DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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 Zdenek 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 △ 1741.9
Depths of craters (rim to floor) .... (400)
Relative Elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated 300

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.

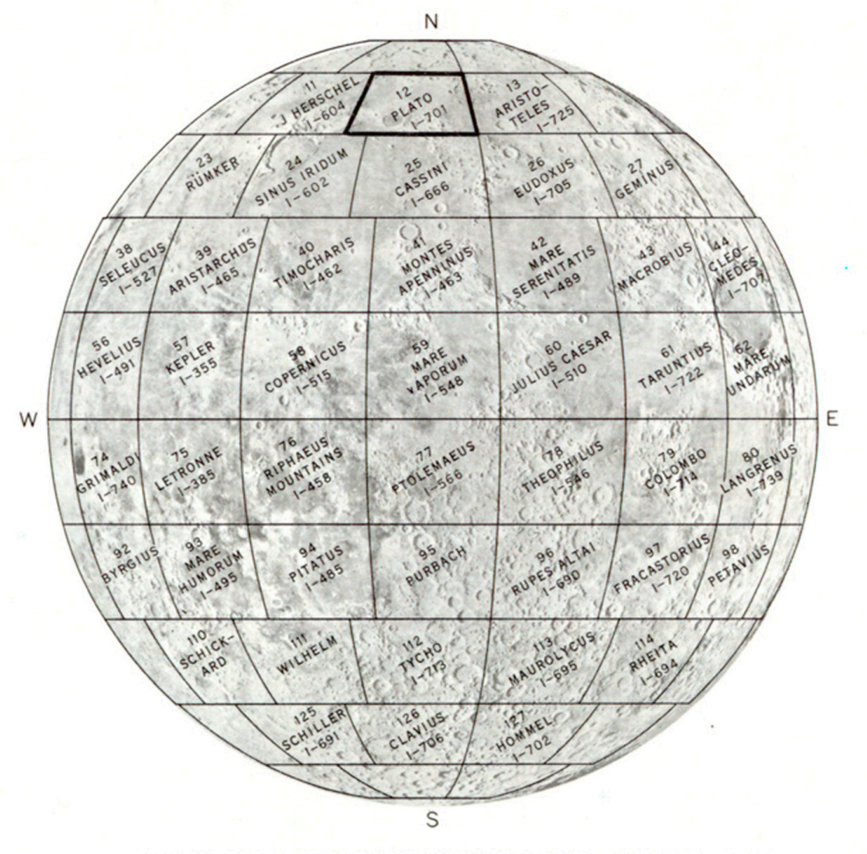
PORTRAYAL

The configuration of the lunar surface features 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 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 12, 1st edition, 1967, by the USAF Aeronautical Chart and Information Center, St. Louis, Missouri 63118

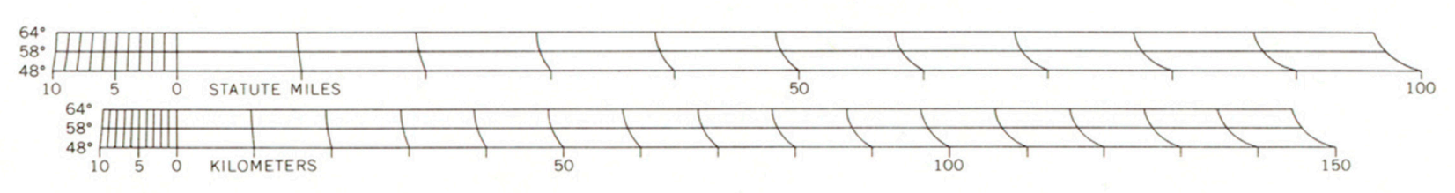
Principle sources of geologic information: Lunar Orbiter IV and V photographs, National Aeronautics and Space Administration (see index map); near-full-moon photographs from U.S. Naval Observatory, Flagstaff, Arizona; photographs from Lick, Pic du Midi, and Catalina observatories. Mapped 1967–1970

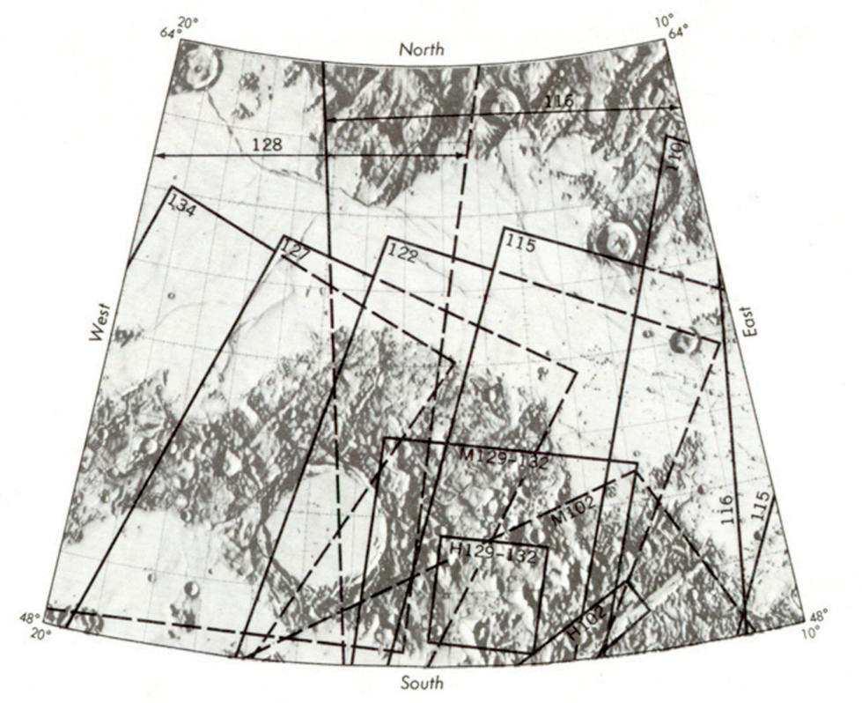
Work performed on behalf of the National Aeronautics and Space Administration under contract No. R-66



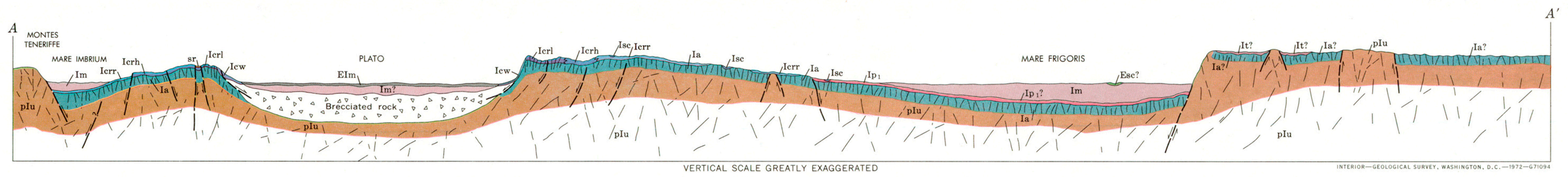
INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON
Number above quadrangle name refers to lunar base chart (LAC series); number below refers to published geologic map

SCALE 1:1 000 000
LAMBERT CONFORMAL CONIC PROJECTION
STANDARD PARALLELS 53°21' AND 74°40'





LUNAR ORBITER PHOTOGRAPHIC COVERAGE OF PLATO QUADRANGLE
Numbers without prefixed letters refer to high-resolution frames of Lunar Orbiter IV. Letters refer to high (H) and medium (M) resolution frames of Lunar Orbiter V



VERTICAL SCALE GREATLY EXAGGERATED
DIAGRAMMATIC CROSS SECTION ALONG LINE A–A'

GEOLOGIC MAP OF THE PLATO QUADRANGLE OF THE MOON

By
John W. M'Gonigle and David Schleicher
1972

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

EXPLANATION

COPERNICAN SYSTEM

Ccd

Dark crater materials

Characteristics
Sharp-rimmed craters and surrounding halos; albedo of rims and halos very low; interior of craters intermediate. Crater rim crest shown by hachured line
Interpretation
Volcanic craters surrounded by dark pyroclastic ejecta or impact craters formed in dark material

Cc | **Ccr** | **Ccw**

Materials of bright-rayed and haloed craters

Characteristics
Cc, *rim and interior materials, undivided. Small (<5 km rim crest diameter) bright craters having generally circular outlines and sharp rim crests; surrounded by diffuse halos having high albedo. Craters > 5 km subdivided as follows:*
Ccr, *rim material. Irregular surface sloping outward from rim crest; albedo intermediate to very high; grades into halo or rays*
Ccw, *wall material. Smooth surface sloping inward; albedo very high; shown on most previously published lunar geologic maps as "bright slope material"*
Interpretation
Mostly young impact craters, as shown by sharpness and height of rims, presence of bright halos and rays, and relatively great length of rays. Rim material is ejecta; wall material is bedrock, brecciated rock, and ejecta fallback

▨

Bright ray material

Characteristics
Bright streaks or plumes superposed on most other units; no relief discernable
Interpretation
Mixture of fine, fresh ejecta from Copernican craters and concentrations of very small Copernican secondary impact craters. Most rays apparently originate from large fresh crater Anaxagoras, north of quadrangle; some patches associated with small craters in quadrangle

ERATOSTHENIAN SYSTEM

Ec | **Ecr** | **Ecw** | **Ecf** | **Ecp**

Materials of sharp-rimmed craters

Characteristics
Morphologically similar to corresponding units of Copernican craters, except in relatively large crater Archytas. Albedo generally lower than Copernican craters; no bright halos or rays
Ec, *crater materials, undivided. Small (<5 km diameter) craters*
Ecr, *rim material. Surface sloping outward from rim crest; around Archytas, shallow grooves or lineaments having radial, northeast, and northwest trends are visible. Albedo intermediate*
Ecw, *wall material. Generally steep, smooth surface sloping inward; in Archytas includes terraces and hummocky surfaces. Albedo intermediate to high*
Ecf, *floor material. Smooth level, locally hilly surface; albedo intermediate to high*
Ecp, *peak material. Cluster of irregularly shaped hills several hundred meters high on floor of Archytas; albedo intermediate to high*
Interpretation
Rim and wall, same as for corresponding units of Copernican craters. Floor material is mainly brecciated bedrock and ejecta fallback; may include some volcanic materials. Peak probably formed of uplifted brecciated material

Esc

Satellitic crater material

Characteristics
Clusters and chains of small craters (up to 5 km diameter) having irregular elongate shapes. Commonly several craters coalesce; many have raised rims and intermediate albedo. Long axes of clusters commonly radial to crater Aristoteles about 100 km east of quadrangle. Map shows individual crater rim crests or outline of clusters and chains
Interpretation
Secondary craters and their ejecta excavated by impact of ejecta from larger Eratosthenian craters; most are probably from Aristoteles

EIm

Younger mare material

Characteristics
Very dark, flat, smooth material occurring principally at edges of Mare Imbrium and Mare Frigoris. Has lower density of small craters than unit Im *and appears to mantle a graben-like trough (Rima Archytas I) in unit* Im. *Typical area: lat 53° N.; long 2° E. Where queried could be unit* Im
Interpretation
Younger than unit Im *but age limits uncertain. Series of layered volcanic materials, probably including lava flows, ash flows, and pyroclastic debris*

IMBRIAN OR ERATOSTHENIAN SYSTEMS

EIc | **EIcr** | **EIcw**

Materials of slightly subdued craters

Characteristics
Intermediate in rim-crest sharpness between Eratosthenian and Imbrian craters of same size. Overall albedo generally intermediate or about same as surrounding terrain, but some walls bright
Interpretation
Same as for corresponding units of Copernican and Eratosthenian craters but craters older and more modified

IMBRIAN SYSTEM

Im

Older mare material

Characteristics
Flat, smooth, dark unit occurring principally in Mare Imbrium and Mare Frigoris, but locally in smaller depressions. Minor positive relief produced by scarps and ridges. Superposed on rim and satellitic crater materials of crater Plato
Interpretation
Volcanic materials like those of unit EIm. *Scarps may be edges of local, thin flow units, and ridges are probably extrusive complexes overlying fissure vents along regional fractures. Local albedo differences may reflect intrinsic differences in mare material or may be caused by unmapped rays or surficial materials*

▨

Dark mantling material

Characteristics
Irregular, somewhat smooth areas having moderately low albedo. Topographic relief and expression nearly same as surrounding units. Typical area: near western end of Rima Plato I (lat 52°15' N.; long 4°15'-40' W.)
Interpretation
Probably deposits of dark pyroclastic materials which thinly mantle older topography

Ip₂

Younger plains material

Characteristics
Fairly smooth, flat to slightly rolling; occurs in depressions and areas of low relief; albedo intermediate to low; cratered more extensively than mare material. Overlies Alpes Formation but embayed by mare units. In places occurs on Plato rim materials but in Vallis Alpes satellitic craters of Plato may be superposed. Typical area: between lat 60°40'-64° N. and long 4°-8°45' E
Interpretation
Probably volcanic flows and pyroclastic material. Younger than Alpes Formation and older than mare units. May be both older and younger than Plato

Ic | **Icr** | **Icrh** | **Icrl** | **Icrr** | **Icw** | **Icf** | **Icp**

Materials of subdued craters

Characteristics
Ic, *crater materials, undivided. Craters small (<6 km), circular to subcircular, more degraded than younger craters. Albedo of rim generally intermediate; of wall, high. In larger craters divided into:*
Icr, *rim materials, undivided. Irregular surface sloping outward from rim crest. Topographically more subdued and apparently less extensive than unit* Ecr *of equal-sized craters. Medium size craters (20-30 km) have polygonal rim crests. Albedo generally intermediate. In Plato divided into:*
  Icrh, *rim material, hummocky. Generally rolling to hummocky. Numerous irregularly spaced, linear depressions commonly tangential to rim crest, bounding broad mounds and linear ridges. Typical area: southwest rim of Plato. Locally on terraces and slumps inside crater*
  Icrl, *rim material, hummocky and lineated. Closely spaced swarms of radial to subradial linear depressions and sharp ridges. Typical area: south and southwest rim of Plato*
  Icrr, *rim material, radial. Continuous around Plato except on southwest side where probably covered by mare material; lower relief than other rim facies; has low, 1-2 km wide hillocks producing mottled appearance on Orbiter IV photographs; radially lineated by shallow depressions or low ridges having "herringbone" pattern, mostly with northeasterly or northwesterly trends. Outer boundary gradational but mapped at approximate limit of continuous rim material. Typical area: north of Plato A*
Icw, *wall material. Generally smooth surface sloping inward. In Plato and other large craters includes concentric terraces and scarps; albedo intermediate to high*
Icf, *floor material. Smooth to locally rough and hilly, generally level; albedo intermediate to low*
Icp, *peak material. Clusters of irregularly shaped hills several hundred meters high on floors of craters Fontenelle and Timaeus; albedo intermediate to high*
Interpretation
*Same as for younger impact craters. Polygonality of craters believed largely developed after cratering by slump along pre-existing lines of crustal weakness, primarily the lunar grid. Linear trends in hummocky rim units of Plato (*Icrh *and* Icrl*) reflect bedrock deformation by a complex of normal and reverse faulting along new fracture trends and lunar grid trends. Linear depressions and ridges in radial rim material largely parallel fracture trends in surrounding terrain and thus probably reflect subjacent fractures; others are primary depositional patterns. Some smaller craters younger than Plato and some older; some may be older than Iridum crater*

Isc

Satellitic crater material

Characteristics
Very similar to unit Esc, *but crater diameters average 3-4 km, with a few as much as 7 km. Most are distributed around Plato; some overlie Iridum satellitic craters in western part of quadrangle*
Interpretation
Secondary impact craters, mostly from Plato; younger than Iridum satellitic craters and therefore the main Iridum crater

Iirr

Radial rim material of Iridum crater

Characteristics
*Irregular, rolling to ridged surface of moderate relief in contrast to the surrounding plains unit (*Ip₁*). Part of outer radial ridge pattern surrounding Iridum crater to southwest (Ulrich, 1969; Schaber, 1969). Albedo intermediate*
Interpretation
Edge of continuous ejecta blanket from Iridum crater. Radially distributed lineaments and ridges genetically related to the Iridum crater; may reflect either surficial depositional patterns or subsurface structures (Ulrich, 1969). Unit appears to overlie, and thus be younger than, older plains material; older than Plato

Iisc

Satellitic crater material of Iridum crater

Characteristics
Similar to Eratosthenian and Imbrian satellitic crater units, except larger and generally elongate approximately radial to Sinus Iridum. Part of field of similar craters surrounding Iridum crater (Ulrich, 1969).
Interpretation
Secondary impact craters formed by ejecta from Iridum crater

Ip₁

Older plains material

Characteristics
Fairly smooth, flat to rolling, low-lying; intermediate to low albedo; heavily cratered; in places (as north and west of Plato) disrupted along linear scarps. Appears to embay Alpes Formation, but to be overlain by mare materials and ejecta from Iridum crater and Plato. Correlative with plains unit southwest of the Vallis Alpes (Page, 1970). Typical area: west of Plato, between lat 52°-54°30' N. and long 16°-20° W
Interpretation
Materials similar to those of younger plains unit; emplaced during early stage of Imbrium and Frigoris basin filling, and may continue under younger mare materials into deeper parts of basins. Linear scarps north and west of Plato possibly faults formed by Iridum crater impact (Ulrich, oral commun., 1970)

It

Hilly terra material

Characteristics
Rolling surface having low, rounded hills and ridges; rougher than plains materials but smoother than Alpes Formation. Albedo intermediate to low. In high-resolution Orbiter V photographs some hills show moderately well-developed lineament patterns similar to those in Alpes Formation and pre-Imbrian material of Montes Alpes; surfaces between hills show faint lineaments. Corresponds to hilly terra material in Cassini quadrangle to south (Page, 1971). Typical area: between lat 48°-49° N.; long 2°-2°40' E.
Interpretation
Thin deposit mantling underlying topography of Alpes Formation and smaller pre-Imbrian hills in Montes Alpes. Unit probably composed of pyroclastic materials, although may be areally restricted deposit of Imbrium basin ejecta

Ia

Alpes Formation

Characteristics
Same as Alpes Formation in type area to south (Page, 1970). Blocky or knobby irregular hills, mostly less than 5 km long, having intermediate to high albedo; separated by more nearly level, rolling surfaces having intermediate to low albedo; also areas of low, irregular, rough, lineated terra (for example, lat 51° N., long 5° E.) having intermediate albedo. Size of hills generally decreases and spacing between hills generally increases towards west and north in quadrangle. Along west side of Vallis Alpes hills have lineated texture similar to pre-Imbrian terra material (Orbiter V photograph H-102); surfaces between strongly textured with short, curving lineaments, mostly having northwesterly trend
Interpretation
Pre-Imbrian bedrock structurally deformed at time of Imbrium basin formation, or material ejected from basin during impact, or, most probably, mixture of these

Ifa

Fra Mauro and Alpes Formations, undivided

Characteristics
Irregular to rolling surface mostly having indistinctly outlined knobs and broad, low hills, but containing scattered distinct irregular hills and ridges; north-trending linear grooves and low, broad ridges common (in addition to northeast and northwest trends common elsewhere on terra); most knobs and ridges appear outlined by shallow, closely spaced lineations. Surface grades from gently rolling near crater Birmingham B to very knobby and irregular north of Fontenelle (outside quadrangle), where it resembles Fra Mauro Formation in adjoining quadrangle to west (J. Herschel). East limit of unit grades into Alpes Formation. Albedo intermediate. Queried where characteristics poorly expressed
Interpretation
Pre-Imbrian bedrock structurally deformed at time of formation of Imbrium basin and covered and admixed with material ejected from the basin. Unit believed to represent transition zone from thick basin ejecta (Fra Mauro Formation) in west to thin in east where bedrock morphology typical of Alpes Formation is more conspicuous

PRE-IMBRIAN

pIu

Terra material, undivided

Characteristics
Principally exposed as steep-sided, angular, mountainous masses and rugged uplands. Albedo intermediate to very high; in general higher south than north of Mare Frigoris. Surface texture generally appears rough in Orbiter IV photographs; slopes of Montes Recti, Teneriffe, and Alpes, and of Vallis Alpes, illuminated by glancing sunlight, appear speckled; in high-resolution Orbiter V photographs, Montes Alpes and Vallis Alpes texture is resolved into characteristic pattern of dark lineaments composed of long shallow depressions trending directly to obliquely downslope and interrupted by shorter, curved, shallow depressions trending parallel or sub-parallel to slope. Areas between depressions light-toned. Lineaments less strongly developed on more level and smoother surfaces of intermediate albedo. Small craters more visible on these surfaces than on the steeper, highly lineated slopes. North of Mare Frigoris, forms rugged, sharp-featured mountain ridges along east side of crater W. Bond, but west of Timaeus and east of Archytas appears as more rounded or subdued ridges and masses
Interpretation
Largely fractured and faulted pre-Imbrian bedrock. High albedo south of Mare Frigoris thought to be intrinsic to materials of unit, enhanced by fractured and blocky surfaces. Well-developed lineaments on steep slopes believed to represent both fractures and faults in bedrock and moderate downslope movement patterns of very coarse blocks. North of Mare Frigoris, lower albedo and rounded morphology of unit may indicate a mantling deposit, possibly Imbrium basin ejecta.

LOCATION AND PHYSIOGRAPHY

The Plato quadrangle in the north-central part of the Moon lies within a series of concentric depressed and raised rings surrounding the Imbrium basin, the center of which lies about 335 km southwest of Montes Teneriffe. The innermost raised ring is marked by isolated ridges and peaks within Mare Imbrium itself, including in the Plato quadrangle Montes Recti and Teneriffe. The band of terra including Montes Alpes forms part of the second and most prominent raised ring, immediately encircling Mare Imbrium. Mare Frigoris is part of the succeeding depressed ring and the terra in the north of the quadrangle part of the third raised ring. It is believed that the Imbrium basin and other multi-ringed basins on the Moon were formed by the impacts of large bodies (Baldwin, 1949 p. 200-216; Hartmann and Kuiper, 1962; Shoemaker and Hackman, 1962; Wilhelms and McCauley, 1971).

The Orientale basin, considered to be the youngest and best-preserved of the multi-ringed basins, forms a model with which to compare the structure and stratigraphy of the older, partly concealed Imbrium basin: the second and third raised Imbrium rings may correspond to the Rook and Cordillera rings, respectively, of the Orientale basin (McCauley, 1968).

GEOLOGIC UNITS

On the basis of direct telescopic observations and study of telescopic and Lunar Orbiter photographs, the surface materials of the Plato quadrangle have been divided into map units having characteristic morphologies and albedos. Many of the units, other than the inferred impact crater units, are interpreted as having a more or less limited range in lithologic composition as well as in age. Impact crater units, however, are probably composed of materials derived from the units upon which they occur; therefore, craters having comparable morphologies and ages may have different lithologies. Relative ages of the units are determined on the basis of superposition and cross-cutting relations (Wilhelms, 1970) and degree of crater degradation (Pohn and Offield, 1970). Stratigraphic ages are assigned according to the system devised by earlier workers (Shoemaker, 1962; Shoemaker and Hackman, 1962; McCauley, 1967; Wilhelms, 1970). Each unit is given either a descriptive designation or a formal stratigraphic name, and a letter symbol comprising an abbreviation of its age (capital) and name (lower case). The units, arranged from top to bottom in order of increasing age, are described and interpreted in the map explanation. For purposes of discussion they may be grouped into three main categories: hilly units; plains, mare, and mantling units; and crater units.

HILLY UNITS

These include mountainous masses having high albedo (pIu), hilly terrain of the Alpes Formation (Ia), and hilly terrain composed of the Fra Mauro and Alpes Formations undivided (Ifa). The mountains probably represent uplifted parts of the terra, of unknown and doubtless mixed lithology, in which the Imbrium basin was formed. The time of exposure of the materials in the mountains varies: north of Mare Frigoris, those in the sides of some of the polygonal craters (for example, W. Bond) have probably been exposed since pre-Imbrian time, whereas those of Montes Alpes may have been exposed by uplift at the beginning of Imbrian time as a result of the formation of the Imbrium basin. Most of Montes Alpes was probably formed by block faulting. Many of the linear margins and fractures of Montes Alpes trend parallel to regional lineament sets throughout other parts of the terra, hence rotation of these masses at the time of their uplift was probably slight.

Two hilly units were probably formed at the time the Imbrium basin was created. The first, the Alpes Formation (Page, 1970), is thought to be composed mainly of deformed terra, mixed with and mantled by a relatively thin blanket of ejecta from the Imbrium basin. The finely lineated texture and high albedo of the hills in the Alpes Formation near Montes Alpes suggests that they are smaller analogs of the pre-Imbrian mountains, having shapes largely controlled by similar lineament directions. Although a continuous blanket of impact ejecta from the Imbrium basin would be expected to be deposited throughout the quadrangle, it may have been disrupted and shed from the hills by post-impact slump of the terra ring toward the basin center, with concomitant basement rock movements along numerous fractures, an explanation advanced by McCauley for similar terrain in Montes Rook of the Orientale basin (1968; oral commun., 1970). Level surfaces between the hills of the Alpes Formation, if not Imbrium basin ejecta, could be regolith developed on bedrock.

In the terra north of Mare Frigoris, the smaller size and greater spacing of the hills and the generally smoother appearance and lower albedo of the surface suggest the presence of a thicker and more continuous blanket of Imbrium ejecta than in the south. The thickness also appears to increase toward the west, where material intermediate between the Alpes Formation and the Fra Mauro Formation mapped in the J. Herschel quadrangle (Ulrich, 1969) is mapped in the Plato quadrangle as a second hilly unit, the Alpes-Fra Mauro Formations undivided. The asymmetrical distribution of the Imbrium ejecta is apparently an original depositional feature.

PLAINS, MARE, AND MANTLING UNITS

Flat, smooth light-colored plains and dark-colored materials occupy many depressions in the quadrangle, including mare basins and low areas on the terra. The mare units (EIm, Im) and light plains units (Ip_1, Ip_2) are distinguished on the basis of superposition relations, albedo, and crater density. The mare units are probably younger than the plains units. Patches of the younger plains unit both predate and postdate the Plato cratering event, and this unit may be gradational with the older plains unit, which predates the formation of the Iridum crater and Plato. The plains materials are believed to be volcanic flows, because they intricately embay, or terminate abruptly against, somewhat higher terrain and appear to completely obscure underlying topography. Some contacts with other units are not distinct, however, and indicate that the plains units may also include pyroclastic material.

Mantling units include a dark unit (shown by hachures) and a hilly lighter unit (It). Their surfaces apparently reflect underlying topography, but both units seem to have a leveling or smoothing effect. The hilly unit seems to be overlapped by the older plains unit in the southeastern part of the quadrangle, but covers the Alpes Formation. Some occurrences of the dark unit appear to overlie Plato ejecta. Both of the mantling units are interpreted as volcanic materials, probably pyroclastics. However, the hilly unit could be a local facies of Imbrium basin ejecta.

CRATER UNITS

Most of the larger craters in the quadrangle are probably of primary impact origin, as indicated by irregular, hummocky to radial rim morphology, interior slump features, and surrounding satellitic crater fields and rays (Shoemaker, 1962; Smith, 1966). The satellitic craters (units Esc, Isc, Iisc), occurring in clusters or having irregular outlines, are interpreted as formed by secondary impact of ejecta from larger primary craters. Craters are assigned ages on the basis of the presence or absence of rays, the relation to other stratigraphic units, and degree of crater degradation. Differences in detail of mapped morphologic subunits is dependent primarily upon crater size; in the larger craters more subunits are mappable than in the smaller craters. Plato, the largest crater in the quadrangle (100 km rim crest diameter), has a morphology and satellitic crater field typical of large impact craters elsewhere on the Moon.

Most craters with dark halos (Ccd) are thought to be volcanic in origin and relatively young, since the halos interrupt Copernican rays. Many chain craters (ch) and shallow depressions may also be of volcanic origin.

STRUCTURE

REGIONAL CONCENTRIC STRUCTURE

The second and third terra rings concentric with the Imbrium basin, which include Montes Alpes and the terra north of Mare Frigoris, respectively, are elevated on their basinward (southern) sides. The inner margin of the second ring is marked by a prominent scarp near Montes Alpes, which disappears westward under Plato ejecta.

If the surface elevations of Mare Frigoris and Mare Imbrium are about the same throughout the quadrangle, as is suggested in stereoscopic views of the embayed terra west of the crater Plato, then the different amounts of terra surface emergent indicate that the Imbrium terra rings, like those of the Orientale basin, lie at progressively lower elevations toward the basin center.

LINEAR TERRA STRUCTURES

Over 900 lineament and fault trends in the terra of the quadrangle were measured in an attempt to determine which trends are related to Imbrium basin structures (Hartmann, 1963) and which to the "lunar grid" (Strom, 1964). Results are presented as rose diagrams in figure 1, for measurements made in each of five sub-areas in the quadrangle, and in figure 2 for all the measurements. The data are interpreted as showing that:

1. About 17 percent of the lineaments and faults, the cluster from N. 20° to 45° E. in figure 2, are radial to the Imbrium basin and are probably genetically related to it.
2. Relatively few lineaments and faults on the terra are concentric with the Imbrium basin (N. 35° to 90° W. and N. 75° to 90° E., fig. 2).
3. "Lunar grid" trends are strongly represented throughout the quadrangle by lineaments and faults; these appear in figure 2 as the trends clustered from N. 20° to 35° W. and N. 50° to 75° E. These directions are almost in concentric and radial orientations, respectively, to the Imbrium basin in the eastern half of the quadrangle. The northwest set has a more northerly trend in the Plato quadrangle than the average of the "lunar grid" over the whole of the Moon's northern hemisphere (Strom, 1964); an explanation is not evident.
4. Northerly lineament and fault trends exist in all sectors measured, and are shown in figure 2 in the peaks at N. 10° to 15° W., N. 5° W. to N. 5° E., and N. 10° to 15° E.

These data can best be explained by postulating the presence of sets of fractures or lines of weakness in northwesterly, east-northeasterly, and northerly directions prior to the formation of the Imbrium basin. During the impact event and subsequent formation of the ring structure, much of the stress was relieved along these pre-existing lines of weakness, so that only a moderate number of new radial fractures and few new concentric fractures were produced.

The Vallis Alpes is interpreted as a graben, down-dropped along faults belonging to Imbrium radial, east-northeast, and other fracture sets.

MARE RIDGES

The trends of the ridges vary throughout the quadrangle but tend to be concentrated in the N. 30° to 40° E. and N. 40° to 55° W. sectors; thus, they may have formed largely along lines of weakness oriented radially and concentrically to the Imbrium basin.

GEOLOGIC ATLAS OF THE MOON
PLATO QUADRANGLE
I–701 (LAC–12)

PLATO CRATER STRUCTURES

The impact which formed Plato and its ejecta blanket also deformed the surrounding bedrock by vertical movements, both concentric and radial to the crater and along pre-existing lineaments and faults. Closely spaced radial lineaments in the hummocky and lineated unit (Icrl) occur in many places along the rim crest. Post-cratering slump, mainly along earlier fracture trends, produced the present polygonal crater rim crest. Farther outward from the rim crest, the cratering produced few new lineament trends. Linear depressions and ridges in the outer, radially distributed ejecta blanket (Icrr) are partly reflections of lineaments in underlying units and partly primary depositional patterns. Both the depositional lineaments and ridges in the ejecta blanket and elongate crater clusters in the secondary crater field produce a "herringbone" pattern, the trends of which are roughly parallel with regional lineament and fault trends seen in older terra units. Uplift and fracturing of the terrain north of Plato along the regional lines of weakness, at some time prior to Plato ejecta deposition, is believed responsible for local enhancement of lineaments in units now covered by the radial rim material.

SUMMARY OF GEOLOGIC HISTORY

Most of the decipherable geologic history of the Plato quadrangle extends from the Imbrian to Copernican Periods. The pre-Imbrian record is obscured by ejecta and structural deformation associated with the formation of the Imbrium basin, but outlines of old craters and regional lineaments in the pre-Imbrian rocks are still visible.

The sequence of major Imbrian and later events in the Plato quadrangle is interpreted as follows:

1. Formation, presumably by impact, of the multi-ringed Imbrium basin. Fracturing and faulting of pre-Imbrian rocks in directions concentric and radial to the basin, in part along older reactivated fractures, produced relative uplift of Montes Recti, Teneriffe, and Alpes, some mountainous relief in the terra north of Mare Frigoris, and finer scale, blocky relief in the Alpes Formation. Ejecta from the Imbrium basin was deposited over most of the quadrangle at this time, more thickly in the west than in the east.
2. Deposition of the hilly terra unit (It) over parts of the Alpes Formation.
3. Formation of the Vallis Alpes by down-faulting, probably after deposition of the hilly terra unit and before deposition of the younger plains unit in the valley bottom.
4. Deposition of the older plains unit in low areas along the edges of the present highlands and, possibly more extensively, as early basin-filling in Mare Frigoris and Mare Imbrium.
5. Formation by impact of the Iridum crater (the crater in which the mare material of Sinus Iridum lies, west-southwest of quadrangle; Schaber, 1969; Ulrich, 1969), deposition of Iridum ejecta, and formation of Iridum secondary craters in the western part of quadrangle.
6. Beginning of deposition of younger plains unit in local areas.
7. Impact forming crater Plato.
8. Deposition of terra mantling unit near Plato, completion of deposition of younger plains unit in local areas, and formation of large sinuous rilles on the rim of Plato.
9. Deposition of Imbrian mare unit over much of present mare areas and production of mare ridges.
10. Local deposition of younger mare unit.
11. Formation of Eratosthenian secondary craters, mostly from the crater Aristoteles east of quadrangle.
12. Wide distribution of Copernican ray material over quadrangle. Some small Copernican craters were formed throughout quadrangle at this time; presumably rayed craters have continued to form until the present.
13. Formation of dark halo craters by volcanism or impact.

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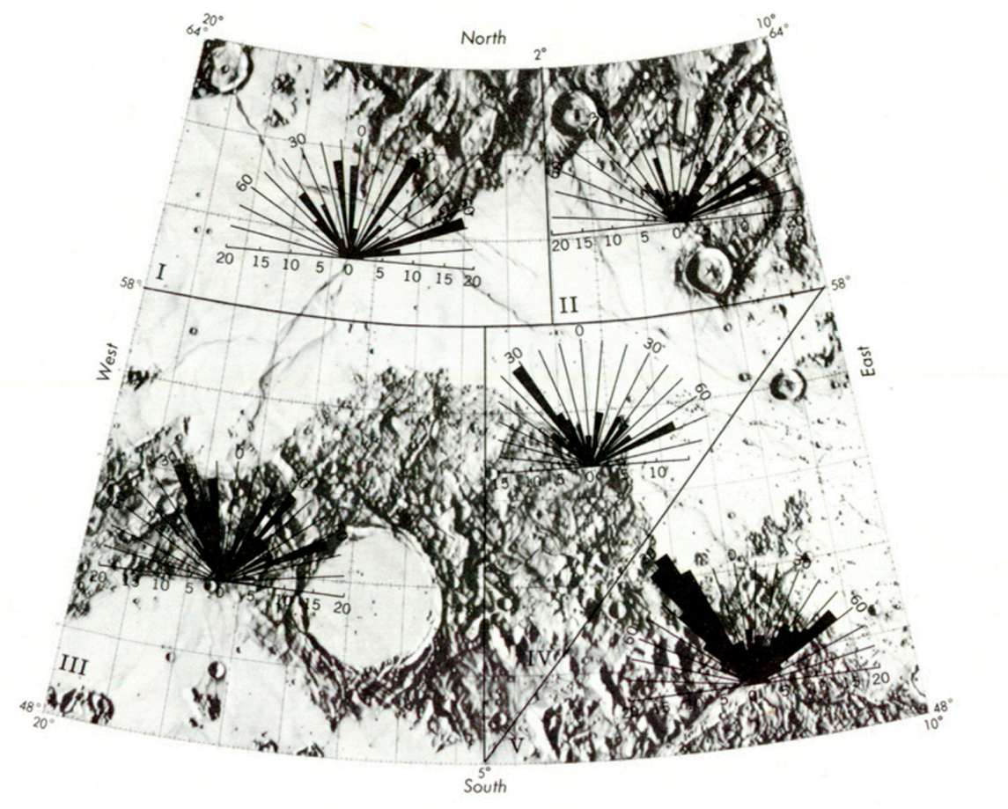

FIGURE 1—Azimuth frequency of lineaments in five areas in the Plato quadrangle

Lineaments and faults in the Plato quadrangle
920 measurements

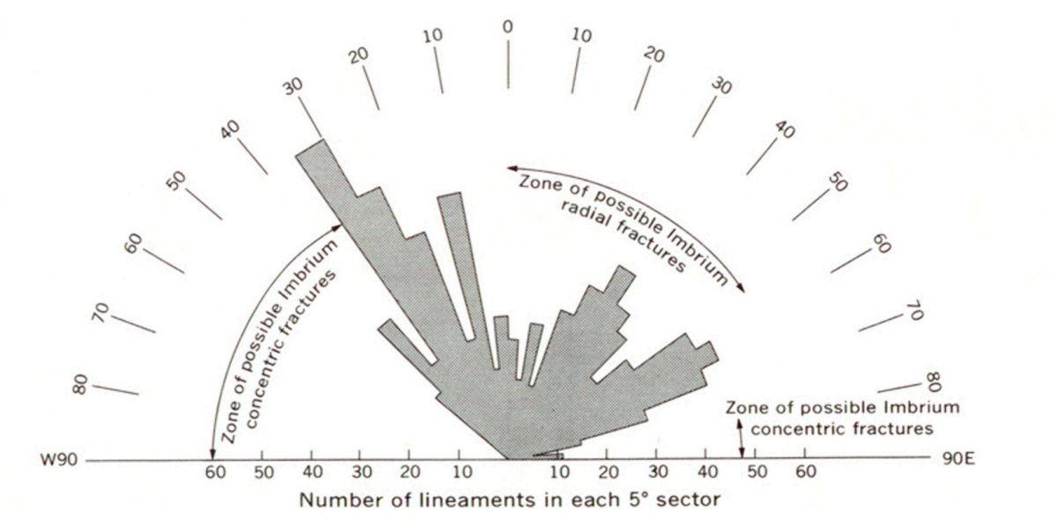

FIGURE 2—*Azimuth frequency of lineaments in the Plato quadrangle*

UNITS NOT ASSIGNED AGES

Upper age limit not known; lower limit shown by superposition relations of individual occurrences

mr

Mare ridge

Characteristics
Curvilinear or sinuous ridge, commonly of great length in Mare Frigoris, locally flat or irregular on top. Line marks approximate crest; in detail crest and ridge commonly made up of short, straight linear segments. Colored where especially wide and conspicuous
Interpretation
Volcanic extrusion along structurally-controlled fissures. Ridges probably follow regional lines of weakness similar to lineaments in the terra. May be younger than mare units, or may be source vents for some mare materials

ch

Chain crater material

Characteristics
Linear depressions or troughs having scalloped edges, and rimless to low-rimmed alined overlapping craters. Albedo intermediate to high
Interpretation
Volcanic craters and collapse depressions. Some linear overlapping craters may be secondary impact craters

Rille (sr, wide sinuous rille)

Characteristics
Linear or sinuous generally narrow depression; crater commonly at one end. Where well exposed, walls are steep and smooth; albedo intermediate
Interpretation
Linear rilles: grabens or fault-controlled volcanic collapse features. Sinuous rilles: may be erosion channels cut by ash flows or collapsed lava tubes

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Contact

Dashed where approximately located, gradational, or transitional; queried where indefinitely located

(pIu)

Concealed unit

Dotted line shows limit of topographically expressed part of apparently buried unit. Concealed unit identified by symbol in parentheses

Fault

Dashed where approximately located, dotted where concealed. Bar and ball on apparent downthrown side. Indicates offset unit or scarp against which younger rocks deposited. In craters, drawn along top and sides of slump blocks

Very subdued crater remnant

Line indicates rim crest. Queried where uncertain

Scarp

Break in slope, dashed where approximately located. Line marks base of slope; barbs point downslope. Interpretation: fault or volcanic flow front

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Lineament

Shallow linear depression or dark line in terra. Interpretation: fault, joint, or fracture zone

Shallow depression

Low depression in Vallis Alpes area and near Rima Plato II. Marked by circular lineament pattern and low incomplete circular rim; otherwise similar to surrounding terrain. Interpretation: Nearly filled impact crater or volcanic vent

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