material; patterned ground occurs in wall and floor material; sharp break in slope present at base of wall; associated crater is pan-shaped to gentle depression.

1	Cc_1

1, crater materials, undivided. Associated crater is very gentle depression.
Cc_1, crater materials, undivided. Rim crest diameter less than 400 meters. No resolvable blocks present; associated crater is gentle depression.

Interpretation
Materials of both primary and secondary impact craters; youngest Cc_8, oldest Cc_1. Morphology of craters with lower numbers evolved from that of higher numbered craters by erosion, micrometeorite bombardment, and slumping due to seismic shaking.

Interpreted engineering properties
All craters except Cc_1 craters have blocks on their rims and constitute landing hazards. Depth to cohesive substrate on large subdued craters is greater than average on floors and less than average on rims.

Scientific interest
The freshest samples of ejected materials will be found around the youngest craters. Samples from craters of all ages may shed light on radiation history.

Crt_a	Crt_b

Tycho ray materials

Characteristics
Crt_a, material of satellitic craters. Walls are bright; abundant blocks occur in wall material of some craters; crater rim crests strongly subdued.
Crt_b, ray material. Underlying topography appears highly subdued.

Interpretation
Materials of secondary and tertiary craters excavated by material ejected from the large primary impact crater Tycho.
Crt_a, material of secondary craters formed by ejecta from Tycho.
Crt_b, tertiary material or ejecta plume associated with the Tycho secondary craters. Apparently consists of a thin layer of fine debris which masks the underlying topography.

Interpreted engineering properties:
Roughness of the surface within these units constitutes a landing hazard. An additional hazard is the abundance of blocks associated with the secondary craters.

Scientific interest
Possible comparison of texture and composition of material from Tycho with bedrock in the ellipse.

Crater cluster materials

Characteristics

Ccc_4

Abundant blocks occur along crater wall; floor material is patterned and occurs on gently sloping surface. Craters in cluster resemble Cc_4 craters and have subdued rim crests.

Ccc_3

Few scattered blocks occur in wall material; craters in cluster resemble Cc_3 craters and are gentle pan-shaped depressions.

Ccc_2

Patterned ground noticeable in floor material; craters in cluster resemble Cc_2 craters and are very gentle depressions.

Ccc_1

Craters in cluster resemble Cc_1 craters and are gentle depressions.

Interpretation
Materials of secondary impact craters clustered in strings or loops.

Interpreted engineering properties
Numerous blocks occuring in and between the craters would constitute landing hazards.

Scientific interest
Possible source area for material ejected from distant or inaccessible craters.

Ccv?

Crater material, volcanic?

Characteristics:
Material of low domes with rimless crater in center; material appears similar to surrounding mare material; no resolvable blocks.

Interpretations:
May be material of volcanic vent or plug-like feature.

Interpreted engineering properties:
Lack of resolvable blocks suggests that the material is small in grain size and unconsolidated.

Scientific interest:
Possible source for samples of deep-seated lunar materials.

IMBRIAN OR ERATOSTHENIAN SYSTEMS

EIm_2

Smooth mare material

Characteristics
Very gently undulating material with slopes of 2° to 3°; faint lineaments trend northeast and northwest; patches of patterned ground present. Crater density lower than that of surrounding mare material (unit EIm_1), but relatively more Cc_2 craters between 40 and 100 meters in diameter are present; very few blocks associated with Cc_3 to Cc_5 craters.

Interpretation
Volcanic flows or ash beds, or both. Uppermost layer may be fragmental debris.

Interpreted engineering properties
The lack of blocks indicates the material is unconsolidated and of unresolvable grain size; surface smoother than mare unit EIm_1, probably was extremely fluid at time of extrusion.

Scientific interest
Would provide samples of subsurface material; may provide insight to the mechanism or mechanisms which cause lunar volcanism.

EIm_1

Mare material

Characteristics
Very gently undulating material; highly cratered with abundant subdued craters. Lineaments moderately abundant. Resolvable blocks around many craters. Many long flow fronts occur in unit.

Interpretation
Probable volcanic flows.

Interpreted engineering properties
Relatively thin fragmental material overlies the cohesive substrate. Resolvable blocks present around many craters.

Scientific Interest
Surface fragmental material apparently thin; bedrock samples may be available in ejecta from small craters. Flow fronts may not be recognizable on ground.

EImr

Mare ridge material

Characteristics
Elevated material in the mare bounded by low scarps 2 to 3 meters high. Crater density and age similar to that of mare material; small fresh craters less than 20 meters in diameter are flat bottomed.

Interpretation
Segments of material uplifted along faults. Margins of material appear to have been shaped into lobes by mass movements.

Interpreted engineering properties
Because of the downslope movement of material the fragmental layer may be thinner here than on other mare units. The material along the periphery of the ridges may be unstable and hazardous to landings and traverses.

Scientific interest
Easily available bedrock samples.

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Moon (Ellipse area). Geol. 1:25,000. 1967. sheet 3-11-8, cop. 1.

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