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

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 of 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 2.4 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-Rechtsteiner 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 provisional 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 heights, in general, is comparable to the precision of measure used, relative height determinations in general E-W direction are more accurate than in the N-S direction.

Elevation (referenced to datum) 1100
Depth of crater (rim to floor) ..... (400)
Relative Elevations (referenced to surrounding terrain) with direction and extent of slope measured 700W

CONTOURS

All contours are approximate
Contour interval is 200 meters
Approximate contour
Depression contour

NAMES

The feature names are adopted from the 1935 International Astronomical Nomenclature Nomenclature system as amended by Commission 16 of the IAU.

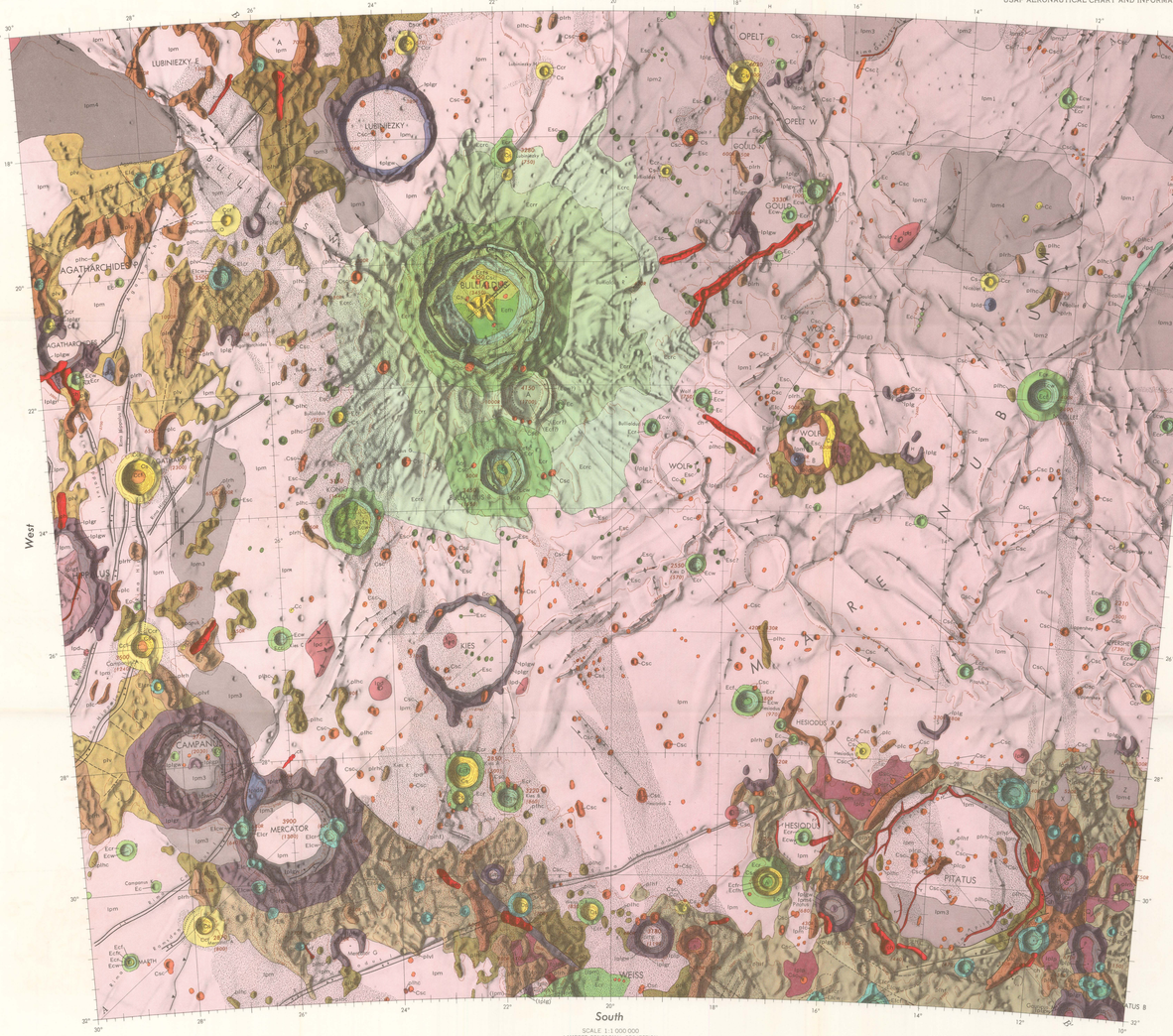
Supplementary formations have been lettered in accordance with the criterion suggested by Blagg and Mueller. Craters are designated by capital letters. Eminences are identified by Greek letters.

PORTRAYAL

The configuration of the relief features shown on this chart was 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 the 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.

EAST-WEST DIRECTION

Orientation of cardinal directions is in accordance with resolution adopted by the IAU General Assembly, 1961.



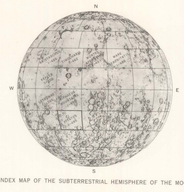
Lunar base chart LAC 94, 1st edition, 1964, by the Aeronautical Chart and Information Center, United States Air Force, St. Louis, Missouri 63118

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

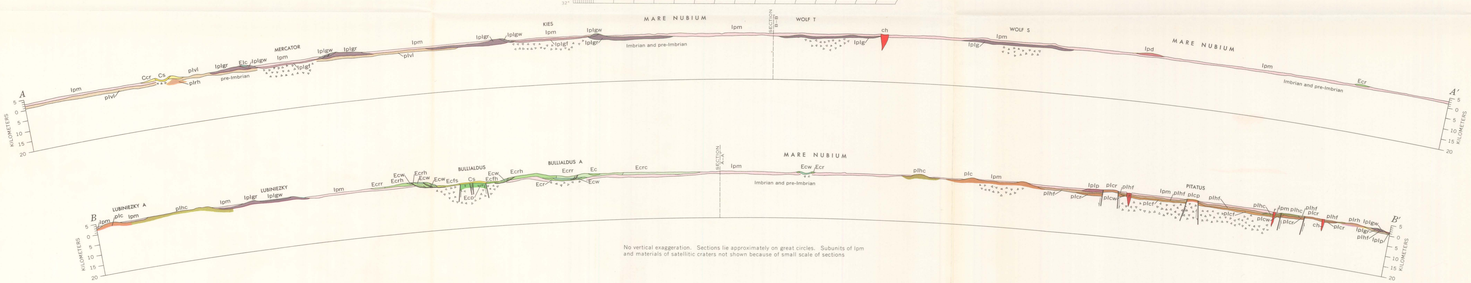
STATUTE MILES
KILOMETERS

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D. C.—1966—G68299

Sources of geologic information: published photographs from Mount Wilson, Lick, and Yerkes Observatories and Lunar and Planetary Laboratory, University of Arizona; unpublished photographs from the Aeronautical Chart and Information Center, Lowell Observatory; visual telescopic observations by N. J. Trask at Lick Observatory, 1964, 1965, and by S. R. Titley at Kitt Peak National Observatory, 1963, 1964



INDEX MAP OF THE SUBTERRESTRIAL HEMISPHERE OF THE MOON



No vertical exaggeration. Sections lie approximately on great circles. Subunits of Ipm and materials of satellitic craters not shown because of small scale of sections

GEOLOGIC MAP OF THE PITATUS REGION OF THE MOON

By
N. J. Trask and S. R. Titley
1966

EXPLANATION

The surface of the moon is heterogeneous. Similar surface materials are grouped into map units by means of telescopic observations, study of lunar photographs, and photometric measurements. Each map unit has lateral continuity and a limited range of physiographic characteristics and optical properties (mainly albedo, the reflectivity under full-moon illumination). Such units are equivalent to the rock-stratigraphic formations of terrestrial geology. By application of the principles of stratigraphic succession, the lunar formations have been arranged in order of relative age and grouped into time-stratigraphic units. Following terrestrial convention, the major time-stratigraphic units are designated systems; corresponding to these are periods of time. The type localities of most of the systems are in the vicinity of Mare Imbrium. Assignment of some of the rock-stratigraphic units in the Pitatus region to the systems established in the Imbrium region is still uncertain.

Following is a list of the periods recognized at present and the major events of each (Shoemaker and Hackman, 1962; Shoemaker, 1962). The most recent is at the top.

PERIOD	EVENTS
Copernicus	Formation of ray craters.
Eratosthenian	Formation of craters whose rays are no longer visible.
	Deposition of the extensive mare material of the Procellarum.
Imbrian	Formation of craters and regional deposits younger than the Fra Mauro Formation and older than at least part of the Procellarum Group.
	Formation of the Mare Imbrium basin and deposition of the Fra Mauro Formation.
pre-Imbrian time (not yet formally divided)	Formation of most of the mare basins on the near side of the moon including the Mare Humorum and Mare Nubium basins in the Pitatus region.

Formations exposed at the surface are outlined on the map by solid or dashed contacts. Formations whose presence beneath surface units is inferred by modification of the physiography of the surface unit are outlined by dotted contacts. Each formation is designated by a descriptive term (e. g. slope material) or a formal stratigraphic name. The symbol for each formation consists of two parts: an abbreviation of its age assignment (capital) and name (lower case). In the explanation, the formations are arranged in stratigraphic order. Below the symbol and name of each formation is a brief statement of its characteristics and an interpretation of its origin or composition.

Approximate albedos are given for some widely exposed units. These albedos were obtained by photographic processing of a full-moon photograph, controlled by telescopic photometric measurements (Rowan and West, 1965). Albedos without numerical values are visual estimates from full-moon photographs.

Recognizable structures such as faults, and distinctively lunar features such as rilles and mare ridges are mapped with symbols analogous to those of terrestrial geology.

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

REFERENCES CITED

Rowan, L. C., and West, Marvin, 1965, A preliminary albedo map of the lunar equatorial belt, *in* Astrogeologic studies ann. prog. rept., July 1, 1964 to July 1, 1965, pt. A: U.S. Geol. Survey open-file rept., p. 159-170.
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 14 of the International Astronomical Union: London, Academic Press, p. 289-300.

COPERNICAN SYSTEM

Cs — Slope material
Characteristics
Albedo very high (greater than 0.111). Occurs on steep portions of many crater walls. Details of topography not discernible
Interpretation
Fresh talus and bedrock exposed by sliding of material on steep slopes. Has not had time to be darkened by meteoritic bombardment, radiation, etc.

Cc — Crater material, undifferentiated
Characteristics
Albedo high. Small rayed craters in which individual units are telescopically indistinguishable
Interpretation
Small impact craters

Ccr — Crater rim material
Characteristics
Albedo medium to high (0.085 to 0.111). All Copernican craters in region are small, and topography of rims appears smooth
Interpretation
Ejecta from impact craters, probably poorly sorted

Ccw — Crater wall material
Characteristics
Similar to Cs but albedo is lower (0.100 to 0.111)
Interpretation
Partially stabilized talus and darkened bedrock

Ccf — Crater floor material
Characteristics
Albedo medium. Appears smooth. Covers small areas
Interpretation
Breccia, fallback, or slump from walls

Csc — Satellite crater material
Characteristics
Albedo low to medium. Material of small, relatively shallow craters occurring in clusters either on rays or on lines radial to large rayed craters. Many satellite craters are elongate radial to the primary crater or are a composite of two or more circular craters
Interpretation
Craters formed by impact of fragments ejected from large rayed craters. Most Copernican satellite craters are secondary to Tycho. Some in the northwestern part of the region may be related to Lalande

Ray — Ray material
Characteristics
Albedo medium to very high (greater than 0.073); grades to that of surrounding material; patchy, streaky. No visible relief
Interpretation
Fine ejecta from primary and secondary impact craters

ERATOSTHENIAN SYSTEM

Ec — Crater material, undifferentiated
Characteristics
Albedo low to medium. Small rayless craters in which individual units are telescopically indistinguishable
Interpretation
Small craters undifferentiated as to genetic type

Ecr, Ecrh, Ecrr, Ecrc — Crater rim material
Ecr, *undifferentiated*
Ecrh, *hummocky*
Ecrr, *radial*
Ecrc, *cratered*
Characteristics
Albedos low to medium (0.060 to 0.085), not greatly different from surroundings. Ecr mapped around small Copernican craters and Ecrh, Ecrr, Ecrc mapped as separate facies around Bullialdus. Ecrh consists of many randomly-oriented, irregular hills up to 3 km diameter; Ecrr consists of low subradial ridges and depressions; Ecrc consists of very low subradial ridges and shallow craters up to 2 km in diameter
Interpretation
Ejecta from impact craters. Hillocks and ridges around Bullialdus produced by ejection of large coherent blocks and clusters of blocks at low angles. Craters in Ecrc formed by impact of clusters of fragments ejected at higher angles

Ecw — Crater wall material
Characteristics
Similar to Cs but albedo is lower (0.085 to 0.111)
Interpretation
Partially stabilized talus and darkened bedrock

Ecf, Ecfs, Ecfh, Ecfr — Crater floor material
Ecf, *undifferentiated*
Ecfs, *smooth*
Ecfh, *hummocky*
Ecfr, *ring material*
Characteristics
Albedos low to medium. Ecf mapped in small craters
Ecfs *in large craters appears smooth.* Ecfh *consists of low hills and broad domes. Domes on floor of Kinoz are elongate and appear to be extensions of domes on rim. Ecfr forms raised rings on floors of Hesiodus A and Mercator*
Interpretation
Breccia, fallback or slump material from walls of craters or possibly later volcanic flows. Ecfh *may be volcanic domes.* Ecfr *is part of the crater floor uplifted along ring fractures; may be underlain by a ring dike*

Ecp — Crater peak material
Characteristics
Albedo observed by Copernicus slope and ray material. Forms low smooth mound in center of craters. Central peak of Bullialdus B has small summit crater
Interpretation
Volcanic dome or rebounded plug of breccia and poorly-sorted debris

Esc — Satellite crater material
Characteristics
Albedo medium. Material of small, relatively shallow craters occurring on lines radial or closely radial to Bullialdus. Many are elongate or composite. Rims generally lower than on Copernican satellitic craters
Interpretation
Craters formed by impact of material ejected from Bullialdus

IMBRIAN SYSTEM

Procellarian Group

Ipm, Ipm1, Ipm2, Ipm3, Ipm4 — Mare material
Ipm, *undifferentiated*
Ipm1, *light*
Ipm2, *intermediate*
Ipm3, *dark*
Ipm4, *very dark*
Characteristics
Albedos very low to medium (less than 0.060 to 0.085); units Ipm1 *through* Ipm4 *have successively lower albedos; albedo of undifferentiated mare material indeterminate because of ray cover. Topography level and relatively smooth at scale of map; relief features such as ridges and scarps have very low slopes. Subunits not shown on cross-sections*
Interpretation
Volcanic materials: flows, ash beds or both. Uppermost layer may be a mixture of rock froth and impact debris. Albedo differences probably reflect differences in age or composition of the uppermost layer only

Ipd — Mare dome material
Characteristics
Albedo same as that of surrounding mare material. Forms smooth circular to elliptical domes up to 15 km across and from 100 to 200 m high. Many domes have summit craters
Interpretation
Shield volcanos

PRE-IMBRIAN AND IMBRIAN

Ipig, Ipigr, Ipigw, Ipiwf, Ipigp — Gassendi Group (new name)
Crater material
Ipig, *undifferentiated*
Ipigr, *rim*
Ipigw, *wall*
Ipiwf, *wall, light*
Ipigf, *floor*
Ipigp, *peak*
Characteristics
Albedos medium except Ipiwf *which has high albedo. Material of craters that are partly or wholly covered with mare material and that have essentially even and complete rims except where embayed by mare material. Raised rims are smooth to hillocky with a few pits and irregular depressions. Walls appear smooth with a few radial ridges and depressions. Floor material in Hippalus has many smooth domes up to 5 km diameter. Includes some small craters with sharp but highly irregular rims that are partly filled by* Ipig. *Type area: crater Gassendi, 18°–24°N, 46°–51°E*
Interpretation
Material of craters superimposed on hummocky materials and partly or wholly covered by mare material. Craters formed by impact; relief reduced by erosion and rebound. Craters superimposed on the Vitello Formation are younger than the Humorum basin. Pitatus B, P, and G may be part of a volcanic chain

Ipls — Plains-forming material
Characteristics
Albedo medium, higher than that of Ipm. *Topography level with a few low ridges and ghost craters. Density of superimposed craters 1 km and larger, higher than on mare material (Ipm)*
Interpretation
Volcanic materials, probably ash-flow tuffs

Ipls — Slope material
Characteristics
Albedo medium. Appears smooth with irregular mounds up to 5 km diameter
Interpretation
Stabilized talus with mounds of landslide debris

Ipld, Ipldd — Terra dome material
Ipld, *light*
Ipldd, *dark*
Characteristics
Albedo of Ipld *medium, of* Ipldd *low. Topography smooth, gently convex upward; slopes 10° or less. All domes have a summit crater*
Interpretation
Shield volcanos. Low albedo of Ipldd *may be caused by veneer of later volcanic ash contemporaneous with* Ipm3

Ipic, Ipicr, Ipicw, Ipicf, Ipicp — Crater material
ipic, *undifferentiated*
ipicr, *rim*
ipicw, *wall*
ipicf, *floor*
ipicp, *peak*
Characteristics
Albedos medium. Material of craters with incomplete and uneven rims; many craters partly embayed by hummocky materials. All units appear smooth. ipicw *and* ipicf *inferred in subsurface only*
Interpretation
Material of old, eroded and faulted craters, partially covered by hummocky materials. Crater materials partly covered by Vitello Formation are older than Humorum basin

ipiv, ipivl — Vitello Formation (new name)
ipivl, *linear hummocky material*
Characteristics
Albedos medium (0.075 to 0.085) ipiv *forms closely spaced equidimensional to slightly elongate hillocks less than 300 m high and from 1 to 2 km in diameter; slopes mostly less than 5°; type of hillocks gently rounded; some hillocks are elongate and parallel to or elongate radial to Humorum basin. Formation surrounds Humorum basin;* ipivl *occurs at outer margin in a few places. Type area: 31°–36°W, 30°–33°S, near crater Vitello*
Interpretation
Ejecta blanket surrounding Humorum basin. ipiv *consists of randomly distributed mounds of ejecta;* ipivl *consists of radial stringers of ejecta.* ipiv *and* ipivl *correspond respectively to* Ecrh *and* Ecrr *around Bullialdus*

ipihr — Hummocky material, fine
Characteristics
Albedo medium. Forms gently rolling terrain with superimposed closely to widely spaced equidimensional hillocks and a few pits; hillocks less than 200 m high, from 1 to 2 km in diameter; slopes less than 10°; type of hillocks gently rounded; some hillocks lie on straight lines parallel to adjacent lineaments
Interpretation
Material not clearly related to any mare basin. May include some ejecta from a basin in the Mare Nubium region. Some may be partially buried coarse hummocky material

ipihc — Hummocky material, coarse
Characteristics
Albedo medium to high (0.075 to 0.111). Forms closely spaced equidimensional hillocks and pits; hillocks less than 200 m high, from 1 to 3 km in diameter; slopes mostly less than 10°; most over 5°; hillocks have relatively sharp peaks; some hillocks lie on straight lines parallel to adjacent lineaments; some have superimposed small hillocks near limit of resolution
Interpretation
Materials not clearly related to any mare basin. Some may be blocks of faulted bedrock; others may be material of volcanos

ipim — Material of smooth ridges and hills
Characteristics
Albedo medium. Smooth-appearing material on relatively large, mostly isolated, tracts that stand above surrounding terrain. Tracts are elliptical to markedly elongate; longest dimension 5 km or more; heights range from 300 to 1000 m above surroundings; steepest slopes greater than 10°
Interpretation
Uplifted ancient bedrock from which younger materials are missing because of non-deposition or subsequent shedding. Some hills may be younger constructional volcanic features

ch — Chain crater material
Albedo low to medium. Material of small contiguous aligned craters, mostly with low rims. Interpretation: Volcanic or satellitic centers of unassigned age

Rille material
Albedo low to medium. Material in straight to gently curving narrow depressions with center-line enlargements up to 2 km in diameter along their length. Interpretation: Volcano-tectonic depressions and craters

Contact
Long-dashed where approximately located, short-dashed where gradational

(ipig)
Concealed contact
Buried formation indicated by symbols in parentheses

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

Lineament
Geticlinear scarp or depression. May appear as slight change in brightness. Interpretation: Fault or surface expression of buried fault

Mare ridge
Line marks crest. Arrow indicates tapered end

Mare scarp
Line marks trace of foot of scarp. Barbs point downslope. Dotted where covered

Slump block
Arrow shows direction of movement

Concealed Crater
Line indicates rim crest

Rimless round crater

Irregular depression
Interpretation: Collapse feature or landslide scar

Breccia lens
Shown on cross sections beneath crater floors. Interpretation: Impact-produced breccia

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