DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

GEOLOGIC ATLAS OF THE MOON
APOLLO LANDING SITES 4 AND 4R
I-625 [ORB III-11(25)]

GEOLOGIC SUMMARY

This map shows the geology of potential early Apollo landing sites 4 and 4R in the Wichmann CA region of the Moon. The map area, south of the lunar equator and east of the north-south axis of Oceanus Procellarum, lies within dark mare material, just beyond the intersection of rays from the craters Kepler and Copernicus. Ray material from the crater Tycho crosses the southwest corner of the area. A 1:100,000-scale map of the Wichmann CA region by Cummings (1970) shows the regional setting of the two sites.

The area is entirely covered by cratered mare material. Three mare units (Em_1, Em_2, and Em_3) have been distinguished on the basis of differences in texture, density of craters, and relative elevation. Their age is interpreted as Eratosthenian (Cummings, 1970)--relatively young in the lunar time scale. Much of the mare surface has a faintly perceptible texture of gentle swales and swells, differing from typical lunar patterned ground in that topographic elements are more randomly arranged. The swales and swells may reflect original volcanic topography, and the fact that they are detectable suggests that the surface is relatively young and that the surficial fragmental layer may be thin. The mare material appears to be continuous with that in Apollo site 5, which is also mapped as Eratosthenian (Titley and Trask, 1969). The spectral reflectivity curve between 0.4 and 1.1 μ for the area resembles that for site 5 (McCord and others, 1969, p. 4386). It shows an enhancement at blue wavelengths (relative to a standard area in Mare Serenitatis) and is similar in this respect to the curve for Apollo landing site 2; however, the curve for site 4 differs in the near infrared from the curve for site 2 (McCord and others, 1969, p. 4387).

The morphology of 474 relatively fresh-appearing craters between 6 and 44 meters in diameter was studied in order to estimate the thickness of the surficial fragmental layer by Quaide and Oberbeck's technique (1968). Three morphologic types were distinguished: normal, flat bottom, and concentric. Craters on the rims of other craters were not included in the analysis because of the probable heterogeneity of the disturbed material composing the underlying crater rim. Percentages of craters of each morphologic type were plotted against crater diameter. From these curves, the fragmental layer is estimated to have a median thickness of about 3 meters and to be from 2 to 5 meters thick over 50 percent of the area. These values are less than in most other Apollo landing sites in the maria (Oberbeck and Quaide, 1968).

Because the surface is relatively young and a thick fragmental layer has not developed, rock fragments of hand-specimen size should be abundant around craters throughout the map area. Fragments which could be identified with specific craters would be especially significant in providing information on crater origin and the process or processes which are subduing and degrading craters and rounding and burying blocks. Details of beds, if a stratified series exists, may be observed along flow fronts as well as along scarps.

A swath of craters in the southwestern part of the map area forms ray material (units Crct and Crft) from the crater Tycho and represents the farthest extent of Tycho rays visible on full-Moon photographs in this region of the Moon. Fragments that were ejected from the southern lunar highlands when Tycho formed may be present on and around the rays. A mission to site 4R would study the ray and collect samples from it.

REFERENCES

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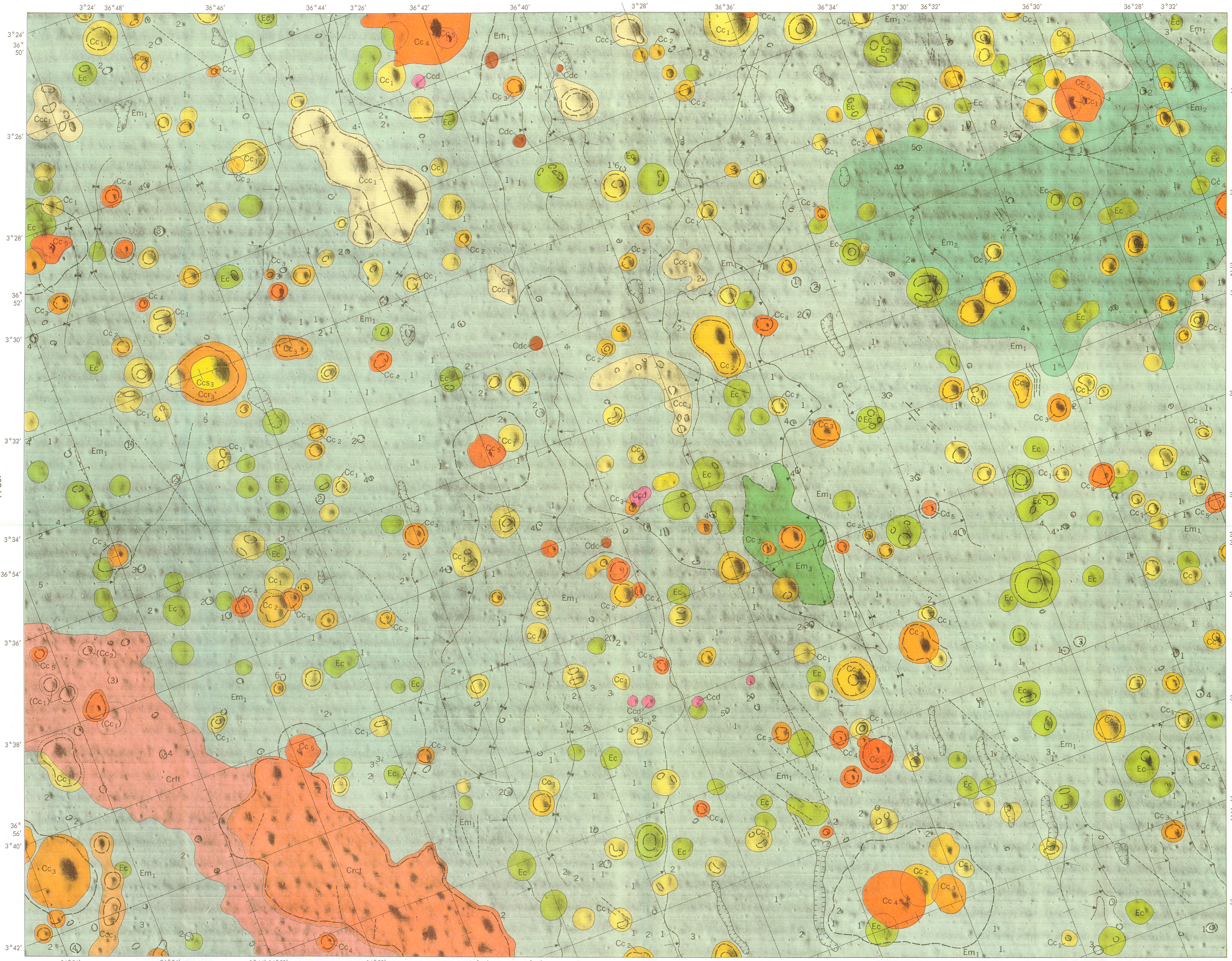
Quaide, W.L., and Oberbeck, V.R., 1968, Thickness determinations of the lunar surface layer from lunar impact craters: Jour. Geophys. Research, v. 73, p. 5247-5270.
Titley, S.R., and Trask, N.J., 1969, Geologic map of Apollo landing site 5 [scale 1:25,000]: U.S. Geol. Survey Misc. Geol. Inv. Map I-623.



Controlled base, part of Photomap ORB III-II (25), prepared by Army Map Service, Corps of Engineers, U.S. Army, Washington, D. C. 20315

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Principal sources of geologic information: Lunar Orbiter moderate-resolution photographs: III—M178; V—M174, Lunar Orbiter high-resolution photographs: III—H177–179; IV—H137; V H169–171, H173, and H174

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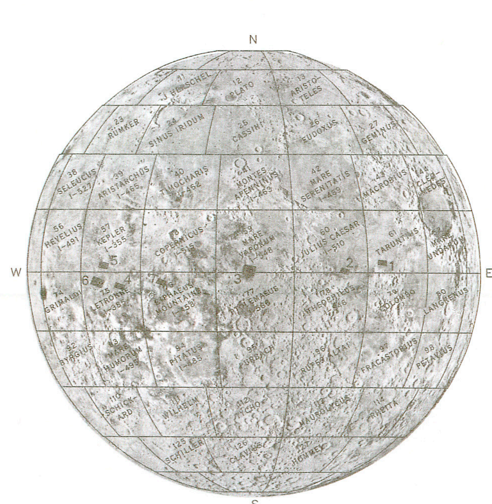
SCALE 1:25 000
MERCATOR PROJECTION

1 NAUTICAL MILE
1 STATUTE MILE
1 KILOMETER

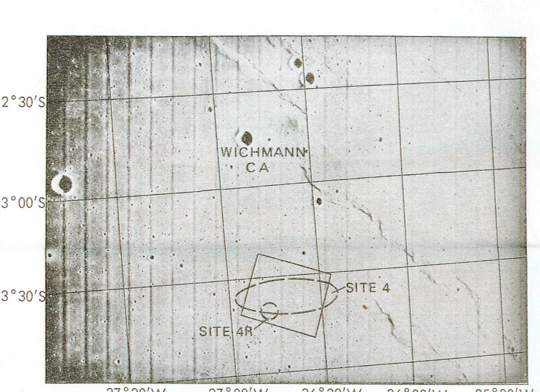
Large numbers 1-7 refer to regions that include early Apollo landing sites:

1. Maskelyne DA region
2. Sabine D region
3. Oppolzer A region
4. Wichmann CA region
5. Maestlin G region
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



PART OF LUNAR ORBITER PHOTOGRAPH V-M175

Area of this report shown by solid line; dashed ellipse indicates original LM landing dispersion ellipse (99% landing probability); dashed circle indicates relocated landing site for possible use on a mission after the first. Approximate scale 1:875,000.

GEOLOGIC MAP OF APOLLO LANDING SITES 4 AND 4R
PART OF WICHMANN CA REGION, OCEANUS PROCELLARUM

By
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1971

EXPLANATION

NOTE: Crater materials are mapped 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 the lunar time-stratigraphic division (system), lower case letters to designate the 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 Copernican craters are not outlined but are indicated by a number only. For example, materials mapped as crater material, Cc_1, outlined, and colored are associated with a relatively old Copernican crater more than 100 m (meters) in diameter; materials designated simply 1 are the same age but are associated with craters from 75 to 100 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_6 | 6

Crater material

Characteristics
Cc_6, material of crater having very bright rays. Abundant resolvable blocks (>2 meters in diameter) present. Arcuate fractures on floor. Crater rim crest sharp
6, material of craters having rays. Abundant blocks. Crater rim crest sharp

Cc_5 | 5

Crater material

Characteristics
Cc_5, material of craters having bright rays. Abundant blocks. Moderately pronounced fractures on floor. Crater rim crest slightly subdued
5, material of craters having rays. Moderately abundant blocks. Floor material hummocky with arcuate terraces and fractures. Crater rim crest slightly subdued

Crct | Crft

Tycho ray material

Characteristics
Material of strongly clustered craters forming a swath radial to Tycho; appears bright on full-Moon photographs
Crct, coarse facies. Craters > 50 m in diameter. Crater rim crests raised and strongly subdued. Crater walls bright. Abundant blocks
Crft, fine facies. Craters < 50 m in diameter. Crater rim crests very strongly subdued. Crater walls are not as bright as in Crct. A few blocks in and around some craters

Interpretation
Material of secondary and tertiary impact craters related to the large primary crater Tycho. May contain material derived from location of Tycho
Crct, coarse material of secondary craters formed by ejecta from Tycho
Crft, fine tertiary material or ejecta plumes downrange from Tycho secondary craters. Probably forms a thin layer of debris

Cc_4 | 4

Crater material

Characteristics
Cc_4, material of craters whose rim deposits appear as bright or only slightly brighter than surroundings. Moderately abundant blocks. Relatively subdued fractures on floor; wall has arcuate terraces. Crater rim crest moderately subdued
4, material of moderately subdued craters whose rim deposits appear no brighter than surroundings. Scattered blocks in rim material. Terraces on walls

Ccc_3

Crater-cluster material

Characteristics
Material of cluster of Cc_3 craters with raised but strongly subdued rim crests. Abundant blocks on walls and floors. Scattered blocks on rims

Interpretation
Material of secondary impact craters. Source of projectiles unknown

Cc_3 | Ccr_3 | Ccs_3 | 3

Crater material

Characteristics
Cc_3, crater material, undivided. Material of craters whose rim deposits appear only as bright as surroundings. Scattered blocks in rim deposits; abundant blocks inside crater. Slightly subdued structure on floor; subdued remains of terraces line lower parts of walls. Crater rim crest raised but strongly subdued
Ccr_3, rim material. Scattered blocks; strong concentric pattern of ridges and troughs
Ccs_3, slope material. Appears bright, abundant blocks
3, crater material, undivided. Material of craters whose rim deposits appear only as bright as surroundings. Scattered blocks in rim deposits; abundant blocks inside crater. Subdued hummocks or terraces on floor. Crater rim crest strongly subdued

Cc_2 | 2

Crater material

Characteristics
Cc_2, material of craters whose rim deposits appear only as bright as surroundings. Sparse blocks in rim material; scattered blocks on wall and floor. Very subdued fractures on floor; concentric ridges and troughs in rim. Crater rim crest strongly subdued
2, material of craters whose rim deposits appear only as bright as surroundings. Scattered blocks on walls. Craters shaped like shallow bowl. Crater rim crest slightly raised but strongly subdued

Cdc

Dome crater material

Characteristics
Material of low mounds having bowl-shaped craters in center. Craters have broad low rounded rims. Diameter of rim deposits relative to crater diameter greater than for other craters. No resolvable blocks

Interpretation
May be material of volcanic vent or plug-like feature

Ccd

Dimple crater material

Characteristics
Material of craters without raised rims; walls convex upward

Interpretation
Collapse features formed by the withdrawal of magma or craters formed by drainage of loose surface fragmental material

Ccc_1

Crater-cluster material

Characteristics
Material of clusters of strongly subdued and shallow, bowl-shaped craters and gentle depressions. Few scattered blocks on walls

Interpretation
Material of secondary impact craters clustered in strings or loops. Source of projectiles unknown

Cc_1 | 1

Crater material

Characteristics
Cc_1, material of shallow, pan-shaped and bowl-shaped craters. Scattered patches of blocks on walls. Weak concentric lineaments on rims and walls. Crater rim crest missing or very low
1, material of gentle depressions. Scattered patches of blocks on walls

ERATOSTHENIAN SYSTEM

Ec

Crater material

Characteristics
Material of pan-shaped to gentle depressions. Sparse patches of blocks on walls. Patterned ground (irregular anastomosing ridges and troughs several meters high and approximately 10 m wide) on walls and floors. Sharp break in slope at base of wall

Em_3 / Em_2 / Em_1

Mare material

Characteristics
Gently undulating cratered material having slopes of 2° to 3°. Lineaments trending north, northeast and northwest. Crater density higher on Em_1 than on Em_2; Em_3 is of very limited extent and is fresher appearing than Em_2. Many long low scarps. Surface texture of swales and swells most pronounced in youngest unit (Em_3) but perceptible in older units. Resolvable blocks present around many craters

Interpretation
Volcanic flows; some ash beds may be present. Low scarps interpreted as flow fronts. Surface texture of swales and swells may reflect original volcanic topography. Surface covered by fragmental material of the lunar regolith. Bedrock samples may be available in ejecta from relatively small craters, because the thickness of the fragmental material is apparently less here than in other sites as indicated by the geometry of small fresh craters and abundance of blocks around small craters

Interpretation of Crater materials
Cc_6–Ec;6–1

Poorly sorted mixtures of shock-metamorphosed breccia and unshocked debris, associated with both primary and secondary impact craters. Craters continuously modified by micrometeorite bombardment and downslope slumping of rim and wall materials. The craters interpreted as youngest are shown by Cc_6 and 6, oldest by Ec. Craters with lower numbers have evolved from those with higher number by subsequent erosion and mass movement. Thickness of regolith above mare bedrock is greater on floors of large subdued craters than on rims. Patterned ground formed by downslope creep of surficial fragmental material

Contact
Dashed where approximately located

(Cc_1)
Buried contact
Buried unit shown by symbol in parentheses

Probable fault
Solid lines at base of scarp. Bar and ball on apparent downthrown side

Lineament
Gentle narrow trough or scarp. May be fault or joint

Scarp
Line at base of scarp; dashed where approximately located; dotted where buried. Barbs point downslope. Probably a fault scarp. Lobes along margins may have formed by mass movement

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

Gentle linear depression
Dashed where inferred. Line drawn in center of narrow symmetrical trough which is 5 to 10 meters wide and 2 to 3 meters deep. May be surface expression of joint

Irregular depression
Depressions having fairly steep walls and fairly flat bottoms. May be collapse feature

Block field
Angular to subangular fragments associated with craters; size range of fragments is 3 to 10 meters

For sale by U.S. Geological Survey, price $1.00
Explanatory pamphlet accompanies map