SURFACE SOIL VARIABILITY AND STRATIGRAPHY AT THE APOLLO 16 SITE

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Measurements of penetration resistance as a function of depth to depths of several tens of centimeters using the Self Recording Penetrometer (Mitchell et al (1)), as well as analyses of footprints and study of LRV-soil interaction and core tube samples have enabled determination of local soil variability and stratigraphy at the Apollo 16 landing site.

Four cone penetration tests were made at Station 4 in the Descartes material on Stone Mountain, and five cone penetration tests were done in the Cayley Plains in the Station 10-ALSEP area. Envelopes encompassing all the penetration vs. depth curves for each test area are shown in Fig. 1. Also shown in Fig. 1 are penetration data for the Apollo 14 and 15 sites and from Lunokhod 1. It is apparent from these data that greater soil variability was encountered on the slopes of Stone Mountain than in the Plains area, and that the average penetration resistance is greater in the Plains than on Stone Mountain.

Detailed analysis of the individual penetration curves, Mitchell et al (1), shows locally variable soil profiles on Stone Mountain and that in some areas profiles exist with soft layers several centimeters thick sandwiched between firmer layers. From a comparison of the penetration curves with X-radiograph data for an adjacent double core tube sample it has been inferred that South Ray Crater material containing abundant rock fragments decreasing with depth overlies the Descartes deposit. The contact between the two material types varies between about 20 and 50 cm. over the area investigated.

The penetration tests in the Station 10-ALSEP area were located along a line southwest from the Rover to the ALSEP area. The ground surface was generally level and free of large rock fragments. A stratigraphic profile, Fig. 2, has been prepared based on the X-radiographs of the drill-core stem (ALSEP site) and the Station 10 core sample and on the penetration curves. Five layers have been detected, as shown, which reflect the complex stratigraphy, created probably as a result of repeated impacts of different magnitude at different locations.

Drive tube, drill stem, and penetrometer data all indicate a general increase in density and decrease in porosity with depth for the depth range investigated (a few decimeters), with the greatest increases developed near the surface. Measured densities are in the range of about 1.4 to 2.0 g/cm^3, with most values in the range of 1.5 to 1.8 g/cm^3. The densities at depths greater than a few centimeters are greater on the Cayley Plains than on Stone Mountain.

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A total of 309 footprints in the Apollo 16 photographs was studied and the porosity variations were analyzed statistically using the method of Houston et al (2). Values determined in this way reflect average porosities for the top 15 cm but are influenced most strongly by porosities in the upper 5 to 10 cm. The results show:

(1) Average porosity of the surface soil varied only slightly among the different locations visited at the Apollo 16 site.

(2) Average porosity (45.0%) of intercrater areas at the Apollo 16 site is slightly greater than that at the four previous Apollo sites (43.3%).

(3) Average porosity on crater rims (46.1%) is about the same as at the four earlier sites (46.7%).

Analysis of Rover tracks by the method of Freitag (3) was also used as a basis for porosity estimation. An average value of about 41% was determined, and the surface soil traversed at the Descartes site is relatively uniform on a regional scale.

It is concluded that the lunar surface as about the same average porosity at all locations regardless of composition or topography, although significant local (on a meter scale) variations may exist which probably reflect relatively recent cratering and depositional events. Vertical stratigraphy of the near surface soil may be complex. This stratigraphy cannot be anticipated on the basis of surface appearances or behavior, but is readily detectable from the results of penetration tests.

REFERENCES

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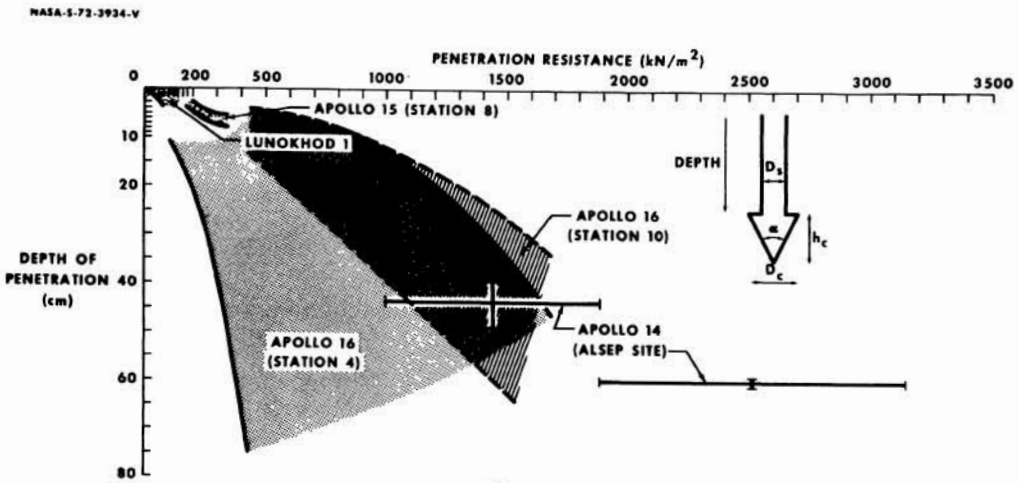

MISSION	NO. OF TESTS	D_c (cm)	α	h_c (cm)	D_s (cm)
APOLLO 14	3	0.95	30°	1.78	0.95
LUNOKHOD 1	327	5.0	60°	4.4	-
APOLLO 15	2	2.03	30°	3.78	0.94
APOLLO 16 (STATION 4)	1	2.03	30°	3.78	0.94
	3	1.28	30°	2.39	0.94
APOLLO 16 (STATION 10)	1	2.03	30°	3.78	0.94
	3	1.28	30°	2.39	0.94

FIG. 1 PENETRATION RESISTANCE OF THE LUNAR SURFACE AT DIFFERENT LOCATIONS.

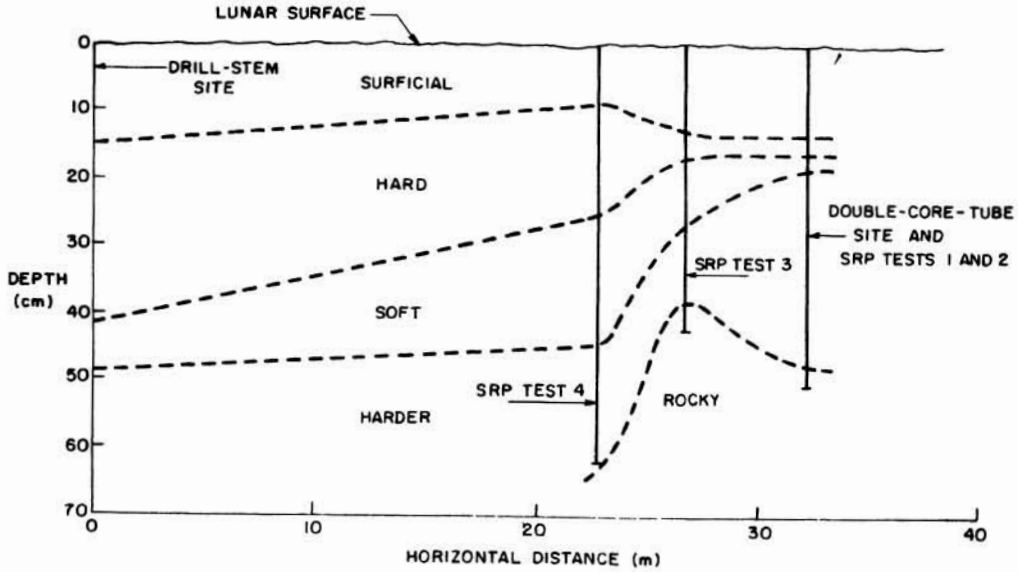

FIG. 2 APPROXIMATE SOIL PROFILE BETWEEN STATION 10 DOUBLE-CORE-TUBE SITE AND DEEP-DRILL-STEM SITE IN ALSEP AREA.