DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
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INTRODUCTION

This map is one of a series showing the geology of areas of special scientific interest–areas considered as candidate sites for Apollo landings. Many of these sites were dropped from the list of candidates owing to operational constraints and curtailment of the Apollo program, together with priority judgments of relative scientific merit. The preliminary work on these areas has been refined, and the maps are being published with a view toward their use in possible future lunar exploration programs, either manned or unmanned. The mapping was done mostly with Lunar Orbiter data, using the methods described by Wilhelms (1970) and Trask (1969).

The Censorinus region lies largely within the terrae in a region where the ring structures that surround three major multi-ringed basins–Tranquillitatis, Fecunditatis, and Nectaris–overlap. The map area, between the two outer rings of the pre-Imbrian Nectaris basin, is about the same distance to the north of Nectaris as the largest patch of Nectaris ejecta–the Janssen Formation–is to the south (Wilhelms and McCauley, 1971). Although probably present, no Janssen material has been recognized in the northern region. Mountainous topography of the type commonly associated with the basin rings is present, but individual topographic highs are not attributable to specific basins. Some mare material of the southern part of the Tranquillitatis basin lies within the map boundaries.

REGIONAL GEOLOGY

The Censorinus region has been affected by basin-forming impacts and tectonic and volcanic activity. The impacts that formed the three major basins that surround the area must have contributed substantial amounts of ejecta; other impact events, related to formation of the more distant Imbrium and Crisium basins, also probably affected the area but to a lesser degree.

Terra units within the map area include materials of rugged ridges and massifs (pIr), rough terrain (pIt), and lineated materials of low relief (pIl), all of which have been assigned a pre-Imbrian age. The lunar uplands are inferred to consist in great part of ejecta layers of varying thickness deposited around the numerous basins during their formation, but distinctive morphologic criteria that might identify these layers are lacking. The intergradational hilly (Ih) and hummocky (Ith) units and the smooth (Its) and cratered (Itc) materials, which also are gradational, may be combinations of basin-derived ejecta and erosionally subdued structural blocks. An Imbrian age for these units is suggested by the scarcity of large pre-Imbrian craters, by the partial filling of some of these craters by hilly and hummocky materials, and by the superposition of craters that are Imbrian in age or younger.

The swirly to lineated texture of the rugged material immediately northeast of the crater Maskelyne A may result from downslope movement of fragmental debris. However, the resemblance of this material to some of the fresher appearing ejecta blankets such as those surrounding the Orientale and Imbrium basins may indicate that it is a basin-related deposit. An analysis of lineament directions within this material showed a general trend of approximately N. 40° W.; the direction to the center of Mare Serenitatis is N. 30° W., and to the center of Mare Imbrium is N. 48° W.

Mare (Im) and plains-forming (Ip) materials have relatively smooth, level surfaces, occur primarily in topographically low areas, and terminate abruptly against higher topography; these characteristics suggest emplacement in a fluid state. The mare material has been shown by Apollo missions 11, 12, and 15 to be of volcanic origin. The origin of the light plains-forming material within the terrae remains obscure. An Imbrian age is indicated by the absence of subdued pre-Imbrian craters and the presence of superposed small post-Imbrian craters.

Craters, other than those described as irregular, presumably were formed by meteorite impact as indicated by the following characteristics: circular form, interiors which extend below the surrounding terrain, elevated rim crests, hummocky rim deposits, ejecta blankets, and secondary craters. Craters which were similar when first formed are modified and degraded through time (Pohn and Offield, 1970). Processes that subdue and degrade features include subsequent impact cratering, filling of basins with mare material, volcanism and blanketing by pyroclastic material, and downslope movement of fragments.

Two large Copernican-age craters occur in the central part of the map area. Beyond the continuous ejecta blanket of the crater Censorinus, a partially mantled area extends to a distance of about an additional crater diameter. Secondary craters too small to be mapped and bright rays from Censorinus are visible beyond the map boundary at a distance of more than 10 crater diameters. A field of blocks, some of them 40 m across, occurs near the rim crest of Censorinus; the block field is not mapped south of the crater owing to lack of high-resolution photographs. The smallest blocks visible on available photography are 3 m across; smaller ones are expected within and beyond the indicated field. Numerous small ridges on the west rim of Censorinus A probably were formed by ejecta from Censorinus.

Craters or crater clusters with irregular outlines (Ici) may be secondary impact craters of the Imbrium basin. The Imbrian age of these craters is indicated by their superposition on pre-Imbrian materials and the fact that they are locally overlain by post-Imbrian craters, most of which are too small to be mapped. Numerous chain craters are present and these appear generally to postdate the irregular craters. They trend both parallel to the generally northwesterly Imbrian radial direction and in a northeasterly direction which may reflect the lunar grid in this area (Strom, 1964) or may be related to one of the nearby multi-ringed basins. The morphology of the chain craters and the evidence for structural control of their distribution suggest an internal origin.

The Censorinus region includes rugged pre-Imbrian massifs which may be remnants of uplifted basin rings. The northerly trend of the largest of these massifs is locally concentric to the margin of Mare Fecunditatis and may be part of the ring structure of this basin. Lineaments in the lineated unit mostly trend northwest; these and others having the same trend may be part of the radial system of fractures related to the formation of the Imbrium basin, most recent of the events that affected the area.

The sequence of major geologic events which shaped the Censorinus region are interpreted to be as follows: 1) impact cratering of the old terra surface, 2) the formation of multi-ringed basins by very large impacts and the widespread almost concurrent emplacement of ejecta, 3) widespread, possibly episodic, filling of depressions by light plains-forming material and mare material, and 4) continued impact cratering.

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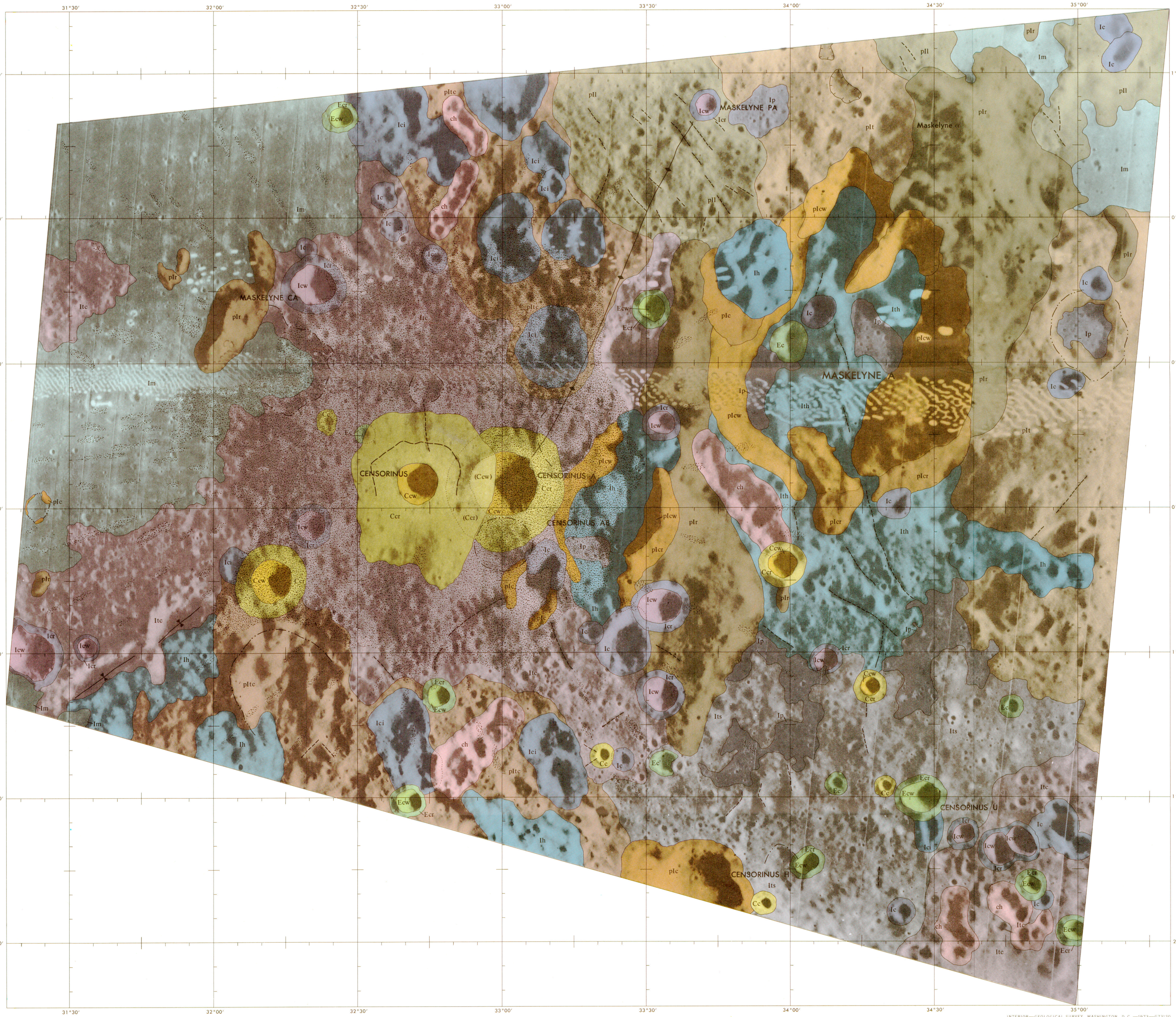

Lunar photomap base Orbiter V, Site 12, 1st edition, 1969, by the U.S. Army Topographic Command

Base compiled from Lunar Orbiter V photograph. Sun illumination angle 69° 19′ from vertical. Control was established by photogrammetric triangulation using orbit constraints and is based on ephemeris data for Lunar Orbiters IV and V dated 15 Oct 1968. Horizontal accuracy ± 144 m. (Vertical spot elevations are shown on original chart published by U.S. Army Topocom.)

SCALE 1:250 000
TRANSVERSE MERCATOR PROJECTION

10 5 0 5 10 NAUTICAL MILES
5 0 5 10 15 STATUTE MILES
5 0 5 10 15 KILOMETERS

Mapped 1971. Principal sources of geologic information: Lunar Orbiter high-resolution photographs IV H72, 73, 77, 78, V H63; Lunar Orbiter medium-resolution photograph V M63; Apollo 10 photographs AS-10-28-4038, 4039, AS-10-32-4843, 4844, 4845; Apollo 11 photograph AS-11-42-6234, 6316; high-illumination photograph 5818, 61-inch reflector, U.S. Naval Observatory; low-illumination photographs, 61-inch reflector, Catalina Observatory, University of Arizona (Kuiper and others, 1967).

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EXPLANATION

COPERNICAN SYSTEM

Cc | Ccr | Ccw

Material of fresh, rayed craters

Characteristics
Craters having bright rays or halos, sharp circular rim crests, and cone-shaped interiors; includes material in and around craters >1.5 km rim crest diameter. Subunits of craters > 2 km are mapped where distinctive
Cc, *crater material, undivided; craters too small for subdivision of units*
Ccr, *rim material; forms continuous ejecta blanket extending outward from rim crest; rough texture; blocks and small ridges on crater Censorinus rim*
Ccw, *wall material; steeply sloping crater interior*
Interpretation
Materials of young craters formed by meteorite impact

Ray material

Characteristics
Streaks or halos of highly reflective material radial or concentric to fresh craters
Interpretation
Secondary craters, blocks, and pulverized material associated with Copernican-age impact craters

ERATOSTHENIAN SYSTEM

Ec | Ecr | Ecw

Material of fresh, rayless craters

Characteristics
Materials of relatively fresh craters lacking bright rays or halos; units slightly more subdued than corresponding ones of Copernican age
Ec, *crater material, undivided; craters too small for subdivision of units*
Ecr, *rim material; more subdued, slightly smoother texture and rim crest less sharp than unit* Ccr; *ratio of rim width to crater diameter less than that of younger units; blocks not visible on available photography*
Ecw, *wall material; slopes less steep than unit* Ccw
Interpretation
Materials of craters formed by impact

IMBRIAN SYSTEM

Im

Mare material

Characteristics
Smooth, level, widespread dark basin-filling material; numerous small superposed craters; some along extensive rays from crater Censorinus
Interpretation
Volcanic flows of basaltic composition probably similar to mare of Apollo 11 site, 270 km northwest (Lunar Sample Analysis Planning Team, 1970). Rays and secondary craters from Censorinus superposed

Ip

Plains material

Characteristics
Smooth, level surface similar to unit Im *but having slightly higher albedo; small occurrences in some crater floors and in depressions; generally higher density of small craters than mare*
Interpretation
May consist of mantle of fine impact ejecta, volcanic flows, or a combination of both. Fluid emplacement indicated by topographic expression; higher albedo suggests composition or age different from unit Im

Ic | Icr | Icw

Material of moderately subdued craters

Characteristics
Units similar but more subdued than corresponding ones of Eratosthenian craters; extent of rim deposits less easily discerned than those of younger craters; more shallow than Eratosthenian craters
Ic, *crater material, undivided; craters too small or too indistinct for subdivision of units; mapped in clusters where closely spaced*
Icr, *rim material; smoother than that of younger craters of similar size*
Icw, *wall material; less steep than that of younger craters*
Interpretation
Materials of craters formed by impact; subdual of all units relative to corresponding units of younger craters caused by greater number of subsequent impacts and more extensive downslope movement of materials

Ici

Material of irregular craters

Characteristics
Crater outlines very irregular; 3-9 km diameter; rims low or absent; shallow interiors. Occur in clusters of overlapping individual craters of the same apparent age
Interpretation
May be secondary craters, possibly formed by ejecta from the Imbrium basin, or may be of internal origin

Ih

Hilly terra material

Characteristics
Numerous rounded to sub-rounded, bulbous, closely spaced hills mostly 1 to 1.5 km across; gradational with unit Ith. *Crater density less than unit* Itc
Interpretation
Erosionally subdued and structurally altered material probably related to basin-forming events. Could be of volcanic origin but positive evidence lacking

Ith

Hummocky terra material

Characteristics
Material having numerous, widespread, small, rounded hummocks mostly 0.5 to 1 km across; intervening areas smooth; gradational with unit Ih
Interpretation
Erosionally subdued and structurally altered material probably related to basin-forming events; superposed craters destroyed by downslope movement of material. Could be of volcanic origin but positive evidence lacking

Its | Itc

Terra material

Characteristics
Its, *more level and less rugged than other terra units; less heavily cratered than unit* Itc; *lacks mounds characteristic of hummocky units; largest subdued craters smaller than those of unit* Itc
Itc, *relatively level with numerous craters 0.5 to 1 km diameter; appears smooth where partially mantled by ejecta from large fresh craters near center of map; gradational with unit* Its
Interpretation
Its, *possibly basin ejecta; admixed volcanic material possible but positive evidence lacking*
Itc, *possibly basin ejecta; admixed volcanic material possible but positive evidence lacking*

PRE-IMBRIAN

pItc | pIr | pIt | pIl

Rugged terra material

Characteristics
pItc, *rough but fairly level topography lacking long steep slopes of unit* pIr *and lineaments of unit* pIl; Ici *craters and chain craters abundant*
pIr, *rugged terrain forming ridges and massifs; some slopes have swirly appearance; steep slopes relatively uncratered*
pIt, *rough material adjacent to more rugged unit* pIr; *indistinct craters and irregular depressions*
pIl, *strongly lineated materials of lower relief than unit* pIt; *level to gently rolling; numerous superposed subdued craters < 2 km diameter; most lineaments trend northwest*
Interpretation
pItc, *materials uplifted by formation of impact basins near map area; probably includes numerous overlapping basin ejecta deposits*
pIr, *basin ejecta probably uplifted by faulting during or following formation of impact basins near map area; steep slopes are smooth and uncratered due to destruction of smaller craters by downslope movement of debris*
pIt, *materials uplifted by formation of impact basins near map area or deposited as basin ejecta; indistinct craters and depressions due to mantling by downslope movement of material*
pIl, *probably mostly basin ejecta reflecting lunar grid or fractures radial to Imbrium basin*

pIc | pIcr | pIcw

Material of strongly subdued craters

Characteristics
Similar to corresponding Imbrian crater units but much more subdued; mapped in clusters where closely spaced; some interiors contain plains material or hilly or hummocky terra materials
pIc, *crater material, undivided; subunits too indistinct to be mapped*
pIcr, *rim material; more narrow than unit* Icr
pIcw, *wall material; commonly slumped or breached*
Interpretation
Most craters probably of impact origin, substantially altered by subsequent impacts and by blanketing materials; some craters could be volcanic

ch

Chain crater material

Rimless or low-rimmed coalesced craters interpreted to be of probable volcanic origin; individual craters 2-3 km diameter; alined along lunar grid or Imbrium fractures

(Ccr)

Contact

Dotted where buried; buried unit shown in parentheses

Lineament

Shallow depression or low ridge

Concealed crater

Symbol at rim crest

Irregular depression

Rimless; lacks arcuate shape of craters

Block field

Continuous to semi-continuous field of blocks mapped from high-resolution photography of crater Censorinus; no coverage south of crater; blocks occur on rim but also visible on illuminated portion of wall

Trough

Prominent depression; line marks center

Ridge

Broad extensive ridge; line marks crest

LOCATION OF MAP AREA
Numbers refer to U.S. Air Force Lunar Charts at 1:1,000,000 scale (LAC)
Arrow indicates region of this report

GEOLOGIC MAP OF THE CENSORINUS REGION OF THE MOON

By

Mareta West

1973

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