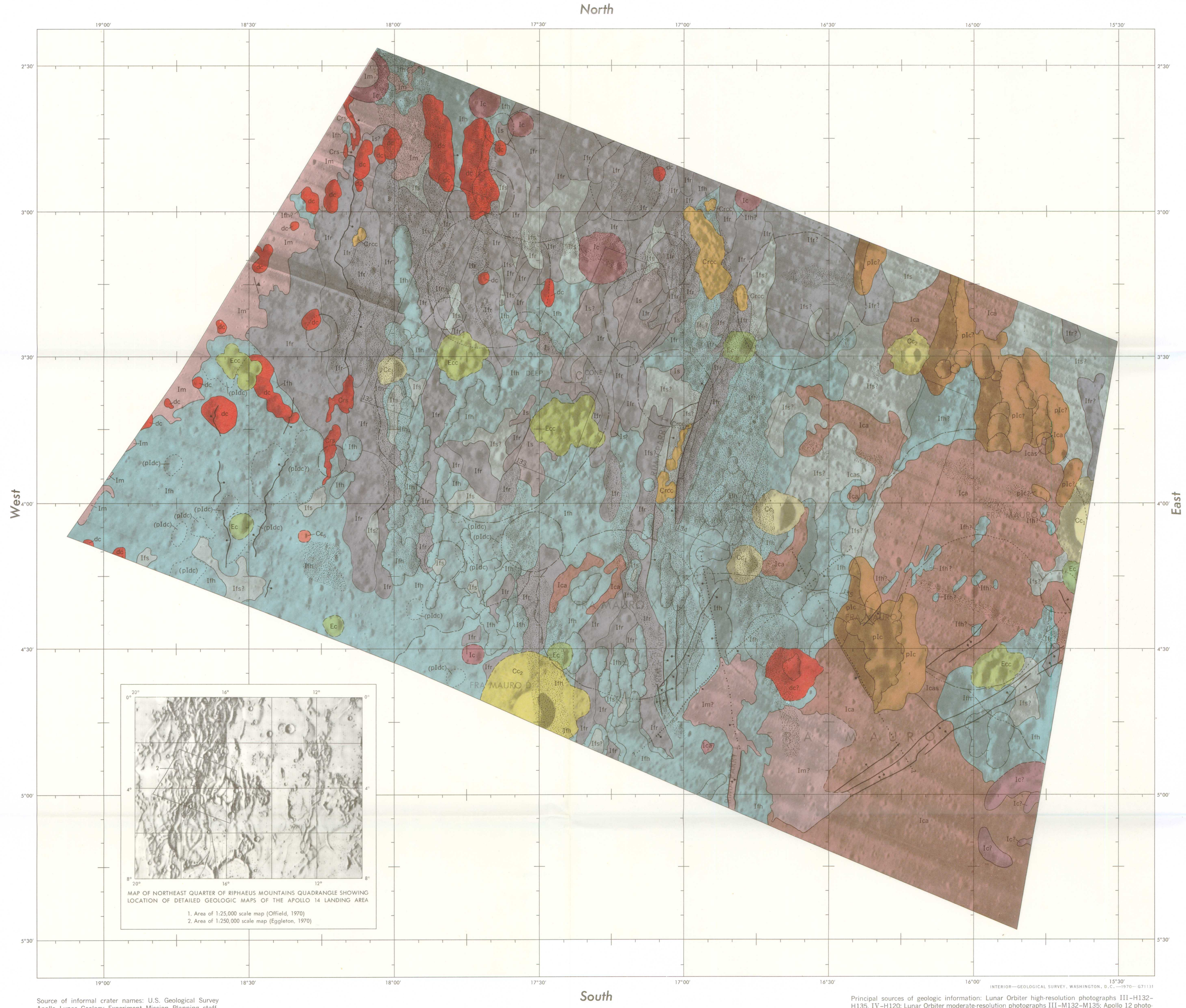
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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



INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1970—G71131

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.

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GEOLOGIC MAP OF THE FRA MAURO REGION OF THE MOON

APOLLO 14 PRE-MISSION MAP

By
R. E. Eggleton

1970

EXPLANATION

COPERNICAN SYSTEM

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

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 400 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_6

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_2

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 ridgy 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 mantles 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° 42′ 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

ERATOSTHENIAN SYSTEM

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 obscured by ray material and, in places, by younger crater rim deposits. Crater interiors are generally bright and have moderately subdued profiles

IMBRIAN SYSTEM

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 intraformational contacts. In places, contact between ridge and hummocky units* (Ifh) *is intergradational*

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 intergradational 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*

Ic

Crater material

Characteristics

Material of craters having strongly subdued rim crests, narrow rim deposits, and gently sloping interiors. Materials are not conspicuously brighter than their surroundings

Interpretation of Crater Materials of Post-Imbrium Basin Age

(Cc_6–Ic)

Materials of impact craters ranging from craters of Copernican age to craters of Imbrian age. Morphologic characteristics indicate a primary impact origin for most of the craters. The older craters were once similar in appearance to the younger craters but have been subdued with time by meteorite and secondary particle impact erosion, and by slumping and downhill creep caused by seismic shaking. The rim deposits of craters consist mainly of poorly sorted crushed rock and some shocked crystalline rock and impact produced glass. Morphologic characteristics of craters and their materials are both age and size dependent (see fig. 1, in text), and the size range of mappable craters is largely determined by map scale. For these reasons the described characteristics for crater materials having the same relative age may vary between maps having different scales

PRE-IMBRIAN

pIdc

Dome and cone material

Characteristics

Generally similar to unit dc, *but more subdued and apparently cratered like unit* Ihf; *patterned ground not distinguishable owing to limited resolution. In places, resembles material apparently accumulated between craters in unit* Ihf

Interpretation

Late pre-Imbrian volcanoes mantled by the Fra Mauro Formation; some may be unit Ihf

pIc

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 pIc *are highly dissected into north-south ridges alined 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

(pIdc)
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.

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High resolution photographic coverage
Showing Lunar Orbiter III frame number

Explanatory pamphlet accompanies map