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

GEOLOGY OF THE MOON
TIMOCHARIS REGION
I–462 (LAC–40)

NOTES ON BASE

The lunar base chart was 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 as compiled by D. W. G. Arthur and E. A. Whitaker in the Orthographic Atlas of the Moon, edited by Dr. G. P. Kuiper, 1960.

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 Schurko-Rechtenstamm computations of J. Franz's measurements of 150 mean craters. The probable error of comparative elevation values is evaluated at 1000 meters. Vertical datum, as established is considered interim and will be refined as soon as a more 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 by the shadow measuring technique as refined by the Department of Astronomy, Manchester University, under the direction of Professor Zdenek Kopal. 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 height is 100 meters. Inherent with measuring techniques used, relative height determinations in the E-W direction are in general more accurate than in the N-S direction

Elevations referenced to datum.....1100
Depth of crater (rim to floor).....1400
Relative elevations (referenced to surrounding terrain).....3000

Direction and extent of slope measured.....

CONTOURS

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

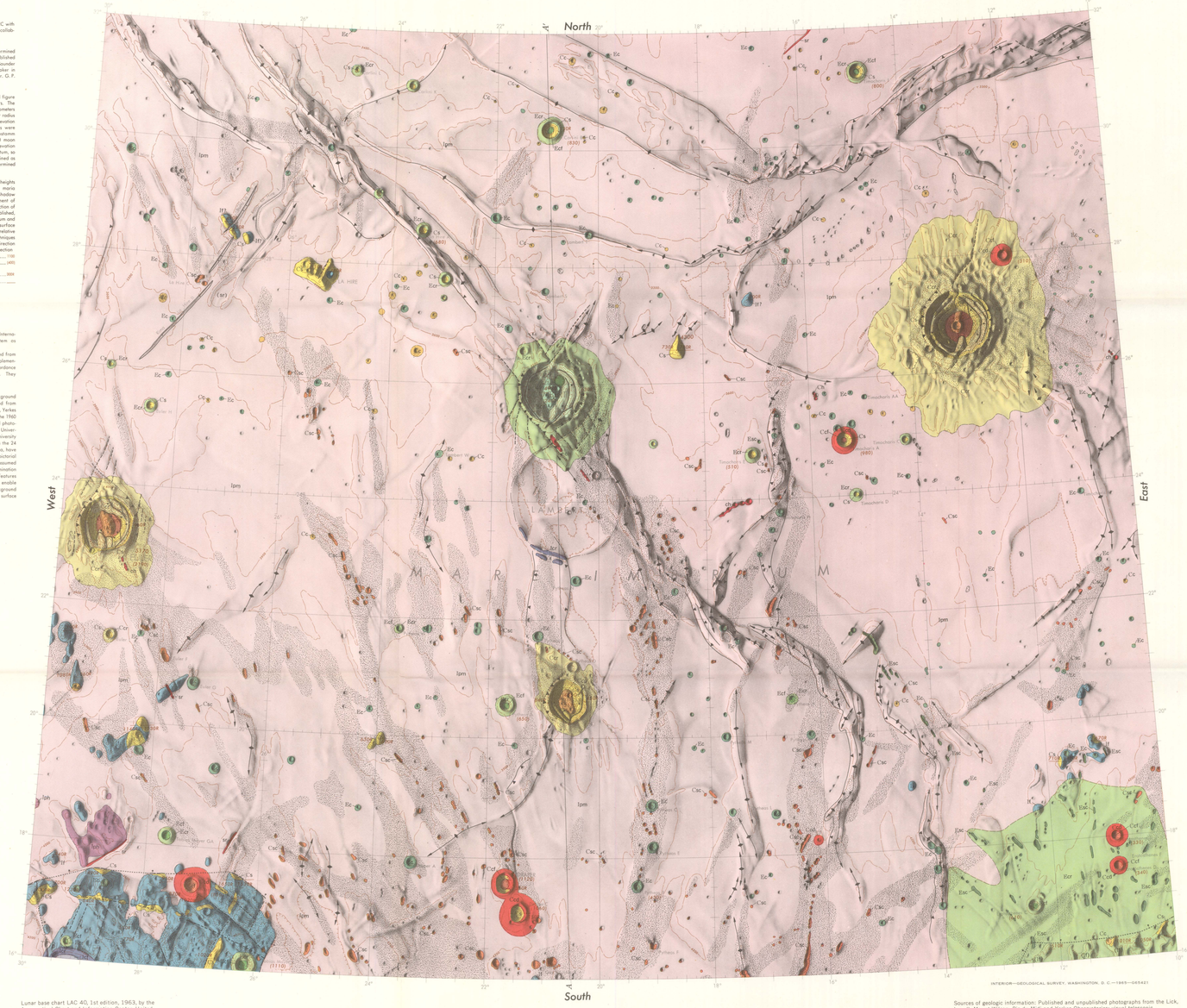
NAMES

The feature names were adjusted from the 1935 International Astronomical Union nomenclature system as amended by Commission 16 of the IAU

Craters designated by capital letters were selected from the I. A. U. list of Named Lunar Formations. Supplementary lettered formations have been added in accordance with the criterion suggested by Blagg and Muller. They are designated by lower case letters

RELIEF PORTRAYAL

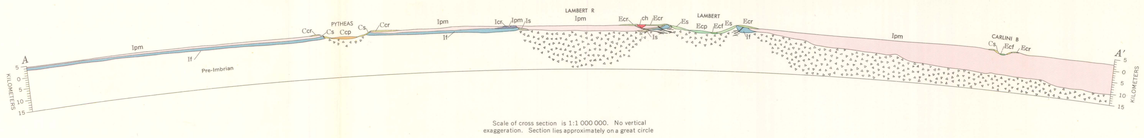
The configuration of the relief features and background coloration shown on this chart were interpreted from photographs taken at Lick, McDonald, Mt. Wilson, Yerkes and Pic du Midi Observatories, and published in the 1960 Edition of the USAF Lunar Atlas and unpublished photographs from the Lunar and Planetary Laboratory, University of Arizona and Department of Astronomy, University of Manchester. 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 light source from the West with the angle of illumination maintained equal to the angle of slope of the features portrayed. Cast shadows were eliminated to enable complete interpretation of relief forms. Background coloration depicts variations in reflectance of the surface under full moon illumination



Lunar base chart LAC 40, 1st edition, 1963, by the Aeronautical Chart and Information Center, United States Air Force, St. Louis, Missouri 63118

Sources of geologic information: Published and unpublished photographs from the Lick, Lowell, Mount Wilson, Pic du Midi and Yerkes Observatories; visual telescopic observations by M. H. Carr at Lick Observatory, 1963 and 1964

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1965—G65421



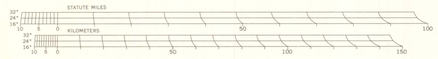
Scale of cross section is 1:1 000 000. No vertical exaggeration. Section lies approximately on a great circle

GEOLOGIC MAP AND SECTION OF THE TIMOCHARIS REGION OF THE MOON

By

M. H. Carr

SCALE 1:1 000 000
LAMBERT CONFORMAL PROJECTION
STANDARD PARALLELS 21°20′ AND 42°40′



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 on 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.
	Apenninian	Formation of post-Apenninian craters older than at least part of the Procellarum Group.
pre-Imbrian time		Events related to the formation of the Mare Imbrium basin. Not yet formally divided.

The boundaries or contacts and photometric and topographic characteristics of the map units have been determined by a combination of direct telescopic observation, visual examination of photographs, 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. A 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 sequences, 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.

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.

Cs — Slope material
Telescopic characteristics:
Very high albedo. Occurs on or at the base of steep slopes
Interpretation:
Freshly exposed bedrock and freshly generated talus. Formed by sliding and slumping. Process of formation may still be continuing.

Ccf — Dark halo crater material
Telescopic characteristics:
Very low albedo. Smooth topography. Readily distinguishable only when superimposed on Copernican ray material
Interpretation:
Either dark ejecta from an impact crater or volcanic ejecta

Ec — Ray material
Telescopic characteristics:
Generally high albedo but grades into that of surrounding material. Local contrast commonly large; 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 is controlled by underlying units. A large number of satellitic craters lie in the unit
Interpretation:
Probably a thin layer of fragmental rock ejected from both primary and satellitic craters

Cc — Crater material, undifferentiated
Telescopic characteristics:
Material in and surrounding small craters with bright haloes. Craters too small to permit identification of individual crater units
Interpretation:
Brecciated bedrock, talus material, and poorly sorted ejecta

Ccr — Crater rim material
Telescopic characteristics:
Moderate to high albedo. Around large craters the unit is hummocky near the rim crest, grading outward into low subradial ridges and depressions away from the crater. Around small craters, topography appears smooth and the unit is mapped on the basis of albedo
Interpretation:
Ejecta from impact craters. Poorly sorted debris, coarsest debris near rim crest. Around large craters the unit is mapped mainly on the basis of topography but a thin layer of debris with no observable topographic expression may extend beyond the area mapped

Ccf — Crater floor material
Telescopic characteristics:
Moderate to high albedo. Underlies areas of smooth topography within large craters
Interpretation:
Exposed brecciated bedrock and impact ejecta that has fallen back into the crater. Possibly some slumped wall material

Ccp — Central peak material
Telescopic characteristics:
High to very high albedo. Forms high ground within large craters. Generally hummocky, cratered topography. In Timocharis the unit consists of a single shallow crater with smooth inner and outer walls
Interpretation:
Either brecciated bedrock uplifted during impact or volcanic material formed during impact induced volcanism

Csc — Satellitic crater
Telescopic characteristics:
Shallow craters with low rims and irregular outlines, commonly elongated radial to primary crater. Many occur in chains or clusters, and merge with one another. Especially common on ray material
Interpretation:
Craters formed by ejects from primary crater

Ec — Crater material, undifferentiated
Telescopic characteristics:
Material in and surrounding small post-mare craters lacking bright haloes. Craters too small to permit mapping of individual units
Interpretation:
Similar to Cc

Ecr — Crater rim material
Telescopic characteristics:
Low albedo. Around large craters the unit is hummocky near the rim crest and grades out into low subradial ridges and depressions away from the crater. Around small craters topography appears smooth
Interpretation:
Similar to Ccr

Es — Slope material
Telescopic characteristics:
Low to moderate albedo. Occurs on and at the base of inner walls of craters
Interpretation:
Talus material formed by sliding and slumping, now stable

Ecf — Crater floor material
Telescopic characteristics:
Low albedo. Underlies areas of smooth topography within large craters
Interpretation:
Similar to Ccf

Ecp — Central peak material
Telescopic characteristics:
Moderate albedo. Forms high ground within large craters. Generally hummocky topography
Interpretation:
Similar to Ccp

Esc — Satellitic 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 ejects from primary crater

COPERNICAN SYSTEM

ERATOSTHENIAN SYSTEM

IMBRIAN SYSTEM

Procellarum Group — Archimedian Series

Ipm — Mare material
Telescopic characteristics:
Low albedo. Surface generally smooth and level except for low, irregular ridges and scarps
Interpretation:
Volcanic materials. Flows, ash beds, or both. Probably fragmental and non-cohesive at the surface

Iph — Dark hummocky material
Telescopic characteristics:
Very low albedo. Topography, low hummocks and irregular shallow depressions
Interpretation:
Either volcanic flows and ash beds or a dark facies of If

Icr — Crater rim material
Telescopic characteristics:
Low albedo with moderate local variation. Hummocky topography but more subdued than the topography of Ecr and Ccr
Interpretation:
Poorly sorted ejecta from an impact crater, coarsest ejecta near the rim crest

Is — Slope material
Telescopic characteristics:
Not exposed but shown on cross section by analogy with Copernican and Eratosthenian craters
Interpretation:
Talus material formed by sliding and slumping, now stable

Icf — Crater floor material
Telescopic characteristics:
Exposed only in the floor of Tobias Mayer where its albedo is masked by ray material. Topography smooth
Interpretation:
Similar to Ccf

Apenninian Series

If — Fra Mauro Formation
Telescopic characteristics:
Moderate albedo with large local variation. Exposed mainly on topographic highs. Characterized by low subequidimensional hummocks 2–4 kilometers across. Topography very rough at a scale of one-half kilometer
Interpretation:
Ejecta from the impact that formed the Mare Imbrium Basin. Ejecta probably poorly sorted with no blocks larger than one-half kilometer

ch — Chain crater material
Telescopic characteristics:
Aligned craters with low rims, commonly merging with one another
Interpretation:
Calderas or maars aligned along a structural lineament

If — Sinuous rille material
Telescopic characteristics:
Shallow sinuous depression. Low albedo
Interpretation:
May be: (1) Erosional feature excavated by a vole ardente; (2) collapsed lava tube; or (3) graben

Irregular depression
Unassigned as to age and type

Contact
Dashed where approximately located

(If)
(Ipm)
Concealed contact
Buried formations indicated by symbols in parentheses

Fault
Dashed where approximately located. Bar and ball on downthrown side

Concealed fault
Bar and ball on downthrown side

Concealed thrust fault
Sawteeth on upper plate

Lineament

Mare ridge
Showing crest line. Tapered end indicated by arrowhead. Dotted where concealed. May be underlain by anticline. Possibly site of volcanic extrusion

Rounded mare scarp
Symbol shows trace of foot of scarp. Only prominent scarps denoted. Dotted where concealed. Probably a monocline

Rim of buried crater

Brecciated rock

INDEX MAP OF THE SUBTERRESTRIAL HEMISPHERE OF THE MOON

AREA OF TIMOCHARIS REGION

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