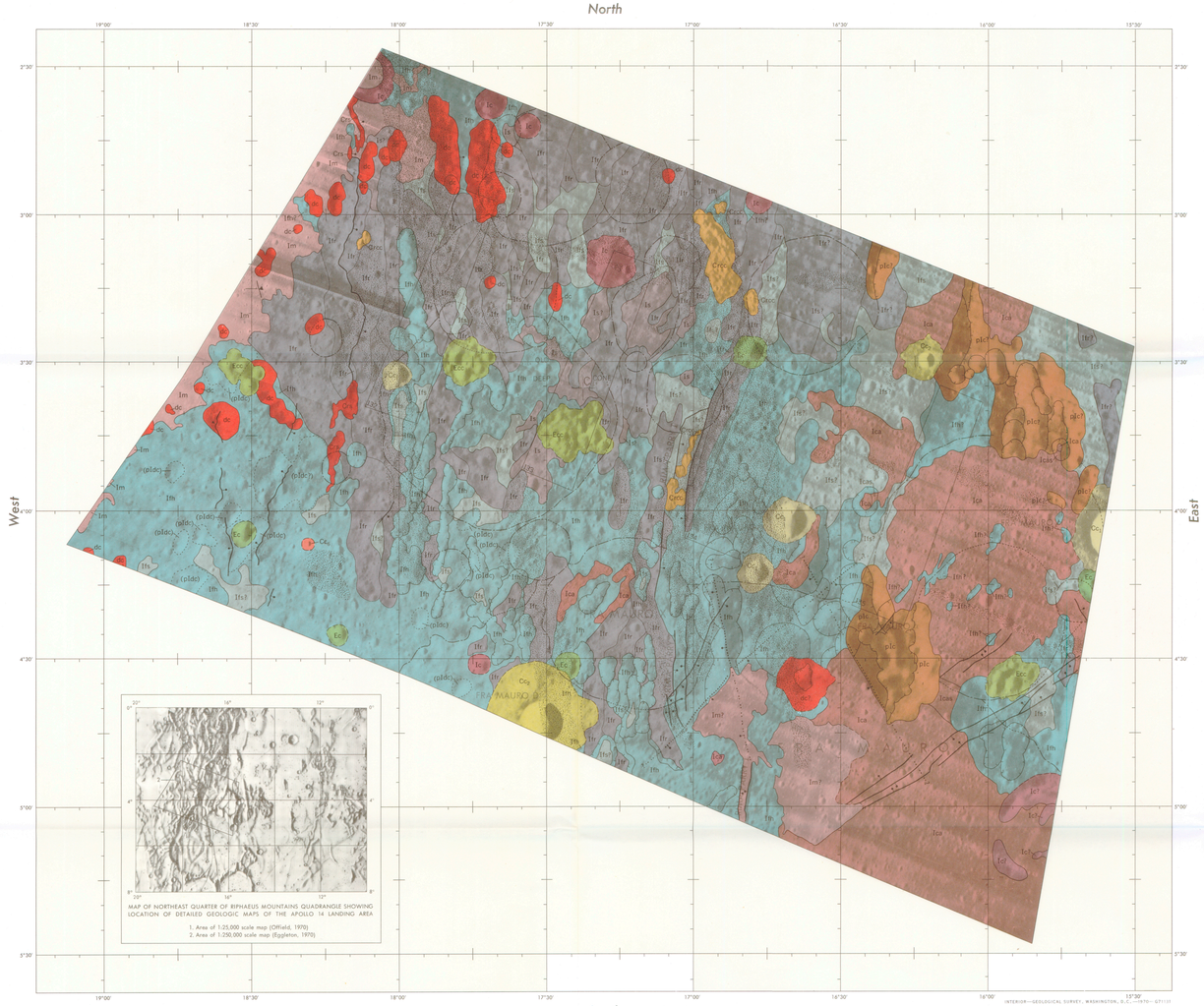
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MANNED SPACECRAFT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION



MAP OF NORTHEAST QUARTER OF RIPHAEUS MOUNTAINS QUADRANGLE SHOWING LOCATION OF DETAILED GEOLOGIC MAPS OF THE APOLLO 14 LANDING AREA

1. Area of 1:25,000 scale map (Offield, 1970)
2. Area of 1:250,000 scale map (Eggleton, 1970)

Source of informal crater names: U.S. Geological Survey Apollo Lunar Geology Experiment Mission Planning staff.

Base map prepared by Aeronautical Chart and Information Center, U.S. Air Force, under direction of Department of Defense for National Aeronautics and Space Administration, 1st. ed. June 1969.
A new base map dated April, 1970 was made subsequent to the completion of this map.

SCALE 1:250 000
MERCATOR PROJECTION

5 0 5 10 NAUTICAL MILES
5 0 5 10 STATUTE MILES
5 0 5 10 KILOMETERS

Principal sources of geologic information: Lunar Orbiter high-resolution photographs III–H132–H135, IV–H120; Lunar Orbiter moderate-resolution photographs III–M132–M135; Apollo 12 photographs; telescopic photograph 1129 by Catalina Station, Lunar and Planetary Laboratory, University of Arizona; and full-Moon plate 5818 taken at U.S. Naval Observatory, Flagstaff, Arizona.
NASA contract No. T–66353G

GEOLOGIC MAP OF THE FRA MAURO REGION OF THE MOON

APOLLO 14 PRE-MISSION MAP

By
R. E. Eggleton

1970

EXPLANATION

Crs — Scarp-line ridge material
Characteristics
Material of sharply bounded ridges along a trend expressed elsewhere as a steep, narrow, slightly sinuous scarp. Ridges are narrow, sinuous, and steep-sided; some have somewhat bulbous tops, others have flat tops locally characterized by very low crater densities
Interpretation
Probably lavas and perhaps pyroclastic material erupted along faults, or alternatively, materials uplifted over intrusions. Copernican age suggested by sharp form of ridges

Crc — Ray material
Characteristics
Forms moderately bright, diffusely bounded streaks and patches mostly radial to the large craters Copernicus and Lalande which lie north and east, respectively, of the map area. Rays radial to Copernicus are more conspicuous. Numerous small craters are associated with the ray material (see text)
Interpretation
Fragmental debris associated with secondary impact craters formed by ejecta mainly from Copernicus and Lalande

Crcc — Crater cluster material, ray-associated
Characteristics
Material of groups or chains of contiguous or overlapping craters lying within rays radial to Copernicus. Craters locally form crude herringbone patterns having long axes directed towards Copernicus. Craters in the large cluster in the north-central part of the map area range from about 100 m to 1 km in diameter generally decreasing in size to the south; craters in other clusters and chains are mostly smaller. Most craters have raised, narrow rims, moderately subdued rim crests, and moderately deep to bright interiors
Interpretation
Materials of secondary impact craters produced by ejecta from Copernicus; material ejected from the crater clusters may constitute a major part of the associated bright ray material

Cc$_4$ — Crater material
Characteristics
Material of a 500 m diameter crater in southwestern part of map surrounded by a very bright halo extending five crater diameters from rim crest visible at ½ km Earth-based resolution. Rim crest sharply raised; interior walls steep and bright. Rim material forms a very blocky and mostly thin continuous deposit extending about one crater diameter from rim crest. Crater age and extent of rim material inferred by comparison with other craters of similar size and appearance on higher resolution photographs

Cc$_3$ — Crater material
Characteristics
Material of two craters lacking distinct rays but having rim deposits considerably brighter than surroundings on full-Moon photographs. Rim crests sharp to slightly subdued. Rim deposits of larger crater sharply raised near crest and grade outward into delicate ridges to hummocky texture. Rim deposits of smaller crater similar but very subdued in their outer part. Crater interiors bright, steep, and deep without floors

Cc$_1$ — Crater material
Characteristics
Material of craters lacking distinct rays but having rim deposits brighter than surroundings in areas where ray material from Copernicus is absent. Clearly expressed raised rim deposits are mostly narrow and have slightly to moderately subdued rim crests. Rim material extending south of Fra Mauro H at east edge of map massifies and strongly subdues rim crest of adjacent Ec crater. Crater interiors are bright, deep, and slightly subdued in profile without distinct floors

dc — Dome and cone material
Characteristics
Material of domical to conical hills, typically 1 to 3 km across, having bright slopes (15° to 20°) covered with well-developed "wavy" patterned ground having wavelengths of 20 m to 100 m. Hills commonly coalesce and form rows. Summit or crestal depressions in hills at lat. 3°13'S., long. 17°13'W. and lat. 3°18'S., long 17°29'W. Hill shown as dc queried in southeast part of map is relatively low and patterned ground is not clearly discernible
Interpretation
Probably volcanoes. Those having summit craters are most likely young cones of pyroclastic material; others, eroded pyroclastic cones or viscous flow domes. All are younger than early Imbrian

Ecc — Crater cluster material
Characteristics
Materials of rims and interiors of groups of contiguous or overlapping craters ranging in size from about 750 m to 2 km. Some individual craters are more subdued than others but most have moderately subdued rim crests and bright, fairly steep interior slopes
Interpretation
Materials of craters formed nearly simultaneously within clusters by secondary impact of ejecta from undetermined sources. Due to close spacing, earlier craters are modified by later ones, although the time span of their formation may have been very short

Ec — Crater material
Characteristics
Materials of craters without rays and having moderately subdued rim crests crenulated by a few small craters. Rim deposits are raised and narrow; albedo is observed by ray material and, in places, by younger crater rim deposits. Crater interiors are generally bright and have moderately subdued profiles

Im — Mare material
Characteristics
Materials of smooth dark plains whose albedo ranges from about 0.095 in the western part of the map to about 0.117 in the southeast. Crater density very low, especially in western area; most craters smaller than 250 m and none larger than 750 m
Interpretation
Probably interbedded lava flows and pyroclastic materials. Crater density and albedo suggest that mare in western part of map is very late Imbrian in age and that in the southeast is only slightly younger than the Cayley Formation

Ica **Icas** — Cayley Formation
Characteristics
Ica, *materials of moderately to highly cratered level plains mostly occurring in eastern part of map. Density of craters >500 m much less than on Fra Mauro Formation but much greater than on mare material. Albedo intermediate, typically about 0.120*
Icas, *materials similar to* Ica *but occurring on slopes as steep as 10°*
Interpretation
Probably mare-like volcanic materials but original dark tone altered by bright materials of numerous small impact craters

Is — Smooth-terrain material
Characteristics
Material having fairly smooth to very gently hummocky surfaces and occurring within low areas of the uplands. Unit does not completely subdue topography of underlying Fra Mauro Formation and is rougher than the Cayley Formation. Albedo similar to that of the Cayley but lower than that of Fra Mauro Formation
Interpretation
Occurrence in low areas and albedo suggest a volcanic origin similar to that of Cayley Formation but unit is thinner than Cayley. Alternatively, unit is a smooth facies of the Fra Mauro Formation made up of fine ejecta which ponded in old craters and other low areas in the pre-Imbrian surface

Ifr **Ifh** **Ifs** — Fra Mauro Formation
Characteristics
Ifr, *ridge material. Generally forms north-trending, slightly sinuous ridges typically 1 to 4 km wide, as long as 30 km or more, and having a local relief of as much as 100 m; locally forms broad tongue-like masses as wide as 8 km. Boundaries between major ridges shown as interformational contacts. In places, contact between ridge and hummocky units (Ifh) is interformational*
Ifh, *hummocky material. Surface very irregular, locally characterized by shallow depressions resembling clusters and chains of coalesced craters typically ranging from 1/2 to 2 km across. Remaining irregular topography probably represents a more complex pattern of mutually interfering craters with the materials between craters constituting the hummocks. Best formed examples of typical coalesced craters are in west two thirds of map area and are outlined by hachured lines. Possibly related larger landforms similarly shown in east third*
Ifs, *smooth material. Resembles units* Is *and* Ica *but is more undulating at horizontal scales of tens and hundreds of meters*
Interpretation
Ifr, *mainly fragmental ejecta from the Imbrian basin deposited as flow ridges radial and subradial to the basin. Where interpreted with unit* Ifh, *may include local pre-Imbrian surface material ejected from secondary impact craters of the Imbrium basin*
Ifh, *a mixture of Imbrium basin ejecta and other fragmental material formed by secondary impact cratering of the local pre-Imbrian surface by Imbrium ejecta. The shallow, coalesced craters that characterize the unit are believed formed by a falling cloud of relatively close-spaced ejecta fragments; their fairly high impact energy, implied by their long trajectories, causes cratering to dominate over deposition away from the basin. Alternatively, the roughness of the unit may reflect incipient megabrecciation and (or) volcanic modification of the region representing partial development of terrain equivalent to the Alpes Formation. The Alpes is well developed to the west of the map area in the vicinity of Lansberg, to the northeast around the type area in the northeastern part of the Imbrium basin, and extensively developed east and northeast of the basin*
Ifs, *fragmental material similar to units* Ifr *and* Ifh *but finer grained and ponded in depressions by flowage during deposition producing nearly flat surfaces*

pldc — Dome and cone material
Characteristics
Generally similar to unit dc, *but more subdued and apparently cratered like unit* Ifr; *patterned ground not distinguishable owing to limited resolution. In places, resembles material apparently accumulated between craters in unit* Ifr
Interpretation
Late pre-Imbrian volcanoes mantled by the Fra Mauro Formation; some may be unit Ifr

plc — Crater materials
Characteristics
Materials of rims and walls of prominent parts of the large crater Fra Mauro (94 km rim crest diameter) and other unnamed craters to the north. Other parts of these craters are mantled or completely obscured by the Fra Mauro Formation and younger materials. Rugged materials of unit plc *are highly dissected into north-south ridges aligned radially to the Imbrium basin. Elsewhere in the area, rims and walls of more highly subdued buried circular depressions are shown by buried crater symbol*
Interpretation
Origin uncertain; two possibilities exist: (1) Rim and wall material of the impact crater Fra Mauro and other pre-Imbrian impact craters to north exposed because local ruggedness caused Fra Mauro Formation to slough off during deposition. (2) Same as above except the craters are of volcanic origin. Several possible interpretations exist for the formation of the rugged north-south trending mountains across the rim crests of Fra Mauro and its neighbors. (i) Eruption of pre-Imbrian volcanoes localized along the north-south component of the lunar grid. (ii) Eruption of post-Imbrium basin volcanoes localized along north-south fractures formed or reactivated by formation of the Imbrium basin and radial to the basin. (iii) Development of fault-blocks bounded by north-south fractures formed or reactivated by the Imbrium event. (iv) The alinement of rim materials (in north-south rows) of large Imbrium basin secondary impact craters etched into the rims of Fra Mauro and other pre-Imbrian craters

Contact
Dashed where gradational

Intraformational boundary
Outlines individual ridges in unit Ifr

(pldc)
Concealed contact
Symbol in parenthesis indicates buried unit

Brink of coalesced craters
Locally forms contact between units Ifh *and* Ifr

Fault
Bar and ball on downthrown side. Dotted where covered; broken dotted line where inferred; queried where extent uncertain

Rounded mare scarp
Line indicates base of scarp. Triangle on slope

Summit depression

Rim crest of buried crater
Dotted where inferred

C
Approximate computer target

NOTE: Landing site correctly located with respect to topographic features; but because of subsequent revision of lunar control network, mission coordinates for same location are lat 3°40'19" S. and long 17°27'46" W.

134
High resolution photographic coverage
Showing Lunar Orbiter III frame number

COPERNICAN SYSTEM
ERATOSTHENIAN SYSTEM
IMBRIAN SYSTEM
PRE-IMBRIAN

Explanatory pamphlet accompanies map