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

NOTES ON BASE

This chart was prepared with advisory assistance from Dr. Gerrit 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 1741.9
Depth 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.

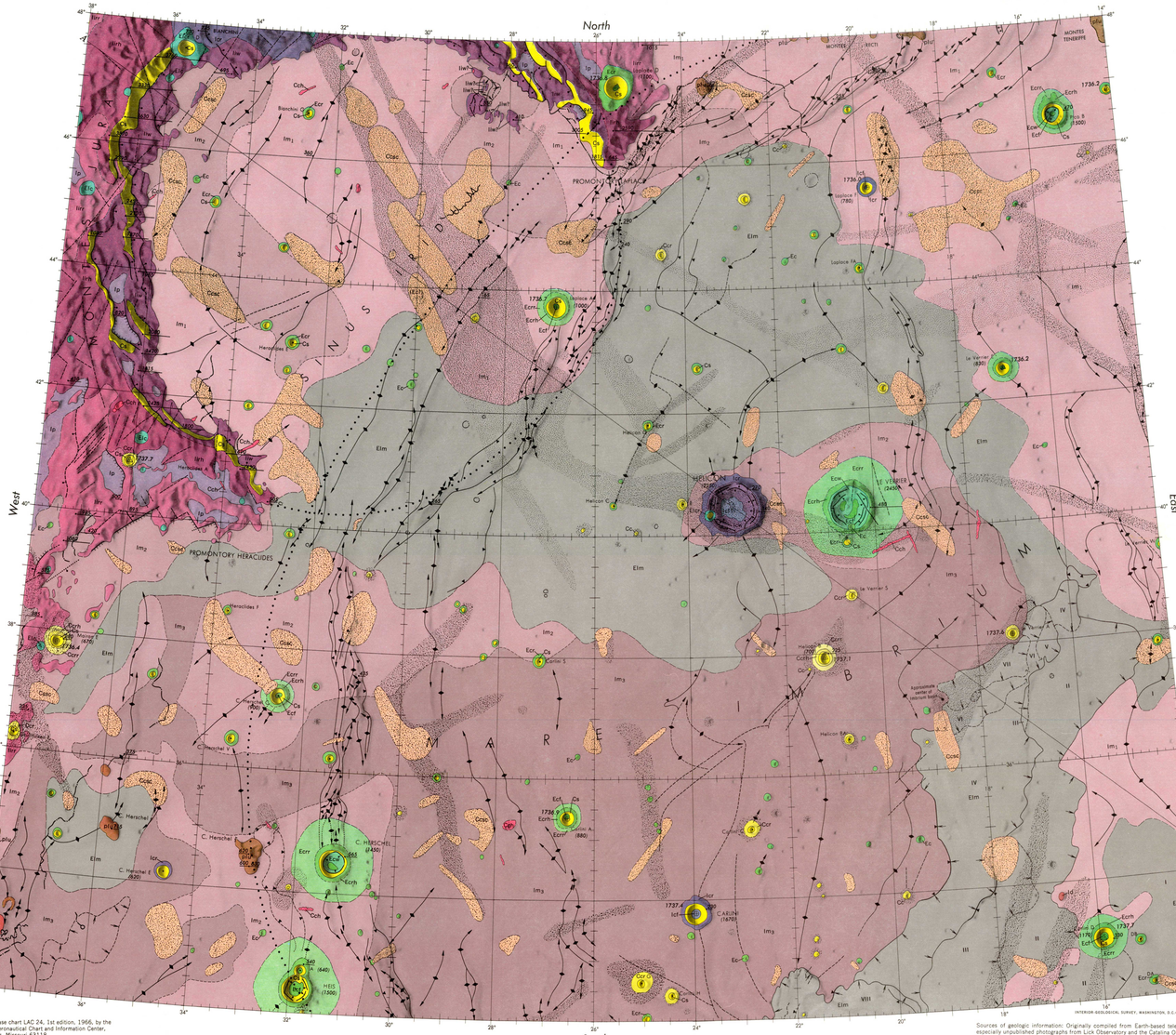
Supplementary features are associated with the named features through the addition of identifying letters. Craters are identified by capital letters. Eminences are identified by Greek letters.

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. Naval, Carolina Biological(University of Arizona, Lick, McDonald, Mount Wilson, Yerkes, Pic du Midi and Kottamia 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 smallest of mosaic detail for recorded pictures graphically. The pictorial portrayal of relief forms is developed using an oblique light source from the West with the angle of illumination maintained equal to the angle of slope of the features portrayed.



GEOLOGIC MAP OF THE SINUS IRIDUM QUADRANGLE OF THE MOON

By
Gerald G. Schaber
1969

EXPLANATION

Cs — Slope material

Characteristics
Albedo very high; typically 0.18-0.14; greater than all adjacent materials. Present only on relatively smooth interior crater slopes including those of the Iridum crater
Interpretation
Relatively fresh rock fragments derived principally by slumping and spalling of material on steep slopes. Source material may be of any age

Cch — Chain-crater material

Characteristics
Material of rimless or low-rimmed, closely spaced or overlapping round, elongate, or linear craters as much as 8 km in diameter
Interpretation
Most chain craters in this quadrangle are probably secondary impact craters. Others are volcanic craters of the maar type or collapse depressions. Believed Copernican in age because of fresh appearance

Cc, Ccr, Ccrh, Ccrr — Materials of rayed craters

Characteristics
Cc, *crater materials, undivided. Materials of sharp-rimmed, rough or hummocky craters too small to permit identification of individual crater units*
Ccr, *rim material, undivided. Forms raised rim around crater. Albedo intermediate to very high. Topography appears smooth to blocky at the limit of Orbiter resolution. In craters Helicon B and Mouton B divided into:*
Ccrh, *rim material, hummocky. Grades to:*
Ccrr, *rim material, radial. Surface has moderate local relief of low ridges subradial to the crater. Albedo high*
Interpretation
Cc, *small craters of uncertain origin*
Ccr, *ejecta from craters of impact origin. Poorly sorted crushed rock containing large blocks*
Ccrh, *impact-produced ejecta of variable thickness and fragment size at the surface, underlain by overturned and fractured bedrock*
Ccrr, *stringers of impact-produced ejecta*

Ccsc — Clustered satellitic crater material

Characteristics
Isolated patches of material of closely spaced low-rimmed round and irregular craters. Albedo high (>0.10). Patches commonly conspicuously elongated
Interpretation
Material of secondary craters excavated by ejecta from large impact craters. Most clusters are secondary to the craters Copernicus, Aristillus, and Aristarchus (outside the quadrangle).

Cr — Ray material

Characteristics
Albedo generally high (>0.10); detectability depends on the albedo of the background material. Distribution generally patchy. Appears to be superposed on other units with no discernible topographic expression of its own. Density of stipple proportional to brightness of ray
Interpretation
Fresh bright materials on lower walls of closely spaced secondary craters like those of unit Ccsc but smaller. The integrated effect of these bright patches of slope material gives the rays a higher albedo than that of surrounding less cratered material

Ecr, Ecrh, Ecrr, Ecrw, Ecrf — Crater materials

Characteristics
Ec, *crater materials, undivided. Materials in and around small postmare craters lacking bright halos or rays. Craters too small to permit mapping of individual crater units*
Ecrw, *rim material, hummocky topography on steep to moderate slopes inside crater; locally crossed by narrow benches roughly concentric with the crater rim. Includes all craters inside small craters. Albedo intermediate to low*
Ecrf, *floor material. Apparently smooth material occurring at break in slope with wall. Albedo low to intermediate*
Ecr, *rim material, undivided. Forms raised rim around crater. Topography appears smooth. Albedo low. In large craters divided into:*
Ecrh, *rim material, hummocky. Surface has high local relief; discontinuous hills and ridges roughly concentric with the crater in the inner part grade outward to a branching pattern. Albedo intermediate. Grades to:*
Ecrr, *rim material, radial. Surface has moderate local relief of low ridges branching subradially from the crater. Albedo intermediate; somewhat patchy*
Interpretation
Ec, Ecr, Ecrh, Ecrr *similar to corresponding Copernican units. Extensive deposits of unit Ecrr such as those around craters C. Herschel and Heis indicate youth, and these craters could be Copernican in age*
Ecrw, *darkened talus and slumped rim material*
Ecrf, *may be ejecta that has fallen back into crater, slumped wall material, or in the large craters Le Verrier, Pico B, C. Herschel, and Heis, may be volcanic materials*

Elm — Mare material

Characteristics
Flat, smooth dark material of mare areas. Albedo lowest (0.078-0.079) of all units in quadrangle. Least cratered mare unit and has no craters larger than 4 km in diameter. Superposed rays are mostly faint. Near Sinus Iridum the unit contains several rings that appear to be flooded or partly flooded craters between 1.5 and 6 km in diameter. Unit appears blue in UV-IR photographs (Whitaker, 1966) and has lobate contacts with the Imbrian mare units. Low scarps (85-40 meters high) form some of these contacts in the southeast quarter of the quadrangle and also border probable flows in an overlapping sequence within unit (see especially Lunar Orbiter V frames 189-188). The Roman numerals I-VIII on the flow units indicate their relative stratigraphic position (VIII, youngest; I, oldest).
Interpretation
A complex overlapping series of volcanic materials covered by a discontinuous thin layer of relatively fine-grained fragmental material formed by impact. Lobate scarps are fronts of individual flows. The wide extent and low relief suggest that mafic flows and/or ash-flow ignimbrite; deposits are the principal materials; the fine fronts suggest the former. Flows are superposed on Imbrian mare units Im_1 and Im_2 and unit is therefore younger, and possibly partly or wholly Eratosthenian in age

Ipl — Plains material

Characteristics
Material of smooth, nearly level surfaces occurring in low-lying areas of the terra. Crater density and albedo slightly higher than mare units but slightly lower than Iridum crater materials. In this quadrangle, unit is restricted to the area of Iridum crater rim deposits
Interpretation
Probably chiefly volcanic flows locally extruded into topographically low areas. May include pyroclastic materials, materials comminuted by meteoroid impact, and mass-wasted materials

Ilw, Ilrh, Ilrr, Ilcf — Materials of the Iridum crater

Characteristics
Ilw, *wall material. Hummocky to smooth material on moderate to steep slopes inside Iridum crater rim; locally crossed by benches. Albedo ranges from high on steeper slopes to rather low on benches*
Ilrh, *rim material, hummocky, rough. Surface has high local relief of hills 1-3 km across and intervening valleys, which are either roughly concentric or radial to crater. Albedo intermediate to high. Embayed in some low areas by unit Ip*
Ilrr, *rim material, radial, smooth. Surface has moderate local relief of low ridges subradial to the crater. Distinctly smoother and more subdued than Ilrh. Embayed in many low areas by units Ip, Im_1, and Im_2*
Interpretation
Ilw, *complex mixture of slumped Iridum ejecta (Ilrh), reworked Imbrian basin ejecta, and uncovered pre-Imbrian basement materials. Extensive slumping may have greatly enlarged the original diameter of the Iridum crater. Benches are the result of normal faulting during the slumping process*
Ilrh, *debris ejected from the impact-formed Iridum crater and deposited from low-angle trajectories. Completely blankets older materials. Thins progressively outward from present rim. Probably more extensive formerly but some has slumped into crater to be incorporated into unit Ilw*
Ilrr, *debris ejected from the Iridum impact primarily as stringers radial to the crater; blankets older terrain partly or totally for a distance of 250 km from the rim crest*

Ipu — Undivided material

Characteristics
Forms rugged islands in Mare Imbrium that are approximately concentric with the basin edge. Albedo intermediate to high
Interpretation
The islands compose a ring of the Imbrium basin, which probably was formed by impact. The ring was probably formed out of pre-Imbrian materials contemporaneously with the basin at the beginning of the Imbrian Period, but may have been tectonically uplifted subsequently. Islands apparently at present elevation prior to accumulation of youngest mare material

Id, Im_2, Im_1 — Mare materials

Characteristics
Im_2, Im_2, and Im_1; *flat, smooth material of mare areas. Albedo is 0.085-0.089, 0.080-0.087, and 0.084-0.108 for respective units. Crater density, as well as the frequency and brightness of rays, decrease with decreasing albedo. Units terminate abruptly against higher topographic forms. Features such as elongate ridges and scarps generally have low slopes. In UV-IR photographs (Whitaker, 1966) units Im_1 and Im_2 appear generally reddish and Im_2 generally bluish, though less blue than unit Elm*
Id, *mare dome material. Albedo generally slightly higher than flat mare material. Occurs as domes elliptical in plan; height to width ratio is low. Large dome has a summit crater*
Interpretation
Im_2, Im_2, and Im_1; *similar to unit Elm but older. Units assigned an Imbrian age because they resemble in albedo, color, and crater density the mare materials in the informal type area of the top of the Imbrian System (near the craters Archimedes, Eratosthenes and Copernicus)*

Ilcf, Ilcw — Crater materials

Characteristics
Ilcw, *wall material. Similar to Ecw and Ccw*
Ilcf, *rim material. Topography is hummocky to smooth in the smaller craters Carlini and Lepkies F. Unit is embayed by mare materials resulting in a sharp break in slope at contact with the mare surface. Albedo low*
Ilcf, *floor materials. Appear smooth. Albedo low.*
Interpretation
Similar to corresponding Eratosthenian and Copernican units. The younger mare units surrounding these craters have covered any radial rim facies that may have existed

Contact
Long-dashed where approximately located; short-dashed where gradational
(Ecr)

Buried contact
Shown limit of topographically expressed part of buried unit indicated by symbol in parentheses

Fault
Solid line where defined by a sharp scarp; dashed where inferred and exposed; dotted where inferred and buried. Bar and ball on downthrown side. Hachures indicate fault scarp against which younger rocks have been deposited (on side with hachures). Faults shown bounding unit Cs preceded formation of unit Cs, which is mapped as if it had zero thickness

Lineament
Gentle linear scarp or depression
Interpretation: Fault or surface expression of buried fault or joint

Sinuous rile
Narrow depressions having a meandering pattern; in places have associated small craters
Interpretation: Channel eroded by volcanic materials

Flow scarps
Dashed where indefinitely located; queried where doubtful; dotted where buried but still detectable. Line marks base. Arrow points downslope in probable direction of flow
Interpretation: Flow fronts of basaltic lava or fluidized ash materials

Depression along flow front
Arrow indicates probable direction of flow

Mare ridge
Dashed where indefinite; dotted where covered by younger unit. Line marks crest; arrow indicates tapered end
Interpretation: Probably underlain by anticline; possible site of volcanic extrusion

Gentle mare scarp
Line marks base of scarp; dashed where indefinite; dotted where covered by younger unit
Interpretation: May be fault, buried scarp or where entirely within a geologic unit, a flow front

Subdued ring
Line marks crest of ring
Interpretation: Buried or partly flooded crater

Slump block
Arrows show direction of movement

Rimless depression
Irregular to circular
Interpretation: Collapse feature possibly of volcanic origin

Basin structure
Maximum original circumference of Iridum crater and inner Imbrian basin ring. For the Imbrium basin ring, symbol connects isolated remnants of topography predating the mare flooding, such as Montes Teneriffe and Montes Recti, and in places a ring of mare ridges concentric to basin

A — A' Line of diagrammatic section shown on figure 1

Sources of geologic information: Originally compiled from Earth-based telescopic data, especially unpublished photographs from Lick Observatory and the Catalina Observatory of the Lunar and Planetary Laboratory, University of Arizona. Detail added from photographs taken by Lunar Orbiter IV (90-meter resolution—frames H-127, 134, 139, 145, 151, and 158) and Lunar Orbiter V (7-meter resolution—Site V-38—frames H-159, 160, 161, and 162). Full-Moon albedo data from Pohn and Wildey (in press). Color data from Whitaker (1966).

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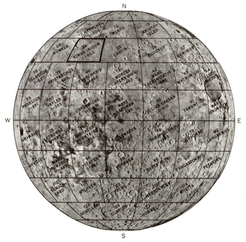
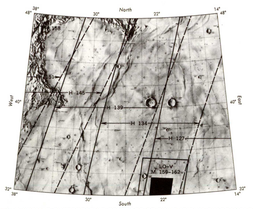


INDEX MAP OF THE EARTHSIDE HEMISPHERE OF THE MOON
Number above quadrangle name refers to lunar base chart (LAC series); number below refers to published geologic map



LUNAR ORBITER PHOTOGRAPHIC COVERAGE OF SINUS IRIDUM QUADRANGLE
All numbers refer to high-resolution frames of Orbiter IV except LO-V M 159-162. Orbiter V medium resolution. Solid black is Orbiter V high-resolution coverage

GEOLOGIC SUMMARY

The Sinus Iridum quadrangle includes the northwestern sector of Mare Imbrium, the Sinus Iridum embayment, the arcuate Montes Jura which partly surround Sinus Iridum, and several terra islands in the mare such as the Montes Teneriffe, Montes Recti, and C. Herschel I. Mare Imbrium occupies a complex depression or basin consisting of an inner basin and several outer concentric troughs separated by raised rings (Hartmann and Kuiper, 1962). The center and much of the inner basin, part of the first raised ring, and part of the first trough lie within the quadrangle. The terra islands are exposed parts of the first raised ring, which is approximately 670 km in diameter. Sinus Iridum embays a simpler and smaller structure, a crater 250 km in diameter (herein referred to as the Iridum crater) whose partly exposed rim crest is the Montes Jura. Mare ridges overlie buried parts of the inner Imbrium ring and the Iridum crater rimcrest. (fig. 1).

FIGURE 1.—*Diagrammatic cross section along line A-A'. The Iridum crater is superposed on structures of the Imbrium basin. Triangles represent probable impact breccia of Iridum crater and Imbrium.*

Lunar geologic units are arranged in order of relative age on the basis of their superposition and cross-cutting relations and are classified stratigraphically according to the system devised by Shoemaker and Hackman (1962; see also Shoemaker, 1962); subsequent revisions of the system have been reported by Shoemaker (1964), Wilhelms (1966), and McCauley (1967).

The oldest materials of the quadrangle are those of the ring of islands (unit pIu). These materials are probably disturbed remnants of much more extensive terrain that resembled the highly cratered southern lunar highlands. The event which formed the ring on this old terrain and created the Imbrium basin is believed to have been the impact of a large solid body from space (Baldwin, 1963, p. 314-332; Hartmann and Kuiper, 1962, p. 62-63; Shoemaker, 1964, p. 42-43). The Imbrian Period by definition began with the formation of this basin.

The next recognizable materials to be formed after the Imbrium basin are those of the Iridum crater, also Imbrian in age. The Iridum crater is genetically unrelated to the Imbrium basin and was formed by a discrete later cratering event. North and east of the quadrangle, Iridum crater materials bury terrain of an outer Imbrium basin ring for a distance of approximately one crater diameter (250 km) (Ulrich, 1969). The crater rim materials include a hummocky and a radial facies (units Ilrh and Ilrr) and are interpreted as ejecta produced by the impact that excavated the crater. Concentric and radial fractures in these rim materials were probably produced by the impact. The rim materials are presumably composed of reworked pre-cratering rocks, including Imbrium basin ejecta and pre-Imbrian basement materials. Wall materials (unit Ilw) are probably rim and pre-cratering materials that have slumped inward.

The filling of the Imbrium basin and Iridum crater by mare materials constitutes the next major recognizable event after the deposition of the Iridum ejecta. The mare materials are divided into four stratigraphic units in this quadrangle on the basis of stratigraphic superposition, albedo, color, and crater density. In general, color differences coincide with albedo differences; the redder the mare the greater the albedo (the brighter). Crater density variations also seem to correlate with these differences; the more numerous the craters, the greater the albedo. Three mare units are believed to be Imbrian in age, as is the majority of lunar mare material, whereas the fourth unit (Elm) could be partly or wholly Eratosthenian. The relative ages of the four mare material units are determined from relations in an overlapping sequence of prominent lobate flows in the southeast corner of the quadrangle. This area contains what may be the best exposure of mare flow structures on the Moon. Many of the flow scarps coincide with color and albedo boundaries (Kuiper, 1965, p. 27-28, especially a map by R. G. Strom, p. 32; Whitaker, 1966, p. 79-83). The dark, bluish unit Elm (albedo approx. 0.077) clearly overlies the somewhat lighter, also bluish unit Im_2 and the much lighter, reddish unit Im_1 (albedo approx. 0.100). Therefore, at least in this part of the Moon, albedo and color can be used as an index of age; the albedo and redness increase with age. On this basis, unit Im_2, which occurs in the west half of the quadrangle and is not bounded by detectable scarps, is believed to fall between Im_1 and Im_2 in age because it is intermediate in albedo and color.

The flows of unit Elm closely resemble terrestrial lava flows in form and approximate some of the larger ones in extent. The highest lobate bounding scarps, those of the youngest flow (VIII), are more than 25 m but probably less than 40 m high (Fielder and Fielder, 1968, p. 7-8). Individual flows or closely related sequences may extend for as much as 200 km. The flows are doubtless of volcanic origin. They could be ash-flow tuff (ignimbrite), but are more likely lava because of the steepness of the scarps (Kuiper, 1965, p. 34-38; Whitaker, 1966, p. 81). A basaltic composition is suggested by analyses made by Surveyor spacecraft of mare material elsewhere on the Moon (Turkevich and others, 1967).

The Imbrium basin, of probable impact origin, is filled, therefore, by mare material of volcanic origin. Filling may have begun soon after the basin formed, but considerable time must have elapsed before the accumulation of the youngest mare material. During this time the Iridum crater formed and considerable slumping took place on its walls, and materials of younger craters of Imbrian age (units Ilcr, Ilcw, and Icf) also formed. The latter include the outer rim materials of the crater Blanchini on the Iridum rim, and embayed materials of several craters including Heliron and Carlini on the partly filled basin floor.

Smooth plains-forming material (unit Ip) occupies topographic lows in the terra. This unit is assigned an Imbrian age because of its relatively high crater density. Much of it may have been deposited before and during the accumulation of the mare material, but parts are very smooth and could be younger than the mare material. The flat surfaces suggest that this unit, like mare material, consists predominantly of volcanic flows, but definite criteria of origin are lacking and it could include other materials.

The most recent units to form in the quadrangle are crater materials superposed on the mare material. They include materials of Eratosthenian-age craters (unit Ec and its subdivisions) having no associated rays but rim deposits extensive relative to rim-crest diameter, and materials of a few mapped and many small unmapped craters of Copernican age (unit Cc and its subdivisions). These Copernican craters are surrounded by bright halos and streaks of ray material. Also present are large conspicuous ray patches and material of satellite crater clusters (unit Ccsc) formed by fragments ejected from the large craters Copernicus, Aristillus, and Aristarchus of Copernican age outside the quadrangle. These rays and clusters are bright and reddish and in this respect resemble mare material units Im_1 and Im_2.

Color differences are faint but can be enhanced by computerized of infrared and ultraviolet photographs (Whitaker, 1966).

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

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