

GEOLOGIC SUMMARY

INTRODUCTION
The Taurus-Littrow region is mainly a highland area at the juncture of Mare Serenitatis and Mare Tranquillitatis (Scott and Pohn, 1972). Highland materials cover most of the area, forming a group of rugged massifs close to the center of the map and more subdued terrain to the east. The highland units (Iph, Ipb) are probably mostly breccias formed by the Serenitatis impact and pre-existing breccias created by this event. Younger Crisium and Imbrium ejecta may also be present but cannot be distinguished. To the west and southwest materials typical of lunar maria, almost certainly basalts, encroach upon and embay the highland terrain. Also in the west is a unit of special interest, a relatively young unusually dark material that mantles both terra and mare. It is draped over a wide variety of terrains in much of the western half of the map area and is interpreted as productive volcanics. The Apollo 17 site lies on this dark mantling material where it covers an embayment of mare materials between uplift massifs. At this location, therefore, relatively young volcanics can be sampled as well as the ancient deposits that form the highland massifs.

STRATIGRAPHY
The oldest units in the area are the massif materials (plm) and the hilly terra material (Iph). These two occur in a similar structural position on the rim of the Serenitatis basin and they are probably very similar in lithology and composition, being largely Serenitatis breccias with a covering of breccias derived from younger more distant basins. They are assigned different ages because of their structural history. The massif material is exposed in rugged, uplifted, crustal blocks around the landing site. Uplift has brought close to the surface deep, old, material that may be incorporated into the talus that surrounds the massifs. In the more subdued hilly terrain, the older, deeply buried rocks are less likely to be a significant component in the surface rocks, hence the younger age. The geologic setting is similar to that of the Apennine Mountains, the massive probably somewhat interbedded breccias derived from the adjacent basin (LSPET, 1972). Some of the massifs resemble terrestrial domes formed by shallow intrusion or extrusion of silicic igneous rocks, but this origin is considered unlikely. The characteristic appearance of the hilly terra unit is believed to result from its deformational history and not from any distinctive lithology. Like the massif materials, it probably consists of interbedded breccias but with a larger component of post-Serenitatis breccias exposed at the surface than in the case of the massifs. Plains material (Ip) is exposed around the outer edge of the Serenitatis basin, where it forms series of benches that stand slightly above the adjacent mare plains. The material also occurs within the highlands, partly filling regular depressions and craters. The origin of the unit is uncertain. The flat, smooth, mare-like surface suggests emplacement in a fluid state and hence a volcanic origin. Materials of similar appearance at the Apollo 16 site were found, however, to be breccias. The plains material may therefore be of diverse origin, being volcanic in places, particularly around the edge of the Serenitatis basin, and consisting of fluted material impacted rocks in other areas.

The terra unit (It) is transitional in appearance between the plains and hilly terra materials. It may not be a separate stratigraphic unit but is mapped in areas where the plains material is thin or only partly covers the underlying hilly area. Mare materials (Im, Em) are assigned different ages largely on the basis of albedo, since elsewhere on the Moon dark mare commonly has fewer craters than light mare. In addition crater density, unit Im is similar to the Apollo 11 basaltic unit Em is similar to the Apollo 16 basalts, and corresponding ages are likely. Where a cover of dark mantling material (Cd) precludes the distinction between mare and plains units, the unit mare or plains material (mp) is mapped instead.

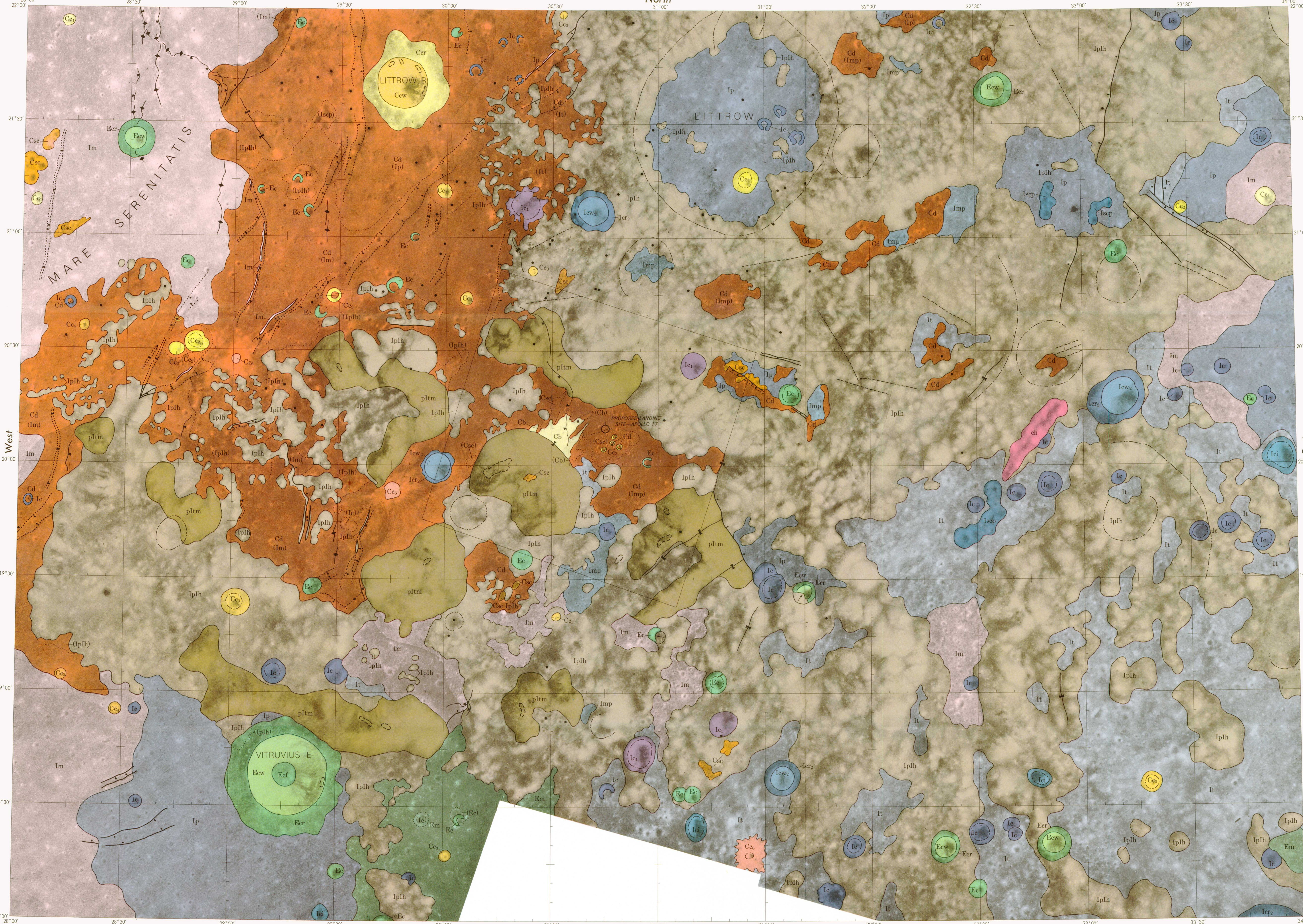
Except for ejecta from late Copernican craters (Co, Cc), the youngest materials in this region, and possibly on the Moon, are the bright and dark mantles. The bright mantle material (Cb) lies at the base of a massif and extends several kilometers across a relatively flat valley floor. The high albedo, low intrinsic relief, and hummocky, ridged texture on the surface are all suggestive of a debris flow, or landslide, originating from the talus around the massif. In most places the unit is mapped as a separate unit, since the dark mantle since the bright albedo has not been masked. In other places, however, the hummocky surface texture of the bright material appears to extend beneath the dark mantle and the normally high albedo of the slide becomes visible. This suggests that the dark material, and possibly the slide itself, was deposited intermediately so that the two units interfinger. Although the emplacement of the slide was a relatively late event, the radiometric age of most of the material that constitutes the slide should be old ($>4.0 \times 10^8$ yrs) and comparable to the materials from the mare.

The age of the dark mantle was estimated by determining the frequency distribution of superposed craters in various size ranges. An upper limiting crater diameter for the steady-state distribution was obtained, the limit being a function of the age of the surface (Morris and Shoemaker, 1968). The results indicate that the dark mantling material appears to be considerably younger than any unit yet mapped in the Apollo program. This young age is not, however, entirely consistent with the stratigraphic relations. In areas other than the landing site, particularly in the northwest corner of the map and in the Sinus Gallicus region (Carr, 1960), very similar material appears to be older than the mare surface. This suggests that deposition of the dark mantling material could span a considerable length of time. The prominent dark crater near the northeast margin of the bright mantle may be a volcanic vent and the source of some of the most recent dark material. Alternatively, the crater may have been formed by impact and its rim and walls darkened by ejecta from the adjacent dark mantle. Many smaller dark craters, thought to be volcanic vents, are scattered throughout the mare and highland region. Some of these are mapped, but many are too small to be readily discernible or are obscured by the dark mantle.

STRUCTURE
The dominant structural pattern in the eastern half of the map area is one of interesting northeast- and northwest-trending fractures of the lunar grid (Strom, 1964). They give much of the terrain its knobby appearance. The fractures appear to be largely pre-Imbrian since they only minimally affect the Imbrium plains materials. In the eastern half of the map, structures related to the Serenitatis and Imbrium basins are the most prominent. The massifs around the landing site have more relief than any other part of the Serenitatis rim except that adjacent to the Imbrium basin. The relief is believed to result from re-activation and uplift along Serenitatis radial fractures during the formation of the Imbrium basin. This is the only part of the remaining Serenitatis rim where the Serenitatis and Imbrium radials are parallel, so that re-activation is probable. The re-entrant in which the landing site lies is elongate radial to both Imbrium and Serenitatis. Prominent also are structures concentric with the Serenitatis basin, the most obvious being the Littrow ridges. Two sets of ridges are recognized. The first occurs in the unit Ip and is embayed by and hence predates the mare (Im); the second set, which is made up of narrower more fresh appearing ridges, cuts and hence postdates the mare.

GEOLOGIC HISTORY
The primordial lunar crust of the region was covered during early pre-Imbrian time by ejecta from several large impact basins such as Tranquillitatis, Peneplatinus, and Nectaris. Most of the upland material presently close to the surface is, however, probably ejecta from the adjacent Serenitatis basin. The original surface texture of the Serenitatis ejecta blanket has been completely destroyed by erosion and fracturing. Formation of the two oldest post-Serenitatis basins, Crisium and Imbrium, may have resulted in deposition of an additional younger veneer of ejecta over the area, but this is not detectable in the photography. Locally, the main effect of the Imbrium event was to cause uplift of the massifs around the landing site. After the Imbrium basin formed, or perhaps even earlier, the basin began to fill with mare basalts, and this may have continued throughout the Imbrium period. Several episodes of faulting along fractures concentric with the Serenitatis basin resulted in the formation of some of the Littrow ridges during this period. Most of the mare deposition terminated at the end of the Imbrian period, but some mare basalts were deposited in later Eratosthenian time in the southern part of the area. Faulting concentric to the Serenitatis basin also continued into post-Imbrian time to form the youngest of the Littrow ridges. The final major event in the geologic history of the area was deposition of the dark mantling material over much of the upland and mare.

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Principal sources of geologic information: Apollo 15 metric photographs AS15-0892, 0895, 0898, 0971, 0972, 0975, 1111, 1112, and 1113; Apollo 16 panoramic photographs AS16-1296, 1300 and 1546-1565; Lunar Orbiter V medium resolution photographs M56-69 and high resolution photographs H56-66; Full-Moon photographs S18 from U.S. Naval Observatory, Flagstaff, Arizona; NASA contract No. T-75074.

Base map from controlled mosaic of Apollo 15 metric photographs AS15-0968, 0970, 0972, 0974, 0975 and 0977, prepared by U.S. Topographic Command under direction of Department of Defense for National Aeronautics and Space Administration, July 1972.

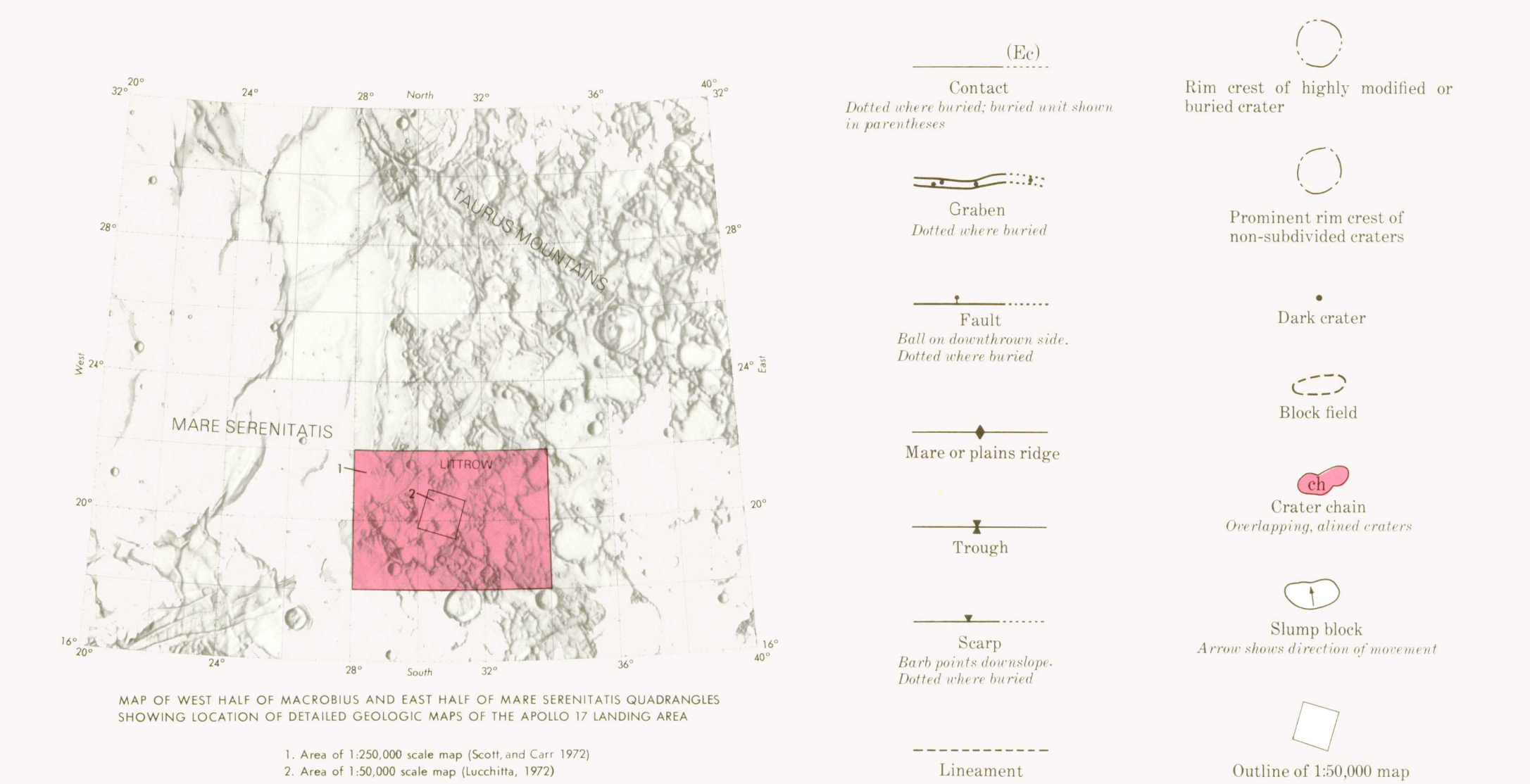
1966 Geologic Map of the Mare Serenitatis region of the Moon. U.S. Geol. Survey Misc. Geol. Inv. Map I-489.

Scale: 1:250,000
SCALE 1:250,000
TRANSVERSE MERCATOR PROJECTION

- EXPLANATION**
- Cer Cd** **Dark mantle material**
Characteristics: Smooth, fine texture, very low albedo, covers part of upland massifs, and highlands; derived in low areas, older than mare materials. Occurs in small areas of middle Copernican age (Cc) and older, younger centers superposed on older centers having diameter of 20 m, 20 m, and 100 m indicate dark mantle is in young as crater Table or younger.
Interpretation: Volcanic material, mostly pyroclastic, originating from many small vents located between craters Littrow and Vitruvius; vents: 10 m diameter indicated by special symbol.
 - Im** **Mare or plains material**
Characteristics: Occurs in depressions like craters, and in some areas, also on highlands; derived in low areas, older than mare materials. Occurs in small areas of middle Copernican age (Cc) and older, younger centers superposed on older centers having diameter of 20 m, 20 m, and 100 m indicate dark mantle is in young as crater Table or younger.
Interpretation: Volcanic material, mostly pyroclastic, originating from many small vents located between craters Littrow and Vitruvius; vents: 10 m diameter indicated by special symbol.
 - Ip** **Plains material**
Characteristics: Smooth to wavy and hummocky at panoramic camera resolution. Albedo moderate, but surface is rugged, and has some older, darker, material superposed.
Interpretation: Basaltic flow, probably of Eratosthenian age.
 - Iph Ipb** **Hilly terra material**
Characteristics: Smooth, bright to moderately bright material forming ridges or mounds as low as 5 m across; relief moderate to high. Hills occur individually and in clusters. Central rift partly divides some hills. Clearly resembles Alps Formation (Type 10) around Imbrium basin. Occurs in and around craters of late Imbrian age and older. Interbedded with terra (It) and mare (Im) units.
Interpretation: Interbedded breccias in ejecta blankets from young lunar basaltic and large craters. Ejecta from Serenitatis basin probably makes up bulk of deposit. Hills and ridges mostly reflect structural modification of basaltic flow, some may be formed by collapse of ejecta.
 - Ip** **Mare or plains material**
Characteristics: Occurs in depressions like craters, and in some areas, also on highlands; derived in low areas, older than mare materials. Occurs in small areas of middle Copernican age (Cc) and older, younger centers superposed on older centers having diameter of 20 m, 20 m, and 100 m indicate dark mantle is in young as crater Table or younger.
Interpretation: Volcanic material, mostly pyroclastic, originating from many small vents located between craters Littrow and Vitruvius; vents: 10 m diameter indicated by special symbol.
 - plm** **Massif material**
Characteristics: Bright, massive, with smooth, steep, conical to straight or gently sloping sides. Craters occur in clusters, but are generally small, with diameter of less than 100 m. Craters are generally circular, with diameter of less than 100 m. Craters are generally circular, with diameter of less than 100 m.
Interpretation: Similar to hilly unit, but layers of basaltic material are not so well developed. Craters are generally circular, with diameter of less than 100 m. Craters are generally circular, with diameter of less than 100 m.
 - Cr Cw** **Materials of crater Littrow B**
Characteristics: Crater rim material. Smooth to hummocky, slightly ridged, few blocks visible on high-resolution (Orbiter V) photographs. In places appears to be partly covered by material of middle Copernican age (Cc) and older, younger centers superposed on older centers having diameter of 20 m, 20 m, and 100 m indicate dark mantle is in young as crater Table or younger.
Interpretation: In present, size of mapped crater decreases progressively with decreasing crater age. Youngest crater (Cc, Cc) has bright rays superposed in places. Dark mantle (Im, Cd) whereas older Copernican craters (Cc) lack bright rays, and are partly covered by dark mantle.
 - Ec Er Ew Ecf** **Materials of sharp-rimmed craters**
Characteristics: Unmodified material of craters having size range (about 1.5-3 km) that are early Copernican to middle Copernican age. Crater rims and walls well defined. Larger craters show multiple terraces. Er, rim material. Smooth, conical, appearing as high, steep-sided peaks in photographs. No blocks visible on high-resolution (Orbiter V) photographs. In Vitruvius E resembles wall material of Littrow B, but never blocks visible. Er, rim material. In Vitruvius E, smooth to hummocky.
Interpretation: Impact craters.
 - ler lew** **Crater materials**
Characteristics: Similar to corresponding units of Er, but with more rounded rims and partly hilly walls low bright, no visible blocks.
Interpretation: Flow partly modified by structural processes that result in hilly material (Iph).
 - It** **Terra material**
Characteristics: Similar to corresponding units of Er, but with more rounded rims and partly hilly walls low bright, no visible blocks.
Interpretation: Flow partly modified by structural processes that result in hilly material (Iph).
 - Ic** **Crater material**
Characteristics: Material of craters having outer rim ranging from elliptical to non-symmetrical, although most are moderately high and rounded. Modified in places in hilly material (Iph).
Interpretation: Morphologic characteristics too degraded for classification as to origin, but most are probably impact craters. Age, early to late Imbrian (Trask, p. 4).
 - Ici** **Material of irregularly shaped craters**
Characteristics: Material of craters having outer rim ranging from elliptical to non-symmetrical, although most are moderately high and rounded. Modified in places in hilly material (Iph).
Interpretation: Morphologic characteristics too degraded for classification as to origin, but most are probably impact craters. Age, early to late Imbrian (Trask, p. 4).
 - Co Cc** **Materials of crater Vitruvius E**
Characteristics: Crater rim material. Smooth to hummocky, slightly ridged, few blocks visible on high-resolution (Orbiter V) photographs. In places appears to be partly covered by material of middle Copernican age (Cc) and older, younger centers superposed on older centers having diameter of 20 m, 20 m, and 100 m indicate dark mantle is in young as crater Table or younger.
Interpretation: In present, size of mapped crater decreases progressively with decreasing crater age. Youngest crater (Cc, Cc) has bright rays superposed in places. Dark mantle (Im, Cd) whereas older Copernican craters (Cc) lack bright rays, and are partly covered by dark mantle.
 - Ce** **Material of secondary craters**
Characteristics: Unmodified material of fresh-appearing craters occurring in clusters, generally in 70°-shaped. In vicinity of landing site and bright mantle (Im, Cd) where older Copernican craters (Cc) are present, secondary craters (Ce) are probably formed by impact of ejecta from Copernican craters. Near landing site and bright mantle (Im, Cd) where older Copernican craters (Cc) are present, secondary craters (Ce) are probably formed by impact of ejecta from Copernican craters.

GEOLOGIC MAP OF THE TAURUS-LITTROW REGION OF THE MOON APOLLO 17 PRE-MISSION MAP

By
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1972



MAP OF WEST HALF OF MARE SERENITATIS AND EAST HALF OF MARE TRANQUILLITATIS QUADRANGLES SHOWING LOCATION OF DETAILED GEOLOGIC MAPS OF THE APOLLO 17 LANDING AREA.

- 1. Area of 1:250,000 scale map (Scott and Carr, 1972).
- 2. Area of 1:50,000 scale map (Lucchini, 1972).

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