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

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 Formations—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 measurement 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. Supplementary 150 meter contours are shown in low relief areas.

Contour

Supplementary Contour

Depression Contour

NAMES

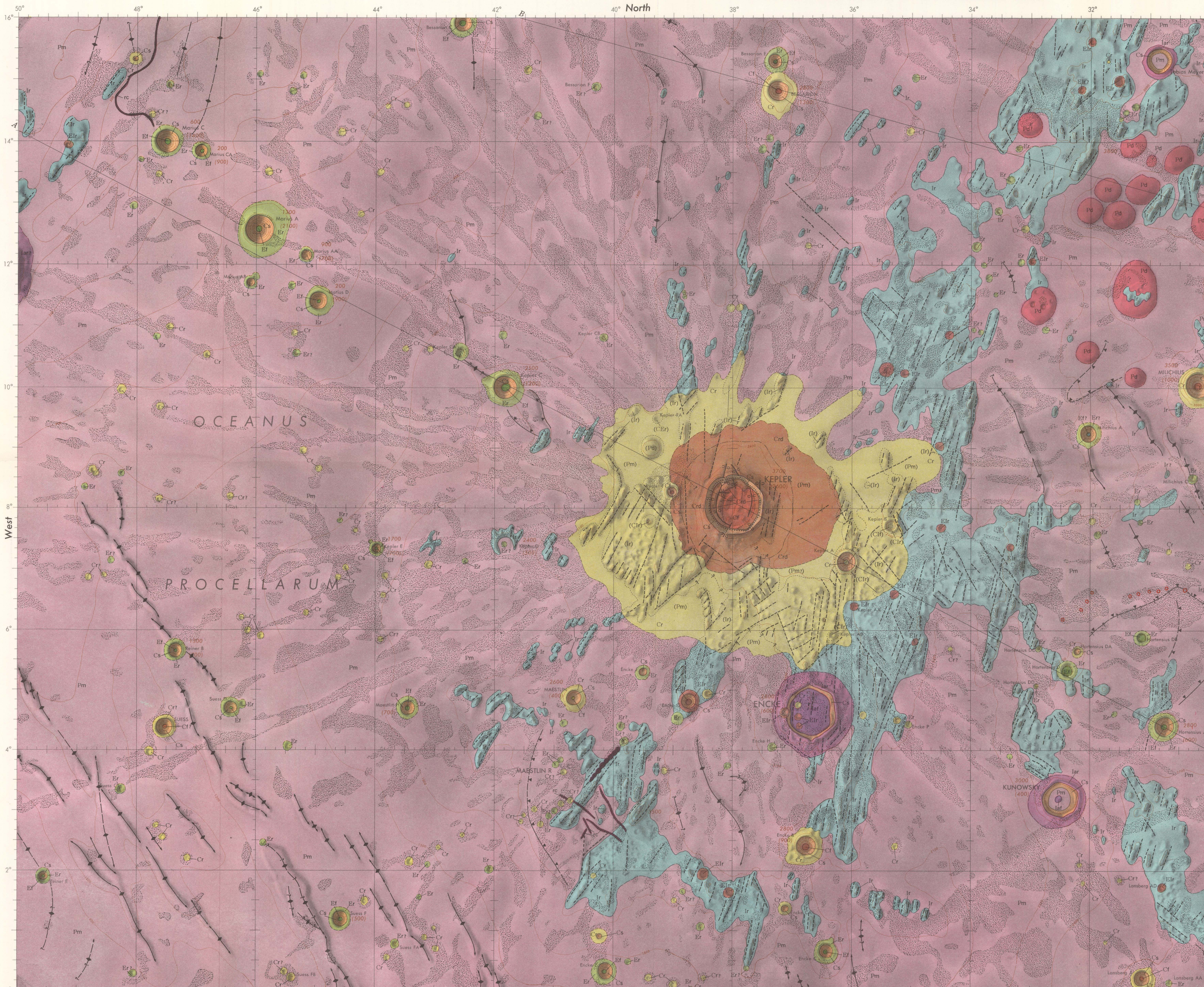
The feature names selected were adopted from the 1935 International Astronomical Union nomenclature system with minor changes introduced in the 1960 edition of the USAF Lunar Atlas.

The following designations have been added to the I.A.U. lettered formations, using the criterion suggested by Blagg and Müller:

Bessarion F
Encke CA
Encke H
Encke P
Hortensius DA
Hortensius DB
Hortensius DC
Hortensius DD
Kepler AA
Kepler AB
Kepler CA
Kepler CB
Kepler FA
Landsberg AA
Landsberg AB
Landsberg AC
Landsberg AD
Marius AA
Marius AB
Marius CA
Milichius C
Suess CA
Suess CB
Suess FA
Suess FB

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 by the compiler with the 40 inch Navy reflecting telescope of the Naval Observatory, Flagstaff, Arizona and by Mr. Arthur, Mr. Whitaker and the compiler with the 40 inch Yerkes refracting telescope, (through the courtesy of Dr. Kuiper) 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 18, Missouri

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—62173

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. J. Hackman made at the Leander McCormick Observatory, University of Virginia, 1960 and 1961

EXPLANATION

Material exposed on the surface of the Moon is heterogeneous. In albedo and most other physical characteristics that have been determined with the use of optical and radio telescopes this material varies from one part of the Moon to another, and the variations are partially correlated with differences in topography. Discontinuities are present in the areal variation which 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 relative ages of the units or the sequence in which they 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 subdivisions of this classification are called systems (Shoemaker, 1961; Shoemaker and Hackman, in press) 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 the oldest at the bottom.

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. Their positions are indicated on the map with special symbols.

Each map unit and each type of probable structure has been given a descriptive name. A genetic name, where warranted, is given in parentheses beneath the descriptive name for certain map units and for probable structural features as well. 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. The cross-sections incorporate these speculative interpretations. Discrimination and mapping of the units and determination of their sequence, however, is 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.

References cited

Shoemaker, E. M., 1961, Interpretation of lunar craters, *in* Kopal, Zdenek, ed., Physics and Astronomy of the Moon: London, Academic Press, p. 283-358.
Shoemaker, E. M., and Hackman, R. J., in press, Stratigraphic basis for a lunar time scale: Internat. Astron. Union Symposium 14, The Moon, Proc., London, Academic Press.

COPERNICAN SYSTEM

Ray 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

Cr Crd — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity moderate to very high. Local contrast in reflectivity moderate to large; lateral variations commonly abrupt. Areas of relatively low reflectivity around craters larger than 25 kilometers in diameter mapped as Crd. Topography around large craters is hummocky near crest of rim and includes low hummocks or low subradial ridges on rim 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 600 meters in thickness

Cf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity generally high to very high. Local contrast in reflectivity moderate; lateral variations generally abrupt. Topography generally smooth or flat in craters less than 16 kilometers across and partly flat and partly hilly to hilly in larger craters
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside small and large craters

Cs — Slope material (Talus?)
Telescopic characteristics:
Reflectivity high to very high. Occurs mostly on smooth slopes ranging from 20° to 40°
Interpretation:
Probably partially sorted fragments ranging in size from dust to large blocks

EIr — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography around large craters is hummocky near crest of rim and includes low hummocks and low subradial ridges on rim flanks. Around small craters topography is smooth
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 200 meters in thickness

EIf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small. Topography generally smooth or flat in craters less than 16 kilometers across and partly flat and partly hilly to hilly in larger craters
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside small and large craters

ERATOSTHENIAN SYSTEM

Er — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography around large craters is hummocky near crest of rim and includes low hummocks or low subradial ridges on rim flanks. Around small craters topography is smooth
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 400 meters in thickness

Ef — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small. Topography generally smooth or flat in craters less than 16 kilometers across and partly flat and partly hilly to hilly in larger craters
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside small and large craters

PROCELLARIAN SYSTEM

Pd — Dome material
Telescopic characteristics:
Reflectivity low and local contrast in reflectivity small. Occurs on domes up to 30 kilometers across and up to 300 meters high generally with a small crater at the summit
Interpretation:
Probably chiefly volcanic flows; may include volcanic ash. Common low reflectivity and low slopes suggest dominantly basaltic composition

Pm — Mare material
Telescopic characteristics:
Reflectivity generally low with small local contrast and gradual to abrupt lateral variation. Forms extensive, relatively smooth 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 from a feather edge to a few thousand meters in thickness

IMBRIAN SYSTEM

Archimedian Series

Iar — Crater rim material (Ejecta blanket)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small to moderate; lateral variations generally gradual. Topography around large craters is hummocky near crest of rim and includes low hummocks and low subradial ridges on rim flanks. Around small craters topography is smooth
Interpretation:
Probably chiefly crushed rock with large blocks. Forms hummocky layers ranging from about a meter to 200 meters in thickness

Iaf — Crater floor material (Breccia?)
Telescopic characteristics:
Reflectivity low to moderate. Local contrast in reflectivity small. Topography generally smooth or flat in craters less than 16 kilometers across and partly flat and partly hilly to hilly in larger craters
Interpretation:
Probably chiefly crushed rock with large blocks. Probably forms deep lenses inside small and large craters

Apenninian Series

Ir — Regional material (Ejecta banket?)
Telescopic characteristics:
Reflectivity ranges from very low to moderate with generally moderate local contrast and gradual lateral variations. Topography characterized by numerous hills and depressions two to four kilometers across
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 1000 meters in thickness. Layer is probably heterogeneous in composition. Areas where Apenninian layer may be generally very thin and pre-Imbrian material locally exposed are shown with ruled pattern

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rc — Rill and chain-crater material
Telescopic characteristics:
Material of generally low to moderate reflectivity lying within narrow linear depressions with associated small craters or within linear series of craters
Interpretation:
Probably includes breccia, fault blocks, and volcanic rocks. Age not definitely established but probably chiefly Eratosthenian

Copernican satellitic craters (Secondary impact craters?)
Telescopic characteristics:
Small, relatively shallow craters occurring in rim material and rays around large Copernican craters. Satellitic craters are commonly composite or elongate with very low rims or no observable rims
Interpretation:
Craters formed by impact of fragments ejected from large, primary craters

Contact
Dashed where approximately located

Indefinite contact

(Pm)
(Ir)
Concealed contact
Queried where location is uncertain
Symbols in parentheses indicate concealed units:
(CEr) *Copernican and Eratosthenian crater rim material, undifferentiated*
(CIr) *Copernican to Archimedian crater rim material, undifferentiated*
(CIf) *Copernican to Archimedian crater floor material, undifferentiated*

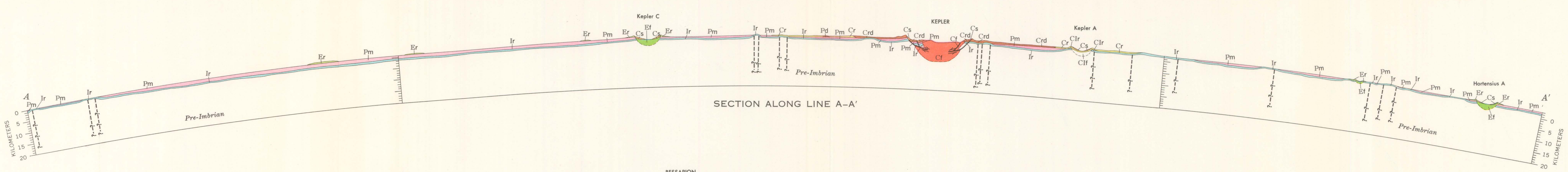
U
D
Offset of surface (Fault)
Showing foot of scarp separating regions of similar topography. U, upthrown side; D, downthrown side. Dotted where concealed

Lineament (Probable fault or fracture)
Partially or completely covered. Inferred from linear topographic features

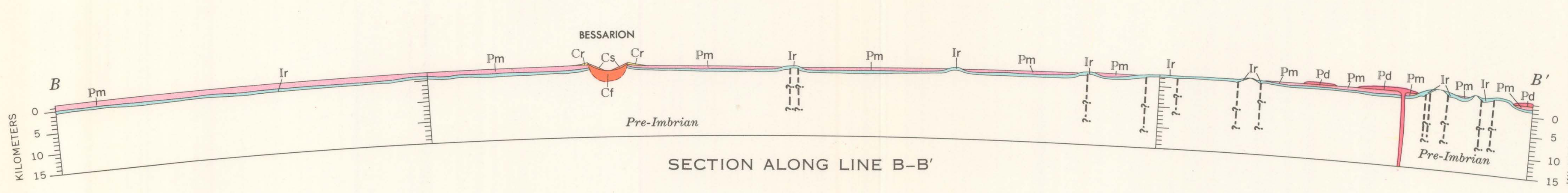
Mare ridge
Showing crest line. Tapered end indicated by arrowhead. Dashed where approximately located. Queried where probable. Probably underlain by anticline; possibly the site of a volcanic extrusion

Rounded mare scarp
Showing trace of foot of scarp. Barbs point in direction of slope. Dashed where approximately located. Queried where probable. Probably a flow front or monocline

Outer limit of telescopically observable low hummocks or low subradial ridges on Copernican crater rim material

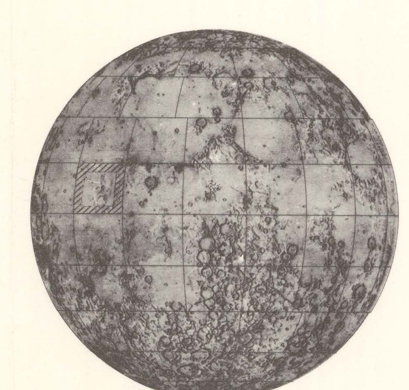


SECTION ALONG LINE A–A′



SECTION ALONG LINE B–B′

In constructing the cross sections 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



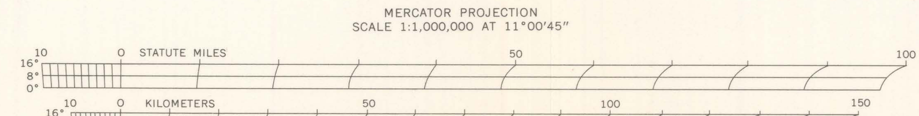
INDEX MAP OF THE SUBTERRESTRIAL HEMISPHERE OF THE MOON

GEOLOGIC MAP AND SECTIONS OF THE KEPLER REGION OF THE MOON

By

R. J. Hackman

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



1962

GEOLOGY OF THE MOON
KEPLER REGION
I-355 (LAC-57)

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