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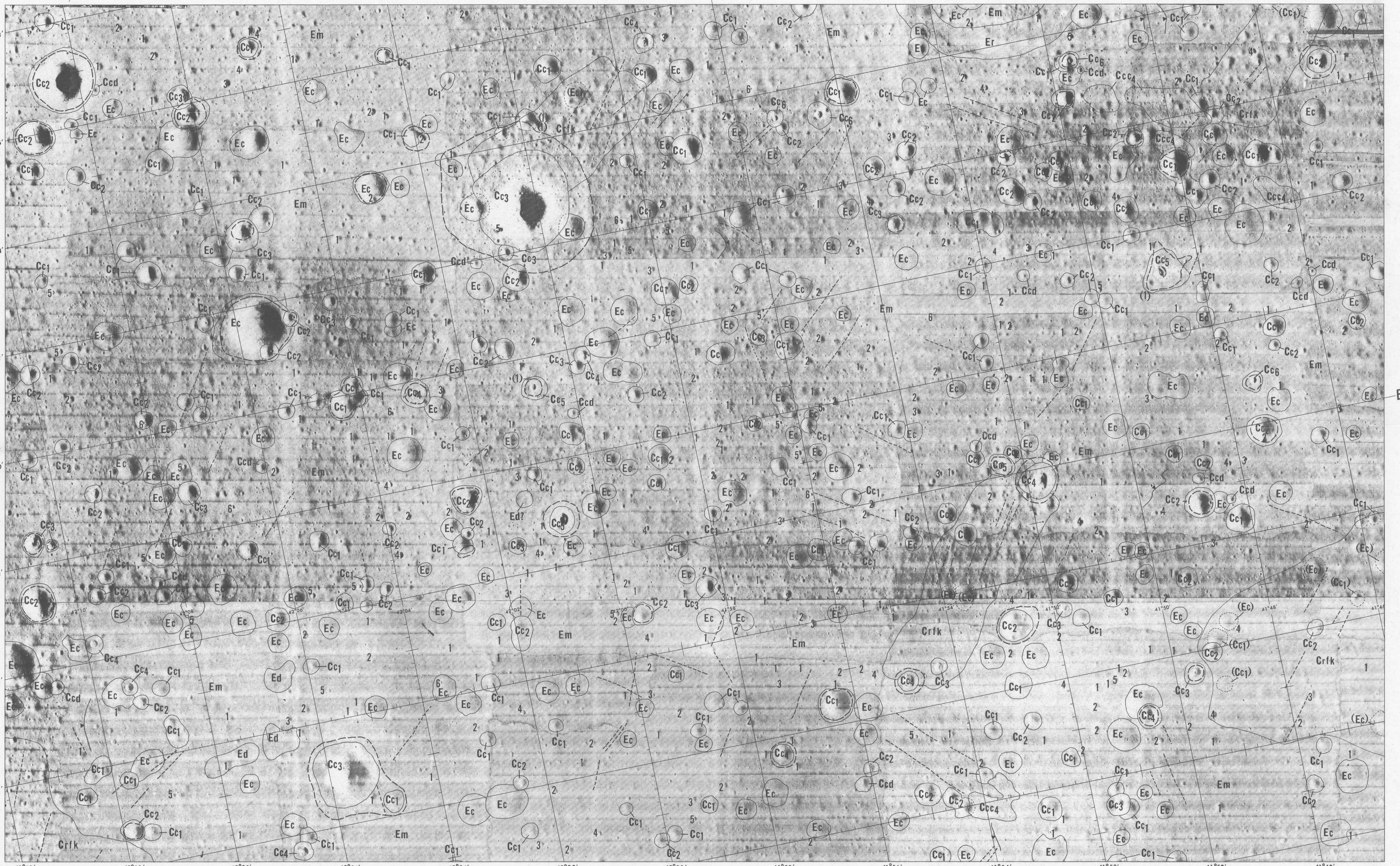

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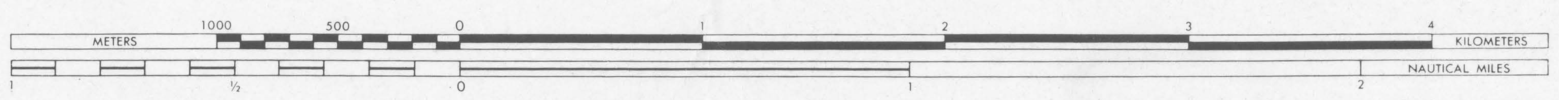
Principal sources of geologic information: Lunar Orbiter moderate-resolution photographs: II - M197-212. Lunar Orbiter high-resolution photographs: II - H198-200, H205-207; III - H165-167 (Langley Research Center, Natl. Aeronautics and Space Adm., 1966, 1967).

SCALE 1:25,000



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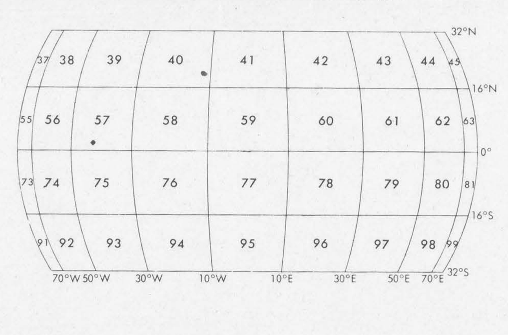

GEOLOGIC MAP OF THE ELLIPSE WEST ONE AREA
(PART OF LUNAR ORBITER SITE II P-13)

By
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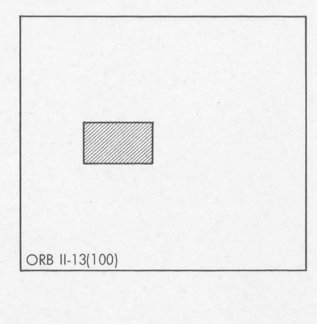
Mercator Projection

SITE LOCATION DIAGRAM KEYED TO ORB II-13(100)



General Geology

This map shows the geology of a potential early Apollo landing site in the lunar equatorial belt.

Ellipse West One is in Oceanus Procellarum approximately midway between the crater Kepler to the northeast and Flamsteed to the southwest. Full-Moon photographs of the area show dark mare materials and two faint rays from Kepler. Materials in the site have been mapped according to their interpreted relative age and assigned to positions in the standard lunar stratigraphic column used for small-scale reconnaissance mapping (Hackman, 1962; Wilhelms, 1966). Most small features on the lunar surface (largely craters less than 100 meters in diameter) apparently belong to the Copernican System. Numbers have therefore been added to the symbols used for most Copernican units in order to provide a finer breakdown by relative age. The highest numbers are for the youngest units. Maps of Lunar Orbiter site II P-13 (scale 1:100,000) by Titley (1967) and Carr and Titley (1968) show the regional setting of the ellipse.

The mare material is apparently of one age. Superposed on it are craters and their deposits. The youngest are fresh and bright; and the oldest, smooth and gentle. The age interpreted for the latter group indicates that the mare material is Eratosthenian in age (Carr and Titley, 1968).

Superposition relations indicate that fresh craters are degraded with time. Crater morphology and details of the rim and floor are used to estimate relative ages according to the diagram shown below (fig. 1). Adjacent crater categories grade into one another without a break. Because the rate of crater destruction may vary from place to place on the Moon, all craters with the same designation in this and other areas may not be strictly equivalent in age. However, all Eratosthenian craters and low-numbered Copernican craters are probably relatively old members of the total population.

Ray materials from the crater Kepler extend across portions of the area from northeast to southwest.

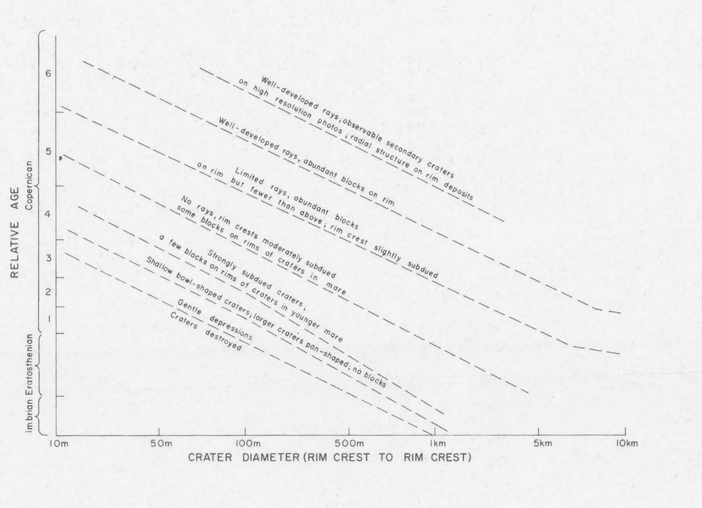


Figure 1.--Relation between diameters, properties, and ages of craters. Categories are intergradational.

Engineering Properties

Similarities in crater size-frequency distribution and albedo strongly suggest that mare materials of this area are nearly identical with those of the area to the southwest where Surveyor I landed (Lunar Orbiter Photo Data Screening Group, 1967). Furthermore, evidence from crater morphology suggests that the soil layers in both areas are relatively thin. Thus, the dynamic resistance of 4 to 7 x 10^5 dynes per cm^2 indicated by Surveyor I (Jaffe and others, 1966) for lunar soils of the dark mare in ellipse III-12-1 (Harbour, 1967) may closely approximate a general value of similar dark-mare soils of this area.

Relatively fresh craters in the southern and western parts of the area are surrounded by ejected blocks as much as 500 meters from the crater rim. North of the crater at lat 1°53' N., long 42°00' W. and west of the crater at lat 1°43' N., long 42°06' W. blocks as large as 10 meters lie on the mare surface. In the central part of the area a few blocks whose size is near the limit of resolution (2 meters) are visible on the mare near the crater at lat 1°46' N., long 41°52' W. and at long 42°01' W. Inasmuch as the mare materials here appear to constitute a single fairly uniform unit, and as the aforementioned craters are in or near the ellipse, data derived from evaluation of blocks as natural penetrometers should be applicable in general to the entire ellipse. All resolvable blocks occur on crater rims or interiors. However, blocks below the limit of resolution, derived from the numerous small fresh craters, are probably abundant throughout the area. Quaide and Oberbeck (1968) estimate that the fragmental layer in site II P-13 is from 1.5 to 9 meters thick with a median thickness of 5.5 meters. In 50 percent of the area, the thickness is between 4 and 7 meters.

A few dimple craters (unit Ccd) of uncertain genesis and significance are present. They may have formed by collapse. In general, however, the widespread and generally uniform distribution of small craters which expose bedrock and the presence of widespread relatively thin fragmental material suggest the collapse features, if present, are local rather than widespread. The dimple craters appear to be randomly distributed. bedrock and the presence of widespread relatively thin fragmental material suggest the collapse features, if present, are local rather than widespread. The dimple craters appear to be randomly distributed.

Scientific Interest

Because upper mare surface material has breached and flooded apparently young craters in the northeastern part of site II P-13 (Titley, 1967), mare of this region may very well be younger than most mare on the east side of the Moon. This possibility is further strengthened by the presence of a comparatively thin (thus, youthful) fragmental layer in this area. Collection of rock samples should be easy because of probably widespread distribution on the surface.

Of considerable scientific interest is the ring north of the ellipse. The unusual morphology and questionable genesis of this feature, one of at least six in site II P-13 (Titley, 1967), make it worthy of investigation. The fact that its albedo is the same as that of the surrounding mare material suggests that it may be an old crater covered by mare material which has differentially compacted over the rim crest.

Thus, the mare material here may have behaved more like an ignimbrite (a deposit capable of extensive differential compaction) than a lava flow. This is a fundamental question of lunar geology which can be attacked by study of this feature. The ring might also be an extrusive feature younger than the surrounding material, in which case, rock samples from it may provide information concerning lunar differentiation history. The mare material inside the ring appears to be more heavily cratered than the mare outside it.

Lastly, unit Crfk is of scientific interest because it may provide an opportunity for sampling materials ejected from the crater Kepler.

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Moon (Ellipse West One area). Geol. 1:25,000. 1968.
cop. 1.

EXPLANATION

NOTE: Crater materials are outlined with geologic contacts or simply numbered according to their relative age and approximate rim crest diameter as shown in the following table:

		Outlined	Numbered only	Unmapped
Cc_6	(youngest)	>50 m	25-50 m	<25 m
Cc_5-Cc_3		>75 m	50-75 m	<50 m
Cc_2-Cc_1		>100 m	75-100 m	<75 m
Ec	(oldest)	>125 m	Not shown	<125 m

COPERNICAN SYSTEM

Cc_6 | 6

Crater materials

Characteristics
Cc_6, materials of craters having well-developed bright rays. Abundant resolvable blocks (>2 meters in diameter) present. Interiors of craters sharply structured with well-developed terraces.
6, materials of craters having intensely bright rays. Crater rim crest very sharp and pronounced. Small craters with less well developed rays would be included in this class but confident identification is not possible.

Cc_5 | 5

Crater materials

Characteristics
Cc_5, materials of craters having weakly to well developed rays. Resolvable blocks abundant in rim deposits but less numerous than for Cc_6 craters. Crater interiors structured and terraced. Crater rim crest sharp.
5, materials of sharp-rimmed to slightly subdued rimmed craters having bright rim deposits. Some resolvable blocks in rim deposits. Floors of most craters are structured but structures are slightly subdued.

Ccc_4

Crater cluster material

Characteristics
Material in areas having a distinctly higher density of craters 10-20 meters in diameter than surroundings. Many craters are elongate northwest; many form herringbone pattern pointing northwest. Craters are strongly subdued.

Interpretation
Material of secondary impact craters made by projectiles of unknown provenance.

Interpreted engineering properties
Abundant craters are a hazard because of numerous slopes. Surficial debris may be more loosely packed than in surrounding areas because abundant craters are relatively young. May have more subresolution blocks than in surroundings.

Scientific interest
Relatively young secondary impact craters may yield information on mechanics of secondary crater formation and may contain exotic blocks in ejecta.

Cc_4 | 4

Crater materials,

Characteristics
Cc_4, materials of craters whose rim deposits appear as bright as or slightly brighter than surroundings. Abundant resolvable blocks present in rim deposits of larger craters. Crater rim crest moderately to slightly subdued.
4, materials of craters whose rim deposits appear only as bright as surroundings. Only a few resolvable blocks present in rim deposits. Crater rim crest moderately subdued.

Cc_3 | 3

Crater materials

Cc_3, materials of craters whose rim deposits appear only as bright as surroundings. A few resolvable blocks present in rim deposits; abundant blocks present in rim deposits of largest craters; rim deposits in largest crater slightly brighter than surroundings. Central mound occurs in some craters. Crater rim crest strongly to moderately subdued.
3, materials of craters having a gradual change in slope from rim crest to surrounding mare material. No resolvable blocks present in rim deposits, but a few present within crater. Structure in wall and rim material generally absent. Crater rim crest strongly subdued.

Crfk

Kepler ray materials

Characteristics
Material in and around densely packed craters in elongate strips generally radial to Kepler; faint to strong linear grooves, shown on map as lineaments, approximately radial to Kepler. Two facies are recognized on 1:100,000-scale map of Orbiter site II P-13 (Carr and Titley, 1968); the coarse facies has more craters larger than 100 meters in diameter than the surroundings; the fine has more craters smaller than 100 meters in diameter than the surroundings. Only the fine facies (unit Crfk) occurs in the ellipse West One area. Craters making up the unit in this area are mostly round and in some places are only slightly more abundant than on surroundings. Lineaments are abundant.

Interpretation
Material of secondary and tertiary impact craters formed by projectiles ejected from Kepler at low angle trajectories.

Interpreted engineering properties
No special hazards in this area other than those of typical Cc_2 craters.

Scientific interest
May contain some fragments derived from relatively deep in the lunar crust at the site of Kepler.

Cc_2 | 2

Crater materials,

Characteristics
Cc_2, materials of craters having strongly subdued rim crests and interiors that range from cup shaped to flat. A few resolvable blocks occur in rim deposits; abundant resolvable blocks occur in interiors of larger craters.
2, materials of craters having the shape of a shallow bowl. No resolvable blocks present in rim deposits. Crater interior smooth. Crater rim crest rounded but raised.

Ccd

Dimple crater material

Characteristics
Material of small craters having distinctive geometry. They lack rims and their inner slopes are slightly to markedly convex upward. Except for their greater depth and the absence of blocks, they resemble small Cc_1 craters.

Interpretation
Origin and significance unknown. They may be slump or collapse features or eroded impact craters.

Interpreted engineering properties
Possibility of collapse dictates that these features be avoided in early missions.

Scientific interest
Material is of interest because origin of craters is uncertain. If of collapse origin there may be no blocks near their centers. If of exogenous origin, numerous blocks may be circumferentially distributed around them.

Cc_1 | 1

Crater materials,

Characteristics
Cc_1, materials of craters having the shape of a shallow bowl. A few resolvable blocks in the rim deposits and interiors of craters larger than 200 meters in diameter. Crater rim crest strongly rounded but raised.
1, materials of craters that are gentle depressions or have the shape of a very shallow bowl.

Contact

(Ec)

Buried contact

Buried unit shown in parentheses.

Lineament

Shallow groove or subdued scarp. In areas of patterned ground the general trend and extent of the troughs and scarps are indicated by several lineament symbols.

Block field

Line outlines continuous or semicontinuous field of resolvable blocks. Subresolution blocks are probably abundant within line and probably extend beyond it.

Scarp

Line marks base of slope. Barb points downslope. Interpretation: Front of low volcanic flow or debris flow.

ERATOSTHENIAN SYSTEM

Ec

Crater materials

Characteristics
Materials of strongly subdued craters. Smaller craters are gentle depressions or have the shape of shallow bowls; larger craters are pan shaped and have a distinct break in slope at rim crest. Resolvable blocks and patterned ground occur in wall material of larger craters.

Interpretation of Crater Materials

Materials of both primary and secondary impact craters; youngest Cc_6, oldest Ec. Ec craters and those with lower numbers are modified forms of higher numbered craters. Craters are modified through erosion by impacting micrometeorites, small meteorites, and secondary particles and by gravitative movement of loose materials caused by seismic shaking.

Interpreted engineering properties
All craters except Ec craters probably have blocks either resolvable or unresolvable on their rims and thus constitute landing hazards. On large subdued craters depth to cohesive substrate greater than average on floors and less than average on rims. Around youngest craters fragmental layer on mare probably has anomalous engineering properties as the result of impact-induced disturbances; the anomalous character probably diminishes as ageing progresses.

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 histories. Soil profiles sampled around rim of youngest craters may provide evidence of age of cratering as well as information on radiation histories.

Ed

Mare dome material

Characteristics
Material of very low, irregular domes 100-400 meters in diameter. Domes are more irregular in shape than in ellipse III-12-1 (Harbour, 1967). Crater density same as on surroundings.

Interpretation
Tumuli or volcanic pipes and vents that have been eroded to the same textural appearance as the surroundings. If domes are sources of surrounding mare material, low topographic relief indicates that ejection probably was not explosive.

Interpreted engineering properties
Same as adjacent mare material, but layer of fragmental debris may be slightly thinner.

Scientific interest
May provide relatively fresh volcanic material and may give information on process of mare formation.

Er

Ring material

Characteristics
Material making up the surface of an annular ridge at north edge of map enclosing a mare-covered floor at a slightly lower elevation. Slopes covered with patterned ground. Albedo about the same as unit Em.

Interpretation
An old crater inundated by mare material (possibly ignimbrite) which compacted differentially to preserve the structure in subdued form. Alternatively, may be a ring-shaped extrusion, or regional mare material unwarped by a younger subsurface ring dike. Patterned ground on slopes caused by downhill creep of surficial debris.

Interpreted engineering properties
Debris-covered slopes and creep textures indicate potentially hazardous surface.

Scientific interest
Of interest for information it may provide on possible ignimbrite origin of the mare material. If feature is an extrusive ring, samples from it may represent a late stage of differentiation. Samples of soil from the ring can be obtained from the toe of the debris apron.

Em

Mare material

Characteristics
Level cratered material making up most of the surface of the ellipse and surrounding region. On Earth-based full-Moon photographs, unit Em is among the darker mare units recognizable.

Interpretation
Probably represents volcanic flows, the surfaces of which are covered by a fragmental layer. No layer of bedrock is positively identifiable at the general level of the surface although some may be present on the floors of craters. The criteria of Eggleton (Lunar Orbiter Photo Data Screening Group, 1967, p. 111) and Quaide and Oberbeck (1968, p. 5264) indicate that the upper layer is relatively thin in the site. Results of experiments on Surveyor V indicate similar but older fragmental mare material in Mare Tranquillitatis is basaltic in chemical composition.

Interpreted engineering properties
See text discussion. The large number of blocky craters suggests a relatively thin upper fragmental layer. Similarity of observable characteristics of this mare with mare of landing sites of Surveyor I suggests similar engineering properties.

Scientific interest
Composition of the mare should reflect differentiation histories of the Moon. Mare material of this site is apparently younger than that in much of the equatorial belt; hence may be of particular interest. Soil profiles should reveal data on radiation history of the Moon.