

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 cartainment 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 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.

Terrae within the map area include materials of rugged ridges and massifs (plr), rough terrain (prt), and lineated materials of low relief (pll), 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 (lh) and hummocky (lth) units and the smooth (lts) and cratered (lts) 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 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 (lm) and plains-forming (lp) 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 profiles, hummocky rim deposits, ejecta blankets, and secondary craters. Craters which were similar when first formed are modified and degraded through time (Pohn and Orfield, 1970). Processes that subside 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 craters occur in the central part of the map area. Beyond the continuous ejecta blanket of the crater Censorinus, a partially mapped 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.

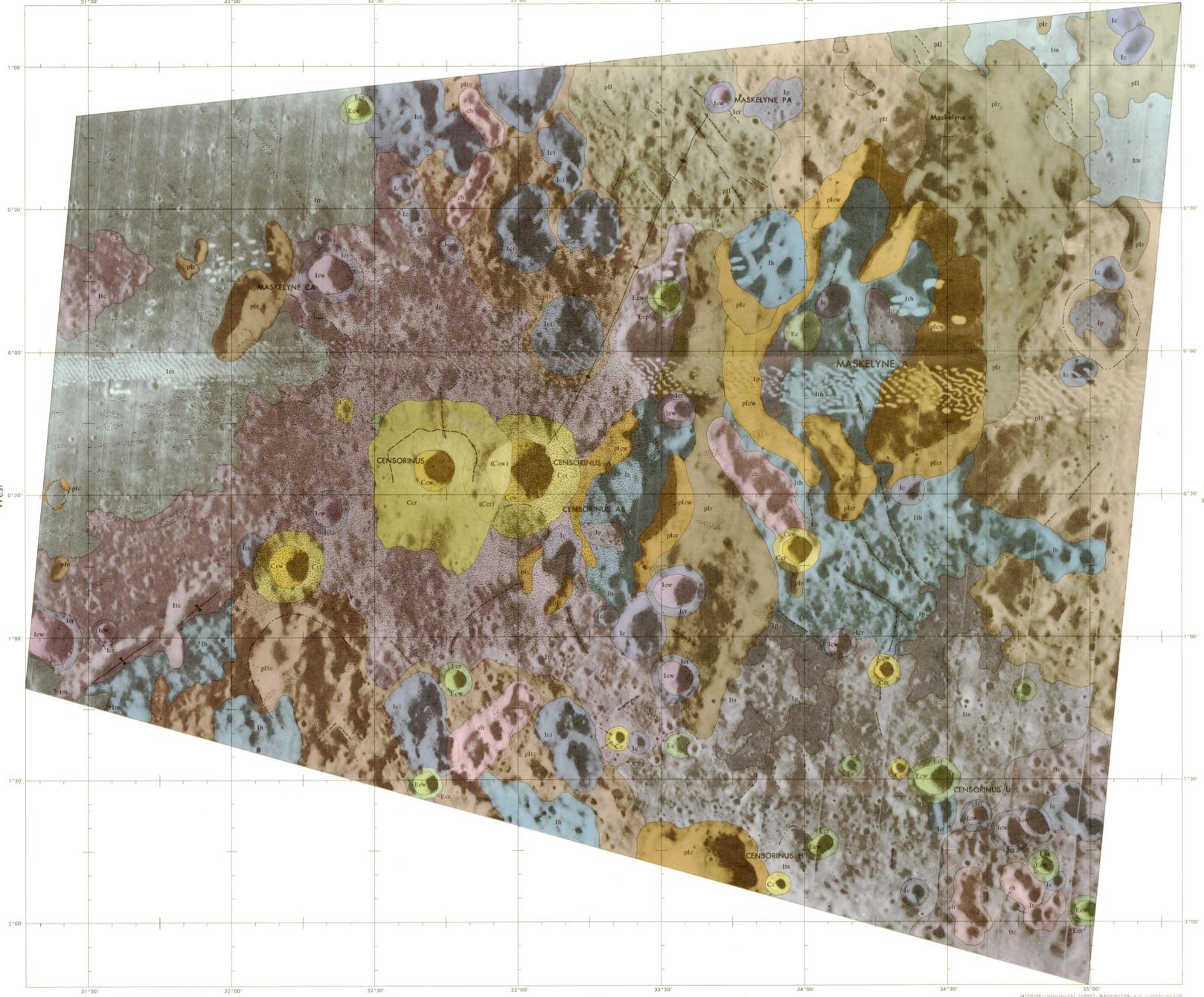
Craters or crater clusters with irregular outlines (lci) may be secondary impact craters of the Imbrian basin. The Imbrian age of these craters is indicated by their superposition on pre-Imbrian materials and the fact that they are locally overlain by post-Imbrian craters, most of which are too small 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 to 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 north-west, and 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.

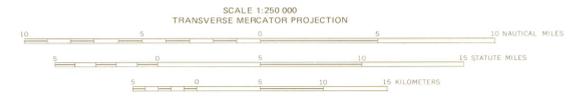
The sequence of major geologic events which shaped the Censorinus region are interpreted to be as follows: 1) impact cratering of the old terrae surface; 2) the formation of multi-ringed basins by very large impacts and the widespread almost concurrent emplacement of ejecta; 3) widespread, possibly episodic,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

REFERENCES

Kuiper, G. P., Whitaker, E. A., Strom, R. C., Fountain, J. W., and Larson, S. M., 1967, Consolidated lunar atlas—Supp. 3 and 4 to the USAF photographic lunar atlas: Arizona Univ. Lunar and Planetary Lab. Contr. No. 4.
Lunar Sample Analysis Planning Team, 1970, Summary of Apollo 11 science conference: Science, v. 167, no. 3918, p. 449-452.
Pohn, H. A., and Orfield, T. W., 1970, Lunar crater morphology and relative age determination of lunar geologic units—pt. 1, Classification, in Geological Survey research 1970: U.S. Geol. Survey Prof. Paper 700-C, p. C153-C162.
Strom, R. G., 1964, Analysis of lunar lineaments, 1: Arizona Univ. Lunar and Planetary Lab. Commun., v. 2, no. 39, p. 205-221.
Trask, N. J., 1969, Geologic maps of early Apollo landing sites of set C: U.S. Geol. Survey open-file report, 27 p.
Wilhelms, D. E., 1970, Summary of lunar stratigraphy—telescopic observations: U.S. Geol. Survey Prof. Paper 599-A, 47 p.
Wilhelms, D. E., and McCauley, J. F., 1971, Geologic map of the near side of the Moon: U.S. Geol. Survey Misc. Geol. Inv. Map 1-703.



Lunar photomast base Orbiter V, Site 12, 1st edition, 1969, by the U.S. Army Topographic Command
Base compiled from Lunar Orbiter V photomast. Sun illumination angle 69° 19' from vertical. Control was established by photogrammetric triangulation using orbital constraints and is based on ephemeris data for Lunar Orbiters IV and V dated 15 Oct 1968. Horizontal accuracy = 144 m. (Vertical scale elevations are shown on original chart published by U.S. Army Topocom.)



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 photographs AS 11-42-6234, 6235; high-illumination photograph 6816; 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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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

EXPLANATION

Material of fresh, rayed craters
Cc, Ccr, Ccw
Material of fresh, rayless craters
Ec, Ecr, Ecw
Ray material
Material of moderately subdued craters
lcr, lcr, lcr
Material of irregular craters
lci

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.

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.

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

Characteristics
Smooth, level surface similar to unit lm but having slightly higher albedo; small occurrences in some crater floors and in depression; 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 lm.

Characteristics
lts, more level and less rugged than other terrae units; less heavily cratered than unit lth; lacks mounds characteristic of hummocky units; largest subdued craters smaller than those of unit lth.
lcr, 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 lts.
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.
lci, possibly basin ejecta; admixed volcanic material possible but positive evidence lacking.

Characteristics
pbc, rough but fairly level topography lacking long steep slopes of unit plr and lineaments of unit plh; lts craters and chain craters abundant.
plr, rugged terrain forming ridges and massifs; some slopes have swirly appearance; steep slopes relatively uncratered.
plc, rough material adjacent to more rugged unit plr; indistinct craters and irregular depressions.
pll, strongly lineated materials of lower relief than unit plr; level to gently rolling; numerous superposed subdued craters < 2 km diameter; most lineaments trend northwest.
Interpretation
pbc, materials uplifted by formation of impact basins near map area; probably includes numerous overlapping basin ejecta deposits.
plc, 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.
pll, 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.
plh, probably mostly basin ejecta reflecting lunar grid or fractures radial to Imbrium basin.

Chain crater material
Irregular depression
Block field
Trough
Ridge
Contact
Lineament
Shallow depression or low ridge
Concealed crater
Symbol at rim crest

Block field
Continuous to discontinuous 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.