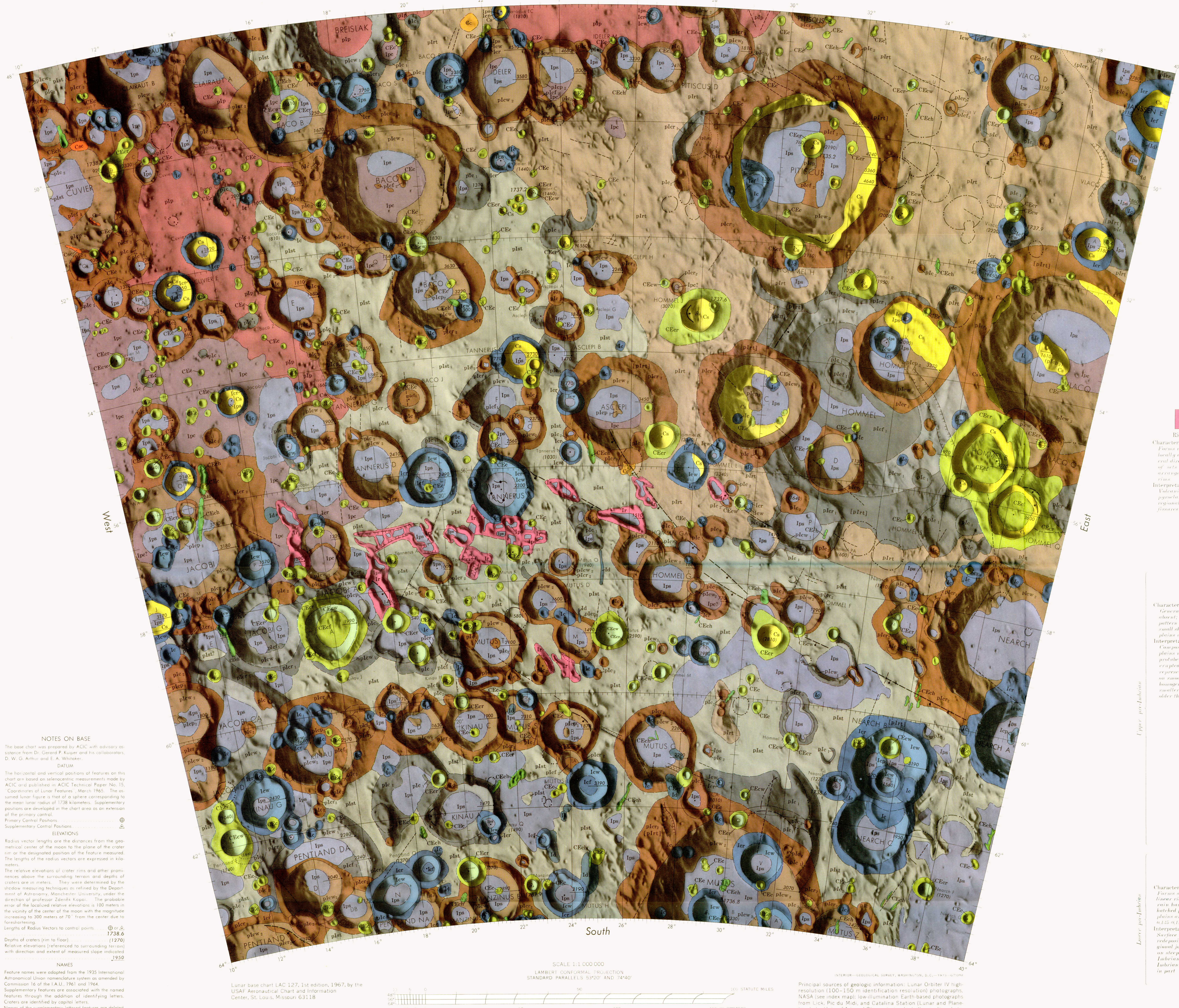
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

GEOLOGIC ATLAS OF THE MOON
HOMMEL QUADRANGLE
I-702 (LAC 127)



Lunar base chart LAC 127, 1st edition, 1967, by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

SCALE 1:1 000 000
LAMBERT CONFORMAL PROJECTION
STANDARD PARALLELS 53°20' AND 74°40'

100 STATUTE MILES
150 KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1972—G71098

Principal sources of geologic information: Lunar Orbiter IV high-resolution (100–150 m identification resolution) photographs, NASA (see index map); low-illumination Earth-based photographs from Lick, Pic du Midi, and Catalina Station (Lunar and Planetary Lab., Univ. of Arizona) Observatories; high-illumination photographs from U.S. Naval Observatory, Flagstaff, Arizona. Albedo data from Pohn and Wildey (1970). Mapped 1967–1968

Prepared on behalf of the National Aeronautics and Space Administration under contract No. R-66

GEOLOGIC MAP OF THE HOMMEL QUADRANGLE OF THE MOON

By
Thomas A. Mutch and R. Stephen Saunders
1972

NOTES ON BASE

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

DATUM

The horizontal and vertical positions of features on this chart are based on selenocentric measurements made by ACIC and published in ACIC Technical Paper No. 15, "Coordinates of Lunar Features", March 1965. The assumed lunar figure is that of a sphere corresponding to the mean lunar radius of 1738 kilometers. Supplementary positions are developed in the chart area as an extension of the primary control.

Primary Control Positions ⊕
Supplementary Control Positions △

ELEVATIONS

Radius vector lengths are the distances from the geometrical center of the moon to the plane of the crater rim or the designated position of the feature measured. The lengths of the radius vectors are expressed in kilometers.

The relative elevations of crater rims and other prominences above the surrounding terrain and depths of craters are in meters. They were determined by the shadow measuring techniques as refined by the Department of Astronomy, Manchester University, under the direction of professor Zdeněk Kopal. The probable error of the localized relative elevations is 100 meters in the vicinity of the center of the moon with the magnitude increasing to 300 meters at 70° from the center due to foreshortening.

Lengths of Radius Vectors to control points ⊕ or △ 1738.6
Depths of craters (rim to floor) (1270)
Relative elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated 1950

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.

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 shown on this chart is interpreted from photographs taken at Lowell, U.S. Navy, Catalina Station-University of Arizona, Lick, McDonald, Mount Wilson, Yerkes, Pic du Midi and Kottomia Obsevatories and Orbiter IV. 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.

EXPLANATION

COPERNICAN SYSTEM

Csc — Satellitic crater material

Characteristics
Material of small craters having sharp, crisp outlines and occurring in irregular clusters or in irregular chains pointing toward crater Tycho northwest of map area. Only a few large clusters mapped; many similar crisp "pin-prick" craters, commonly 1 km or less in diameter, occur throughout map area, superposed on all other geologic units
Interpretation
Material of secondary craters formed by impact of material ejected from Tycho

Cc — Material of rayed craters

Characteristics
Material of small (less than 3 km) rayed craters having albedo higher than 0.16; individual units not resolved
Interpretation
Material of very young impact craters

Cs — Slope material

Characteristics
Albedo higher than 0.16. Occurs on interior walls of craters and on central peak of crater Vlacq
Interpretation
Talus and freshly exposed crater materials at head of slope; talus formed by post-Eratosthenian downslope movement of brecciated crater materials

ERATOSTHENIAN OR COPERNICAN SYSTEM

CEch — Chain-crater material

Characteristics
Material of alined and commonly overlapping craters and clusters of small fresh craters
Interpretation
Most are secondary impact craters of larger impact craters outside quadrangle; those in southern part may be secondary craters of Moretus (southwest of quadrangle). Some may be of volcanic origin, alined along linear fissures

CEc | CEcr | CEcw | CEcf — Materials of sharp-rimmed craters

Characteristics
Materials of craters having sharp, undissected rims and smooth walls. Craters 3–20 km in diameter have circular rim crests and conical interiors. Larger craters have polygonal rim crest outlines and distinct wall-floor boundaries. Many show anomalously low eclipse cooling rates with respect to surrounding terrain (Shorthill and Saari, 1969). Craters smaller than 3 km not mapped
CEc, *crater materials, undivided*
CEcr, *rim material. Slopes markedly steeper than those of surrounding material. Some rim material mantles and subdues adjacent topography*
CEcw, *wall material. Forms steep smooth interior slopes of craters; gently undulating in larger craters*
CEcf, *floor material. Ropy, bulbous material of crater floor*
Interpretation
Materials of young craters of probable impact origin. Volcanic collapse origin possible for Hommel B, Jacobi A, and Hommel Q (see accompanying text). Rim material most commonly includes bedrock raised and thrust outward at time of impact and material ejected as a mantle of debris; relatively thick close to crater becoming progressively thinner away from crater. Wall material formed at time of impact and subsequently modified by downslope movement of fractured and unconsolidated particles and blocks. Floor formed by a filling material—fallback after impact, volcanic material erupted from below, or slump from adjacent walls

IMBRIAN SYSTEM

Ips — Smooth plains material

Characteristics
Forms level surfaces, smooth at resolution of Orbiter IV photographs. Superposed sharp-rimmed craters present but in lower density than on other plains units. Unit commonly present in interiors of Imbrian and older craters but also occurs outside craters at different levels. Albedo 0.128–0.134
Interpretation
Volcanic floors; youngest flow material within quadrangle. Occurrence in isolated regions and at different levels suggests unit formed by volcanic extrusion from many separate feeders

Ir — Ridge material

Characteristics
Forms roughly linear ridges locally alined in one or several directions. Intersection of sets produces gridlike arrangement of craterlike rims
Interpretation
Volcanic material (lava or pyroclastics) extruded from regionally controlled linear fissures

Id — Dome material

Characteristics
Forms domes elongate to roughly circular in plan having smooth gentle slopes
Interpretation
Local intrusion or extrusion of volcanic material

Ic | Icr | Icw | Icf | Icp — Material of dissected-rim craters

Characteristics
Materials of craters having slightly dissected rim crests. Interior pools of plains material common
Ic, *crater materials, undivided*
Icr, *rim material. Close to crater, generally similar to unit CEcr but less extensive. In places shows textural and structural features of underlying terra unit indicated by symbol in brackets*
Icw, *wall material. Faintly hummocky in most craters; irregularly terraced in larger craters*
Icf, *floor material. Hummocky and lineated topography forming crater floor. Commonly gradational with wall*
Icp, *peak material. Sharply raised area on crater floor*
Interpretation
Materials of craters formed predominantly by impact but as for Eratosthenian or Copernican craters, volcanic origin possible. Peak formed of brecciated material uplifted by rebound following impact

Ipc — Cratered plains material

Characteristics
Similar to smooth plains material except significantly more cratered. Not commonly confined to crater interiors. Albedo 0.128–0.134 but slightly higher than smooth plains material
Interpretation
Same origin as smooth plains. Higher crater density probably a consequence of greater age. Alternatively, some surfaces possibly overprinted with local concentrations of secondary impact craters or volcanic craters

PRE-IMBRIAN

Upper pre-Imbrian

pIst — Smooth terra material

Characteristics
Generally similar to ridged terra material (pIrt); ridged aspect subdued and locally absent; ridges commonly have gentler slopes and less relief than in unit pIrt; lineated pattern dominates over cross-hatched one. Areas between ridges partly level and smooth; small sharp-rimmed craters well preserved. The larger smooth areas mapped as Imbrian plains units
Interpretation
Composite unit produced by partial flooding of unit pIrt by pre-Imbrian and Imbrian plains materials; low relief features completely buried with only higher ridges and other protuberances projecting above flooded surface; probably also mantled with pyroclastics erupted along with plains material; dominance of lineated over cross-hatched pattern represents elimination of weaker lineament set. Preservation of sharp-rimmed craters on smooth surface may result from (1) better preservation of impact craters on smooth homogeneous flows than on rubbly slope debris of unit pIrt; or (2) volcanic origin of some smaller craters, associated with emplacement of flows. Age indeterminate but appears older than plains units and thus assigned to pre-Imbrian

pIp — Highly cratered plains material

Characteristics
Forms level surface nearly saturated with 1–3 km craters. Most areas have faint northwest-trending lineation defined by very gentle swells and depressions. Albedo 0.128–0.134. Occurs only in north and northwest regions of quadrangle
Interpretation
Material of lava or ash flows. Old relative to units Ips and Ipc; many craters possibly of internal origin, but morphology of superposed craters and crater density consistent with this age interpretation

pIc$_2$ | pIcr$_2$ | pIcw$_2$ | pIcf$_2$ | pIcp$_2$ — Materials of moderately subdued craters

Characteristics
Materials of craters having irregular discontinuous rim crests. Most crater floors covered by Imbrian plains materials
pIc$_2$, *crater materials, undivided*
pIcr$_2$, *rim material. Topography strongly subdued; rim crest incomplete. In places shows texture of underlying terra unit indicated by symbol in brackets*
pIcw$_2$, *wall material. Roughly textured by superposed craters, terraces, and radially disposed channels. Part of rim crest and lineaments within wall commonly coincide with regional lineaments*
pIcf$_2$, *floor material. Generally similar to unit Icf, except more strongly lineated, commonly along lines coincident with regional lineaments*
pIcp$_2$, *peak material. Similar to unit Icp*
Interpretation
Materials of moderately old craters. Morphologic characteristics blurred but in places resemble correspondingly lettered units of younger craters and probably of impact origin although some possibly volcanic. Extensive structural modification and downslope movement of surficial materials have taken place on walls and floors along lines of weakness defined by regional joints and faults. Extensive volcanic filling

Lower pre-Imbrian

pIrt — Ridged terra material

Characteristics
Forms surface apparently level at 10-km scale and ridged at 1-km scale. Numerous linear ridges trending northwest and north-northeast; where northwest set dominant, terrain has lineated appearance at telescopic resolution; where both sets present, cross-hatched pattern is formed. Many concealed craters; fewer sharp craters than on cratered plains and smooth terra units. Occurs on some early pre-Imbrian crater floors. Albedo 0.135–0.142
Interpretation
Surface materials include ejecta, breccia from numerous cratering events. Erosion and redeposition by cratering has occurred concomitant with structural movement along regional joint systems. Paucity of sharp craters attributed to instability of crater forms on steep irregular slopes composed of rubbly material. Appearance similar in pre-Imbrian time, though surface modified in more recent periods, especially by late pre-Imbrian cratering. Deposited mostly during early pre-Imbrian time; possibly younger in part

pIc$_1$ | pIcr$_1$ | pIcw$_1$ | pIcf$_1$ | pIcp$_1$ — Materials of strongly subdued craters

Characteristics
Materials of craters having strongly modified rim crests and walls; rim crests irregular and discontinuous
pIc$_1$, *crater materials, undivided*
pIcr$_1$, *rim material. Relief low; rim crests incomplete. In places shows texture of underlying terra unit indicated by symbol in brackets*
pIcw$_1$, *wall material. Similar to unit pIcw$_2$, except radial channels more conspicuous (especially in smaller craters) and density of superposed craters higher. Large parts of wall, rim, and floor commonly buried*
pIcf$_1$, *floor material. Similar to unit pIcf$_2$*
pIcp$_1$, *peak material. Similar to unit Icp*
Interpretation
Materials of oldest craters mapped. Structures highly modified by erosion, impact, and cumulative movement on many faults to point of partial elimination. Origin uncertain but presumed to be predominately by impact

Contact — *Long dashed where approximately located; short dashed where gradational*

Concealed contact (Ips) — *Buried unit indicated by symbol in parentheses*

Fault — *Dashed where approximately located. Bar and ball on apparent downthrown side. Offsets a unit or forms scarp against which younger rocks deposited*

Concealed crater — *Symbol indicates rim crest*

Lineament — *Conspicuous scarp or depression; may be a composite of discontinuous but alined features*
Interpretation: Mostly faults but sense of movement cannot be determined

Rille — *Narrow curvilinear depression*
Interpretation: Fracture associated with foundering of volcanic rocks inside crater Tannerus

Irregular depression — *Interpretation: Collapse depression or graben*

Extrinsic texture [pIrt] — *Texture of crater materials modified by texture of underlying unit pIrt*

INTRODUCTION

The Hommel quadrangle is in the southeast highlands of the earthside hemisphere of the Moon. The major geologic units are smooth and ridged terra materials, plains-forming materials, and crater materials. Mare material is absent. In the absence of extensive stratigraphic datum horizons, the geologic units were tentatively correlated with the type areas of the lunar geologic systems (Shoemaker and Hackman, 1962; Wilhelms, 1970) by means of a graded sequence of crater morphologies.

CRATER UNITS

The graded sequence of crater morphologies comprises five categories. Materials of rayed craters (Cc), identified by rays and high albedo, are assigned to the youngest system, the Copernican. Materials of the four other categories are tentatively assigned ages according to apparent freshness. The sequence, from most subdued to freshest and therefore presumably from oldest to youngest, is: materials of strongly subdued craters (pIc$_1$), materials of moderately subdued craters (pIc$_2$), materials of dissected-rim craters (Ic), and materials of sharp-rimmed craters (CEc).

These categories are based on standard crater types, as in a system devised by Pohn and Offield (1970) through a systematic lunar-wide examination of crater morphology apparently related to both age and crater size. The categories have been dated relative to the units which define the lunar time-stratigraphic systems (Offield, 1971). The majority of large craters in the Hommel quadrangle are assigned to the late pre-Imbrian (pIc$_2$). In certain instances a hierarchy of morphology and superposition for craters within this informal category is discernible; for example, in the northwestern sector of the quadrangle Baco A is younger than Baco and Baco B is younger than Clairaut A. However, difficulties in systematically ranking all upper pre-Imbrian craters necessitated the retention of this single large category. The upper pre-Imbrian as used here corresponds to the combined middle and upper pre-Imbrian of Offield (1971) and of the quadrangles adjacent to the Hommel quadrangle (Scott, 1971; Stuart-Alexander, 1971).

Three craters, Jacobi A, Hommel B, and Hommel Q, require special comment. They are mapped as Eratosthenian or Copernican but they have certain features which do not characterize other craters so mapped. They contain protuberances of ropy, bulbous floor materials. Crater walls do not have circular symmetry but are irregularly scalloped. Topographically prominent rims are lacking, but relatively smooth and uncratered rim deposits appear to blanket the surrounding terrain for distances as much as half a crater diameter. Satellitic craters are lacking. These features suggest a volcanic origin for the three craters and their associated materials, whereas the majority of other Eratosthenian or Copernican craters are believed to be of impact origin.

PLAINS-MATERIAL UNITS

Three plains-material units have been mapped: pre-Imbrian pitted plains (pIp), Imbrian cratered plains (Ipc), and Imbrian smooth plains (Ips). They are characterized by level surfaces broken by younger craters and scattered remnants of subjacent topography. Plains units are most widespread in the northwest part of the quadrangle. There is a general structural or topographic control; plains occupy the lowest topographic regions within the map area. The three units are interpreted as volcanic; they differ mainly in density of superposed craters. This difference may result from age differences, although the significance of crater frequencies is not well established. Assuming that the frequency of craters indicates relative age for similar surfaces, the smooth plains unit is younger than the cratered plains unit as it has fewer total craters (larger than about 1 km diameter) per unit area (fig. 1).

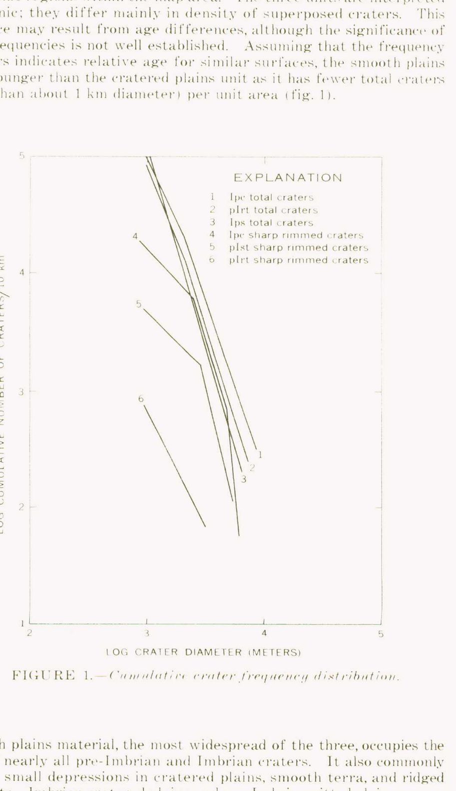


FIGURE 1.—*Cumulative crater frequency distribution.*

Smooth plains material, the most widespread of the three, occupies the floors of nearly all pre-Imbrian and Imbrian craters. It also commonly occupies small depressions in cratered plains, smooth terra, and ridged terra units. Imbrian cratered plains and pre-Imbrian pitted plains occupy much of the area between the craters Jacobi, Cuvier, and Baco. They partly bury pre-Imbrian craters and are overlain by Imbrian and younger craters.

The pre-Imbrian age assignment for pitted plains materials is based, in part, on extrapolation of relations displayed in the Maurolycus quadrangle directly to the north, where craters believed to be secondary impact craters of the Imbrium basin are superposed on pitted plains materials (Scott, 1971). A lobe of these pre-Imbrian plains materials extends south into the Hommel quadrangle just north of Pitiscus.

RIDGED AND SMOOTH TERRA

Two units of terra, ridged (pIrt) and smooth (pIst), both level on a scale of tens of kilometers but displaying linear ridges and grooves or a cross-hatched structure at the kilometer scale, form most of the quadrangle surface not covered by plains or crater materials. The typical ridged terra unit is best exposed east of the crater Pitiscus. It has conspicuous sets of parallel linear ridges, one trending northwest and a second slightly east of north. The terrain is marked with the faint outlines of highly subdued or buried craters. This unit is interpreted to be complexly cratered highland material. The linear features are interpreted as having been produced by movement along faults apparently related to a Moon-wide fracture system. Smooth terra is a composite unit having all the characteristics of ridged terra but with more local flooding by plains units. Numerous linear ridges and domes whose materials constitute separate units occur in the smooth terra, especially near the center of the quadrangle. These ridges and domes are interpreted as volcanic features. The distinction, then, between ridged and smooth terra is that tectonic and volcanic activity occurred in the area occupied by smooth terra during late pre-Imbrian and Imbrian time, whereas the area occupied by ridged terra has been dormant since the formation of the lineaments of pre-Imbrian time.

VOLCANIC FEATURES

There are only a few areas of the Moon, chiefly in the maria, where evidence for the existence of volcanic features is convincing. Some features in the Hommel quadrangle resemble features in those areas and thus may be of volcanic origin. In the quadrangle, certain domical hills and linear ridges of Imbrian age are morphologically similar to features displayed more clearly in the region of the Marius Hills (McCauley, 1968). Linear forms are more common in the Hommel quadrangle than in the Marius Hills, possibly indicating that fissure eruptions were particularly common in one area and central pipe eruptions in the other. Possible volcanic craters are described in the preceeding "crater units" section.

CRATER FREQUENCIES

One of the most puzzling features of the region is that there are more small (<10 km) craters on some of the plains units than on the older ridged terra (fig. 1, compare curves 1 and 2). An even greater contrast is in the distribution of sharp-rimmed craters, which are over an order of magnitude more numerous on cratered plains than on ridged terra. Seemingly in contradiction to the crater statistics, however, the plains are interpreted to be younger than the terra because (1) plains material is superposed on terra, (2) old, highly subdued craters that are common on the ridged terra are absent on the plains, and (3) the plains units lack structure and lineaments characteristic of the terra. This anomalous relationship between terra and plains may be explained either by endogenous crater production on the plains or by more rapid erosion (hence, more rapid obliteration of craters) on the steep, rough terra slopes. Additionally, the terra may have a relatively thick regolith of fragmental materials in which crater shapes are poorly preserved.

REGIONAL STRUCTURE

A simplified structural map is shown in figure 2. A dominant set of faults trending northwest and a second, less well developed, set trending east of north, divide the region into blocks which have been relatively depressed or elevated. Low blocks have been almost completely flooded by plains material, intermediate blocks partly flooded, and high blocks only slightly flooded or not flooded at all. All the possible faults are nearly continuous and the relative vertical movements (fig. 2) have been inferred from the relations of plains materials. One of the more noticeable linear structures, shown on the geologic map as a fault, trends northwest from just south of the crater Nearch for a distance of at least 200 km. Movement is interpreted as down on the southwest because that region is extensively covered by smooth plains (Ips). Several semicircular depressions terminate abruptly against the fault. Young craters which lie astride conspicuous lineaments show no evidence of being displaced, suggesting that the structural blocks formed early in lunar history and have not moved extensively since.

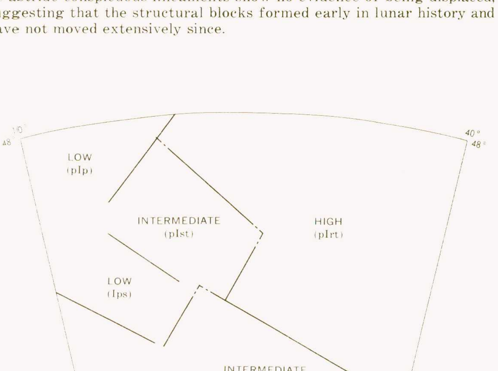


FIGURE 2.—*Diagrammatic structural map showing relative displacement of regional blocks. Low blocks have been depressed relative to high ones. Some block junctions can be uniquely correlated with lineaments or faults on the geologic map. Other junctions, shown schematically in this figure, occupy irregularly discontinuous zones on the map.*

SUMMARY OF GEOLOGIC HISTORY

The major events of pre-Imbrian time whose record is still visible were the formation of almost all of the larger craters in the quadrangle, the creation of the lunar grid, and the volcanic emplacement of plains materials. Many of the grid lineaments were active as faults in pre-Imbrian time, creating large block-fault provinces which were flooded with volcanic materials. Episodic volcanic activity continued throughout the Imbrian Period. A variety of plains-forming materials were deposited and other features interpreted as volcanic ridges and domes were formed. The highest areas were least affected by pre-Imbrian and Imbrian volcanism. Craters formed throughout the history of the region, mainly by impact. The most recent large crater to form nearby is Tycho, 450 km northwest of the map area. Bright ray material (unmapped) which covers most of the area and secondary craters are evidence of that impact.

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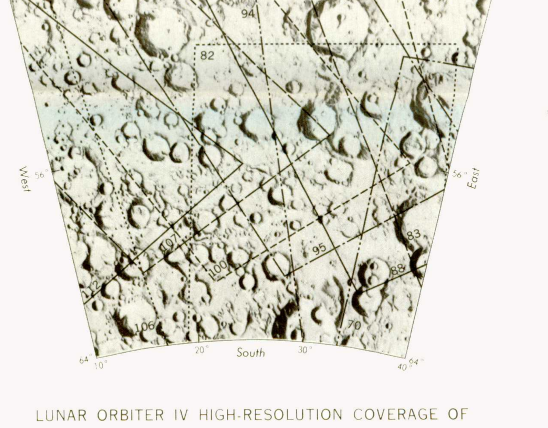
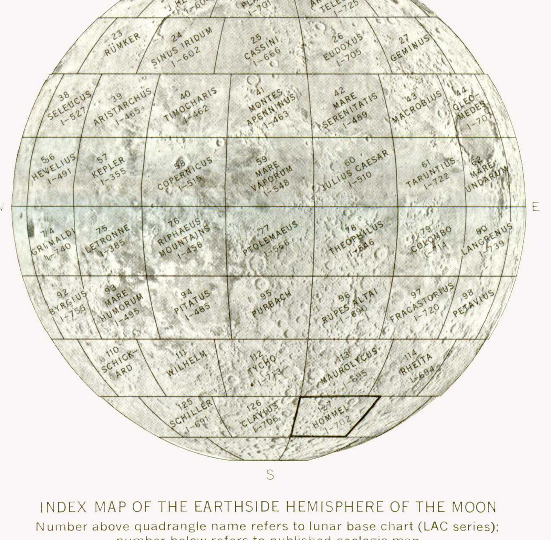


LUNAR ORBITER IV HIGH-RESOLUTION COVERAGE OF HOMMEL QUADRANGLE



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

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