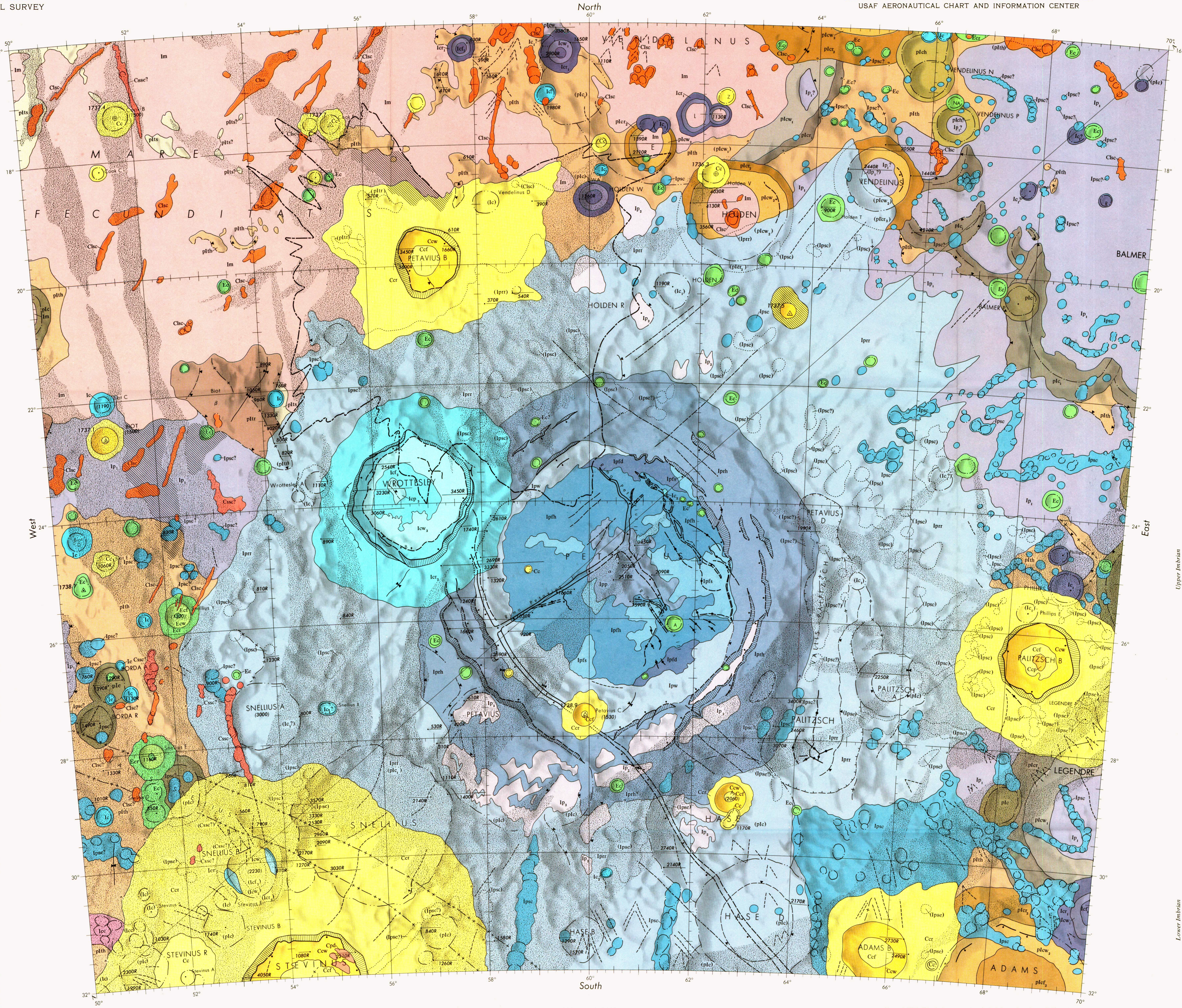
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

GEOLOGIC ATLAS OF THE MOON
PETAVIUS QUADRANGLE
I–794 (LAC 98)



Lunar base chart LAC 98, 1st edition, 1966, 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'

10 5 0 STATUTE MILES 50 100

10 5 0 KILOMETERS 50 100 150

Mapped 1971. Principal sources of geologic information: Lunar Orbiter photographs, as shown on index map; high illumination photographs 5818 and 8288 F, 61-inch reflector, U.S. Naval Observatory; low illumination photographs, 61-inch reflector, Catalina Observatory, University of Arizona (Kuiper and others, 1967); Apollo 8 frames 2484-2485; thermal data from Shorthill and Saari (1969); numerical albedo data from Pohn, Wildey, and Sutton (1970). Preliminary geologic maps were made by D.E. Wilhelms (1965) and E.A. Holm

Prepared on behalf of the National Aeronautics and Space Administration under contract No. W-13,130

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 ⚠ *1737.1*
Depths of craters (rim to floor) . . . . *(1500)*
Relative elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated *610R*

NAMES

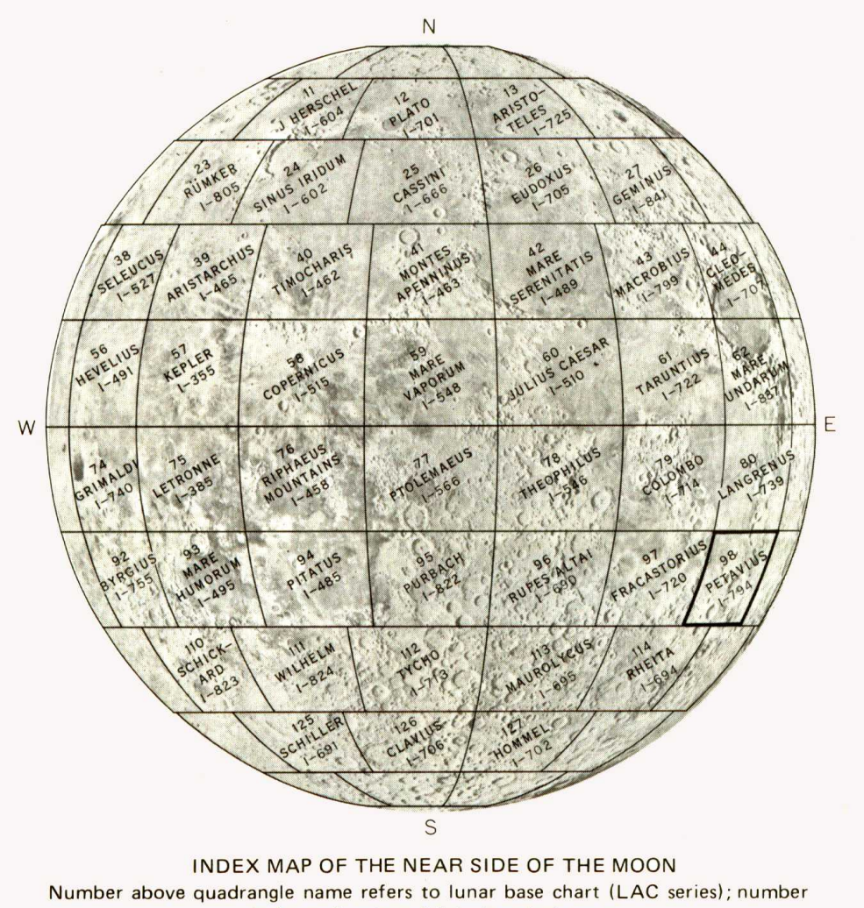
Feature names were adopted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the I.A.U., 1961 and 1964.

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.

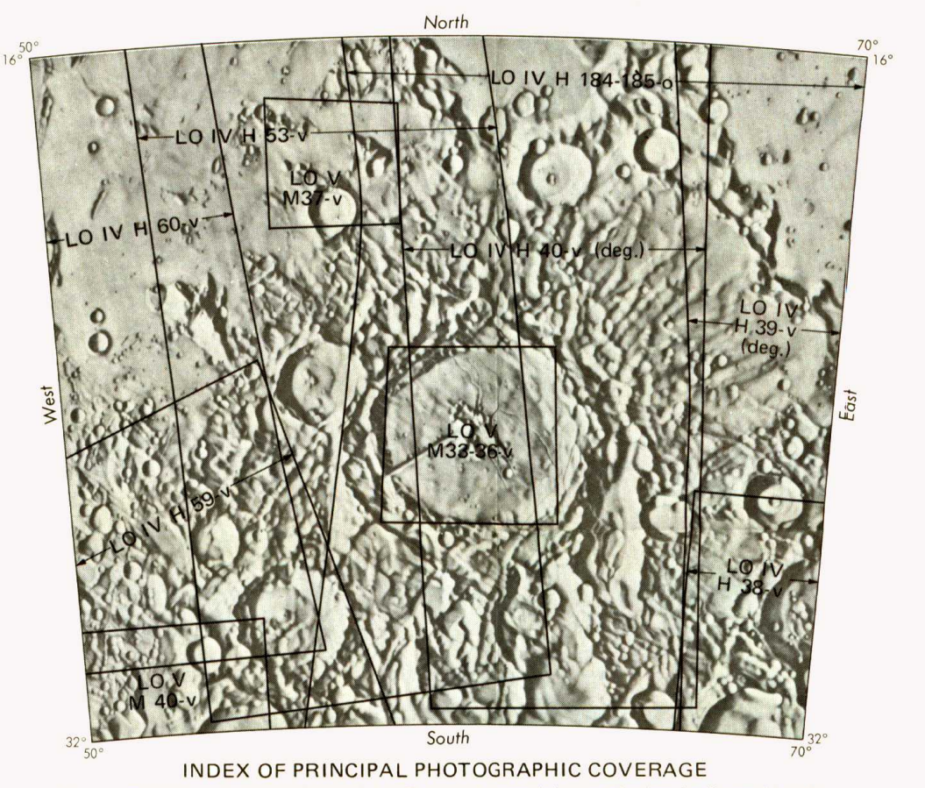
Names of the supplementary lettered features are deleted when the association with the named feature is apparent. A black dot is included, where necessary, to identify the exact feature or features named.

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.



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



INDEX OF PRINCIPAL PHOTOGRAPHIC COVERAGE
Lunar Orbiter mission indicated by Roman numerials; resolution indicated by H (high) or M (medium); frame numbers indicated by Arabic numerals; vertical or oblique angle of view indicated by v or o; badly degraded photographs so designated (deg.); entire quadrangle covered by earthbased telescopic photographs, Lunar Orbiter IV medium resolution frames, and whole Moon photographs from Apollo 8

Contact
Queried where doubtful; dotted where buried; limit of buried unit, indicated in parentheses, inferred on basis of topographic expression

Laterally gradational contact
Shown only in cross section

Fault
Line at base of sharp scarp; dashed where questionable, dotted where buried; bar and ball on downthrown side; narrow graben indicated by ball between closely spaced lines; furrow indicated by ball on line; coincident with contact at some places

Major lineament
Subdued ridges, troughs or ledges in conspicuous alinement

Textural lineament
Narrow, shallow groove or low ridge, associated mainly with radial texture of rim materials around Petavius and Copernican craters; commonly forming V-shaped "herringbone" pattern; some grooves formed by chains of very small or indistinct craters

Vallis Snellius
Subdued, parallel rims of long, narrow, shallow valley extending across southwest corner of map; best observed on earth-based photographs; oriented radial to Nectaris basin to west; discontinuous offset at distal end southeast of map area

base crest
Scarp
Line along base or crest, whichever more obvious, of prominent scarp; dashed where approximate or buried; Vallis Palitzsch indicated by crest symbol

Terra ridge
Line along crest of prominent ridge in highlands
Interpretation: *Tectonic feature, or possibly old crater rim segments so degraded as to be unrecognizable*

Trough
Line along axis of depression in terra materials; no genetic connotation implied

Concealed crater rim
Crater rim crests recognized topographically but mantled by younger material; crater age shown in parentheses where estimate reasonably certain, but geologic units not subdivided unless obvious topographically

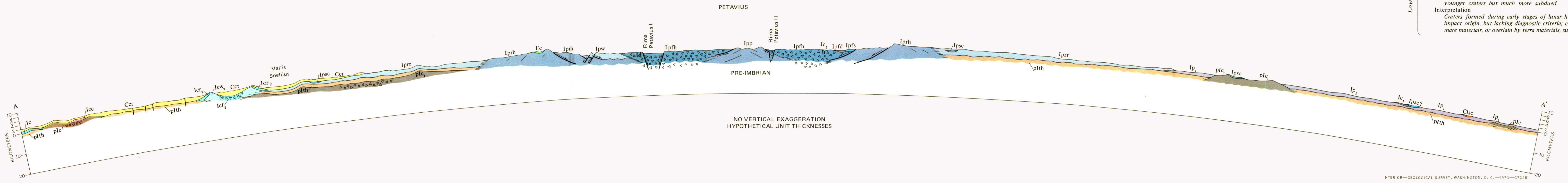
Rim crest within geologic unit
Generally confined to small or old craters where materials not subdivided

Limit of Petavius B texture
Approximate limit of high concentration of small craters, commonly in distinct herringbone pattern or alinement radial to Petavius B; mainly negative topography
Interpretation: *Surface texture attributed to effects of Petavius B ejecta but not part of continuous ejecta blanket*

Scarp within crater
Prominent scarp, with albedo slightly higher than that of adjacent materials, exposed on interior walls of large craters of Imbrian age or younger; fault indicated at base; most common at rim crests, but also on interior walls of terrace blocks in Petavius
Interpretation: *Bedrock and rim materials exposed by interior slumping of crater walls*

Dark material
Rim material of dark halo crater, and patches of terra, plains, and ejecta materials having exceptionally low albedo
Interpretation: *Problematic origin; possibly material with high concentration of dark minerals, dispersed uniformly by impact comminution and vitrification (Adams and McCord, 1972)*

Breccia lens
Shown interpretively in cross section beneath crater floors to represent breccia produced by crater-forming impact



NO VERTICAL EXAGGERATION
HYPOTHETICAL UNIT THICKNESSES

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1973—G72481

GEOLOGIC MAP OF THE PETAVIUS QUADRANGLE OF THE MOON

By
Carroll Ann Hodges
1973

EXPLANATION

COPERNICAN SYSTEM

Cpd
Dark plains material
Characteristics
Small flat patches of material isolated among blocks of wall material in crater Stevinus
Interpretation
Post-crater volcanic materials erupted along fractures produced by Stevinus impact

Cc Ccr Ccw Ccf Ccp
Crater materials
Characteristics
Walls and rims of moderate to high albedo, surrounded by ray material; high thermal anomalies at eclipse usually associated with those craters large enough (generally >10 km) to be resolved by infrared scan; craters <3-4 km in diameter not mapped unless isolated and therefore "landmarks"
Cc, *crater materials, undivided. Small craters (generally <10 km) with conical to bowl-shaped interiors, lacking well-defined floors; topographically sharp; subdivided morphologically in larger craters as follows:*
Ccr, *rim material. Generally hummocky around rim crest, with positive relief decreasing progressively outward; radial texture and small satellitic crater chains common in materials around largest craters*
Ccw, *wall material. Bright slopes of steep crater interiors; generally smooth*
Ccf, *floor material. Central flat or slightly convex surface adjoining crater wall with sharp break in slope; both smooth and hummocky materials exposed on floor of crater Stevinus*
Ccp, *peak material. Chaotic jumble of blocks forming central peak within Palitzsch B*
Interpretation
Impact origin of craters suggested by hummocky rim structure, circular symmetry, presence of rays, radial texture, and satellitic craters; high thermal anomalies probably due to exposures of fresh rocks (Shorthill and Saari, 1969); surficial rim materials deposited ballistically, but most visible relief probably due to block and thrust faulting of bedrock; extensive scarps apparently formed by cohesive bedrock exposures; wall materials composed of colluvium and talus; floor materials (both smooth and hummocky) probably a mixture of colluvium, bedrock breccia resulting from impact, and fallback; peak materials likely composed of uplifted bedrock

Clsc Cssc
Satellitic crater materials
Characteristics
Materials of small shallow craters, commonly elongate, overlapping, or alined in chains radial to an identifiable parent crater; clusters, chains, and individuals mapped; prominent crater rim crests within clusters or chains indicated by partial circle and dot
Clsc, *Langrenus satellitic crater material. Orientation radial to Langrenus*
Cssc, *Stevinus satellitic crater material. Orientation radial to Stevinus*
Interpretation
Secondary craters formed by impact of ejecta from Langrenus and Stevinus

Ray material
Characteristics
High albedo relative to adjacent materials; occurring in radial streaks or halos around Copernican craters; highest albedo around topographically sharpest craters; no visible relief; partly coincident with Langrenus and Stevinus satellitic craters; particularly conspicuous around Petavius B because of asymmetry, but also notable around Palitzsch B, Adams B, Stevinus, Stevinus A, and Furnerius C (just south of map area)
Interpretation
High albedo related to young ejecta, associated with chains and swarms of secondary or tertiary impact craters of large primary craters

ERATOSTHENIAN SYSTEM

Ec Ecr Ecw Ecf
Crater materials
Characteristics
Materials of sharp-rimmed craters, with moderate to moderately low albedo and thermal anomalies at eclipse; subdivisions similar to corresponding Copernican units, but generally somewhat more subdued; rays absent; craters <3-4 km in diameter generally not mapped unless isolated
Interpretation
Impact origin suggested by similarities to Copernican craters with characteristics most satisfactorily explained by impact hypothesis; rays believed to have been present originally but to have darkened since formation; reduced thermal anomaly at eclipse attributed to gradual insulation of fresh bedrock by surficial disintegration in place or accumulation of younger material; topographic subdivisions genetically analogous to corresponding Copernican units

IMBRIAN SYSTEM

Im
Mare material
Characteristics
Level plains material with low to moderately low albedo, occupying topographic depressions; fewer superposed craters than in terrae, excluding areas covered by Langrenus satellitic craters; scalloped embayments around terra materials and some Imbrian craters; isolated mounds and ridges, possibly covered in part by mare material, mapped as terra units
Interpretation
Volcanic materials, mainly flows of basaltic composition, possibly interlayered with pyroclastic materials; fluid emplacement and relative age indicated by embayment relations

Upper Imbrian

Ic_2 Icr_2 Icw_2 Icf_2 Icp_2
Crater materials
Characteristics
Materials of craters with prominent rim crests and smooth or slightly hummocky but subdued flanks; texture not well defined in rim material; low frequency of superposed craters; subdivisions similar topographically to corresponding units of Copernican and and Eratosthenian age, but more subdued; rays absent; superposed on Petavius rim materials; best represented by Wrottesley
Interpretation
Origin unknown but impact suggested by approximate general resemblance to younger craters of apparent impact origin; subdivided units genetically analogous to corresponding Copernican and Eratosthenian units; post-Petavius age indicated by superposition on Petavius ejecta

Ip_2
Plains material
Characteristics
Smooth flat material of limited extent occurring on terraces within Petavius and in depressions on rim materials; numerous small superposed craters; albedo higher than that of mare materials
Interpretation
Possibly volcanic; genetic relation to Petavius suggested by localization in and around that crater, but younger age indicated by superposition; volcanism possibly generated by impact which formed Petavius. Alternatively, debris mass wasted from slopes around local depressions

Ic
Crater material
Characteristics
Material of craters with raised but subdued rim crests and smooth flanks; rays absent; few superposed craters; generally <10 km in diameter; mapped outside Petavius rim material
Interpretation
Origin unknown, but impact suggested by approximate circularity and general resemblance to younger craters of apparent impact origin; assignment to upper or lower Imbrian prevented by lack of association with Petavius materials and small size

Lower Imbrian

Iprr Iprh Ipw Ipfs Ipfh Ipfd Ipp
Materials of crater Petavius
Characteristics
Topographic detail moderately subdued; rays absent; subdivided on basis of distinctive morphology and surface texture
Iprr, *rim materials, radial. Exterior to and laterally gradational with unit* Iprh; *subdued herringbone pattern apparent, formed by grooves and ridges in V-shaped arrangement radial to crater, but intrinsic relief less than that of unit* Iprh; *outermost limit drawn at inferred boundary between continuous rim deposits and apparently unburied terrain, characterized on the east by unit* Ipsc
Iprh, *rim materials, hummocky. Irregular blocky collar of materials with high relief; large coherent segments of crater interior terraces included because of similar appearance*
Ipw, *wall material. Chaotic blocks forming talus-like accumulation along basal part of interior crater wall; several bulbous or dome-shaped structures also included*
Ipfs, *floor material, smooth. Part of crater floor having approximately level surface and moderate, slightly mottled albedo*
Ipfh, *floor material, hummocky. Crater floor material having blocky texture and uneven relief, with moderate albedo*
Ipfd, *floor material, dark. Somewhat arcuate patches of relatively smooth material, having moderately low albedo, at north and south margins of crater floor; hummocky in part*
Ipp, *peak material. Chaotic jumble of large blocks forming rugged central peak with maximum relief about 2500 m above crater floor; high albedo, moderate thermal anomaly; transected by faults; individual large blocks and outcrop ledges readily identified on moderate- and high-resolution Lunar Orbiter V photographs*
Interpretation
Impact origin suggested by hummocky rim collar, irregular central peak, radial array of apparently contemporaneous satellitic craters, and "herringbone" texture of rim materials; approximate mid-Imbrian age indicated by morphologic comparison with type crater series (Pohn and Offield, 1970), lack of rays, lack of thermal anomaly, and presence of secondary craters on plains (Ip_1) *but not on mare* (Im)
Iprr, *ejecta deposited ballistically or as ground-hugging cloud of poorly sorted debris moving rapidly as a unit downslope; "herringbone" texture likely formed by ridges or "dunes"*
Iprh, *structurally disturbed bedrock, including pre-Imbrian materials, in probable thrust slices and fault blocks, mantled in part by fine ejecta; gradational outward with unit* Iprr *and downward with undisturbed bedrock; terraces within Petavius probably formed by cohesive fault blocks of same material*
Ipw, *bedrock blocks and talus material, probably derived from fractured rim materials; bulbous and dome-shaped structures possibly volcanic*
Ipfs, *fine debris, possibly mass wasted from slopes adjacent to topographic lows; alternatively, initially fluid or pyroclastic volcanic material*
Ipfh, *bedrock blocks disrupted by impact*
Ipfd, *probably basaltic lava, and possibly pyroclastic material, as suggested by low albedo. Initial fluid state of north patch indicated by flat surface, crescentic shape conformable with crater wall, and lower elevation; dark mantle over north end of fractured ridge possibly remnant from initially higher level of lava prior to solidification. Uneven surface of south exposure possibly a result of early higher fluid level or mantling of subjacent topography by pyroclastic debris. Probably similar in composition to mare material but thinner, as suggested by irregular texture*
Ipp, *brecciated bedrock, including pre-Imbrian materials, derived from considerable depth; probably formed in response to deformation caused by impact (Dence, 1968); upward movement of materials from depth thought related to inward slumping of blocks along walls (Wilshire and others, in press); probably gradational at depth with undisturbed bedrock; thermal anomaly probably caused by rock exposures (Shorthill and Saari, 1969)*

Ipsc
Petavius satellitic crater material
Characteristics
Material of small shallow craters, commonly elongate, overlapping, and alined radial to Petavius; rim crests generally subdued; clusters, chains, and individuals mapped, and prominent crater rim crests within clusters indicated by partial circle and dot; two unusually deep chains south of Petavius. Some craters within Petavius radial facies exceptionally subdued and shown by dotted contact
Interpretation
Secondary craters formed by impact of ejecta from Petavius; origin suggested by generally shallow depth, elongation, proximity to and radial alinement toward Petavius; structural control possibly associated with deep chains. Craters shown as buried apparently overrun by Petavius ejecta

Ic_1 Icr_1 Icw_1 Icf_1
Crater materials
Characteristics
Materials of craters with distinct rim crests but smooth, subdued rim materials; moderately high density of superposed small craters; some craters apparently buried by Petavius rim materials; subdivisions similar topographically to corresponding units of Copernican and Eratosthenian age but more subdued; rays absent
Interpretation
Origin unknown, but probability of impact suggested by lack of recognizable evidence for volcanism, together with the greater abundance of impact as opposed to volcanic craters in Eratosthenian and Copernican Systems (Wilhelms and McCauley, 1971); subdivided units genetically analogous to corresponding Copernican and Eratosthenian units; pre-Petavius age inferred from apparent superposition of Petavius materials

Ip_1
Plains material
Characteristics
Smooth level terrain, bounded by large arcuate escarpments in northeast part of map area; also adjacent to south margin of Mare Fecunditatis in west central part; density of superposed craters higher than on mare; moderate albedo
Interpretation
Possible formation as fluid or semi-fluid volcanic material suggested by lateral extent, sharp contacts with escarpments, and flat surface; pre-Petavius age indicated by superposition of secondary craters of Petavius; pre-mare age indicated by higher crater density and apparent embayment by Mare Fecunditatis; considered lower Imbrian in this quadrangle; possibly equivalent to Cayley Formation mapped elsewhere (Morris and Wilhelms, 1967)

Icc
Crater cluster material
Characteristics
Material of shallow elongate craters, 5-8 km in long dimension; long axis of cluster approximately parallel to Imbrium sculpture; moderately subdued rim crests, indicated by partial circle and dot
Interpretation
Possibly secondary craters formed by ejecta from Imbrium basin, as suggested by shape, orientation, and distance from that basin; similar to Imbrium secondary craters described elsewhere (Scott, 1972)

PRE-IMBRIAN

Middle and upper pre-Imbrian

pIcr_2 pIcw_2 pIcf_2
Crater materials
Characteristics
Rim crests subdued and cratered; slumped, hummocky walls lacking well defined terraces and escarpments; rim materials not distinct; subdivisions analogous topographically to corresponding units of younger craters but considerably more subdued
Interpretation
Origin unknown but subdivisions believed genetically similar to corresponding units of younger impact craters; no evidence of volcanic origin, but interpretive criteria obliterated by degradation; probably younger than Nectaris basin, as implied by apparent superposition on terra materials

pIch
Crater chain material
Characteristics
Two shallow, circular, overlapping craters at northeast border of map forming south end of a series of seven such craters beginning southeast of crater Langrenus, north of quadrangle; smooth rim flanks; progressive decrease in rim crest diameters (30-20 km) southward; consistent northward overlap relations; queried on single detached crater with similar morphology immediately southeast of chain
Interpretation
Secondary craters formed by ejecta from large multi-ring Crisium impact basin, about 800 km north of map border; secondary origin suggested by alinement, shallow depth, consistent "uprange" overlap, size, and apparent age

Lower pre-Imbrian

pIc_1 pIcr_1 pIcw_1
Crater materials
Characteristics
Rim crests rounded and subdued; commonly mantled by other units or interrupted by numerous superposed craters; hummocky wall materials with no well defined interior terraces; subdivisions analogous topographically to corresponding units of younger craters but much more subdued
Interpretation
Craters formed during early stages of lunar history; generally large, and believed of impact origin, but lacking diagnostic criteria; commonly flooded by younger plains or mare materials, or overlain by terra materials, suggesting a pre-Nectaris age

pIc
Crater material
Characteristics
Rim crests subdued and commonly somewhat polygonal; many craters obscured by terra material or Petavius rim materials and therefore shown only as buried rim crests
Interpretation
Craters of probable pre-Imbrian age; impact origin assumed, but distinctive characteristics generally obliterated by overlying materials

pIts pIth pItr
Terra materials
Characteristics
Highland terrain characterized by numerous superposed craters as well as subdued, apparently mantled crater rims
pIts, *terra material, smooth. Highly subdued surface of low relief with smoothed and rounded topographic irregularities*
pIth, *terra material, hummocky. Undulating surface of moderate relief*
pItr, *terra material, rugged. Moderately sharp topography characterized by irregular slopes and significant relief*
Interpretation
Smooth material, probably mantle of variable thickness, composed largely of impact ejecta from many sources; hummocky material probably composed of ejecta as well as disrupted bedrock (partially equivalent to pre-Imbrian terra mapped in adjacent Langrenus quadrangle); rugged unit probably composed of pre-Imbrian bedrock and megabreccias, possibly incorporating early differentiates of lunar crust in fault blocks and crater rims

NOTE: Albedo data are based on map by Pohn, Wildey, and Sutton (1970); qualitative terms used herein have been applied arbitrarily to the numerical scale as follows: very low - .069-.079; low - .079-.096; moderately low - .096-.108; moderate - .108-.142, moderately high - .142-.159; high - .159-.192; very high - .192-.239.

GEOLOGIC SETTING

The large crater Petavius, about 180 km in diameter, is the dominant geologic feature within this quadrangle at the southeast border of Mare Fecunditatis, on the east limb of the near side.

Four categories of materials have been distinguished herein: (1) terrae, with rugged to gently rolling topography and moderate albedo; (2) plains, of low relief and moderate albedo; (3) craters, with low to rugged relief and low to high albedo; (4) maria, with essentially no relief and very low to moderately low albedo. Materials are placed in chronologic sequence according to stratigraphic position and(or) physical characteristics believed indicative of relative age. Development of the lunar time-stratigraphic nomenclature has been summarized by Wilhelms (1970).

Multi-ring impact basins provide a framework for much of the geologic history of the lunar near side. Mare Fecunditatis is believed to occupy one of the oldest of these large basins (Wilhelms and McCauley, 1971; McCauley and Scott, 1972) and is considered analogous genetically to the better preserved and presumably younger Imbrium and Orientale basins. Unlike the latter two, structural rings concentric to the Fecunditatis basin are not prominent and the mare borders are extremely irregular, but these differences can reasonably be attributed to effects of degradation with age. Other large impact basins whose formation likely influenced the early history of the Petavius quadrangle include Nectaris and Crisium, the centers of which are 800 km northwest and 1300 km north of the center of Petavius, respectively.

STRATIGRAPHY

Terra materials.—The highlands in this quadrangle are largely pre-Imbrian in age and probably are composed at depth of materials related to the Fecunditatis basin. Ejecta from Nectaris, Crisium, and smaller impact craters, and perhaps material from local volcanic sources, constitute most of the surficial terra materials. The terrae are presumably different in composition from the basaltic maria and may include early differentiates of the lunar crust, significantly brecciated and redistributed by cratering events of various sizes.

The terra units are subdivided according to textural differences. Smooth terra (pIts) may be primarily a mantling unit, consisting in large part of ejecta, subduing underlying structures. Hummocky terra (pIth) forms gently rolling topography and is interpreted as partly mantled bedrock and old crater rims. Rugged terra (pItr) comprises steep escarpments and ridges of high relief and consists primarily of faulted bedrock, disrupted by formation of the Fecunditatis basin and other early impact events.

Plains materials.—The northeast corner of the quadrangle is dominated by light plains material (Ip_1) which apparently flooded pre-existing crater depressions. This unit also occurs south of the mare in the west central map area, and may represent basin fill that preceded emplacement of mare materials. Superposed craters are more numerous on these plains than on the mare, indicating that the plains are probably older. The nearly level surfaces suggest, however, that modes of emplacement may have been similar, invloving fluid or semi-fluid materials in both cases.

Small patches of younger plains (Ip_2) are superposed on Petavius materials, perhaps as a result of volcanism related to the Petavius impact or possibly by mass wasting of debris into local depressions.

Mare materials.—Analyses of the core sample from Luna 16, an unmanned Soviet probe which landed at 0°41'S., 56°18'E., north of this quadrangle, indicate that Mare Fecunditatis is composed of basaltic materials (Vinogradov, 1971), similar to those of Apollo samples from maria elsewhere. K/Ar and Rb/Sr dating of a small fragment from the Luna 16 core indicates an approximate age of 3.4 AE for the basalt at that site (Huneke, Podosek, and Wasserburg, 1972). This is within the age range of Apollo specimens (Papanastassiou and Wasserburg, 1972), somewhat younger than those from Tranquillitatis (~3.65 AE, Apollo 11), but older than those from Procellarum (~3.3 AE, Apollo 12) and Imbrium (~3.3 AE, Apollo 15). On the relative time scale, the Fecunditatis materials belong to the uppermost part of the Imbrian System, to which absolute dates can now be applied.

Soil (regolith) samples from the Luna 16 core are dated radiometrically at ~4.1 to 4.2 AE (Papanastassiou and Wasserburg, 1972), in approximate accord with Apollo samples of regolith. The ages of unconsolidated material have consistently been older than the ages of rocks, presumably as a result of "contamination" by debris from the highlands, which probably comprise remnants of older lunar crust (Papanastassiou and Wasserburg, 1972). As for all maria, the basalt flows are believed considerably younger than the basin structures they occupy (Wilhelms and McCauley, 1971).

Crater materials.—Where stratigraphic data are lacking, probable impact crater materials are assigned approximate ages according to albedo and thermal properties as well as morphologic characteristics assumed to reflect a continuous rate of degradation with time (Pohn and Offield, 1970). Distinctive craters are discussed below.

Petavius is among the largest craters on the near side, and its general morphology is characteristic of typical impact craters. As in many large craters, such as Langrenus in the adjacent quadrangle, Petavius has apparently been enlarged by slumping, faulting, and fracturing of the rim materials (Iprh). A semi-continuous terrace arcs around part of the crater interior, but adjacent to Vallis Palitzsch, the wall consists of large chaotically arranged blocks and a distinct rim crest cannot be traced. The terraced and blocky materials which grade almost imperceptibly into the hummocky rim unit are mapped as the latter, inasmuch as they appear to be highly fractured and subsequently downfaulted rim segments. Thus, materials have not been divided at the rim crest into separate units; the term "wall material" (Ipw) is applied only to disrupted accumulations of talus on the lower slopes of the walls, and to conical and dome-shaped structures which may be volcanic and younger than Petavius. The rock exposed in both the rim and the central peak is probably pre-Imbrian, but it is assigned the apparent age of the event responsible for its present outcrop pattern.

The asymmetric distribution of satellitic craters (Ipsc) around Petavius may result in part from their greater prominence on plains than on terra materials, but assuming that these are secondary craters formed by ejecta from Petavius, a preferred distribution could have been imposed on that ejecta by an oblique impact (Moore, 1971). Two chains mapped as satellitic craters south of Petavius are exceptionally deep and are much closer to the crater rim than most well defined secondary chains. These features are similar to the radial sculpture around the Imbrium basin, commonly thought to reflect structural control, and the large impact which formed Petavius may have generated local radial faults. Despite their depth, these craters exhibit the elongate shape, overlap, and marginal V-shaped texture characteristic of secondary craters so that structural control is not conclusively demonstrated.

Rim materials of the crater Wrottesley, superposed on Petavius, probably consist mainly of reworked Petavius ejecta and therefore are practically indistinguishable from the latter. The lack of rays, thermal anomaly, radial texture, and recognizable secondary craters suggests that Wrottesley is as old as Imbrian, and its superposition on Petavius requires upper Imbrian (Ic_2) designation.

Faint rays are associated with Stevinus, but they are almost obscured by those from two tiny but very young craters on either side, one of which, Stevinus A, is in the southwest corner of the quadrangle. The large crater has a thermal anomaly which is prominent but lower than those of its two small neighbors. Stevinus is probably of early Copernican age, perhaps contemporary with Langrenus, secondary crater chains of which occur in the north part of the map area. Younger large impact craters of Copernican age include Adams B, Palitzsch B, and Petavius B. The rim materials of Petavius B display fine textural detail with lineations and secondary craters forming a conspicuous "herringbone" pattern. Its distinctive asymmetric ray pattern may have resulted from a low-angle meteorite impact (Moore, 1971).

STRUCTURE

Distinctive structures in this quadrangle include Vallis Snellius, Vallis Palitzsch, and the prominent Petavius rim faults and interior trenches. Vallis Snellius is a shallow trough-like feature 23 km wide and about 800 km long (Hartmann, 1964, p. 177), radial to the pre-Imbrian Nectaris multi-ring basin to the northwest. It is similar in length and width to Vallis Rheita, southwest of the Petavius quadrangle (Stuart-Alexander, 1972), but much shallower and more subdued topographically. Hartmann (1964, p.184-5), interpreted these troughs as graben which originated as a direct result of the impact which formed the Nectaris basin, and inferred that the distinct en echelon offset of the Snellius structure southeast of the map area precluded gouging by "flying fragments," the hypothesis suggested by Baldwin (1949, p. 44, 202-205, 215; 1963, p. 317-318, 330).

Vallis Snellius is bordered by slightly raised rims, subdued craters occur along it, and each of its en echelon segments terminates in a near-circular crater. The large crater Snellius appears to be older than the valley; its rim is displaced slightly inward and is more degraded where the valley strikes across it, whereas younger and smaller craters astride Vallis Snellius show no such distortion. Had vertical faulting been involved, the crater rim either would show no displacement, or with subsequent degradation, would be displaced outward. The apparent offset suggests that the rim may simply have been battered down by a stream of ejecta hurled from Nectaris. Furthermore, the depth and linear scarps of Vallis Rheita are not duplicated in Vallis Snellius, and the latter, therefore, may be best ascribed to sculpturing by "flying fragments," rather than subsidence along graben faults. This interpretation is shown on the cross section, where the valley is mapped as a topographic rather than structural feature.

Vallis Palitzsch, just east of the rim of Petavius, is an irregular depression about 150 km long, 10-40 km wide, and as much as 3,000 m deep. It is evidently older than Petavius, whose rim materials mantle but do not obliterate the depression. The trough may have been formed (1) by impact of an attenuated clot of ejecta from the Crisium impact basin, somewhat as the shallow chain craters at 66°E., 16°-17°S. (pIch) probably formed; (2) by impact of a disintegrating meteoritic or cometary body, as described by Sekiguchi (1970); or (3) by an internal mechanism. The second suggestion perhaps best accounts for the depth and lack of discrete crater morphology at this distance (1300 km) from Crisium. The rectilinear furrows in the south part of the valley floor perhaps suggest volcanism, but these furrows do not have the "turtle-back" pattern characteristic of many lava pools in lunar craters, and more likely are tectonic features, possibly rejuvenated by the Petavius impact.

The most conspicuous structural features of the crater Petavius are the internal, linear, graben-like rimae (rilles), and the two long, narrowly spaced faults which strike southeast across the west-south-west rim and extend a considerable distance beyond the map area. Rimae Petavius I, II, III form an interconnecting, triaxial system of trenches on the crater floor and transect the central peak; the linearity and steep walls of these trenches suggest that they are graben, the largest of which, Rima I, is over 1,000 m deep. A partly arcuate, partly angular fracture, which also appears fault-controlled, parallels Rimae II and III in the northeast quadrant of the crater floor and intersects the small patch of dark material at the base of the north wall. The faults postdate the central peak, and possibly resulted from gradual isostatic adjustment of the crater floor. A slight convexity of the floor is suggested by the somewhat crescentic shape of the north dark patch.

The two closely spaced normal faults, downthrown to the southwest, merge toward the southeast, outside the map area, with a long narrow graben of similar strike. Rima Petavius I intersects and offsets both these faults, and the rim materials of the crater Wrottesley appear to overlie them at their north ends. The faulting, of unknown cause, preceded both the Wrottesley impact and the isostatic adjustment of Petavius which probably produced the interior graben.

SUMMARY

Formation of three major impact basins apparently influenced the early geologic development of the Petavius quadrangle. First of these was Fecunditatis, whose outer structure probably underlies much of the terrae. Large degraded craters such as Snellius formed subsequently, followed by the Nectaris impact basin and its associated radial features, including Vallis Snellius. Crisium may be youngest of the three basins and is represented in this quadrangle by the terminus of a secondary crater chain and by ejecta forming at least parts of the smooth and hummocky terra materials.

Petavius apparently formed by impact during mid-Imbrian time, its ejecta blanketing much of the surrounding topography, including the early Imbrian light plains. Slumping and terracing of the rim material and uplift of the central peak probably occurred nearly instantaneously at the time of formation, and subsequent isostatic adjustment of the crater floor may have caused the triaxial graben system. Small patches of light plains and the dark floor units possibly represent volcanic materials erupted from fractures produced by the impact.

Formation of the crater Wrottesley and extrusion of the mare material occurred in late Imbrian time. Only small impact craters represent the Eratosthenian System; large Copernican craters include Stevinus, Adams B, Palitzsch B, and, probably youngest, Petavius B.

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