DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE
USAF AERONAUTICAL CHART AND INFORMATION CENTER

GEOLOGIC ATLAS OF THE MOON
SABINE DM REGION
I-594 (RLC-9)

NOTES ON BASE

The base chart was produced in consultation with Dr. Gerard P. Kuiper and the staff of the Lunar and Planetary Laboratory, University of Arizona. Photography and trajectory information was supplied by the Jet Propulsion Laboratory. Elevation data was compiled by the University of Manchester under Air Force Contract. This is one of a series of seven Ranger VIII charts compiled from television records of the six Ranger VIII cameras.

CONTROL

The lunar features on this chart are positioned to conform with the selenographic latitude and longitude coordinates based on selenocentric measurements made by ACIC and published in ACIC Technical Paper No. 15, "Coordinates of Lunar Features," March 1965. Supplementary positions are developed in the chart area as an extension of the primary control.

NAMES

Feature names are adopted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the I.A.U., 1961 and 1964.

Supplementary features are associated with the named features through the addition of identifying letters. Craters are identified by capital letters.

A black dot is included, where necessary, to identify the exact feature named.

ELEVATIONS

The depths of craters were determined by the shadow measuring technique, utilizing Ranger VIII photography. Depths are shown in meters.

Depth of crater (rim to floor) .... (400)

PORTRAYAL

The configuration of the relief features shown on this chart is interpreted from Ranger VIII television records. The pictorial portrayal of relief forms is developed using an assumed light source from the west, with the angle of illumination maintained equal to the angle of slope of the features portrayed. Cast shadows are eliminated to enable complete interpretation of relief forms.

Lunar base chart RLC 9, 1st edition, 1966 by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

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Sources of geologic information: Ranger VIII photographs (Calif. Inst. Tech., Jet Propulsion Lab., 1965, 1966); Lunar Orbiter II photographs M67-M71; Lunar Orbiter V photographs M73, M74. Work performed under contract WO-5171, Jet Propulsion Laboratory

GEOLOGIC MAP OF THE SABINE DM REGION OF THE MOON

By

N. J. Trask

1969

SCALE 1:50 000
MERCATOR PROJECTION

1 ½ 0 STATUTE MILES 1 2 3

1 .5 0 KILOMETERS 1 2 3

EXPLANATION

br

Material of bright-rimmed craters

Characteristics
Material of craters with exterior rim material that appears brighter than the surrounding material. Bright material of the rim extends outward from the rim crest beyond topographically raised rim. Rim crests are relatively high and sharp; profile of exterior rim concave upward. In this region, all bright craters are small relative to the largest representatives of other crater types. Topographic detail of the walls not visible
Interpretation
Material of impact craters. On the rims, crushed rock with scattered blocks smaller than the limit of photographic resolution; exposed bedrock and talus on the walls

cc

Material of cratered cones

Characteristics
Material of low, roughly conical mounds with summit depressions; fewer small craters than surroundings; surface appears smooth except for small craters
Interpretations
Lava or ash flows surrounding small volcanic vents

cl

Crater cluster material

Characteristics
Material in and around distinct cluster of small (10-50m diameter) craters south of Sabine ED. Craters moderately to strongly subdued
Interpretations
Secondary impact craters; crater-forming projectiles of unknown provenance

dr

Material of dark-rimmed craters

Characteristics
Material of sharp craters with well-defined rim deposits that appear only as bright as the surrounding material. Rim material mantles adjacent topography and fills adjacent craters; most rim materials have poorly-defined radial ridges and irregular lumps. Rim crests are relatively high; profile of exterior rim concave upward. Topographic detail of walls not visible
Interpretation
Material of impact craters. Older than unit br, blocks comminuted by micrometeorite impact, albedo lowered by mixing of rim material with darker lunar soil and by solar proton bombardment

cct

Satellitic crater material

Characteristics
Material in and around clustered, irregular to elongate subdued craters; direction of elongation radial to Theophilus. Craters 300-1,000 meters in diameter. Material between craters gently rolling with relatively few superposed craters; appears higher than surroundings; high density of lineaments in places
Interpretation
Material of secondary impact craters formed by projectiles from Theophilus. Pieces of the projectiles may be present in the ejecta. Craters degraded by micrometeorite impact so ejecta blankets are poorly defined

sr

Material of subdued craters

Characteristics
Material of craters with low rounded rims and shallow interiors. Rim material is continuous around the crater and mantles and smooths adjacent topography. Around some craters, rim material appears to extend as much as one crater diameter from the rim crest and end in a low scarp. No textures visible on rims, walls, or floors except for superposed craters. Rim crest is very broad and convex upward. Distinguishing features visible only in relatively large craters
Interpretation
Material of impact craters. Older than unit dr and further degraded by meteorite impact and mass wasting. Rim deposits extending unusually far from rim crest and ending in a scarp were formed by mass movement down gentle slopes

mr

Mare ridge material

Characteristics
Elevated parts of the mare material consisting of connected linear segments. Contact with mare material is an abrupt scarp in places and a gently sloping transition zone in others; several discontinuous scarps occur within units
Interpretation
Segments of the mare material uplifted along faults; may include relatively young flows derived from feeder dikes along the crests of the ridges

m_2

Mare material

Characteristics
Flat to very gently rolling material; fewer unmapped subdued craters 50-200 meters in diameter than on unit m_1. Appears lower than surroundings
Interpretation
Lava and/or ash flows stirred and comminuted by impact to form a fragmental layer at the surface. Absence of subdued craters 50-200 meters in diameter may result from burial by fragmental debris eroded from higher surroundings. Alternatively may include a component of pyroclastics younger than the material making up unit m_1

m_1

Mare material

Characteristics
Gently rolling material, highly cratered with abundant unmapped subdued craters 50-200 meters in diameter. Irregular gentle hills and troughs give the impression of a ridged texture
Interpretation
Lava and/or ash flows stirred and comminuted by impact to form a fragmental layer at the surface. Debris may be thinner than on m_2 because of downslope movement or because relatively young pyroclastic material is lacking

Contact
Dashed where approximately located

Fault
Offset of the surface in unit cct, only slightly buried by younger material. Bar and ball indicate downthrown side

Scarp
Line indicates foot of scarp. Barb points downslope
Interpretation: Buried fault. Front of debris flow around subdued craters

Narrow ridge
Line marks crest. Arrow indicates tapered end
Interpretation: Structural upwarp or surface expression of shallow intrusive

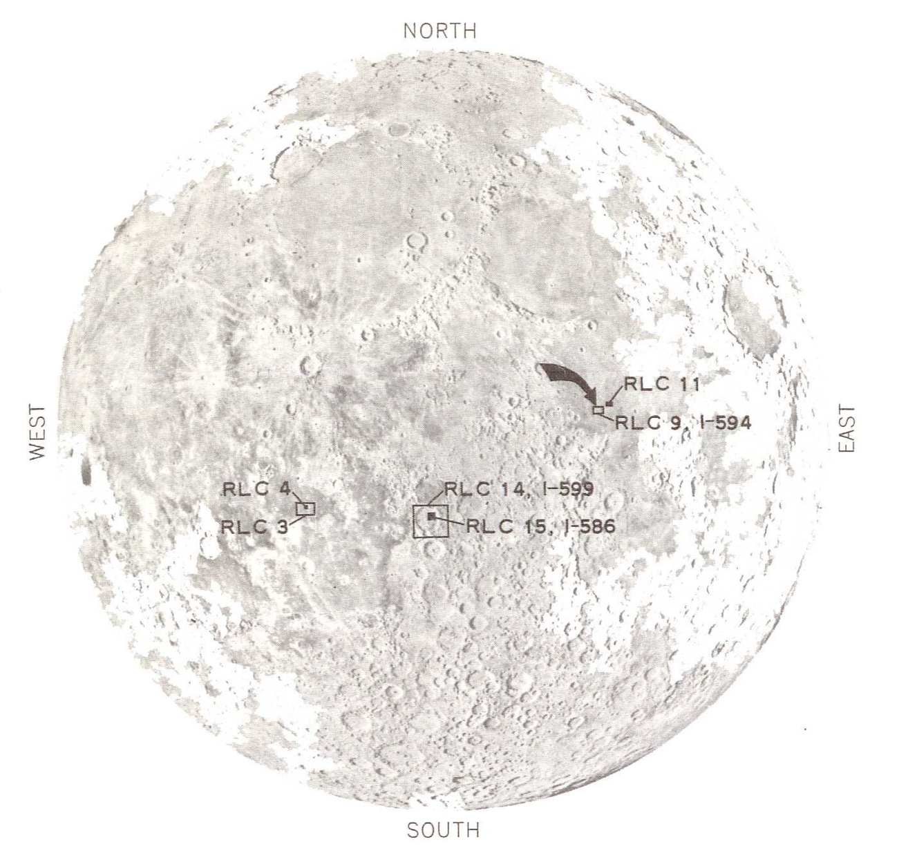
Landslide block
Arrow shows direction of movement

Lineament
Very faint ridge, scarp, or depression
Interpretation: Fracture in surface materials along which there has been little or no movement

Narrow trough or depression
Line marks base of steepest slope. Relatively shallow depression with craterlike enlargements along its length. Many depressions head in a well-defined crater
Interpretation: Collapse depression, tectonically controlled or situated over lava drainage channel

5 4 3 2 1
Craters
Numbers on craters indicate degree of sharpness and are assigned according to the fraction of the crater interior appearing black or gray on single set of good contrast prints of the Ranger VIII series
5. *Greater than 0.4 of rim crest diameter appears black.*
4. *0.1 – 0.4 of rim crest diameter appears black*
3. *Less than 0.1 of rim crest diameter appears black*
2. *Wall nearest sun appears gray*
1. *Crater barely discernible*

These crater numbers are only a rough indication of crater age because the effects of differences in crater diameter are not taken into account and because shadow alone is not a reliable indicator of age. Most type 5 craters and many type 4 craters are young enough to have mappable deposits preserved around them. Most type 2 craters and all type 1 craters are too old to have surrounding mappable deposits. A bright ejecta blanket can be mapped around some small craters even though a number cannot be assigned. The smallest craters that can be studied are 20 meters in diameter in the northeast corner of the map area. The resolution to the Ranger photographs is poorer to the west and south



INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON
SHOWING REGIONS MAPPED GEOLOGICALLY FROM RANGER PHOTOGRAPHS

Large arrow indicates area of this report. First number refers to base chart (RLC 9). Second number refers to published geologic map (I-594)

GENERAL INFORMATION

This 1:50,000-scale geologic map is one of a series constructed at various scales from photographs transmitted by the Ranger VII, VIII, and IX spacecraft. The center of the map area is about 23 km southwest of the Ranger VIII impact point, in the southwest part of Mare Tranquillitatis (U.S. Air Force Aeronautical Chart and Information Center Chart AIC 60 C, Arago). In general, geologic maps of the Moon portray similarities and differences in the characteristics of the lunar surface. These characteristics, mainly topography and albedo, probably depend on the nature of the underlying rock units and the manner in which they formed. Information about the lunar surface for this map was obtained mostly from the Ranger VIII photographs, which were taken with the setting sun approximately 15° above the local horizon. A few photographs from Lunar Orbiters II and V, which were taken under a rising sun, 22° and 20° above the local horizon respectively, were used to fill in details around the margins of the map area where the Ranger data are poor.

OBSERVATIONS

The area studied is on a generally level mare plain. The mare surface in this region can be divided into two indistinct subunits: (1) unit m_1, with a relatively high density of subdued craters with diameters in the size range 50-200 m, and (2) a smoother unit m_2, with a lower areal density of such craters and fewer indistinct ridges and irregular depressions. Viewed stereoscopically, the contact between the two units in many places appears as a narrow transition zone within which there is a gradual change in surface texture and a slight change in photographic density.

Craters are abundant throughout the map area. The forms range from craters with sharp bright rims and relatively deep interiors to craters with rounded rims and very shallow interiors. The artist's portrayal of the craters on the base by the Aeronautical Chart and Information Center shows this variation in crater form. A further assessment of the range of form is provided by the numbers assigned to many of the craters. These numbers indicate relative sharpness according to the percentage of the interior that appears black on a single set of photographs with good contrast (type 5 sharpest, type 1 most subdued). The raised rims of many craters of types 4 and 5 consist of ejecta that extend outward from the rim crest and appear to mantle the surrounding topography. The rim materials of about half of these appear brighter than the surrounding intercrater material. Ill-defined hummocks occur in rim materials near the crests of some of the larger type 4 and type 5 craters, and faint ridges extend radially from these craters. The 700-meter-diameter crater Sabine EF, in the northeast corner of the area, best displays these features. The ridge pattern around this crater resembles that around small experimental and explosion craters (H.J. Moore, *in* Shoemaker, 1966, p. 263). What appears to be low hummocks at the resolution of Ranger photographs may actually be large blocks, such as those shown on some crater rims in the Surveyor photographs. Clusters of irregularly shaped, subdued craters with rolling topography between individual craters (unit cct) are prominent in the eastern half of the map area.

INTERPRETATION

The material of the mare plains has been generally interpreted as volcanic – either lava flows or ash flows (Baldwin, 1949, p. 36; Shoemaker, 1962, p. 346). The two mare units apparently reflect surficial differences that developed in the mare material after its deposition. A layer of fragmental material (discussed below) probably covers the entire area and hampers study of the units. One tentative explanation for them is that the mare underwent slight vertical tectonic movements after its solidification followed by extensive meteorite impact. Surficial debris created by this impact would tend to collect in the downdropped areas under the action of gravity and form unit m_2. Unit m_1 may represent slightly uplifted blocks with a relatively thinner accumulation of debris. The many lineaments in the region may be an indication of continued slight vertical movements in the bedrock beneath the fragmental layer.

Crater frequency studies by Shoemaker (1965, p. 116) and Trask (*in* Shoemaker, 1966, p. 252; 1967, p. 270) imply that a layer of fragmental debris should be present over most of the lunar maria; in this model of the surface, the type 1 and 2 craters are partially eroded craters that were once sharp. Alternatively, Kuiper, Strom, and LePoole (1966, p. 91) have interpreted the shallower craters as being mainly collapse depressions situated over drained chambers in lava flows. In their model, fragmental material at the surface is either very thin or absent over most of the maria. However, pictures returned by the Surveyor spacecraft (e.g., Morris and others, 1968) show that a layer of fragmental debris at least 1 meter thick is present at all four Surveyor landing sites in the maria.

If craters pass through the evolution sequence suggested by Shoemaker (1965), those with subdued and darkened rims (unit dr) represent post-mare events of intermediate age and those with bright halos and sharp rims (unit br) represent the youngest events on the surface. Clusters of subdued craters (unit cct), some of which are elongate radial to Theophilus, a bright-rayed crater 300 km to the south, can be seen on Lunar Orbiter IV photographs to be part of the field of satellitic craters surrounding Theophilus. They were probably formed by the impact of fragments thrown out from Theophilus, a large primary impact crater. Several very low cones with summit depressions (unit cc) may represent volcanism of intermediate age and limited extent.

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