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**GEOLOGY OF THE APOLLO 17 SITE.** W. R. Muehlberger,  
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The Apollo 17 landing site was unique in several respects: (1) It was the only site that was not selected from telescopic-based geologic interpretation; interest in the site was generated by the visual observations of Al Worden, Apollo 15 Command Module pilot, who interpreted dark-haloed craters as possible cinder cones. (2) Instead of 20-m-resolution photographs, as was the norm for all earlier missions, this site had Apollo 15 panoramic camera photography coverage that had 2-m resolution. (3) It had a geologist-astronaut aboard who was intimately involved in all stages of planning and mission operation, and was also instrumental in the design of a long-handled sample bag holder that eliminated the need for the crew to dismount before collecting a sample, which then permitted sampling between major stations.

The following summary is mainly verbatim extracts (paragraphs) from reference [1], to which the interested reader is referred for details of site geology, sample description, and geologic synthesis of the site as viewed from studies through 1976.

The two major geologic objectives identified by the NASA Ad Hoc Site Evaluation Committee for this (the last) mission to the Moon were (1) sampling of very old lunar material such as might be found in pre-Imbrian highlands as distant as possible from the Imbrium Basin and (2) sampling of volcanic materials significantly younger than the mare basalts returned from the earlier missions. Photogeologic interpretation had suggested that such young volcanic materials on the Moon were pyroclastic, which would make them attractive not only for extending our knowledge of the Moon's thermal history, but because they might provide a record of volatile materials from the Moon's interior; furthermore, they might contain xenoliths of deep-seated lunar rocks.

**Premission Plans:** The three traverses were designed to sample, observe, and photograph each of the units recognized in the landing area (listed in order of decreasing priority): highlands (massifs and

Sculptured Hills), dark mantle (interpreted to be young pyroclastic material), and subfloor material (interpreted to have been emplaced as a fluid, or fluidized, material).

Highland materials rim the Taurus-Littrow Valley and thus would be sampled at several stations along the base of the mountain fronts. In addition, large boulders that had rolled down the slopes would be sampled so that they could be restored to their initial position to determine whether there was any internal stratigraphy to the highlands (Serenitatis Basin or older basin ejecta beneath a cap of Imbrium ejecta). The light mantle at the base of the South Massif (an avalanche deposit believed to have been caused by ejecta from Tycho when it impacted the South Massif) was to be sampled at stations at various distances from the base of the massif in the hope that these would be samples representative of different stratigraphic (?) levels on the massif.

Dark mantle material, a veneer of dark material over both valley floor and highland regions, would be collected at several localities on the valley floor. The rims of large craters were places that it was hoped that the contact relations between the younger dark mantle and the older crater rim, wall, and floor materials could be observed. Ambiguous age relations where the boundary between the dark and light mantles appeared to be diffuse led to the possibility that they were, at least in part, deposited concurrently. Shorty and Van Serg Craters were planned for the study and collection of dark mantle material supposedly erupted from volcanic vents or excavated by impacts. Sampling of the dark mantle at different locations would provide information about lateral variation.

Large blocks on the rims of the large craters on the valley floor were interpreted to be subfloor material blasted to the rim by impact. Because Apollo 16 demonstrated that plainslike surfaces could be formed by impact ejecta, the nature and origin of the valley-filling material was in doubt, and awaited sampling to demonstrate that it was basalt as was the surface on which most other lunar landings had been made.

**The Mission:** The actual traverses closely approximated the planned ones. This was probably the result of fewer parts failures, better photography, which permitted better premission interpretation/planning, and a timeline that had some flexibility. Emory Crater on EVA 1 was deleted, but Steno Crater, one of comparable size but closer to the LM, was sampled. Sherlock Crater, the last planned stop of EVA 3, was also deleted and only a scoop sample using the long-handled sampler was obtained about a crater radius from Sherlock.

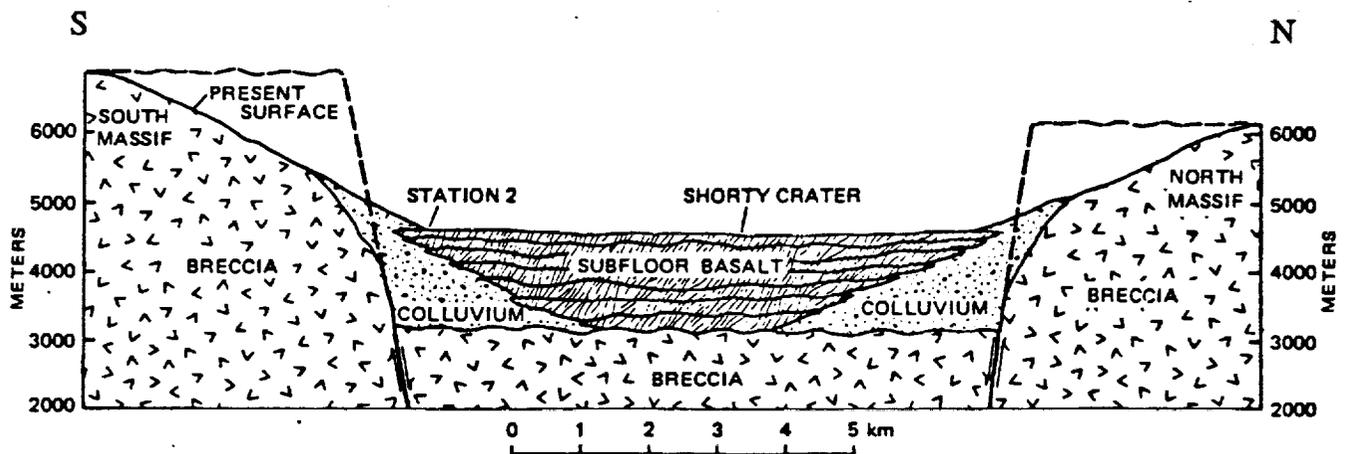


Fig. 1. Relations inferred among major subgeolith units. Dark mantle is too thin to draw at this scale. Light mantle extends from the South Massif to just beyond Shorty Crater. No vertical exaggeration. Figure 242 in [1].

The astronauts worked approximately 22 hr on the lunar surface, traversed about 30 km, collected nearly 120 kg of samples, took more than 2200 photographs, and recorded many direct geologic observations (all lunar records!). The lunar surface data, sample results, and geologic interpretation from orbital photographs are the bases for the following geologic synthesis.

**Postmission Interpretation:** The Taurus-Littrow massifs are interpreted as the upper part of the thick, faulted ejecta deposited on the rim of the transient cavity of the large southern Serenitatis Basin, which was formed about 3.9 to 4.0 b.y. ago by the impact of a planetesimal. The target rocks, predominantly of the dunite-anorthosite-norite-troctolite suite or its metamorphosed equivalents, were fractured, sheared, crushed, and/or melted by the impact. The resulting mixture of crushed rock and melt was transported up and out of the transient cavity and deposited on and beyond its rim. Hot fragmental to partially molten ejecta and relatively cool cataclastic and relict target rocks were intermixed in a melange of lenses, pods, and veins. Crystallization of melts and thermal metamorphism of fine-grained fragmental debris produced breccia composed of rock and mineral fragments in a fine-grained, coherent, crystalline matrix. Such breccia dominates the massif samples.

High-angle faults that bound the massifs were activated during the formation of the basin, so that structural relief of several kilometers was imposed on the ejecta almost as soon as it was deposited. Massive slumping that produced thick wedges of colluvium on the lower massif slopes probably occurred nearly contemporaneously with the faulting. Material of the Sculptured Hills, probably largely cataclastic excavated from the southern Serenitatis Basin by the same impact, was then deposited on and around the massifs.

Basalt, estimated to be about 1400 m thick at the landing site, flooded the Taurus-Littrow graben before approximately 3.7 b.y. ago. The basalt (subfloor basalt) is part of a more extensive unit that was broadly warped and cut by extensional faults before the accumulation in Mare Serenitatis of younger, less deformed basalts that overlap it. A thin volcanic ash unit (dark mantle), probably about 3.5 b.y. old, mantled the subfloor basalt and the nearby highlands. It, too, was subsequently overlapped by the younger basalt of Mare Serenitatis.

In the time since the deposition of the volcanic ash, continued bombardment by primary and secondary projectiles has produced regolith, which is a mechanical mixture of debris derived mainly from the subfloor basalt, the volcanic ash, and the rocks of the nearby massif and Sculptured Hills. The regolith and the underlying volcanic ash form an unconsolidated surficial deposit with an average thickness of about 14 m, sufficiently thick to permit abnormally rapid degradation of the smaller craters, especially those less than 200 m in diameter, so as to create a surface that appears less cratered than the other mare surfaces. Admixed volcanic ash gives the surface a distinctive dark color, which, in combination with the less cratered appearance, led to its interpretation before the mission as a young dark mantling unit.

The uppermost part of the regolith over much of the landing area is basalt-rich ejecta from the clustered craters of the valley floor. Most of the valley floor craters are interpreted as part of a secondary cluster formed by projectiles of ejecta from Tycho, 2200 km to the southwest. When they struck the face of the South Massif, the projectiles mobilized fine-grained regolith material that was deposited on the valley floor as the light mantle. Exposure ages suggest that the swarm of secondary projectiles struck the Taurus-Littrow area about 100 m.y. ago.

The Lee-Lincoln fault scarp is part of an extensive system of wrinkle ridges and scarps that transect both mare and highland rocks.

The scarp cuts Lara Crater, but the major part of the displacement occurred before the deposition of the light mantle. Small extensional faults cut the surface of the light mantle west of the Lee-Lincoln scarp.

**References:** [1] Wolfe E. W. et al. (1981) *U.S. Geol. Surv. Prof.*

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**THE APOLLO 17 MARE BASALTS: SERENELY SAMPLING TAURUS-LITTROW.** Clive R. Neal<sup>1</sup> and Lawrence A. Taylor<sup>2</sup>, <sup>1</sup>Department of Civil Engineering and Geological Sciences, University of Notre Dame, Notre Dame IN 46556, USA, <sup>2</sup>Department of Geological Sciences, University of Tennessee, Knoxville TN 37996, USA.

As we are all aware, the Apollo 17 mission marked the final manned lunar landing of the Apollo program. The lunar module (LM) landed approximately 0.7 km due east of Camelot Crater in the Taurus-Littrow region on the southwestern edge of Mare Serenitatis [1]. Three extravehicular activities (EVAs) were performed, the first concentrating around the LM and including station 1 approximately 1.1 km south-southeast of the LM at the northwestern edge of Steno Crater [1]. The second traversed approximately 8 km west of the LM to include stations 2, 3, 4, and 5, and the third EVA traversed approximately 4.5 km to the northwest of the LM to include stations 6, 7, 8, and 9. This final manned mission returned the largest quantity of lunar rock samples, 110.5 kg/243.7 lb, and included soils, breccias, highland samples, and mare basalts. This abstract concentrates upon the Apollo 17 mare basalt samples.

One hundred and fifty-six basaltic samples were returned weighing 32.19 kg, or approximately one-third the total weight of Apollo 17 samples. The majority of Apollo 17 mare basalts were found at station 1A (75 samples), 22 from station 0, 19 from station 8, 11 from station 5, 10 from station 6, and 9, 4, 3, 2, and 1 from stations 4, 9, 7, 2, and 3 respectively. Note that these statistics include rake samples, but do not include basaltic clasts from breccia samples (e.g., [2]). Practically all these samples have been studied to various degrees, whether it be just a thin-section cut, to rare-gas, magnetic, isotope, and whole-rock analyses.

**Petrographic Studies:** The Apollo 17 mare basalts were divided into a three-fold classification on the basis of petrography. The petrographic divisions were derived independently by three different studies [3-5] and the differences between the groups defined by each petrographic study are identical. The petrographic groups are

1. *Type 1A: Olivine porphyritic ilmenite basalts.* These are usually fine-grained (typically <1 mm) with a general subvariolic to variolitic texture, or vitrophyric (e.g., 71157). All type 1A basalts contain olivine and ilmenite phenocrysts (e.g., 71048). Armalcolite, where present, forms cores to ilmenite, is partially rimmed by ilmenite, or is rarely present as discrete grains (up to 0.2 mm; e.g., 71097). Chromite-ulvöspinel is present either as discrete grains (0.1-0.3 mm) or as inclusions in olivine (<0.1 mm). All type 1A basalts contain ilmenites with sawtooth margins, indicative of rapid crystallization (e.g., [3]). Pink pyroxene prisms (≈0.4 mm) and plagioclase laths (≈0.3 mm) are interstitial, sometimes combining to form "bowtie" textures.

2. *Type 1B: Plagioclase-poikilitic ilmenite basalts.* All type 1B basalts are coarse grained (>2 mm), with rare medium-grained examples (e.g., 74287). However, all are olivine poor. In all cases, ilmenite has exsolved both ulvöspinel and rutile, which are present as thin (<0.05 mm wide) lamellae within ilmenite. Armalcolite and discrete chromite-ulvöspinel (0.2-0.5 mm and 0.1-0.2 mm respectively), where present, are inclusions in olivine, pyroxene, and/or