DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED BY THE U.S. GEOLOGICAL SURVEY IN COOPERATION
WITH THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
AND THE USAF AERONAUTICAL CHART AND INFORMATION CENTER

GEOLOGY OF THE MOON
RIPHAEUS MOUNTAINS REGION
I-458 (LAC-76)

NOTES ON BASE

Lunar Base Chart prepared by USAF-ACIC with advisory assistance from Dr. G. P. Kuiper and his collaborators, D. W. G. Arthur and E. A. Whitaker

CONTROL

The position of features on this chart was determined through the use of selenographic control established primarily from the measures of J. Franz and S. A. Saunder. A collated listing of this control was published under the auspices of the International Astronomical Union in 1935. (Named Lunar Formation—Blagg and Müller)

VERTICAL DATUM

Vertical datum is based on an assumed spherical figure of the moon and a lunar radius of 1738 kilometers. The datum plane was subsequently adjusted to 2.6 kilometers below the surface described by the 1738 kilometer radius to minimize the extent of lunar surface of minus elevation value. Gradients of major surface undulations were established by interpolating Schrutka–Rechtenstamm computations of J. Franz's measurements of 150 moon craters. The probable error of comparative elevation values is evaluated at 1000 meters. Vertical datum, so established, is considered interim and will be refined as soon as an accurate figure of the moon is determined

ELEVATIONS

All elevations are shown in meters. The relative heights of crater rims and other prominences above the maria and depths of craters were determined through photographic measurements utilizing the Z. Kopal and G. Fielder Shadow Progression Technique. Relative heights, thus established, have been referenced to the assumed vertical datum and have been integrated with the gradients of the surface undulations. The probable error of the localized relative heights is 100 meters. Inherent with measuring technique used, relative height determinations in general E-W direction are more accurate than in the N-S direction

Spot Elevation (referenced to datum) 1100
Crater Elevations
Rim (referenced to Datum) 300
Depth of crater (rim to floor) .... (400)

CONTOURS

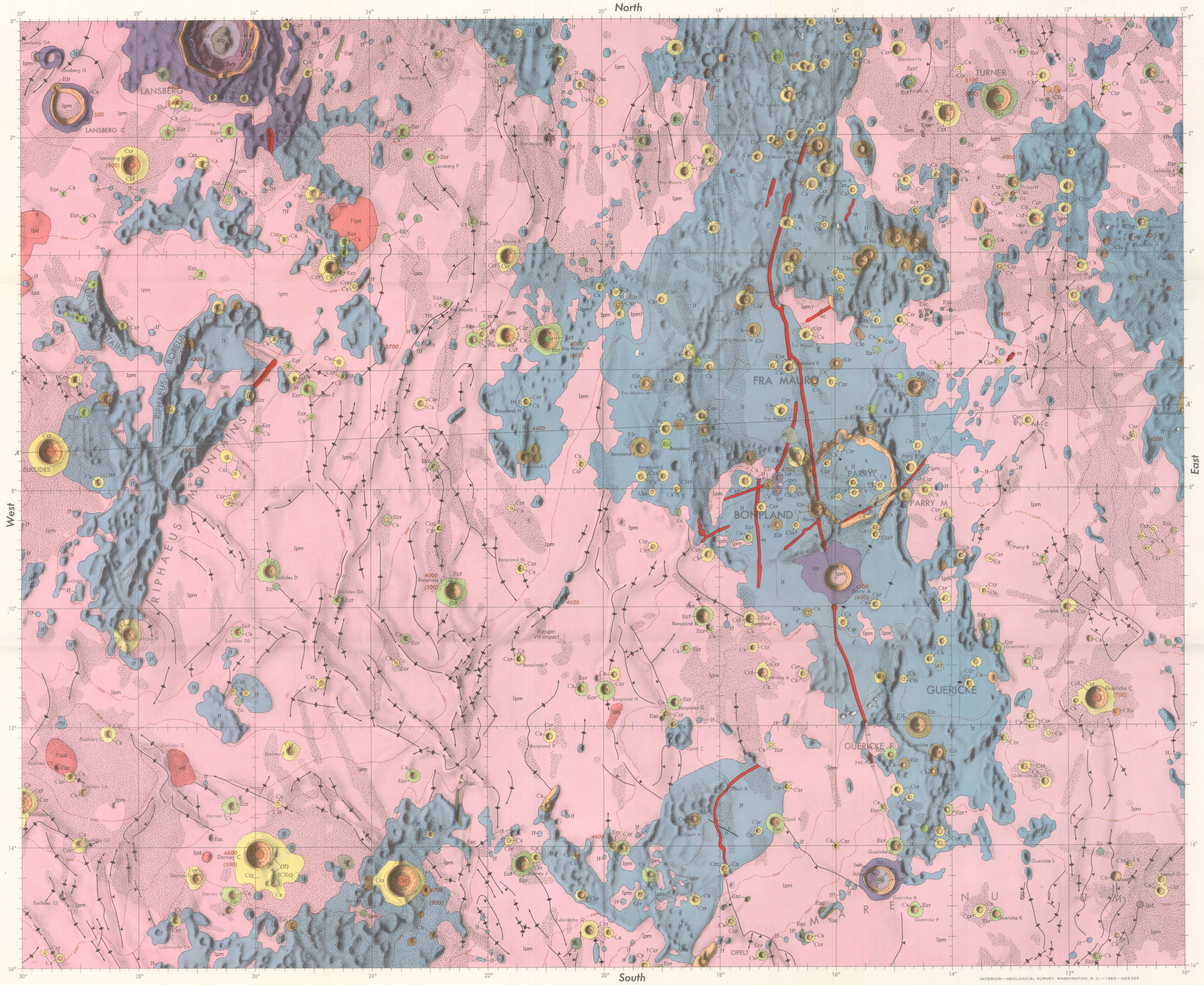
All contours are approximate
Contour interval is 300 meters
Approximate contour — 600 —
Depression contour

NAMES

The feature names selected were adopted from the 1935 International Astronomical Union nomenclature system with minor changes introduced in the 1960 edition of the USAF Lunar Atlas

RELIEF PORTRAYAL

The configurations of the relief features and background coloration shown on this chart were interpreted from photographs taken at Lick, McDonald, Pic Du Midi, Mount Wilson and Yerkes Observatories, and published in the USAF Lunar Atlas, and unpublished photographs supplied by Yerkes and Pic Du Midi Observatories. Visual observations made with the 24 inch Lowell refracting telescope, Flagstaff, Arizona, have also been used to add and clarify details. The pictorial portrayal of relief forms was developed using an assumed illumination. All relief features have been portrayed as they would appear when illuminated by an idealized light source located in the west direction and at an angle above the lunar horizon approximately equal to the angle of slope of the feature. This means that the altitude of the light source would appear to change between the steep and gradual sloping features.

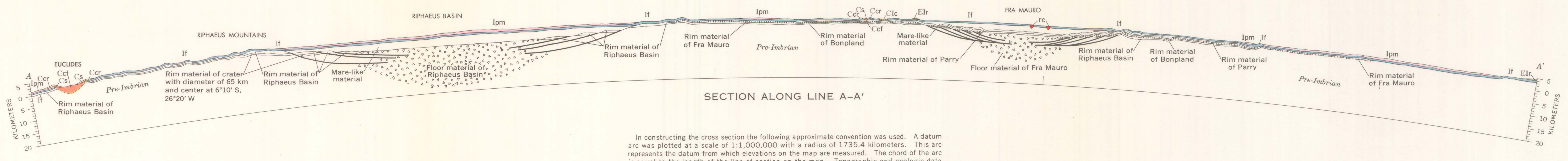


Lunar base chart by the Aeronautical Chart and Information Center, United States Air Force, St. Louis, Missouri 63118

MERCATOR PROJECTION
SCALE 1:1 000 000 AT 11°00′45″

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1965—G65365

Sources of geologic information: Published and unpublished photographs from the Lick, McDonald, Mount Wilson, Pic Du Midi, and Yerkes Observatories; visual telescopic observations by R. E. Eggleton made at the Lowell and Lick Observatories, 1961, 1962, and 1963, and the U.S. Geological Survey Observatory in 1964; preliminary examination of Ranger VII imagery



SECTION ALONG LINE A–A′

In constructing the cross section the following approximate convention was used. A datum arc was plotted at a scale of 1:1,000,000 with a radius of 1735.4 kilometers. This arc represents the datum from which elevations on the map are measured. The chord of the arc is equal to the length of the line of section on the map. Topographic and geologic data points along the line of section are projected perpendicular to the chord onto the concentric arc which is at the appropriate level in the cross section

GEOLOGIC MAP OF THE RIPHAEUS MOUNTAINS REGION OF THE MOON

By

R. E. Eggleton

1965

EXPLANATION

Material exposed on the surface of the Moon is heterogeneous. The albedo and other physical characteristics that have been determined with the use of optical and radio telescopes vary from one part of the moon to another, and the variations are partially correlated with differences in topography. Discontinuities in the areal variation permit the surface material to be divided into map units, each exhibiting a limited range of photometric properties associated with a limited range of topographic characteristics. Each map unit is further characterized by a distinctive pattern of distribution, and the patterns of certain units are in places superimposed on the patterns of other units. From the relations of superposition it is possible to determine the sequence in which the units were formed.

For the purpose of geologic mapping a classification has been adopted in which map units are grouped according to sequence or relative age. The major divisions of this classification are called systems (Shoemaker, 1962; Shoemaker and Hackman, 1962) and subdivisions of the systems are called series. The systems and series are arranged below in the order of relative age, the youngest at the top and oldest at the bottom.

Each system or series corresponds to a period or epoch whose salient events are listed in the table below:

PERIOD	EPOCH	EVENTS
Copernican		Formation of ray craters
Eratosthenian		Formation of craters of which rays are no longer visible
Imbrian	*Archimedian*	Extensive deposition of mare material of the Procellarum Group. Formation of post-Apenninian craters older than at least part of the Procellarum Group
	Apenninian	Events related to the formation of the Mare Imbrium basin
pre-Imbrian time		Not yet formally divided

The boundaries or contacts and photometric and topographic characteristics of the map units have been determined by a combination of visual examination of photographs, telescopic observation, and traversing of photographs with a continuously recording microdensitometer. Relative reflectivity is described for full moon illumination. The photometric properties observed are those only of the material exposed at the surface. The distribution of certain units that are concealed or partly concealed by superimposed material has been inferred entirely from topographic characteristics.

Certain elements of the lunar topography suggest the presence of a variety of structural features in the Moon's crust. These are indicated on the map with special symbols.

Each map unit and each type of probable structure has been given a descriptive name. An interpretive genetic name, where warranted, is given in parentheses beneath the descriptive name. A more detailed genetic interpretation follows the description of each unit and probable structure. These interpretations are based partly on analogy with terrestrial features and partly on analysis of the detailed interrelations of the features on the Moon, and are necessarily speculative. Discrimination and mapping of the units and determination of their sequence, however, are independent of the genetic interpretations placed on them.

The geologic mapping has been carried out to the precision obtainable with existing telescopic technique. As more detailed information is acquired through lunar exploration further refinement of the chronologic sequence of map units will be possible, and greater precision in the discrimination and location of geologic units and structures is to be expected.

A question mark before a map-unit symbol (for example, (?Er) indicates that the existence of the feature is questionable. A question mark after the age label (E?r) indicates that the age designation alone is questionable. A question mark after the whole map-unit symbol (Er?) indicates that the stratigraphic designation is questionable in some way other than age alone.

References cited

Shoemaker, E. M., 1962, Interpretation of lunar craters, *in* Kopal, Zdenek, ed., Physics and Astronomy of the Moon: London, Academic Press, p. 283-359.

Shoemaker, E. M., and Hackman, R. J., 1962, Stratigraphic basis for a lunar time scale, *in* Kopal, Zdenek, and Mikhailov, Z. K., eds., The Moon—Symposium of the International Astronomical Union: London, Academic Press, p. 289-300.

COPERNICAN SYSTEM

CEc — Crater materials, undifferentiated (Ejecta blanket and breccia?)
Telescopic characteristics:
Reflectivity low to very high. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography generally smooth
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 30 meters in thickness on flanks of craters. Probably forms deep lenses inside craters

Ray and bright halo material
Telescopic characteristics:
Reflectivity generally high but grades to that of surrounding material. Local contrast in reflectivity generally large; lateral variations locally abrupt; characterized by bright patches and streaks. Ray material is superimposed on parts of all other units except dark halo material. Except for satellitic craters, topography controlled by underlying units
Interpretation:
Probably chiefly crushed rock. Forms thin patchy layers, in most places probably not more than a meter thick

Ccr — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity moderate to very high. Local contrast in reflectivity moderate to large; lateral variations commonly abrupt. Topography around craters larger than about 12 kilometers in diameter is hummocky near crest of rim and includes low hummocks or low subradial ridges around flanks. Around small craters topography is smooth. Crater rim material grades to ray material away from craters
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to about 150 meters in thickness

Cs — Slope material (Talus?)
Telescopic characteristics:
Reflectivity high to very high. Occurs mostly on smooth slopes of about 30°. Mapping outside craters not complete
Interpretation:
Probably partially sorted fragments ranging in size from dust to large blocks

Ccf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity moderate to high; lateral variations gradual. Topography generally smooth or flat
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside craters

Csc — Satellitic crater (Secondary impact crater)
Telescopic characteristics:
Shallow craters with low rims and irregular outlines, commonly elongated radially to primary crater. Many occur in chains or clusters, and merge with one another.
Interpretation:
Craters formed by ejecta from primary crater

CIc — Crater materials, undifferentiated (Ejecta blanket and breccia?)
Telescopic characteristics:
Reflectivity low to very high. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography generally smooth
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 30 meters in thickness on flanks of craters. Probably forms deep lenses inside craters

ERATOSTHENIAN SYSTEM

Ec, Crater material, undifferentiated (Ejecta blanket and breccia?)
Ecr, Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography generally smooth. Ec includes slopes of about 30° inside craters
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to about 100 meters in thickness on flanks of craters. Ec probably includes deep lenses of breccia inside craters

Ecf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity moderate. Topography smooth or flat
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside craters

Esc — Satellitic crater (Secondary impact crater)
Telescopic characteristics:
Shallow craters with low, rounded rims, and irregular outlines that are less distinct than Csc. Commonly elongated radially to primary crater. Many occur in chains or clusters and merge with one another
Interpretation:
Craters formed by ejecta from primary crater

EIc, Crater materials, undifferentiated (Ejecta blanket and breccia?)
EIr, Crater rim material (Ejecta blanket)
Telescopic characteristics:
Relectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography generally smooth. EIc includes slopes of about 30° inside craters
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 50 meters in thickness on flanks of craters. EIc probably includes deep lenses of breccia inside craters

EIf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity moderate. Topography smooth or flat
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside craters

IMBRIAN SYSTEM

Procellarum Group

Ipd — Dome material
Telescopic characteristics:
Reflectivity low and local contrast in reflectivity small. Forms domes up to about 20 or possibly 25 kilometers across and up to about 100 meters high
Interpretation:
Probably chiefly volcanic flows; may include volcanic ash. Common low reflectivity and low slopes suggest dominantly basaltic composition

Ipm — Mare material
Telescopic characteristics:
Reflectivity generally low with small local contrast and gradual to abrupt lateral variations. Forms extensive, relatively smooth but locally wrinkled horizontal surfaces abruptly terminated against many topographic forms
Interpretation:
Probably volcanic flows. Great extent and relatively smooth topography suggest thick sheets of basalt or ignimbrite. Forms layers ranging in thickness from zero to a few thousand meters

Archimedian Series

Icr — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography is hummocky around craters larger than 12 kilometers in diameter
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky to smooth layers ranging from about a meter to about 350 meters in thickness

Iwh — Hummocky crater-wall material (Landslide debris)
Telescopic characteristics:
Reflectivity low to high. Local contrast in reflectivity moderate to large; lateral variations generally abrupt. Topography consists of hummocky slope
Interpretation:
Probably a jumbled mass, possibly partly stratified, of large blocks and finer debris in landslides

Icf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity moderate. Topography smooth to very gently rolling
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside craters

Icp — Central peak material (Breccia?)
Telescopic characteristics:
Reflectivity high to moderate. Topography consists of rugged hills with slopes as steep as 20°
Interpretation:
Probably chiefly large blocks with some finer debris

Apenninian Series

If, **Ifhd** — Fra Mauro Formation (Ejecta blanket)
Telescopic characteristics:
Reflectivity ranges from very low to moderate with generally moderate local contrast and gradual lateral variations. Ifhd has much lower reflectivity than If. Topography characterized by numerous hills and depressions 2 to 4 kilometers across in northern one-half to one-fourth of map area. Topography to south is varied and includes ridges, hills, valleys, small to large subdued craters, and large relatively flat but gently undulating areas
Interpretation:
Probably chiefly crushed rock and great blocks derived mainly from the region of Mare Imbrium. Forms a layer probably ranging from a few meters to about 500 meters in thickness. Layer is probably heterogeneous in composition

d — Dark halo material (Dark ejecta?)
Telescopic characteristics:
Reflectivity low. Topography smooth
Interpretation:
Probably basaltic or dark-colored volcanic ash. Forms layers ranging from 0 to about 20 meters in thickness surrounding small craters (probably volcanoes of the maar type)

c — Satellitic craters (Secondary impact craters)
Telescopic characteristics:
Small, relatively shallow, commonly composite or elongate craters with very low rims or no observable rims
Interpretation:
Craters formed by impact of fragments ejected from large, primary craters

rc — Rill and chain-crater material
Telescopic characteristics:
Material of generally low to moderate reflectivity lying within narrow linear depressions locally with associated small craters or within linear series of craters
Interpretation:
Probably includes breccia, fault blocks, and volcanic rocks

sr — Sinuous rill material (Volcanic flow channel deposits?)
Telescopic characteristics:
Material of moderate reflectivity lying within sinuous troughs
Interpretation:
Probably volcanic ash and blocks and erratic blocks in the floors of channels, possibly formed by nuées ardentes

Rimless depressions (Collapse features?)
Telescopic characteristics:
Irregular or circular depressions having fairly steep walls probably mainly with slopes of 10° to 30°, and having fairly flat bottoms. Always in mare terrain and usually containing Copernican slope material
Interpretation:
Probably volcanic collapse features

Contact
Dashed where approximately located

Indefinite contact

(Ipm)
(If)
Concealed contact

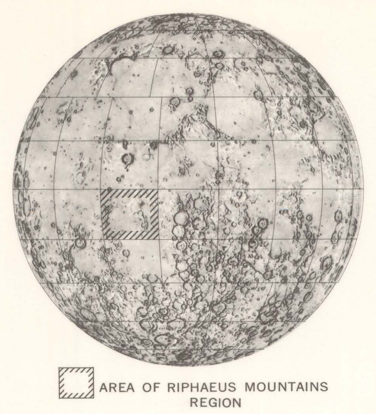
U
D
Offset of surface (Fault)
Showing foot of scarp separating regions of similar topography. U, upthrown side; D or barb and ball, downthrown side. Dotted where partly or completely covered, but inferred from topography

Mare ridge
Showing crest line. Tapered end indicated by arrowhead. Dotted where covered. Probably underlain by anticline; possibly the site of a volcanic extrusion

Mare trough
Showing trough line. Probably underlain by syncline

Rounded mare scarp
Showing trace of foot of scarp. Barbs point down-slope. Dotted where covered. Probably a flow front or monocline

INDEX MAP OF THE SUBTERRESTRIAL HEMISPHERE OF THE MOON



AREA OF RIPHAEUS MOUNTAINS REGION

For sale by U.S. Geological Survey, price $1.00