DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE
USAF AERONAUTICAL CHART AND INFORMATION CENTER

GEOLOGIC ATLAS OF THE MOON
MACROBIUS QUADRANGLE
I-799 (LAC-43)

NOTES ON BASE

This chart was prepared with advisory assistance from Dr. Gerard P. Kuiper and his collaborators, D. W. G. Arthur and E. A. Whitaker.

DATUM

The assumed lunar figure is that of a sphere corresponding to the mean lunar radius of 1738 kilometers. Elevations are referred to a spherical datum 2.6 kilometers below the mean radius to minimize minus elevation values.

CONTROL

The horizontal and vertical positions of features on this chart are based primarily on the positions of 150 lunar features measured by J. Franz and computed by Schrutka-Rechtenstamm. This control network is supplemented by ACIC extensions in localized areas. Additional horizontal positions have been selected from the Consolidated Catalog of Selenographic Positions by D.W.G. Arthur and the coordinates of 696 lunar features by R. Baldwin. The probable error of the control is evaluated at 1000 meters.

ELEVATIONS

All elevations are in meters. They are referenced to the assumed vertical datum unless indicated as relative elevations. The relative elevations of crater rims and other prominences above the surrounding terrain and depths of craters are determined by the shadow measuring technique as refined by the Department of Astronomy, Manchester University, under the direction of Professor Zdenek Kopal. The probable error of the localized relative elevations is 100 meters in the vicinity of the center of the lunar disk with the magnitudes increasing to 300 meters at 70° departure from the center due to foreshortening.

Elevations (referenced to datum) 1100
Depth of crater (rim to floor) . . . . (400)
Relative Elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated 300R

CONTOURS

All contours are approximate
Contour interval is 300 meters
Approximate contour ——— 600 ———
Depression contour

NAMES

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

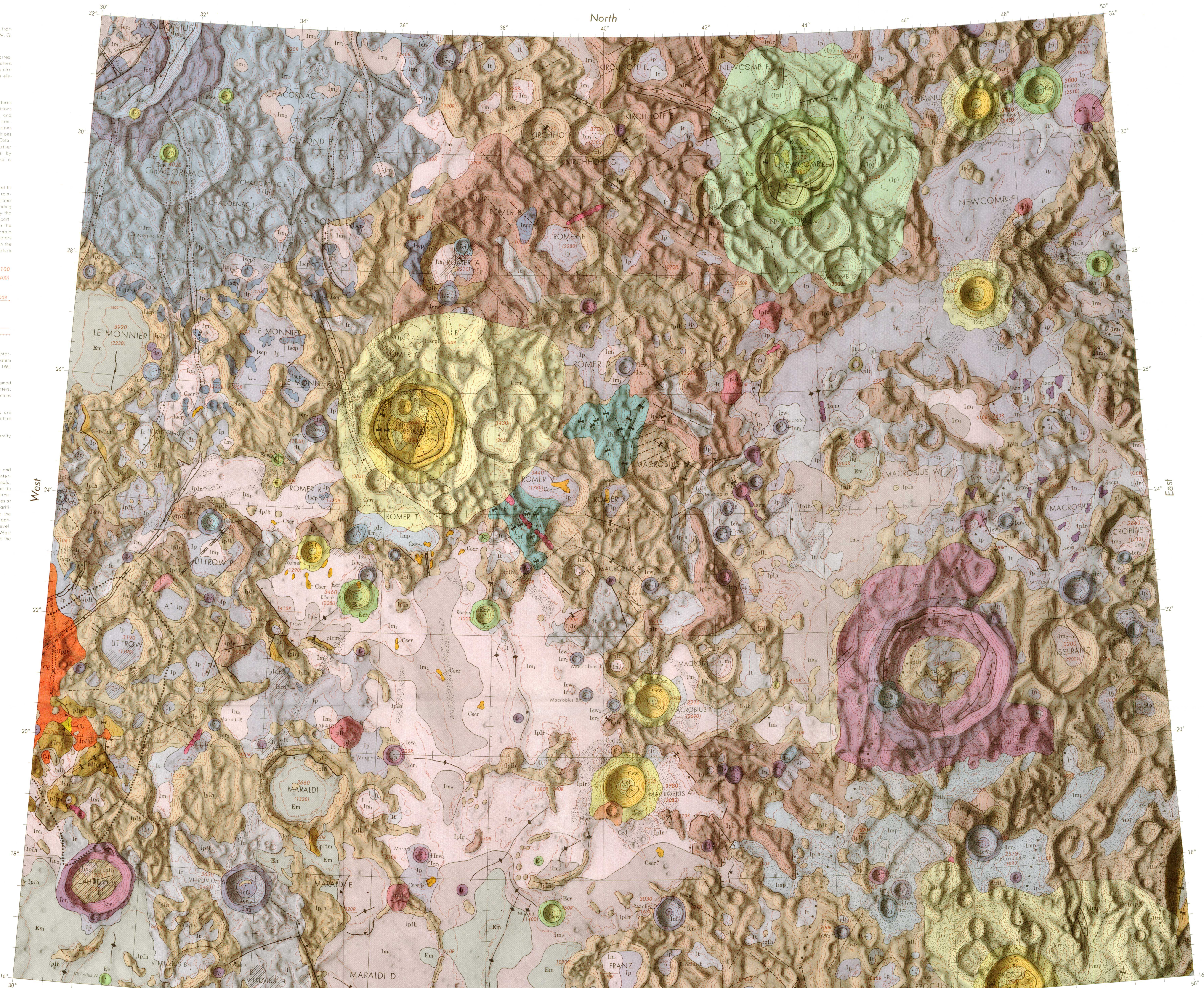
Supplementary features are associated with the named features through the addition of identifying letters. Craters are identified by capital letters. Eminences are identified by Greek letters.

Names of the supplementary lettered features are deleted when the association with the named feature is apparent.

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

PORTRAYAL

The configuration of the lunar surface features and background coloration shown on this chart is interpreted from photographs taken at Lick, McDonald, Mt. Wilson, Yerkes, Stony Ridge, Kwasan, and Pic du Midi Observatories. Supplementary visual observations with the 20 and 24 inch refracting telescopes at Lowell Observatory provide identification and clarification of indistinct photographic imagery and the addition of minute details not recorded photographically. 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.



Lunar base chart LAC 43, 1st edition, 1965, by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

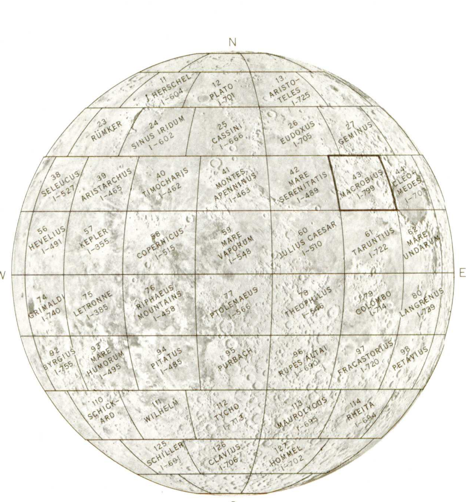
SCALE 1:1 000 000
LAMBERT CONFORMAL PROJECTION
STANDARD PARALLELS 21°20' AND 42°40'

STATUTE MILES 10 5 0 50 100
KILOMETERS 10 5 0 50 100 150

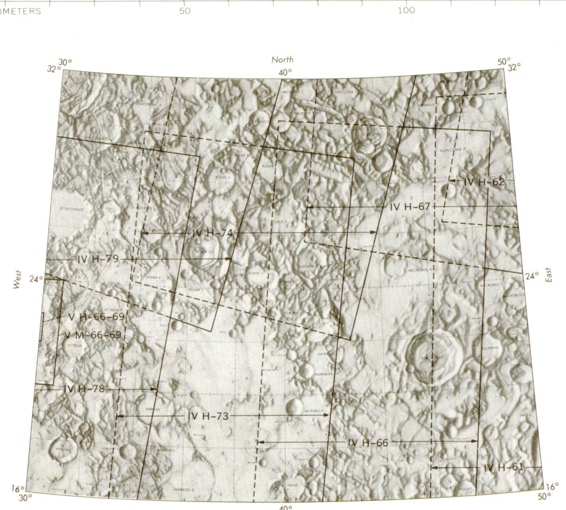
Principal sources of geologic information: Lunar Orbiter and Apollo 15 photographs, as shown on index maps; Catalina Observatory of the Lunar and Planetary Laboratory, University of Arizona photographs No. 111 and 687; Lowell Observatory photographs L7-193-2-2 and L7-193-5-2; Naval Observatory full moon photograph No. 5819. Mapped 1971-72.

Prepared on behalf of the National Aeronautics and Space Administration under contract Nos. R-66 and W-13,130

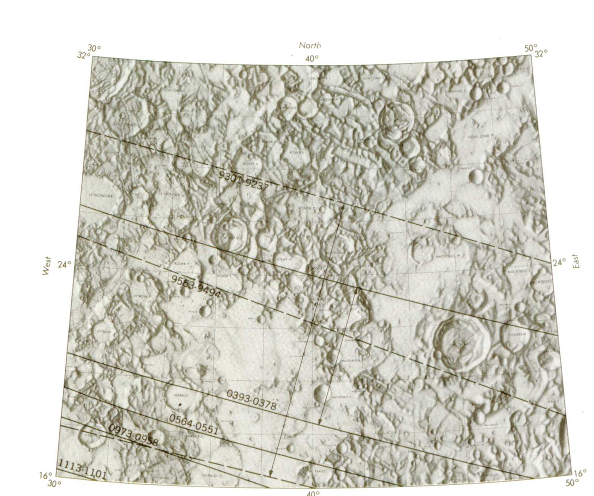
INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972—G72515



INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON
Number above quadrangle name refers to lunar base chart (LAC series); number below refers to published geologic map



LUNAR ORBITER PHOTOGRAPHIC COVERAGE OF MACROBIUS QUADRANGLE
Roman numerals (IV and V) refer to Orbiter mission. Arabic numerals refer to photo frame number. Letters refer to high (H) or moderate (M) resolution.



APOLLO 15 METRIC AND PANORAMIC CAMERA COVERAGE OF MACROBIUS QUADRANGLE
Metric and panoramic camera coverage shown by solid and dashed lines respectively. Arrows show approximate width of the belt, and partly overlapped strips, photographed during one revolution. Number pairs designate all frames included within each strip.

EXPLANATION

COPERNICAN SYSTEM

Cc, Ccr, Ccrr, Ccw, Ccf, Ccp — Materials of craters with bright rays or halos

Characteristics
Craters have sharp, high, nearly circular rim crests; rims strongly concave upward. Craters >7 km diameter have high thermal response at eclipse
Cc, *crater materials, undivided. Craters ≥3 km rim-crest diameter but too small for subdivision of units*
Ccr, *rim material, undivided. Prominent ring outside rim crest, concave upward, hummocky to smooth; numerous blocks visible on Apollo 15 high-resolution (about 2 m) panoramic photographs. Outer part mapped as:*
Ccrr, *rim material, radial. Smooth, undulating, lineated subradial to crater; subdues but expresses topography of subjacent terrain*
Ccw, *wall material. Smooth to blocky, steep slopes extending from rim crest to crater floor. Includes terraces and landslides in larger craters; in craters <10 km diameter includes floor material*
Ccf, *floor material, undivided. Hummocky to smooth; sharp break in slope at base of crater wall*
Ccp, *peak material. Large, high dome with blocky ledges near center of Römer. Bulbous, overlapping lobes near base*
Interpretation
Crater morphologies, blocky rims, and bright rays and halos indicate an impact origin
Ccr, *mostly unsorted, coarse to fine ejecta and imbricate thrust sheets of highly fractured bedrock*
Ccrr, *mainly fine ejecta deposited by base surge, and pre-existing surficial material redistributed by numerous secondary impacts*
Ccw, *fractured, brecciated bedrock freshly exposed by faulting and downslope movement*
Ccf, *brecciated, highly shocked bedrock and ejecta fallback*
Ccp, *brecciated and metamorphosed bedrock, uplifted by adjustment to stresses produced by impact. Basal lobes may be flows produced by shock melting*

Cscr — Material of craters satellitic to Römer

Characteristics
Material of sharp, bright, circular to elongate, shallow craters occurring singly and in clusters around Römer. Readily distinguishable on mare and plains materials
Interpretation
Secondary impact craters formed by ejecta from Römer; queried where age or origin uncertain

Ccd — Material of dark craters

Characteristics
Dark wall and rim material of two small (1.5-5 km) sharp to moderately sharp-rimmed craters superposed on rim material of Macrobius A. Numerous nearby smaller unmapped occurrences mostly in mare material. Dark material appears as halos rather than rays around craters. Other craters in vicinity of similar size and morphology have moderate to high albedo
Interpretation
Probably volcanic craters; alternatively, dark material excavated by impact from mare material underlying bright rays from Macrobius A, B, and Proclus. Copernican age indicated by superposition on Macrobius A rim material

Cd — Dark mantle

Characteristics
Material with very low albedo; darkens mare, plains, and highland materials (units pItm *and* IpIh*) in western part of quadrangle. Concentrated in troughs within hummocky terra unit (IpIh) and locally within and around small (<100 m) craters on both mare and terra materials between craters Littrow and Vitruvius. Some small, unmapped Copernican craters mantled by unit but others superposed. Density of small bright craters less than that of adjacent mare*
Interpretation
Volcanic material. Mostly pyroclastic debris erupted from numerous small vents and fissures in mare and terra. Highly mobile, accumulated to greatest thickness in low areas. Age, middle Copernican

Cb — Bright mantle

Characteristics
Small, bright, triangular patch at base of mountain front, lat 20° N., long. 30.5° E. High-resolution photographs show lineaments approximately normal to face of massif (unit pItm*)*
Interpretation
Debris flow and rock slide from adjacent massif unit; high albedo suggests young age of slide (not age of component rocks)

Bright ray material

Characteristics
High albedo; irregular streaks and halos extending outward from Copernican-age craters. High-resolution photographs show clusters of small craters along rays
Interpretation
Impact ejecta and bright walls of numerous small secondary craters

ERATOSTHENIAN SYSTEM

Ec, Ecr, Ecrr, Ecw, Ecf, Ecfs — Materials of sharp-rimmed craters

Characteristics
Materials of bright, non-rayed craters. Individual units resemble those of correspondingly lettered units of Copernican craters but rim material more subdued, fewer blocks. Craters <4 km diameter not mapped. Crater floor material divided into smooth floor unit (Ecfs) *in Newcomb*
Interpretation
Impact crater materials. Absence of rays and subdual of units result from longer exposure to lunar erosional processes

Em — Mare material

Characteristics
Smooth, level at Orbiter IV resolution; albedo low; sharp boundaries with highland materials. High-resolution photographs indicate oldest superposed craters Eratosthenian in age based on criteria developed by Trask (1971, fig. 2)
Interpretation
Basalt flows of Eratosthenian age

IMBRIAN SYSTEM

Im_2 — Mare material

Characteristics
Similar to Eratosthenian mare material but albedo and small crater density higher. Upper Imbrian craters embayed, Eratosthenian craters superposed
Interpretation
Similar to Eratosthenian mare material but older, probably late Imbrian

Im_1 — Mare material

Characteristics
Similar to younger mare materials but albedo and small crater density higher. Upper Imbrian craters and Posidonius satellitic craters embayed
Interpretation
Same as younger mare materials; age, late Imbrian

Imp — Mare or plains materials

Characteristics
Fills depressions between Proclus and Macrobius and near Römer; smooth, level similar to mare or plains units but albedo and density of small craters obscured by rays and secondary craters from Proclus
Interpretation
Mare or plains material of probable Imbrian age

Ic — Crater material

Characteristics
Similar to undivided material of younger craters (Cc, Ec) but more subdued and less bright. Craters <5 km not mapped
Interpretation
Impact craters of Imbrian age

Icr_2, Irr_2, Icw_2, Icf_2, Icp_2 — Crater materials

Characteristics
Similar to corresponding units of younger craters but more subdued and wall materials less bright (Irr_2 *corresponds to* Ccrr *and* Ecrr*). Embayed by mare materials, superposed on plains material. Part of eastern wall and floor of Posidonius raised and tilted toward west*
Interpretation
Impact crater materials of late Imbrian age. Posidonius tilted westward after subsidence of eastern margin of Serenitatis basin (Scott, 1972)

Ihf — Hilly and furrowed material

Characteristics
Material of small (1-5 km), clustered, round hills and sinuous furrows 1-3 km wide and up to 10 km long; furrows trend mainly northwest. Albedo intermediate. Embayed by plains material, gradational with hilly unit (IpIh)*. Resembles Descartes material at Apollo 16 landing site (Milton and Hodges, 1972)*
Interpretation
May be volcanic material erupted from structurally controlled fissure vents or consists of interlayered crater and basin ejecta blankets as postulated for hilly material (IpIh)*. Imbrian age assigned but parts may be older*

Ici — Material of irregularly shaped craters

Characteristics
Material of elongate, generally elliptical craters having rim crest length-to-width ratios of about 3 to 2. Craters do not resemble couplets or other composite forms. Rim-crest sharpness like that of upper Imbrian craters
Interpretation
Craters of Imbrian age produced by low-angle primary impacts or by volcanism

Icr_1, Irr_1, Icw_1 — Materials of subdued craters

Characteristics
All units much more subdued than those of younger craters. Rims more rounded, walls less bright; radial facies (unit Irr_1*) only partly visible around Macrobius*
Interpretation
Most are probably impact crater materials

Iscp — Material of craters satellitic to Posidonius

Characteristics
Shallow, low-rimmed craters and crater clusters having elongate, irregular, and V-shaped outlines with long axes generally directed toward Posidonius. More subdued than craters satellitic to Römer; superposed on plains but not mare materials
Interpretation
Secondary craters of Posidonius; queried where age and origin uncertain

Iscm — Material of craters satellitic to Macrobius

Characteristics
Similar to satellitic craters of Posidonius but mostly smaller and much more subdued
Interpretation
Secondary impact craters of Macrobius

Il — Lobate material

Characteristics
Overlapping scarp-like lobes of smooth to slightly hummocky material lying on unit Ip *in northeast corner of quadrangle. Occurs at low end of northwest-trending depression. Albedo low*
Interpretation
Volcanic flow probably issuing from graben. Imbrian or younger age

Ip — Plains material

Characteristics
Resembles older mare material but is brighter (albedo intermediate) and more highly pitted with small craters; some patches in vicinity of unit Cd *have low albedo. Boundaries with other units less distinct than those of mare materials. Satellitic craters from Posidonius and possibly Macrobius superposed but unit also occurs on floor of Macrobius. Elsewhere on Moon similar-appearing materials called Cayley Formation (for example, Milton and Hodges, 1972)*
Interpretation
General similarity to mare material suggests plains unit may be lava flows but more degraded and probably extruded prior to the onset of major mare volcanism; however, other characteristics indicate it may consist of pyroclastics or relatively fine impact ejecta; thinly covered by dark unit in places

It — Terra material

Characteristics
Smooth, gently undulating to low, hilly terrain. Intergradational in places with plains unit (Ip)*, hilly material* (IpIh)*, and rugged material* (IpIr)
Interpretation
Probably a complex of mass-wasted debris, crater ejecta, and some volcanic materials. Mostly emplaced during Imbrian Period

PRE-IMBRIAN

IpIr — Material of rugged terra; IpId — Dome material; IpIh — Material of hilly terra

Characteristics
IpIr, *ranges from smooth, undulating material having moderate relief to large hills and mountains having high relief (1500m). Commonly lineated; north of Römer resembles distal parts of Fra Mauro Formation in Eudoxus quadrangle (Scott, 1972). Some Imbrian crater and plains materials superposed*
IpId, *smooth and massive to hummocky and bulbous; irregular to nearly circular outlines. Dome northeast of Tralles A has summit crater. Occurrences near Maraldi and Littrow A resemble large clusters of hilly unit* (IpIh)*. Embayed by plains material*
IpIh, *material of round, smooth hills and hummocks occurring individually and in groups mostly adjacent to basins. Hills 0.5-5 km across; central cleft commonly developed. Lineaments present, abundant in places, trending northwest and northeast. Similar in appearance to Alpes Formation (Page, 1970) but hills more rounded and more closely clustered. Occurs in craters ranging from late Imbrian to pre-Imbrian in age, but progressively more abundant in older craters. Many pre-Imbrian crater forms consist entirely of this unit*
Interpretation
IpIr, *overlapping, brecciated ejecta blankets from the Imbrium and older basins and large craters of various ages. Imbrium basin ejecta (Fra Mauro Formation) may constitute thin uppermost blanket north of Römer (Wilhelms and McCauley, 1971)*
IpId, *volcanic domes and (or) large local clusters of basin ejecta. Variations in texture and morphology may reflect compositional differences. Age probably ranges from pre-Imbrian to Imbrian*
IpIh, *origin and composition probably similar to rugged terra unit* (IpIr) *but greater roughness due to nearness to source. The progressive increase in abundance of the unit with increasing crater age must reflect the cumulative effect of modification with time, by processes such as mass wasting, seismic shaking, fracturing, faulting, and impact erosion*

pItm — Massif material

Characteristics
Smooth, bright material exposed along high, steep scarps mainly bordering the Serenitatis and Crisium basins. Boulders and rocky ledges visible on high-resolution photographs. In places, appears to grade upward into hilly unit (IpIh)
Interpretation
Basin ejecta, thickest near basin of origin. Around Serenitatis, exposed by faulting and uplift subsequent to basin formation. Upward change in morphology probably shows the effect of lunar erosional processes on fractures and joint systems

pIc — Undivided material of highly subdued craters

Characteristics
Materials of craters having incomplete rims, walls, or floors and too degraded for further age classification
Interpretation
Materials of craters probably formed by impact, but definitive morphologic criteria of origin absent

(Ip)
Contact
Short-dashed where concealed; buried units shown by symbols in parentheses

Fault
Short-dashed where concealed. Bar and ball on downthrown side; ball on line where faults closely spaced

Trough

Mare or plains ridge
Line marks ridge crest

Scarp
Line marks base of scarp. Barbs point downslope

Lineament
Linear trough or ridge

Ridge marking rim crest of highly degraded or buried crater

Prominent rim crests of irregularly shaped craters and pre-Imbrian craters

Dark material

Depression

ch
Crater chain
Three or more alined, tangential or overlapping craters
Interpretation: *Structurally controlled volcanic vents or collapse depressions*

Landslide
Arrows show direction of movement

Crisium basin rings

Area in which dark craters are concentrated

GEOLOGIC SUMMARY

The Macrobius quadrangle is in the northeast quadrant of the Moon's near side. Although predominantly a highland area centered around the Taurus Mountains (Montes Taurus), it is bounded by three major mare-filled basins: Tranquillitatis, the oldest, to the south; Serenitatis to the west; and Crisium on the east. Most of the geologic units within the quadrangle have been profoundly affected by the formation of these basins and by that of the younger Imbrium basin farther to the northwest. Some of the youngest material on the Moon, believed to be of volcanic origin, blankets part of the mare and terra along the southwest margin of the map. Sampling this material will be a primary objective of the Apollo 17 mission, whose proposed landing site is approximately at lat. 20° 10' N., long. 30° 45' E. near the western edge of the map area.

STRATIGRAPHY

Crater materials are dated relatively and assigned positions in the lunar stratigraphic column primarily on the basis of their morphology, using guidelines and criteria set forth by Pohn and Offield (1970) and Trask (1971). Stratigraphic units which mark the base of the Imbrian System cannot be confidently recognized within the quadrangle. However, superposition and embayment relationships between classified crater materials and regional units such as mare, plains, and some terra deposits are used to determine the position of the mapped units relative to the Imbrian–pre-Imbrian boundary.

Pre-Imbrian.—Pre-Imbrian materials include those of craters (pIc), massifs (pItm), and parts of hilly (IpIh) and rugged (IpIr) terra units not separable on the basis of morphology from their Imbrian components.

Most pre-Imbrian craters can be recognized by their outlines, but their materials are indistinguishable from the surrounding terrain, especially where they occur within the hilly unit. Some of these craters predate the adjacent basins, except possibly Tranquillitatis; their advanced stage of degradation may be due to erosion and partial burial by basin ejecta. Many craters, however, postdate the basins, and the extreme modification of their rims and walls is believed to be primarily the result of cumulative structural deformations accompanied by mass wasting.

The massif material resembles that of the Apennine Mountains near the Apollo 15 landing site (Carr and El Baz, 1971) and probably also consists of breccias ejected from adjacent basins. Episodic faulting and uplift subsequent to basin formation have exposed the breccia deposits as high smooth scarps, kept fresh and bright by continuous downslope movement of material. The massif unit locally is overlain by, or grades upward into, hilly material. The hilly material and the rugged terra unit form a complex believed to be made up of basin and crater ejecta. Morphological differences between the two units may reflect distance from basin of origin and relative age. The more distal ejecta facies (IpIr) is smoother and resembles the Fra Mauro Formation, whereas the hilly unit (IpIh) is closer to its basin(s) of origin and more nearly resembles the Alpes Formation (Page, 1970). Thus, the three units represented by massif, hilly, and rugged materials, though morphologically distinguishable, may consist of lithologically similar breccias whose emplacement ages are mostly pre-Imbrian, like their basins of origin; admixtures of Imbrium-basin, Imbrian-crater, and mass-wasted materials account for the Imbrian to pre-Imbrian age range assigned to the hilly and rough terrain units.

Imbrian System.—Terra, plains, and mare materials generally occupy successively lower topographic levels in the quadrangle. Terra material (It) is a blanket which partly fills depressions and subdues subjacent terrain without exhibiting any particular morphologic characteristics of its own. It is chiefly a mixed unit made up of reworked surficial materials, impact ejecta, mass-wasted products, and possibly some volcanic materials locally introduced. As the terra unit is formed by processes which have continued in varying degrees throughout lunar history, its overall age depends largely on when these processes or events culminated in any particular region. In the Macrobius quadrangle the unit appears to have been mostly developed during Imbrian time.

Mare units (Im_1, Im_2) are typical of those elsewhere on the Moon now known from Apollo samples to consist mostly of basaltic lavas.

Plains material (Ip) appears to be intergradational with both the terra and mare deposits. In the Macrobius quadrangle, and as interpreted elsewhere by many previous workers, it is probably of mixed origin (for example, McCauley, 1972; Wilhelms, 1972). In some areas the unit may consist of pyroclastics or of relatively textureless impact ejecta; in other places it may consist of older and more thoroughly impact-churned lava flows extruded prior to the onset of the major pulse of mare volcanism. Descriptions of the Cayley Formation (a plains unit) made by Apollo 16 astronauts and documented by the Apollo Lunar Geology Investigation Team (1972) indicate that much of the material is composed of fragmental rocks, probably impact breccias.

Hilly and furrowed terra (Ihf) occurs in many places on the Moon, and sampling it was a major objective of the Apollo 16 mission at the Descartes landing site (Milton and Hodges, 1972). This type of material generally has been considered to be of volcanic origin, but it closely resembles the hilly terra unit (IpIh) and the possibility that it also is related to a basin-forming event cannot be excluded (Trask and McCauley, 1972). Preliminary descriptions of some Apollo 16 samples indicate that both crystalline rocks and breccias have been found in this material.

Secondary craters formed by ejecta from Posidonius (northwest corner of the map) are younger than the numerous rilles upon which they are superposed. The rilles, in turn, appear to transect patches of Imbrian mare materials. Posidonius, however, is embayed by both recognized mare units. These seemingly anomalous age relationships indicate that pre-existing rilles may preserve a fresh, relatively sharp appearance even where partly filled by younger lava flows, or that some mare material is older than Posidonius.

Eratosthenian and Copernican Systems.—The darkest mare material and sharp, bright craters without rays are assigned to the Eratosthenian System. All rayed craters, including those with dark halos, are Copernican in age. Overlapping ray patterns of various intensity and large contrasts in morphology between small Copernican craters indicate a wide range in crater ages within the Copernican System. These age subdivisions are not made at the 1:1,000,000 map scale but have been attempted at the 1:250,000 (Scott and Carr, 1972) and 1:50,000 (Lucchitta, 1972) scales.

Among the youngest Copernican units, two are of special interest and will be primary objectives at the Apollo 17 landing site. Dark mantling material of probable volcanic origin (Cd) covers mare and terra materials in the southwest part of the quadrangle. This units resembles the Sulpicius Gallus Formation mapped along the southwestern margin of Mare Serenitatis (Carr, 1966). The dark material within the Macrobius quadrangle is considered to be Copernican because (1) it has a much lower density of small bright craters than adjacent mare surfaces, and (2) the oldest superposed craters appear to be about middle Copernican in age on the basis of their morphology (Trask, 1971). Bright mantling material (Cb) in the same locality has some of the characteristics of a terrestrial landslide or debris flow and extends across a plains surface at the base of a scarp that borders a massif. It appears relatively thin, and its contact with the dark mantling material is serrate and indistinct.

STRUCTURE

Tectonic activity throughout this region has produced prominent structural trends expressed by normal faults, ridges, depressions, crater chains, and lineaments of subtle, unresolved topographic features.

Azimuth-frequency distributions show high concentrations of the structural elements in the N. 45°-60° W. and N. 40°-50° E. directions, similar to those of the "lunar grid" in the northern hemisphere (Strom, 1964). Northwest azimuths are especially common, however, and closely coincide with radials to the Imbrium, Serenitatis, and Crisium basins, whose centers (and the center of the quadrangle) lie approximately along a great circle. Thus, global stresses responsible for the northwest grid sets seem to have been reinforced and reactivated by the formation of the basins.

Rimae Littrow I, II and Rima Chacornac I are large grabens concentric with the main rim of Mare Serenitatis; they extend nearly continuously for more than 300 km across mare, plains, and terra from the southwest to the northwest corners of the quadrangle. In like manner, the long rilles Rimae Römer I, II and Rima Bond I are roughly concentric with the Crisium basin, as is the large mare- and plains-filled depression extending from near Macrobius A to the northeast corner of the map. Between this depression and an ill-defined arcuate trough adjacent to the Crisium rim, a broad high area, extending through the crater Macrobius, marks an outer ring of the Crisium basin.

GEOLOGIC HISTORY

The large impacts which successively formed the Tranquillitatis, Serenitatis, and Crisium basins covered the Macrobius quadrangle with a series of overlapping ejecta blankets as much as 2.5 km thick (Short and Forman, 1970, fig. 4). This complex of interlayered breccias also received smaller contributions of impact ejecta from large craters within the area, as well as from nearby basins such as Fecunditatis and Nectaris. The ejecta blankets and underlying lunar crust were fractured and faulted along global and basin radial systems by internal stresses, including seismicity resulting from the high flux of large impacting bodies during this early time. Mass wasting and slumping, which appear to have been especially active from pre-Imbrian time through the Imbrian Period, have modified the highly structured lunar surface into rounded hills (unit IpIh) and rugged terrain (unit IpIr).

The impact which formed the Imbrium basin and marked the beginning of the Imbrian Period may have covered parts of the quadrangle with a relatively thin mantle of ejecta. Some of this material may comprise parts of the smooth terra (It) and plains (Ip) units as well as the northwesterly lineated terrain north of Römer partly mapped as Fra Mauro by Wilhelms and McCauley (1971). The Imbrium impact induced faulting along pre-existing zones of structural dislocation and weakness which is manifest in this region by the system of distinct northwest-trending normal faults. During the Imbrian Period, low-viscosity lava flows began to be extruded, filling depressions and some crater floors with plains material and mare basalt.

Mare volcanism and impact cratering continued at a decreasing rate during the Eratosthenian Period. Vestiges of waning volcanic activity in Copernican time occur in the southwestern part of the map area, where a very dark mantle (unit Cd) resembling an ash-fall tuff partly covers mare and terra alike.

REFERENCES

Apollo Lunar Geology Investigation Team, 1972, Preliminary report on the geology and field petrology at the Apollo 16 landing site: U.S. Geol. Survey open-file report, p. 1-59.
Carr, M. H., 1966, Geologic map of the Mare Serenitatis region of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-489.
Carr, M. H., and El-Baz, Farouk, 1971, Geologic map of the Apennine-Hadley region of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-723.
Lucchitta, B. K., 1972, Geologic map of part of the Taurus-Littrow region of the Moon, Apollo 17 pre-mission map: U.S. Geol. Survey Misc. Geol. Inv. Map I-800.
McCauley, J. F., 1972, Geologic map of the Grimaldi quadrangle of the Moon: U.S. Geol. Survey Misc. Inv. Map, I-740 [in press].
Milton, D. J., and Hodges, C. A., 1972, Geologic maps of the Descartes region of the Moon, Apollo 16 pre-mission maps: U.S. Geol. Survey Misc. Geol. Inv. Map I-748.
Page, N. J., 1970, Geologic map of the Cassini quadrange of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-666.
Pohn, H. A., and Offield, T. W., 1970, Lunar crater morphology and relative age determination of lunar geologic units—Part 1. Classification, *in* Geological Survey Research 1970: U.S. Geol. Survey Prof. Paper 700-C, p. C153-C162.
Scott, D. H., 1972, Geologic map of the Eudoxus region of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-705.
Scott, D. H., and Carr, M. H., 1972, Geologic map of the Taurus-Littrow region of the Moon, Apollo 17 pre-mission map: U.S. Geol. Survey Misc. Geol. Inv. Map I-800.
Short, N. M., and Forman, M. L., 1970, Thickness of impact crater ejecta on the lunar surface: Modern Geology, v. 3, p. 69-91.
Strom, R. G., 1964, Analysis of lunar lineaments, 1.—Tectonic maps of the Moon: Arizona Univ. Lunar and Planetary Lab. Commun., no. 39, p. 205-221.
Trask, N. J., 1971, Geologic comparison of mare materials in the lunar equatorial belt, including Apollo 11 and Apollo 12 landing sites, *in* Geological Survey Research 1971: U.S. Geol. Survey Prof. Paper 750-D, p. D138-D144.
Trask, N. J., and McCauley, J. F., 1972, Differentiation and volcanism in the lunar highlands: photogeologic evidence and Apollo 16 implications: Earth and Planetary Sci. Letters, v. 14, p. 201-206.
Wilhelms, D. E., 1972, Preliminary geologic map of the region around the candidate Proclus Apollo landing site, *in* Apollo 15 preliminary science report, part J: Natl. Aeronautics and Space Adm. Spec. Pub. SP-289, p. 25-72–25-75.
Wilhelms, D. E., and McCauley, J. F., 1971, Geologic map of the near side of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map I-703.

GEOLOGIC MAP OF THE MACROBIUS QUADRANGLE OF THE MOON
By
D. H. Scott and H. A. Pohn
1972