APOLLO 16: FURTHER EVIDENCE FOR VITRIFICATION DARKENING OF LUNAR SOILS. John B. Adams, West Indies Laboratory, Fairleigh Dickinson University, St. Croix, U.S.V.I. 00820; and Thomas B. McCord, Department of Earth and Planetary Sciences, M.I.T., Cambridge, Mass. 02139.

Spectral reflectance measurements have been made of six soil samples from Apollo 16. The soils appear to be representative of the main types that were encountered at the site. The gray soil that is typical of the area near the Apollo 16 LM is very similar to the Luna 20 soil (1), but has a slightly higher albedo than the common soils at the Apollo 14 site and at the Apollo 15 Appenine front. Light gray soils from the ray craters, or that were encountered at depth, have higher albedos than any soils previously returned, with the exception of Cone Crater (Apollo 14). The high-albedo soils show well developed pyroxene absorption bands near 0.94 µm and 2.1 µm, whereas the more typical darker soils have subdued bands at the same wavelengths.

The darker soils are very similar chemically to the lighter soils (2). The darker soils, however, have a notably higher population of dark, glassy agglutinates (3). As at other sites on the moon the development of the agglutinates (through micrometeoroid bombardment) depresses the albedo of the soil, and subdues the spectral contrast, thereby weakening the pyroxene absorption bands. Attenuation of light occurs within the agglutinates through electronic (largely charge-transfer) absorptions involving Ti^{3+} and Fe^{2+} ions in the glass phase and in the opaque minerals (largely ilmenite, and to a lesser extent, free iron).

The effect of agglutinates on the optical properties is illustrated by samples 61221 and 61241 which are, respectively light and dark soils from a trench sample. The dark soil overlies the lighter one and probably has been derived from it by exposure at the lunar surface (2). Both soils are thought to have been derived from North Ray Crater. Analyses reported by LSPET (2) are: 61220---SiO_2 45.35, TiO_2 0.49, Al_2O_3 28.25. FeO 4.55, MnO 0.06, MgO 5.02, CaO 16.21; 61240---SiO_2 45.32, TiO_2 0.57, Al_2O_3 27.15, FeO 5.33, MnO 0.07, MgO 5.75, CaO 15.69.

Agglutinates were separated from the < 250 µm fractions of both soils magnetically, taking advantage of the fact that the dark glassy fragments contain dusty inclusions of ilmenite, metalic iron and other opaque phases. The darker surface soil yielded 43.6 wt.% agglutinates whereas the lighter subsurface soil yielded 12.5 wt.%. The magnetic fractions are considerably darker than the respective parent soils. The non-magnetic fraction of the darker surface soil (61241) closely approached the albedo of the bulk subsurface soil (61221) which has a reflectance of .37 at .55 µm, supporting the ideas that the surface soil was derived from the subsurface one, and that formation of the dark glass is a primary mechanism for darkening at the lunar surface. These results are in accord with previous conclusions by Adams and McCord (4, 5) and by Nash and Conel (6, 7).

Reflectance curves of the non-rayed Apollo 16 surface soil closely match the earth-based telescopic curves of a 10 km area which includes the landing site (8). The mature Apollo 16 soil (agglutinate-rich) appears to be typical of the mature soils observed in all other highland areas, implying that the same darkening process is affecting the entire moon. The highlands, however, darken less than the maria, because highland materials contain substantially less iron and titanium than do the mare basalts.

REFERENCES

1. J.B. Adams, P.M. Bell, J.E. Conel, H.K. Mao, T.B. McCord, and D.B. Nash, Geochim. Cosmochim. Acta (1973) in press.

2. Lunar Sample Preliminary Examination Team, Science (1972).

3. D.S. McKay, G.H. Heiken, R.M. Taylor, U.S. Clanton, and D.A. Morrison, Proc. Third Lunar Sci. Conf. Vol. 1, 983-944, M.I.T. Press (1972).

4. J.B. Adams and R.L. Jones, Science 167, 737-739 (1970).

5. J.B. Adams and T.B. McCord, Proc. Second Lunar Sci. Conf. Vol. 3, 2183-2195, M.I.T. Press (1971).

6. D.B. Nash, J.E. Conel, and R.T. Greer, Science 167, 721-724 (1970).

7. D.B. Nash, and J.E. Conel, The Moon (1973) in press.

8. T.B. McCord, M.P. Charette, T.V. Johnson, L.A. Lebovsky, and C. Pieters, The Moon 5, 52-89 (1972).