PETROGRAPHY OF APOLLO 17 SOILS, Grant Heiken and David S. McKay,
Earth and Planetary Sciences Division, Johnson Space Center, Houston, TX 77058

Introduction: Apollo 17 soils were sampled from regolith developed on three basic geologic units; the massifs surrounding the valley of Taurus-Littrow, the sculptured hills, and the mare lavas and "dark mantle" deposits of the valley floor (1). Grain mount thin sections of the 90-150 μm fraction from a suite of 33 soils representing these photogeologic units are the basis for this study.

"Dark mantle" deposits: The floor of the Valley of Taurus-Littrow is characterized by deposits of unusually dark regolith which are part of the continuous dark mantle rimming the southeast edge of Mare Serenitatis and the adjacent highlands. Soils from the "dark mantle" are typical of lunar soils and are what one would expect from the comminution of basalt flows by meteorite bombardment over the last 3.82 b.y. [the age of the lavas (2)]; they contain 25-66% basalt fragments, clinopyroxene, ilmenite, and plagioclase (fig. 1). The basaltic fragments exhibit the same textural variation found in larger samples collected at the site (3), i.e., equigranular to subophitic, medium to coarsely crystalline and finely crystalline, variolitic varieties. Both dominant types of basalt contain 15-25% opaque minerals, mostly ilmenite. Agglutinate contents range from 9-56%. Agglutinates consist of mineral and lithic detritus bonded together with clusters of brown heterogeneous brown glass. Previous studies (4) indicate that agglutinates are melt products from meteorite bombardment of the lunar surface and increase with longer exposure to the lunar environment. Most of the soils from the Apollo 17 landing site have moderate to high agglutinate contents and are considered to be mature soils. The agglutinates derived from ilmenite-rich basalt at this site have a dull, submetallic luster, which, along with basalt fragments, may be responsible for the low albedo. Agglutinates derived from massif soils normally have a vitric luster. Orange and black droplets are present in portions from 2 to 18%, with an average of about 5%. The black droplets are quench crystallized equivalents of the orange glass, consisting of olivine, ilmenite and glass. There are convincing arguments for a pyroclastic origin of these spherules (5). The greatest concentration of orange and black droplets are at young (fresh) Shorty Crater, where it is possible that some of the ejecta, which in part consists of weakly lithified aggregates (100% droplets), is from some tens of meters below the surface where there may be deposits interbedded with or adjacent to the basalt flows and regolith soils. Elsewhere in the valley, soils contain a substantial orange and black droplet component. Brought to the surface by craters now in a degraded state, any aggregates such as those in the ejecta at Shorty Crater have probably been broken up and mixed into the regolith by meteorite bombardment. In summary, the "dark mantle" at the Apollo 17 landing site is typical regolith formed by impact processes. The low albedo is due primarily to ilmenite-rich basalt fragments and dark-colored agglutinates, except at Shorty Crater, where the darker albedo may be due principally to black droplets. There may be, however, interbedded with lavas at this site, a layer or layers consisting of droplets, pyroclastic in origin. These droplets have been mixed into the regolith by subsequent impacts.

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South Massif and "Light Mantle" Soils: Soils of the South Massif and the "light mantle" (an avalanche deposit) are characterized by a relatively high albedo. Most of the lithic and mineral soil components consist of comminuted vitric and metamorphosed anorthositic breccias, with traces of anorthosite and cataclastic anorthosite. The variety of rock types characteristic of the massif are described by LSPET (3). Massif soils (Sta. 2) and avalanche soils (Sta. 2A, 3, LRV-6) are very similar. The components are summarized in fig. 1 The largest variation from sample to sample is in the agglutinate content (25-48%). In the case of the "marbled" avalanche deposit at Sta. 3, differences between gray and white zones are mainly in the agglutinate content; these may have been layers similar to those seen in regolith cores which were mixed during the avalanche or in the ejecta from a nearby 10 m crater. The sample from the avalanche prong at Sta. LRV-2 (fig. 1) is either thoroughly mixed into or overlain by mare-derived regolith; consists of primarily mare-derived soil components, although collected from an area with higher albedo.

North Massif and Sculptured Hills Soils: The soils consist of mostly lithic and mineral detritus derived from comminuted metamorphosed breccia and are very similar to soils collected at the South Massif (fig. 1, Sta. 6,7,8).

Lateral Mixing between Geologic Units: Although most of the components in soils studied at this site appear to have been derived during comminution of underlying bedrock, all are "contaminated" by fragments from other geologic units. Nearly all of the mare soils contain a few percent metamorphosed breccia fragments, most likely derived from the massifs. Massif soils contain mare-derived lithic and mineral fragments, ranging from ≈1-7% for those from the South Massif to ≈2-17% for those from the North Massif. Slopes of the South Massif were cleared by an avalanche (mass wasting on a grand scale) as evidenced by the small amount of mare-derived soil components. The North Massif samples were collected near the mare-massif contact and are, not surprisingly, heavily "contaminated" with mare-derived soil components. It is interesting to note that lateral transport by impact cratering is more effective than mass-wasting at the base of the North Massif. This lateral mixing of soil components by impact cratering should be considered when interpreting bulk soil analyses.

References:

(1) Apollo Field Geology Investigation Team, Science, 182, 672 (1973).

(2) Evensen, et al., Trans. Amer. Geophys. Union, 54, 587 (1973); Kirsten, et al., ibid., 54, 545 (1973).

(3) Lunar Sample Preliminary Examination Team, Science, 182, 659 (1973).

(4) McKay, et al., Proc. of Second Lunar Sci. Conf., 1, 755 (1971); Duke, et al., Geochim et Cosmochim. Acta, Suppl. 1, vol. 1, 347 (1970).

(5) McKay and Heiken, Trans. Amer. Geophys. Union, 54, 549 (1973); Reid et al., ibid., 54, 606 (1973); Glass, B. P., ibid., 54, 590 (1973); Prinz, et al., ibid., 54, 605 (1973).

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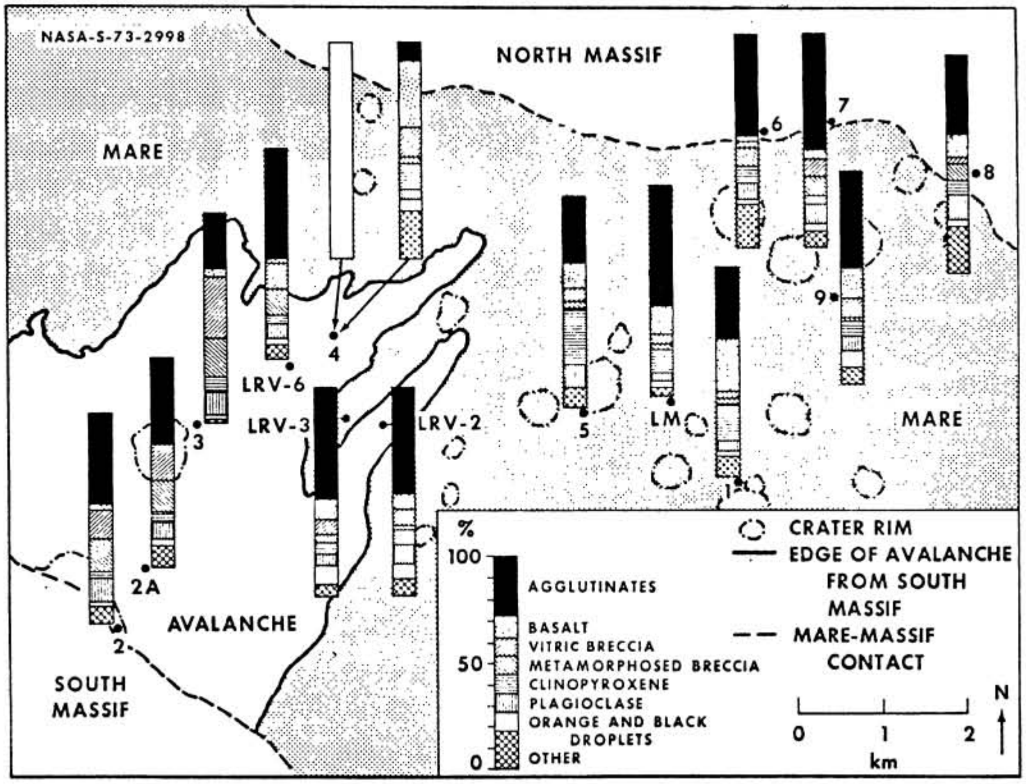

Fig. 1: Modal analyses of the 90-150μm soil fraction; average of 1-5 samples per station. "Other" includes a variety of glass types and unusual lithic fragments present in small amounts

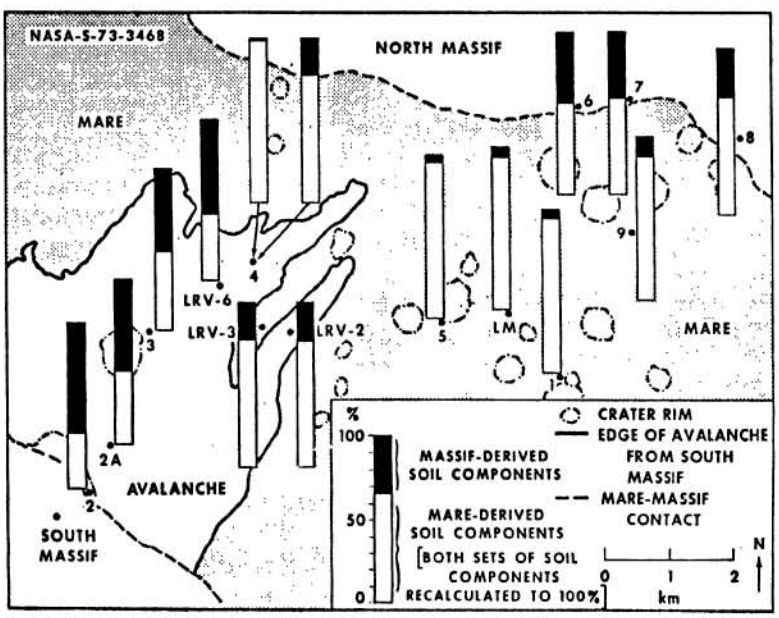

Fig. 2: Relative portions of massif- and mare-derived soil components