

Mineralogical Characterization of Lunar Highland Soils.

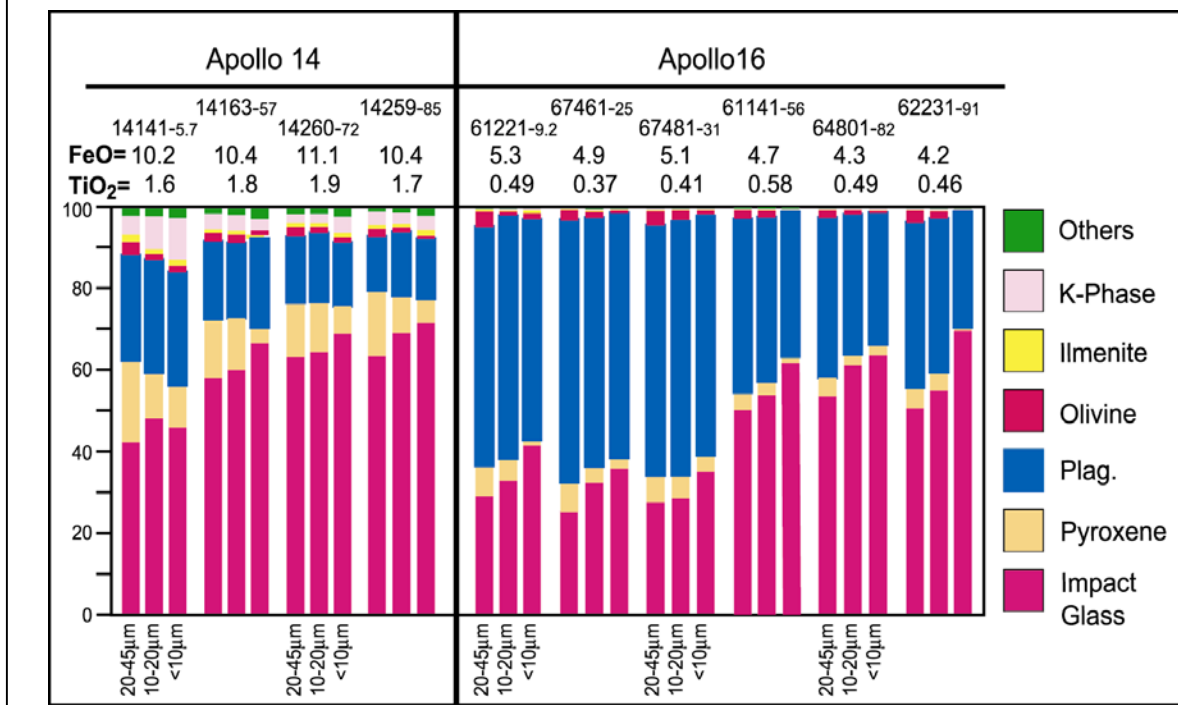
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Introduction: It has been theorized that the effects of space weathering during soil formation on the Moon are similar to those for many other airless bodies (e.g., Vesta, Eros) [1,2]. Therefore, the study of these effects on lunar soils may form the basis for our understanding of other heavenly bodies. This is a particularly valid axiom for reflectance spectroscopy of these soils. It has been repeatedly demonstrated that it is the fine fractions that dominate the spectral reflectance signatures of lunar soils [3-4], and it is the 10-20 μm size fraction that has overall spectral properties most similar to the bulk soil. However, it is these same fractions that contain the major effects of space weathering, e.g., nanophase Fe^0 , that create the overall spectral reddening, lowered albedo, and attenuated absorption features of the observed spectra. In order to attempt to unravel these effects on lunar spectra, the **Lunar Soil Characterization Consortium (LSCC)** was

established [5] for the collaborative study of lunar soils by various techniques, all related to the quantification of space weathering effects and the deciphering these effects in reflectance spectra.

Methodology: Ten pristine highland soils were selected for this study from Apollo 14 and 16 collections. These soils were chosen for their contrasting maturities, as reflected in their I_S/FeO values [6]. For each soil, the 44-20, 20-10, and $< 10 \mu\text{m}$ size fractions were obtained by wet sieving, with triply distilled water [7]. As outlined in Taylor et al. [2], each soil was split into appropriate sizes and distributed to LSCC members. The Tennessee team has characterized these soil size fractions both chemically and mineralogically, with detailed modal and phase compositional analyses, using techniques described previously by our group [8]. The results of the bulk chemistry of each size fraction of the

Figure 1. Modal abundances of Phases in the Fine Fractions of Highland Soils.

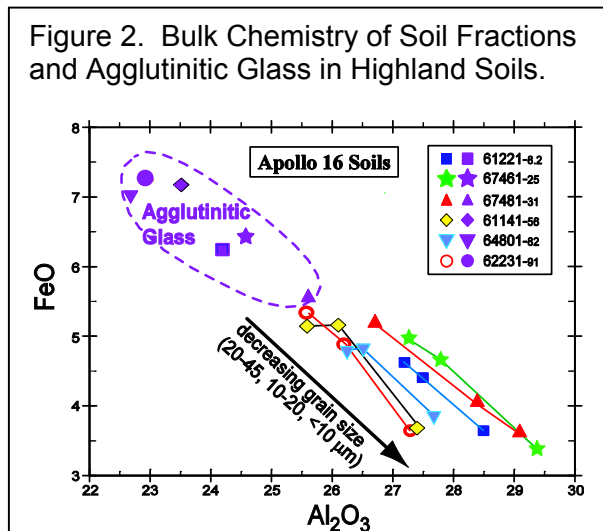


highland soils was presented earlier [9].

Modal Analyses of Minerals and Glasses:

The modes of 12 different minerals and glasses were determined on polished grain mounts of each size fraction, utilizing the x-ray digital-imaging techniques outlined by Taylor et al. [8]. The data for the major phases in the 10 highland soils are shown in Figure 1. The pyroxene values shown in Figure 1 are for total pyroxene, by combining abundances of the four (4) different pyroxenes compositional groups. In addition to detailed modal abundances, we also have determined the average composition of each phase. These are the soil characterizations that are the input data for the quantitative modeling of the reflectance spectra of the lunar soils.

Figure 2. Bulk Chemistry of Soil Fractions and Agglutinitic Glass in Highland Soils.



Modal Mineralogy: Within a given soil and with decrease in grain size, the abundances of the agglutinitic glasses always increase. Although the amount of plagioclase does not appear to change appreciably, there are distinct reductions in pyroxene abundances with decreasing grain size. This would appear to indicate that the composition of the finer fractions should contain less Fe and Mg, which is the case. This is also apparent with the chemistry of the various size fractions, as documented previously [9].

Comparisons between soils show systematic overall increases in the abundances of agglutinitic glass with increase in the de-

gree of maturity of the soils, as measured by I_s/FeO values [9]. This is to be expected, since the longer the exposure of a soil on the surface of the Moon, the more the micro-meteorite gardening and space weathering, which results in the increase in the melt products due to impacts (i.e., agglutinates and vapor-deposited patinas). It would appear that the amount of agglutinitic glass is greater for mare soils than highland soils for the same maturity.

Agglutinitic-Glass Compositions: With one important exception, all of the systematic changes for the modes of the minerals and agglutinitic glass and their chemistries are the same for the mare and highland soils (also discussed by [10]). In the mare soils, with decrease in grain size, the bulk chemistry of each fraction became higher in Al_2O_3 and lower in FeO, appearing to approach the composition of the agglutinitic glass with the lowest FeO content [1,2]. With the Apollo 14 soils, the bulk compositions of each size, although becoming slightly depleted in FeO, contained about the same FeO as the agglutinitic glass.

Figure 2 shows the chemistry of the Apollo 16 fine-soil fractions and the composition of the agglutinitic glasses. NOTE: the trends with the agglutinitic glass shown by the mare soils is reversed with Apollo 16 highland soils. The soils become depleted in FeO with decreasing grain size, BUT the composition of the agglutinitic glass is richer in FeO and poorer in Al_2O_3 . This a complete and unexpected surprise and awaits explanation, as discussed by [10]. Careful re-examination has demonstrated that this is not a rudiment of the X-ray analysis program.

References: [1] Taylor et al. (2001) MaPS; [2] Taylor et al. (2001) JGR; [3] Pieters, C. (1993) Remote Geochem. Anal.; [4] Fischer & Pieters (1994) Icarus; [5] Taylor et al. (1999) LPSC XXX; [6] Morris (1977) PLPSC 8; [7] Noble et al. (1999) LPSC XXX; [8] Taylor et al. (1996) Icarus; [9] Taylor et al. (2002) LPSC XXXIII; [10] Pieters & Taylor, this volume.