SITE LOCATION DIAGRAM KEYED TO LAC

55 56 57 58 59 60 61 62 63

73 74 75 76 77 78 79 80 81

/16°S

70°W 50°W 30°W 10°W 10°E 30°E 50°E 70°E 32°S

al setting of the area.

zones of weakness.

91 92 93 94 95 96 97 98 99

16°N

General Geology

early Apollo landing site in the lunar equatorial belt. The center of the ellipse is lat 3°37'30" S., long  $36^\circ42'30"$  W.

cellarum, a major feature of extensive mare material. The site

lies within a dark mare area, just beyond the end of discernible

intersecting rays from the craters Kepler and Copernicus, and it

contains ray material from the crater Tycho. A 1:100,000 scale

map of Orbiter site III P-11 by Cummings (1968) shows the region-

east of the map area; the nearest ones are approximately 15 km

away. These ridges may be constructional features along regional

The area is entirely covered by cratered mare material.

Three mare units  $(\text{Em}_1, \text{Em}_2 \text{ and } \text{Em}_3)$  have been distinguished on the basis of differences in texture, density of craters, and relative elevation. Their age is interpreted as Eratosthenian-relatively young in the time scale established by Shoemaker and

Much of the surface has a faintly perceptible texture of

gentle swales and swells, differing from patterned ground in that

topographic elements are more randomly arranged. The fact that

the swales and swells are detectable is additional evidence that

A swath of craters in units Crct and Crft in the southwestern

Craters are mapped on the basis of interpreted relative age.

the surface is relatively young and also suggests that the sur-

part of the area contains ray material from the crater Tycho and

represents the farthest extent of Tycho rays in this region of

A series of crater types is recognized ranging from sharp-rimmed

craters to shallow rimless depressions. Superposition relations

is probably ballistic erosion. On the assumption that craters

were originally sharp and fresh in appearance, they are assigned

numbers indicating relative age according to their degree of ap-

Small craters are destroyed more rapidly than large ones so that

a small subdued crater may be the same age as a large sharper one.

Figure 1 shows the general morphologic criteria used in assigning

parent degradation. Higher numbers indicate younger craters.

indicate that craters are degraded with time; the modifying agent

A series of elongate low northwest-trending ridges occurs

This map shows the geology of Ellipse West Two, a potential

The map area is east of the north-south axis of Oceanus Pro-

<50 m <75 m

Cc4 4

Cc3 | Ccr3 | Ccs3 | Ccf3 | 3

lower than that of surroundings.

Crater-cluster material

**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:

Crater materials

Crater materials

Cc5, materials of craters having bright ray material. Abundant blocks present. Moderatey pronounced structure occurs in floor material. Crater density on rim material lower

5, materials of craters having rays. Moderately abundant blocks present. Floor material is hummocky and has arcuate terraces. Crater density on rim material lower than that of

Cc6, materials of craters having bright rays. Abundant resolvable blocks (>2 meters in diameter) present. Pronounced structure occurs in floor material. Crater density on

6, materials of craters having rays. Abundant blocks present. Crater rim crest sharp.

rim material lower than that of surroundings. Crater rim crest sharp.

than that of surroundings. Crater rim crest slightly subdued

surroundings. Crater rim crest very slightly subdued.

75-100 m

Characteristics Abundant blocks present in wall materi scattered blocks present in rim. Craters in cluster resemble Cc3 craters and have raised rim

Tycho ray materials

Crct, coarse facies. Crater walls are

bright. Abundant blocks are present

Crft, fine facies. Crater walls are not

associated with some craters. Crater

rim crests very strongly subdued.

Materials of secondary and tertiary

craters excavated by material ejected

from the large primary crater Tycho.

Crct, coarse material of secondary cra-

ters formed by ejecta from Tycho.

Crft, fine tertiary material or ejecta

Interpreted engineering properties

Scientific interest

plumes associated with Tycho seconda-

ry craters. Probably is a thin layer

Roughness of the surface due to high density of craters constitutes a landing hazard. An additional haz ard is the abundance of blocks.

Possible comparison of texture and

composition of material from Tycho.

as bright as in Crct. Few blocks are

in wall material of some craters. Crater rim crests strongly subdued.

Characteristics

Cc3, crater materials, undivided. Materials of craters whose rim deposits appear only as bright as

Crater materials

posits; abundant blocks present inside crater. Slightly subdued structure occurs 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. Ccr3, rim material. Scattered blocks present. Strong concentric pattern present in rim material. Crater density on unit same as that of surroundings. Ccs<sub>3</sub>, bright slope material. Occurs on steep slopes. Abundant blocks present.

Ccf<sub>3</sub>, floor material. Occurs on gentle slopes. Patterned ground present. 3, crater materials, undivided. Materials of craters dued hummocks or terraces occur in floor material. Crater density on rim material same as that of sur-

whose rim deposits appear only as bright as surroundings. Scattered blocks present in rim deposits; abundant blocks present inside crater. Subroundings. Crater rim crest subdued.

Cc2 2

Crater materials

Ccc2 Crater-cluster material

Characteristics Abundant blocks present in crater wall material. Floor material is patterned and occurs on gently sloping ters in cluster resemble Cc2 craters and have

subdued rim crests.

Ccc1

Crater-cluster

material

Characteristics

Few scattered

blocks present

in wall materi-

al. Craters in

Cc<sub>1</sub> craters and

are gentle de-

pressions.

cluster resemble

as bright as surroundings. Sparse blocks present in rim material; scattered blocks in wall and floor. Very subdued structure present in floor material; concen-

Characteristics

tric structure present in rim. Crater rim crest strong-2, materials of craters whose rim deposits appear only as bright as surroundings. Scattered blocks present in wall material. Crater density on rim material same as that in surroundings. Associated craters has shape of shallow bowl. Crater rim crest slightly raised.

Cc2, materials of craters whose rim deposits appear only

Crater materials

Characteristics Cc1, materials of shallow bowl shaped craters. Scattered patches of blocks present in wall material. Slight concentric structure occurs in rim and wall materials. Crater density on rim material same as that of surroundings. Crater rim crest very slightly raised. l, materials of gentle pan-shaped depressions. Scattered patches of blocks present in wall material.



Crater materials

Materials of pan-shaped to gentle depressions. Sparse patches of blocks present in wall material. Patterned ground occurs in wall and floor materials. Sharp break in slope present at base of wall.

Poorly sorted mixtures of shock-metamorphosed breccia and unshocked debris, associated with both primary and secondary impact craters. Crater morphology indicates that craters are continuously modified by micrometeorite bom-Materials of secbardment and downslope slumping of rim and wall materials. ondary impact cra-The youngest craters are shown by Cc6; the oldest by Ec. ters clustered in Craters with lower numbers are being continuously evolved strings or loops. those of higher number by subsequent erosion and

> Interpreted engineering properties Craters of all ages may have associated blocks and both the craters and blocks 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 Crater deposits provide a range of shocked and unshocked surface and subsurface materials. Samples from craters of all ages may shed light on radiation history; the freshest samples being found around the youngest craters. Projectile fragments, although scarce, may provide samples of extralunar materials around primary craters and

Controlled base prepared by Army Map Service, Corps of Engineers, U.S. Army, Washington, D.C. 20315

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 (Langley Research Center, NASA, 1966, 1967); albedo data from full-Moon plates 5818 and 5819 taken at U.S. Naval Observatory, Flagstaff,

## GEOLOGIC MAP OF THE ELLIPSE WEST TWO AREA (PART OF LUNAR ORBITER SITE III P-11)

Mareta West and P. Jan Cannon

SCALE 1:25,000

November 1968 Mercator Projection

CRATER DIAMETER (RIM CREST TO RIM CREST)

Engineering Properties Experiments conducted by the Surveyor I spacecraft, which landed 200 km west of the map area, indicate that the static bearing capacity of the fragmental layer on the mare surface is ap-

Figure 1.--Relation between diameters, properties,

and ages of craters. Categories are intergrada-

proximately 3 x  $10^5$  dynes per cm<sup>2</sup> (5 psi), assuming homogeneity to a depth of 30 cm (Natl. Aeronautics and Space Adm., 1966, p. Surveyor III, 400 km east of the map area, tested properties of the lunar regolith to a depth of about 7.5 cm with its Soil Mechanics Surface Sampler. A static bearing capacity of 2 x  $10^5$  dynes per cm<sup>2</sup> (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  $5.5 \times 10^5$  dynes per cm<sup>2</sup> (8 psi) was estimated from footpad im-

prints of Surveyor II The studies of crater morphology, crater frequency, and thickness of the fragmental layer suggest that the regolith in the map area is similar to that in the Surveyor I site and is younger than that tested by Surveyor III. Numerous blocks, most of which are preferentially distributed on crater rims and walls, are visible on the surface of the map area. Shape of the blocks is related to the age of the associated crater. Blocks around Cc6-Cc4 craters are angular to subangular and appear to rest on the mare surface. Blocks around Cc3-Ec craters are partly buried and appear to be subrounded. The size and abundance of blocks increase in direct proportion to the crater diameter. Blocks extend outward a maximum distance of one to three crater diameters around Cc6-

The morphology of 474 fresh-appearing craters between 6 ness of the surface fragmental layer. Three morphologic types were distinguished: normal, flat bottom, and concentric, as classified by Quaide and Oberbeck (1968). Craters on the rims of other craters were not included in the analysis, because of the heterogeneity of the disturbed material composing the underlying crater rim. Craters were recorded by type on a frequency polygon. Percentages of craters of each morphologic type were derived from the frequency polygon and plotted to diameter. The small craters indicate that the fragmental lay er has a median thickness of about 3 meters and is from 2 to 5 meters thick over 50 percent of the area. Features which constitute possible hazards to a landing spacecraft include craters and their associated blocks; lineaments, especially if these are collapse features; flow fronts;

low scarps and ridges; and the surface texture of swales and

Scientific Interest

The most distinctive geologic feature in this area is the relatively young mare material. Because the surface is young, a thick fragmental layer has not developed, and bedrock occurs near the surface as shown by the abundance of excavated blocks. Rock fragments of hand-specimen size, visible in Surveyor sites, should also occur on the surface throughout the map area. These bedrock samples would be easy to collect. 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. Subsequent analysis of craters would furnish further criteria for the definition and cor-Details of beds, if a stratified series exists, may be

References

observed along flow fronts as well as along scarps.

Cummings, David, 1968, Geologic map of Lunar Orbiter site III P-11 [scale 1:100,000]: U.S. Geol. Survey map (in prep.). 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.

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. Shoemaker, E. M., and Hackman, R. J., 1962, Stratigraphic basis for a lunar time scale, in Kopal, Zdenek, and Mikhailov, K., eds., The Moon--Internat. Astron. Union Symposium

14, Leningrad 1960: London, Academic Press, p. 289-300.

interpreted engineering properties



## SITE LOCATION DIAGRAM KEYED TO ORB III-11/100

Cdc Domed crater material Material of craters which have broad low rounded rims. Gives the appearance of bowl-shaped

Long dashed where approximately located.

Buried contact Buried unit shown by symbol in parentheses.

Solid line at base of scarp. Bar and ball on

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

Scarp

Long dashed line at base of scarp; short dashed

cealed. Barb points downslope. Interpretation:

Gentle sinuous scarp

Long dashed line at base of gentle scarp; ar-

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. Interpretation:

Irregular depression

Block field

craters; size range of fragments is 3 to 10

Angular to subangular fragments associated with

meters. Interpretation: Fragments of bedrock

Depressions having fairly steep walls and fair-

y flat bottoms. Interpretation: May be col-

rows 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.

May be surface expression of joint.

lapse feature.

excavated by impact.

where approximately located; dotted where con-

Fault scarp. Lobes along margins may have

downthrown side.

lapse feature.

formed by mass movement.

crater in center of mound. 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. Interpreted engineering properties Texture and cratering on rims similar to surrounding mare.

Scientific interest Possible late stage volcanism. May indicate differentiation.

Interpreted engineering

Interior of crater may be blocky. Walls steep. Scientific interest Determination of prob-

Ccd

Dimple crater

Craters without raised

rims. Walls convex up-

Collapse features formed

by the withdrawal of

Characteristics

Interpretation

magma.

able origin.

Ecc Crater-cluster material

Interpreted

engineering

properties

Numerous blocks

occurring in and

constitute land-

Scientific interest

Possible source

area for materi-

al ejected from

distant or inac-

cessible craters.

between craters

ing hazards.

Gently undulating cratered material having slopes of 2° to 3°. Lineaments occur trend-Characteristics ing northeast and northwest. Patterned ground present in patches. Crater density Patterned ground ochigher on Em<sub>1</sub> than on Em<sub>2</sub>; Em<sub>3</sub> of very limited extent and is fresher appearing than Em<sub>2</sub>. Many long low scarps occur. Surface texture of swales and swells most pronounced in curs in floor material Craters in cluster re youngest unit (Emg) and perceptible in older units. Resolvable blocks present around semble Ec craters and are very gentle depressions.

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. Upper-Interpretation of most layer is fragmental debris. Crater-cluster Materials

Relatively thin fragmental material over a more cohesive substrate. Thickness of fragmental material apparently lower here than in other sites as indicated by the geometry of small fresh craters and abundance of blocks around small craters. Secondary craters formed by ejected blocks occur around of fresh crater northwest of the map area.

Surface fragmental material apparently thin. Bedrock samples may be available in ejecta from relatively small craters. Flow fronts of interest if recognizable on ground.

Em3

Em<sub>2</sub>

Mare materials

Ec

Interpretation of Crater Materials

seismically initiated mass movement.

samples of distant lunar regions around secondary craters.