Plains-forming material

Sparsely to moderately cratered. Covers

floors of most early Imbrian and older

craters. Also fills some other depressions.

Contacts of many less cratered patches quite

Debris, ignimbrite, lava, or mixture of

these. May contain small amounts of both

pre-Imbrian and post-Imbrian plains

Plains-forming material

Similar to Imbrian

plains-forming material

except more highly

Debris, ignimbrite, lava,

or mixture of these.

May also include some

Contact

Dashed where approximately located or gradational

(all outer crater rim boundaries are gradational)

Buried contact

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

Inferred fault

Dashed where approximately located; dotted where

buried. Bar and ball on apparent downthrown

side. Offsets a unit or forms scarp against which

younger rocks are deposited. Ball on line indicates

narrow graben

younger deposits

Interpretation

Rolling terra material

Gently rolling, poorly

defined terrain with

minor weak linear

trends, some radial to

ing northeast. Queried

in crater Janssen where

identification uncertain

due to disruption by

nearby younger crater

Mixture of materials:

some may be reworked

original lunar material,

some may be volcanic,

all forming relatively

thin cover over the

Janssen Formation

Interpretation

Nectaris and some strik- Interpretation

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.

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

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 △

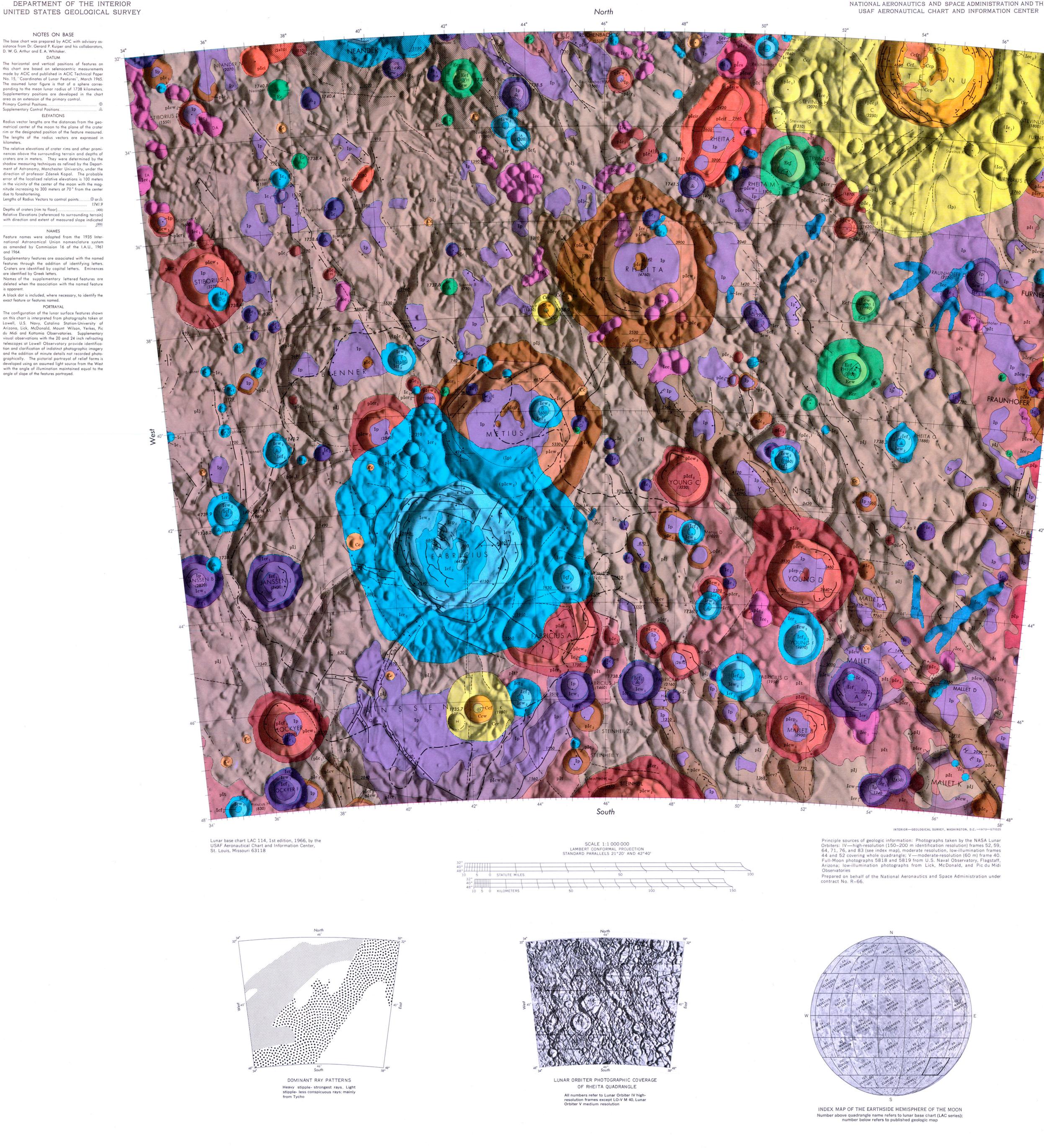
Depths of craters (rim to floor)..... Relative Elevations (referenced to surrounding terrain) with direction and extent of measured slope indicated

Feature names were adopted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the I.A.U., 1961 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 A black dot is included, where necessary, to identify the

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 photo graphically. 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.

exact feature or features named.



GEOLOGIC MAP OF THE RHEITA QUADRANGLE OF THE MOON

Desiree E. Stuart-Alexander

EXPLANATION

Cc, $crater\ material$, undivided. $Craters > 10\ km\ divided\ into:$

Material of rayed craters. Albedo generally high. Rim crests sharp, inside walls steep, and rim deposits extensive, up to one crater diameter width. Anomalously low cooling rates during penumbra in Stevinus, Janssen K, and Furnerius C (Shorthill and

Ccr, rim material. Forms relatively smooth surface near rim crest and slopes outward into faint radial pattern. Most of Stevinus material has high local relief near rim crest and thins outward into radial and faintly braided textures Ccw, wall material. Steep, smooth, non-terraced slopes and very high albedo inside smaller craters; highly terraced and albedo moderate to locally high in Stevinus Ccf, floor material. Nearly level floor having some sharp detail in Janssen K; in Stevinus mostly level but bumpy at a fine scale Ccfr, rugged floor material. Partly ridged in Stevinus; convex and hummocky in Ccp, peak material. Several sharp to rounded mounds of considerable relief in Stevinus Craters of impact origin. High albedo and thermal anomaly indicate exposure of more fresh rock than in surrounding terrain

Ccr, ejecta blanket thinning outward Ccw, local bedrock with slumps and some colluvium Ccf, breccia, fallback, and some slumped rock

Ccfr, probably material slumped from walls Ccp, structurally complex bedrock uplifted during crater-forming process

Crater material Material of rayless craters. Albedo intermediate to high. Rim crests slightly less sharp than in comparable-sized Copernican craters. Stevinus D and Rheita B have somewhat low cooling rates during penumbra (Shorthill and Saari, 1970) Ec, crater material undivided. Floors indistinguishable in smaller craters, just discernible in craters approaching 10 km in diameter. Craters >10 km divided into: Ecr, rim material. Appears relatively smooth Ecw, wall material. Steep, smooth, unbroken slopes

Ecf, floor material. In craters < 15 km level, smooth, covers less than 1/3 crater diameter; in craters about 20 km, convex, hummocky with slump blocks, covers at least 1/2 crater diameter All probably of impact origin. Units interpreted as for Copernican craters



Covers Janssen Formation and craters, subduing normally sharp features such as crater rim crests. Albedo intermediate. Occurs only in northwest section of quadrangle Interpretation
Probably ash fall

Crater cluster material

High density of predominantly small (<3 km) craters, many of which overlap. Shallow, sharp to subdued craters, largest ones pan-shaped; most are circular; some near Rheita A and Stevinus J elongate and very shallow. Most clusters elongate and most trend NNE to ENE Interpretation Probably clusters of secondary impact craters of craters Petavius and Humboldt, to the

north and northeast. Narrow elongate cluster just north of Rheita A possibly decep-

tively old-looking and may be secondary to Stevinus to which it is also radial

Material of shallow crater

Unusually shallow crater (Reich-

enbach U) with extensive rim

deposits (pIcsr). Crater and

rim deposits form much larger

mound than usual for craters in

this state of degradation. Floor

and wall material (pIcs) grada-

Volcanic shield and caldera

Interpretation

Crater material Crater features range from sharp to moderately subdued with decreasing crater size. Albedo mostly intermediate except for bright patches on walls of larger craters Ic., crater material, undivided. Moderately shallow, no floors. Craters > 10 km divided cro, rim material. Considerably reduced in extent compared to small Copernican and Eratosthenian craters. Appears smooth around smaller craters. Around Fabricius appears relatively smooth close in and grades outward into radial gouges and small

Icwo, wall material. In small craters generally smooth except for crenulations near rim crest; in Fabricius many well-developed terraces Icf₂, floor material. Smooth and slightly convex in small craters; fine bumps to small mounds and small smooth patches in Fabricius cp., peak material. Two large, segmented mounds in

Probably of impact origin. Units interpreted as for Copernican and Eratosthenian

Crater features less sharp than comparable-sized upper Imbrian craters. Plainsforming material covers most floors. Albedo intermediate Ic1, crater material undivided. Some are shallow, bowl-shaped Icr, rim material. Narrow and quite smooth Icw, wall material. Greater development of wall terraces in the 20-40 km size range

 Icf_1 , mostly slumped material

than for any other age Icf₁, floor material. Convex with some hummocks Interpretation Most craters probably of impact origin. The small bowl-shaped craters resemble some craters in the lower Imbrian clusters and may be isolated Imbrium basin secondaries Icr_1 , ejecta blanket Icw_1 , colluvium, slumps, and some local bedrock

Crater cluster material Clusters of overlapping, mostly 5-10 km craters; moderately subdued, shallow. Elongate direction or overlap direction of most clusters approximately radial to Imbrium basin; a few clusters perpendicular to this direction Most clusters probably secondary impact craters of Imbrium basin because same in

dence for this origin is convincing (Scott, 1972)

shape and freshness as abundant crater clusters in Maurolycus quadrangle where evi-

Crater features subdued in larger craters, very subdued in small ones (<10 km); polygonal outline moderately to strongly developed. Albedo intermediate pIc3, crater material undivided. Many quite shallow 3, rim material. Narrow with numerous small craters superposed pIcw3, wall material. Terraces generally coalesced and becoming indistinct compared to younger craters. Minor radial channeling in some craters pIcf₃, floor material. Convex and uneven in small craters (<20 km), becoming more uneven and hummocky with increasing crater size; in the largest, Fabricius A, highly irregular with massive hummocks

pIcp₃, peak material Most are probably impact craters. Fabricius A and Young C, shallow with large part of crater consisting of floor material, possibly volcanic; alternatively, they may be Interpretation on unstable ground where landslides unusually active. Units interpreted as for lower

pIcir, rim material. Smooth, very gentle slope outside rim crest pIciw, wall material. Albedo slightly

higher than surrounding terrain pIcif, hummocky floor material Probably volcanic

Crater features very subdued; outline strongly polygonal. Rim crest irregular and

interrupted by smaller craters. Albedo intermediate and indistinguishable from surrounding terrain pIc2, crater material undivided. Most relatively shallow with poorly defined channels on walls, very narrow rim material, and filled by Imbrian plains material pIcr2, rim material. Narrow and structureless compared to younger craters, but with abundant small craters superposed pIcw2, wall material. Terraces reduced in number, poorly defined, and subdued, particularly in Metius and Rheita, compared to Stevinus and Fabricius pIcp2, peak material. Relatively low mounds in the two largest craters, Metius and Rheita, compared to Fabricius

Probably impact craters, although diagnostic features such as shape and original depth mostly obliterated by this time in smaller craters. Units interpreted as for

Janssen Formation (new name) Rolling terrain with strong linear trend approximately radial to Nectaris basin and fanning from NW in east to NNW in west. Linear elements are ridges, escarpments, grooves (linear elements emphasized by use of structural symbols, particularly ridgecrest symbols). As mapped, includes small patches of Imbrian plains-forming material. Type area, lat 43° to 45° S., long 37½° to 39° E. in the older crater Janssen for which formation is named

ejecta blanket (Fra Mauro Formation (Eggleton, 1964; Wilhelms, 1970, p. 23-27)), and sur face probably largely reworked by subsequent impacts and possibly some volcanism. Most ridges and grooves are depositional features, probably combination of material moving outwards as viscous fluid or base surge and some material transported in low angle ballistic trajectories. Long scarps or scarp systems (such as that from west of crater Neander south to Brenner) probably faults

Crater-trough valley Valleys consisting of troughs and craters with some relatively steep, sharp scarps; roximately radial to Nectaris basin; slightly raised rim along much of valley; crater chains that bifurcate from Fabricius F are mainly overlapping crater forms with only minor scarps. Some craters are contiguous, and where two overlap, southernmost superposed on northern. Features subdued; younger craters superposed randomly on the

Material of irregular craters

Elongate craters; Neander F, K, and N

are single craters but Rheita E possibly

pIci, undivided material. Most of crater

is gently sloping wall material with rim

and floor areas very small. Rheita E

Nectaris basin ejecta blanket. Analagous to, but much more subdued than, ejecta blanket Relation to Nectaris basin shown by radial arrangement and degree of subdual. May be surrounding the Orientale basin (McCauley, 1968). Also more subdued than the Imbrium either secondary impact craters and gouges or structurally controlled grabens with some impact hypothesis supported by chains with few scarps

Highly subdued, very shallow craters; most partly or entirely covered by Janssen Formation, although some in southern part of map not buried. Rim crests broad and pIc_1 , crater material, undivided

pIcr₁, rim material. Narrow and poorly defined pIcw₁, wall material. Terraces obscure Probably impact craters, now mostly covered by colluvium

mined; locally grades into graben Ridge crest

Lineament Linear element: most apparently shallow grooves, although some have no apparent relief Interpretation: Zones of weakness; may be joints, fractures, or faults with sense of movement undeter-

Linear and arcuate ridges; most symmetrical Interpretation: Most of those radial to the Nectaris basin probably ejecta from basin; some possibly horsts and some remnants of features now covered by Nectaris ejecta. Arcuate ridges mark crater ridge crests in the crater-trough valleys

____ Outer limit of Fabricius material Marks outermost observable extent of thin and patchy Fabricius crater rim material and abundant smal satellitic craters and gouges. Lies outside boundary of continuous rim material, shown in color

Covered crater rim crest

Landslide (slump) block

Arrows show direction of movement

INTRODUCTION Photographs returned by unmanned Lunar Orbiters have contributed greatly to the current lunar geologic mapping program. This is particularly true for quadrangles near the limbs, such as Rheita in the southeast earthside quadrant. The new data and revised interpretations amend the geologic framework established by earlier workers (Shoemaker (1962) and Shoemaker and Hackman (1962) applied basic strati graphic principles to set up a lunar time scale; McCauley (1967) summarized changes made in the next five years of study; Wilhelms (1970) compiled all the telescopic refinements and additions to the original framework). Detailed studies of crater morphologies from Lunar Orbiter photographs (Pohn and Offield, 1970) permit the placement of most craters within the time-stratigraphic systems (Offield and Pohn, 1970; Offield, 1971). Other advances in understanding lunar processes include establishing the sequence of formation and features of large, multiringed basins (McCauley, 1968; Stuart-Alexander and Howard, 1970) and criteria for distinguishing between impact and possible volcanic craters (McCauley, 1968). For this map, features are described as seen on Lunar Orbiter IV high resolution (approximately 150 m) photographs: adjectives such as "smooth," "level" and "featureless" may be inappropriate at a different scale. The surface of the quadrangle is peppered with craters. In general, craters greater than 3 km in rim-crest diameter are mapped and the materials of craters larger than 10 km in diameter are subdivided into two or more units. However, middle and lower pre-Imbrian craters smaller than about 10 km are not mapped because they seem too subdued to provide useful stratigraphic information. In addition, the materials of some craters larger than 10 km have not been subdivided if the units would be small and contribute no significant information.

I-694 (LAC-114)

GEOLOGIC SUMMARY The geology of the Rheita quadrangle is dominated by deposits and structures resulting from the event that produced the multiringed Nectaris basin, an 840-km (measured from the outermost mountain ring) circular basin that lies northwest of the quadrangle (Hartmann and Kuiper, 1962). The deposits (presumably ejecta) and their structures, which include the Vallis Rheita and other crater-trough valleys (Baldwin, 1963, p. 317-318; Hartmann, 1964), give a northwest "grain" to the area; younger and less abundant lineaments trend mainly northeast and seem to reflect the lunar grid (Fielder, 1961; Strom, 1964) rather than the Nectaris event. The next most obvious geologic units are materials of craters, most of which are probably of impact origin. They range in age from the oldest recognizable units in the quadrangle to the

youngest. Among the crater units are clusters of presumably secondary impact craters formed by projectiles thrown out by large, distant impacts. A few craters and chains of craters may be volcanic in origin. The least obvious, but nevertheless significant, materials are those of the plains-forming units These fill low areas such as crater floors and depressions between ridges. In addition, the surface material of the "rolling terra" may be a thinner layer of the plains-forming material superposed on Nectaris ejecta (Janssen Formation) or it may have a different origin. Exposed remnants and buried rim crests of lower pre-Imbrian craters are the oldest recognizable features in the area. Only large (>90 km) craters are clearly visible in the northern two thirds of the map area, presumably because the Janssen Formation is thickest there and has obliterated smaller craters. Typical of craters that show through the Janssen Formation cover is the Janssen-Brenner cluster of three large. overlapping craters of which some of the southern wall of the main Janssen crater is exposed. Several lower pre-Imbrian craters are cut by Vallis Rheita; the northernmost, the crater Young, is also covered by Janssen Formation, whereas the southern craters are only partly covered by Janssen Formation. Two highly subdued unnamed depressions are probably very old pre-Imbrian craters. The smaller of these ≥150 km) is incomplete and lies just north of the crater Rheita; the larger (200 km) extends south from Stevinus. Interpretation of the most extensive geologic unit of the quadrangle, the Janssen Formation, as related to the Nectaris basin is based on analogy with the fresh-appearing Orientale basin as described by McCauley (1968). An ejecta blanket basin. The ejecta has a pronounced radial lineation consisting partly of a coarsely braided texture, with the braiding becoming more conspicuous outward from the basin whereas the troughs and ridges have smaller amplitudes outward. Buried craters are more obvious and appear more numerous with increasing distance from the basin, presumably because the ejecta blanket thins outward. All of these features are duplicated in the Rheita quadrangle, although the equivalent topographic features are greatly subdued. The center of the ectaris basin lies approximately 550 km north-northwest of the Rheita quadrangle and the southernmost point of the outer ring (an extension of the Altai scarp and equivalent in position to the Cordillera Mountains) lies about 35 km north of the northwest corner of the Rheita quadrangle. The dominant textures and structures within the Janssen Formation are approximately radial to the outer Nectaris ring. Traces of a braided texture remain in the convergence of some linear elements. In addition, thinning of the ejecta blanket away from the Nectaris basin is evident in the greater prominence of the smaller pre-Janssen Formation craters to the southeast. Other features related to the Nectaris basin are structures and crater-trough valleys. A major westward-facing scarp system runs from west of the crater Neander southeastward into the crater Brenner, and other lesser apparent faults occur throughout the Janssen Formation; most are radial or subradial to Nectaris basin.Crater-trough valleys have the same preferred orientation, although their method of formation is less obvious. The dominant valley in the quadrangle, Vallis Rheita, is a composite of craters, troughs, and scarps. Many craters are not contiguous, but where two overlap the southern one appears superposed on the northern, suggesting a sequence of formation outward from the Nectaris basin. This sequence occurs in all chains of secondary impact craters that have been observed, and is also consistent with any other structure that would form from a central source. The scarp segments within Vallis Rheita suggest internal structures rather than impact secondaries, and the craters could be collapse depressions over some subsurface weakness, or volcanic craters such as maars. The evidence is inadequate to choose definitely among these alternative methods of origin. However, the cratertrough valleys apparently overlap in time with the main ejecta blanket and therefore probably formed rapidly. Secondary impact craters would form rapidly, faults and associated collapse depressions could form rapidly, but from terrestrial experience it seems unlikely that a volcanic crater chain could become fully developed so quickly. The smaller bifurcating crater chains that head under the younger crater Fabricius F particularly resemble secondary impact craters. Most of the remaining geologic units have a prolonged history of development. A staccato overprint of impact cratering followed deposition of the Janssen Formation and continued throughout the history of the area. Rolling terra was formed primarily in the southern and southeastern parts of the quadrangle and seems to rest upon the Janssen Formation; faint lineations are visible, some radial to the Nectaris basin and some nonradial, and much of the unit is gradational with the Janssen Formation. Two small areas of pre-Imbrian plains lie along the southeastern border and are continuous with more extensive exposures east and south of Rheita quadrangle. The Imbrian plains unit was deposited as a filler in low places of limited extent throughout the map area. These plains units, with their level surfaces and generally sharp contacts with adjoining units, must have been emplaced in a relatively fluid state from local sources whereas the greater relief and the gradational nature of the rolling terra is much more suggestive of clastic debris from something like ash falls or slow downslope movement of loose material. More limited in time and area are the materials of the pre-Imbrian irregular craters, the Imbrian crater clusters, and the Imbrian or Eratosthenian terra mantling unit. The few craters having irregular shapes or floors above the level of the surrounding terrain stand out in contrast to the vast majority of craters which are circular and have floor levels generally at or below the local terrain level; the irregular craters are interpreted as being of probable volcanic origin and the others as of impact origin. Probable secondary impact craters (unit Icc1) of the Imbrium basin make an excellent stratigraphic marker for the base of the Imbrian System and are scattered over the quadrangle. The younger clustered craters (unit Icc2) are limited to the eastern half of the area and are probably secondary impact craters of the craters Petavius and Humboldt to the north and east of the quadrangle. The terra mantling unit seems to have been deposited rapidly over a relatively small area and the underlying features show through clearly, suggesting that the unit is a layer of volcanic ash.

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