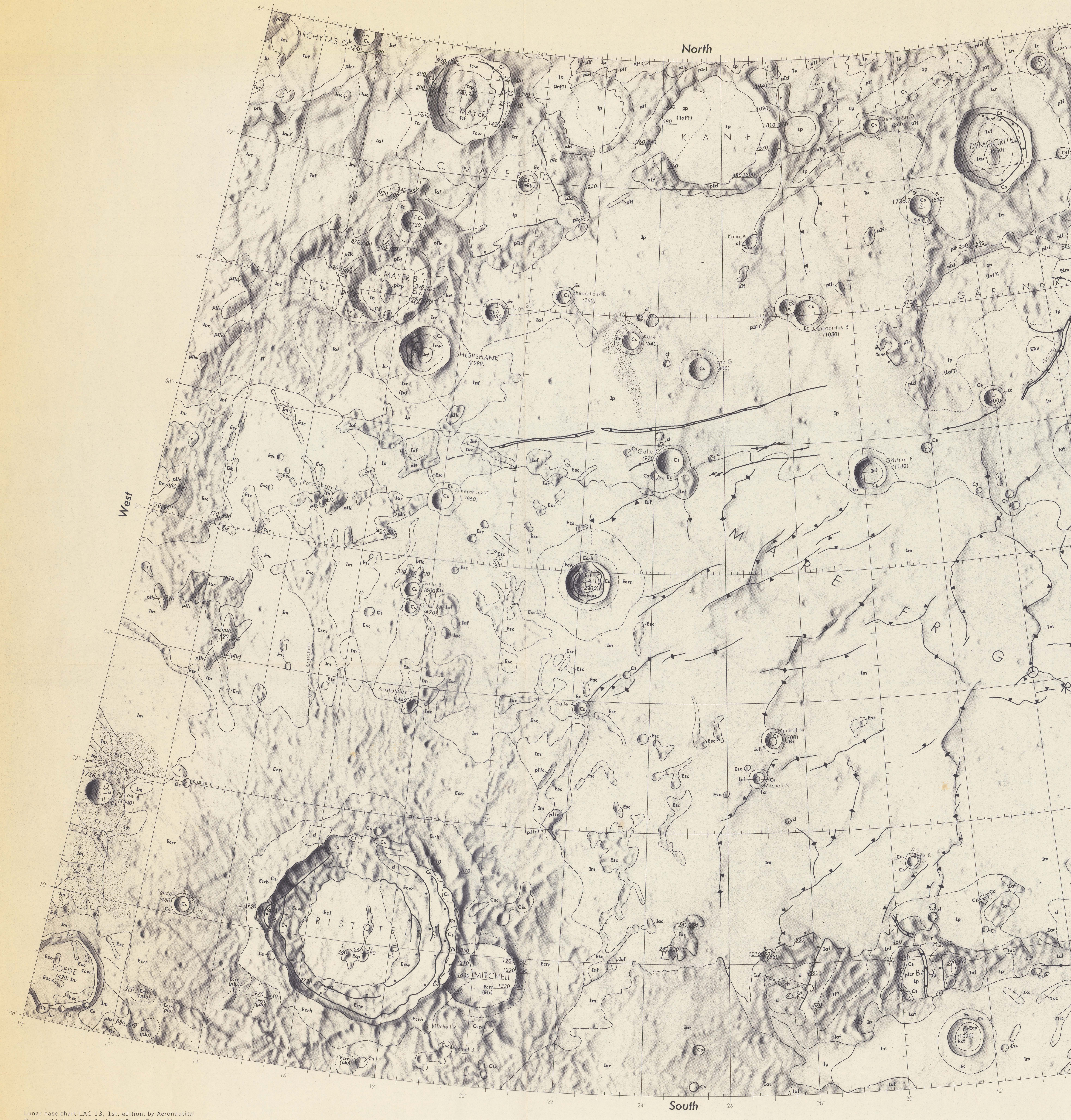
PREPARED IN COOPERATION WITH THE
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION AND THE
USAF AERONAUTICAL CHART AND INFORMATION CENTER
UNDER NASA CONTRACT NO. R-66



Lunar base chart LAC 13, 1st edition, by Aeronautical Chart and Information Center, U.S. Air Force, St. Louis, Missouri 63118.

Principal sources of geologic information: published and unpublished photographs by Catalina Station, Lunar and Planetary Laboratory, University of Arizona; Naval Observatory, Flagstaff, Arizona; and Observatoire Pic du Midi; and Orbiter IV high-resolution photographs.

PRELIMINARY GEOLOGIC MAP OF THE ARISTOTELES QUADRANGLE OF THE MOON

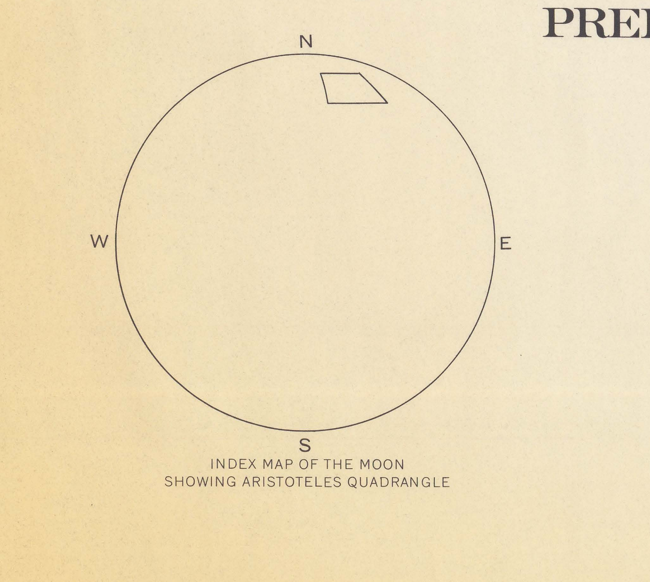
By
Baerbel Koesters Lucchitta
1970

Lambert Conformal Projection
Scale 1:1,000,000

STATUTE MILES

KILOMETERS

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.



INDEX MAP OF THE MOON
SHOWING ARISTOTELES QUADRANGLE

EXPLANATION

COPERNICAN SYSTEM

Cs — Slope material

Characteristics
Occurs on steep slopes, mostly crater walls. Albedo significantly higher than that of surroundings.

Interpretation
Unit is essentially composed of underlying material that has been reworked and freshly exposed owing to mass wasting on steep slopes.

Cc — Crater materials, undivided

Characteristics
Exposed on rims, walls, and floors of relatively deep craters having high albedo, sharp rims, and ray pattern.

Interpretation
Materials of craters that are thought to be young and of impact origin owing to depth and shape of craters, sharpness and height of rims, bright rays, and distance to which ejecta was thrown. Some small craters may be of volcanic origin.

Ray material

Characteristics
Bright material on and around craters mapped as Cc. Material occurs in halo or occurs as true rays diverging from craters. No visible surface relief.

Interpretation
Very thin blanket of fine ejecta from young craters, or bright slope material in secondary and tertiary craters, or both, overlying older units. Rays are absent around older craters due to rapid obliteration by erosional processes.

Csc — Satellitic crater material

Characteristics
Material of irregularly shaped, shallow craters or partly merged crater clusters east of the crater Aristoteles.

Interpretation
Material of craters whose shape, size, direction of alinement, location, and superposition on the Aristoteles ejecta blanket indicate an origin associated with the formation of the Copernican crater Eudoxus (south of map area) by impact (Page, 1967).

d — Dark mantling material

Characteristics
Dark material that completely masks or subdues, to varying degrees, the subjacent topography. In Aristoteles, albedo is slightly lower than that of mare material; in Egede A, is similar to that of mare. Unit has lowest albedo in map area where it is associated with chain craters or with small hills in eastern part of map area.

Interpretation
The association of the material with dark small hills, dark domes, or chain craters and its thin, mantling characteristic suggest that this material consists of surface flows or ash deposits. Age may vary, but material is generally considered to be young because it has not been removed by erosion even though it is only a thin layer and because it locally partly fills the inside of young craters.

ERATOSTHENIAN SYSTEM

Ec, Ecrh, Ecrr, Ecw, Ecf, Ecp — Crater materials

Characteristics
Ec, crater materials, undivided. Materials of 5-20 km craters having moderately sharp rim crests and no ray pattern. Larger craters have the following morphologic subunits:
Ecrh, rim, hummocky. In Aristoteles, has angular blocky appearance. Outer limit of unit marked in places by a sharp scarp; in other places is transitional to Ecrr. Width of occurrence is 5-20 km. Albedo is locally like that of mare and locally slightly higher. In Galle, is fairly smooth and has very subdued hummocks.
Ecrr, rim, radial. Has smooth, radially ridged, undulating surface. Ridging is more prominent outward; merges into branching pattern and satellitic crater clusters. Contact with Esc is gradational. Albedo is similar to that of mare, but is higher in a raylike pattern locally developed on Ecrr.
Ecw, wall. Occurs on inside of crater walls. In Aristoteles, pronounced steep-walled scarps are continuous for almost all of crater circumference. Generally rugged, having hummocks and sharp scarps and few interspersed smooth, level surfaces. Hummocky mass covering east side of Aristoteles floor is included in wall material. Albedo intermediate; many small light spots, few large dark patches. In Galle, wall material is smooth and scarps are continuous for about ½ of crater circumference.
Ecf, floor. In Aristoteles, floor is flat, smooth, and mottled having an albedo similar to that of plains material. Locally floor is hummocky, especially near the south edge. Few isolated small hills are present in other areas of the floor. Floor of Galle is hummocky and has albedo similar to that of mare.
Ecp, peak. In Aristoteles, comprises two large and two small elongate domes having moderately sharp peaks and smooth slopes. In Galle, peak is smooth dome.

Interpretation
Impact origin is suggested for Aristoteles and other large craters by the size and shape of the craters, the morphology of the ejecta blanket, the pattern of the secondary craters, and the distance of the secondary craters from the crater center.
Ec, size and shape of craters suggests an origin similar to that of Cc. Eratosthenian age is suggested by the absence of rays and the more subdued morphology.
Ecrh, rugged, fractured appearance with some steep scarps around the outside edge indicates brecciated and altered bedrock, only locally overlain by a blanket of finer material. This bedrock may be mainly in place, may have been moved as thrust slices, may constitute overturned flaps from the interior part of the crater, or may be chaotic aggregates of huge bedrock blocks. Probably a combination of these is present.
Ecrr is a blanket of finer material derived by impact from the inside of the crater and deposited along ballistic trajectories around the crater. The increasingly strong radial pattern away from the crater suggests separation of the ejecta mass into separate streamers.
Ecw in Aristoteles is extensively altered owing to slumping, other forms of mass wasting, and accumulation of material in low areas, including possibly lava. Hummocky mass of east side of floor is believed to be slumped wall material.
Ecf is probably a fill covering a rugged topography. The material is believed to be of endogenetic origin and may be similar to the plains material, as suggested by the similarity of the general topography and the albedo. Small hills on the floor of Aristoteles may be protrusions from the subsurface floor or may be volcanic cones.
Ecp is assumed, by analogy with terrestrial impact structures, to be brecciated bedrock protruding from the subsurface.

Esc — Satellitic crater material

Characteristics
Material associated with irregularly shaped craters, merging craters, and chain craters. Craters occur around outer periphery of large craters. Locally chain craters branch outward. Craters mostly shallow and have low rims; a few are deep. Albedo slightly higher than that of mare material.

Interpretation
Material of secondary craters. After meteorite impact, large blocks of ejecta are believed to be thrown to great distance, excavating shallow craters and series of craters. Source of ejecta which formed these craters was the large primary crater Aristoteles.

cl — Low-rimmed-crater material

Characteristics
Material occurs associated with round, elongate, or irregular-shaped craters having low rims or no rims. Most of these craters are shallower than high-rimmed craters. Some have the shape of a shallow bowl and resemble isolated craters of units Csc, Esc, and Isc. Hachures point downslope.

Interpretation
An endogenetic origin is favored because the morphology is generally different from that of craters interpreted to be of impact origin and because unit is locally associated with dark mantling material, chain craters, and graben. Low rims are believed to consist of volcanic material. Craters having no rim may be caused by collapse.

ch — Chain crater material

Characteristics
Material of craters that are similar to those of unit cl but that merge into series of craters, large elongate bowls, and narrow grabenlike features. Hachures point downslope.

Interpretation
Material associated with these craters is believed to be of volcanic origin because the craters merge into large steep-sided irregular-shaped troughs associated with dark mantling material or they occur along tectonic features, notably graben.

IMBRIAN OR ERATOSTHENIAN SYSTEM

EIc — Crater materials

Characteristics
Unit comprises buried rim, wall, floor, and central peak materials of crater Mitchell near east rim of Aristoteles.

Interpretation
Age assigned owing to well preserved crater shape underneath cover of Aristoteles ejecta.

EIm — Mare material

Characteristics
Patches of mantling material mostly having an albedo lower than that of mare unit Im. Unit is only locally smooth; in most places texture of plains material is visible.

Interpretation
Probably represents volcanic material covering underlying plains unit.

r — Rugged hill material

Characteristics
Material of individual smooth, high domes or assemblage of bulbous masses, which characteristically transect other features, including fault scarps, and overlap crater rims. Albedo variable.

Interpretation
Believed to be of extrusive or shallow intrusive origin. Domes and hills near dark mantling material (unit d) are probably volcanic cones associated with surface flows. Those on or near the Alpes Formation are probably composed of material fed by lava conduits along zones of weakness in the fractured Alpes bedrock. Domelike masses disrupting old crater rims are thought to be similar features developed along zones of disturbance caused by impact and rebound.

IMBRIAN SYSTEM

Ic, Icr, Icrh, Icrr, Icw, Icf, Icp — Crater materials

Characteristics
Ic, crater materials, undivided. Material associated with 5 to 10 km craters whose rims are more subdued than those of Ec. No ray pattern. Craters larger than 10 km are subdivided into the following morphological units:
Icr, rim, undivided. Forms smooth, somewhat hummocky, locally radially ridged surface. Albedo similar to that of plains material (unit Ip). Democritus has slightly higher albedo, Sheepshank slightly lower. For crater Hercules, rim is further subdivided into:
Icrh, rim, hummocky. Similar to Ecrh, but relief more subdued. Albedo higher than albedo of mare, lower than albedo of plains. Locally gradational outward into Icrr.
Icrr, rim, radial. Similar to Ecrr, but relief more subdued. Radial ridging is considerably less conspicuous. Albedo variable.
Icw, wall. Forms steep-sided inner wall of craters. Is smooth surfaced and has slump blocks continuous for more than ½ of crater circumference.
Icf, floor. Mostly smooth material having appearance and albedo similar to those of unit Ip. Floor of C. Mayer consists of small rugged hills but is smooth at south side of crater.
Icp, peak. Forms conspicuous rugged peaks in C. Mayer and subdued smooth hills in Democritus.

Interpretation
Most small and all large craters are believed to be of impact origin because of their similarity to younger impact craters. More subdued topography of the ejecta blankets and scalloped shape of crater walls is attributed to the longer action of mass wasting processes. Small craters are thought to be pre-Eratosthenian in age because of their subdued topography. Craters are below 5.5 (exclusive) in the Pohn and Offield (1970) crater classification scale. Crater Hercules of Imbrian age (Grolier, 1970), southeast of map area, is younger than most mare material because its secondary craters are superposed on mare material and because very faint rays emanating from the crater overlie a large part of southeastern Mare Frigoris.

Isc — Satellitic crater and crater cluster material

Characteristics
Similar to unit Esc but is more subdued. Material associated with crater clusters merges to nearly continuous cover north of crater Hercules. Albedo is slightly higher than that of plains material.

Interpretation
Same as for Esc but unit is associated with primary crater Hercules.

Im — Mare material

Characteristics
Forms smooth mostly flat surface having low albedo and low crater density. Prominent ridges and irregular scarps disrupt surface.

Interpretation
Extensiveness of area covered, smooth appearance, and embayment of older features suggest an origin as lava flows or ash flows. Numerous intersecting rays are superposed. Unit was deposited within the Imbrian timespan because some Imbrian features are embayed and some are covered and some are superposed.

Ip — Plains forming material

Characteristics
Flat-lying smooth material having very finely mottled texture and higher albedo than mare. Crater density, particularly that of small (limit of resolution about 3 km) craters, is significantly higher than that of mare surface.

Interpretation
Material is believed to be of a somewhat different origin from mare material because of its different albedo, surface texture, and crater density. Also, material overlaps topographic irregularities, whereas mare material embays them. Material may consist of ash-flow and ash-fall tuffs. Unit is embayed by mare material and is therefore older. Superposition of material on features sculptured by the Imbrium impact event indicates a lower age limit of Imbrian.

Iac, Iaf — Alpes Formation

Characteristics
Iac, coarse. Has irregular knobby texture of local smooth round or oval hills ranging in size from 1 to 5 km. Some larger hills exhibit sharp angular peaks. Hills are steeper, sharper, and more distinct than those of the Fra Mauro Formation. Isolated larger hills in northwestern part of map area are elongate in direction of regional grain.
Iaf, fine. Has fine knobby texture. Knobs are irregular; some are sharp peaked, some are smooth. Large hills are present locally, but are generally not as large as those of Iac. Contact with Iac is gradational.

Interpretation
Iac is distributed around the periphery of the Imbrium basin suggesting a genetic relation to the Imbrium impact event. The coarse, irregular texture can be likened to similar textures found on the hummocky, inner rim of smaller impact craters. In analogy with these craters, the Alpes Formation is also believed to consist mostly of bedrock, though extensively fractured, brecciated, and otherwise chaotically disturbed. A relatively thin mantle of Imbrium ejecta may cover the bedrock in most places without, however, completely obscuring the underlying topography.
Iaf is a facies of the Alpes Formation occurring in areas farther removed from the center of the Imbrium basin. The smoother texture of the material may be caused by a lesser degree of brecciation of the bedrock, or an increase in superposed ejecta material, or a combination of both.

If — Fra Mauro Formation

Characteristics
Has irregular knobby texture as in Iaf, but hills locally are connected and merge into sinuous ridges that generally trend northeast. Unit grades into both facies of the Alpes Formation. On south side of map area, formation is characterized by a set of coarse, swirling ridges.

Interpretation
Thick deposit of Imbrium basin ejecta. The blanket obscures the underlying topography, whereas in the Alpes Formation, where the ejecta blanket is thin, the underlying bedrock topography controls the texture of the surface.

PRE-IMBRIAN

pIcr, pIcp — Crater materials

Characteristics
pIcr, rim and wall. Material associated with crater rims and walls not having pervasive lineation. Subdued ridges define part of circular structures. In crater Baily, wall is well defined and smooth.
pIcp, peak. Forms smooth dome in center of crater C. Mayer B. Albedo somewhat higher than that of surrounding plains material.

Interpretation
Craters are thought to be of impact origin by analogy with younger impact craters. Crater rims are believed partly obliterated by faulting, by elastic rebound, by erosional processes, and by endogenetic constructional processes. Ejecta blankets have been mostly destroyed by erosion and superposition of later material. Age is assigned on the basis of morphology, and superposition of Imbrian sculpture.

pIcl — Lineated crater material, undivided

Characteristics
Comprises crater rims and walls having a pervasive northeast-trending lineation, which is expressed by alinement of round and elongate hummocks and by dissection of crater walls.

Interpretation
Craters are similar to those mapped as unit pIcr but rims are modified by superposition of a pervasive linear pattern trending radially outward from the Imbrium basin. Dissection of crater rims is caused by the same processes as described for pIlc and pIf.

pIlc, pIf — Lineated material

Characteristics
pIlc, coarsely lineated. Material of high plateaus having rugged edges and of sharp-crested ridges having smooth slopes. Northeast-trending lineation consists of alinement of ridges and direction of dissection of plateau edges.
pIf, finely lineated. Material of mountains having a pervasive northeast-trending fine lineation. Lineation consists of rows of ridges and small sharp-edged round or elongate hummocks.

Interpretation
Units consist of old material which is sculptured by the Imbrium impact event and which, in most places, does not have a thick cover of younger units. The mountains have been dissected together with the pre-Imbrian crater rims by faulting or by accelerated erosion along planes of weakness following a fracture pattern caused or accentuated by the Imbrium impact. Some of the ridges may be later endogenetic constructs along joints, though most recognizable features attributed to that origin are mapped as r. pIlc is the more coarsely dissected member. pIf probably originated from less violent fracturing and faulting of the bedrock in a concentric ring farther from the center of the Imbrium basin.

pIu — Terra material, undivided

Characteristics
Material of high, irregular mountain clusters and domes that are covered by ejecta from the crater Aristoteles.

Interpretation
Material may be part of unit that is mapped as pIlc, but the true nature could not be established because of the cover of Aristoteles debris.

Contact

Long dashed where approximately located; short dashed where units are transitional.

(pIu) Buried contact

Shows limit of topographic expression of buried units. Buried unit indicated by symbol in parentheses.

Fault

Solid line at base of prominent scarps; dashed where inferred. Bar and ball on downthrown side.

Graben

Solid lines outline graben, single line where too narrow to map sides separately; dashed where very faint.

Ridge

Barbs point downslope. Interpretation: Intrusion of subsurface material along fissure causing doming.

Scarp

Barb points downslope. Interpretation: Some may be fault scarps and some may be flow fronts.

Concealed crater

Symbol indicates rim crest of buried craters.

x x x x Hill

Small hill having low albedo that is associated with dark mantling material in eastern part of map area. Interpretation: Small volcanic dome associated with the effusion of lava.

REFERENCES

Grolier, M. J., 1970, Preliminary geologic map of the Geminus quadrangle of the Moon [scale 1:1,000,000]: U.S. Geol. Survey open-file report.
Page, N. J, 1967, Preliminary geologic map of the Eudoxus quadrangle of the Moon [scale 1:1,000,000]: U.S. Geol. Survey open-file report.
Pohn, H. A., and Offield, T. W., 1970, Lunar crater morphology and relative age determination of lunar geologic units, pt. 1, Classification, in Geological Survey Research 1970: U.S. Geol. Survey Prof. Paper 700-C [in press].