VISIBLE TO MID-INFRARED PROPERTIES OF LUNAR SOILS AND SOIL SEPARATES. C. M. Pieters, Dept. Geological Sciences, Brown Univ., Providence, RI 02912

In order to provide a comparative baseline for a variety of remote compositional analyses, reflectance spectra from the visible through the mid-infrared have been acquired for representative mature soils from Apollo 11, 12, 14, and 16. Similar spectra were acquired for size separates for Apollo 11 soil 10084. The finest fraction dominates both the visible and the midIR. Apollo 16 soils exhibit the shortest Christiansen Frequency (CF), a trend consistent with their feldspathic character. Finer soil size fractions, however, are observed to have longer CF, perhaps due to the effective strength of the Reststrahlen bands (RB). Altogether, features in the near-infrared are currently the most readily interpreted in terms of mineral composition and space weathering effects.

A brief survey of lunar mid-infrared properties was presented by Nash (1). Reflectance spectra of lunar samples presented here were acquired with the RELAB bi-directional spectrometer (0.3-2.5 μm) and bi-conical Nicolet 740 FTIR spectrometer (1 - 25 μm). The data were spliced, typically at 2.4-2.5 μm, to form a composite spectrum. Spectra of bulk samples of mature soils 10084, 12070, 14259, 62231 (2) are shown in Figures **a** and **b** and spectra of size separates and agglutinates of 10084 (3) are shown in Figures **c** and **d**.

When electromagnetic radiation interacts with solid materials it is affected by the natural frequencies of the material which often embed diagnostic features in the spectrum. Absorption features are, however, significantly modified by the physical state of the material and the number of interactions an average photon incurs. For lunar materials, and the terrestrial planets in general, three parts of the spectrum can be discussed based on the type of electromagnetic interactions that occur. The pertinent characteristics of the lunar soils and separates of Figures a - d are:

<u>Visible to near-infrared (0.3 - 2.5 μm)</u> Radiation from the Moon is reflected solar radiation. Light interaction with the surface involves volume scattering where radiation is transmitted through particles and is typically scattered by multiple interactions. These spectra are dominated by a red continuum (increasing reflectance toward longer wavelengths) principally the result of cumulative space weathering (3) and superimposed Crystal Field absorptions (4) diagnostic of pyroxene near 1 and 2 μm (high Ca pyroxenes exhibiting slightly longer wavelengths). Although the larger particles exhibit stronger absorptions, the finest fraction dominates the bulk optical properties (3). For the bulk soils, albedo is a function of the feldspathic/mafic composition.

<u>Short wave infrared (2.5 - 7 μm)</u> Both reflected solar and thermal emission photons account for lunar radiation at these wavelengths. Equal amounts of both typically occurs near 3.5 μm depending on albedo and temperature. This part of the spectrum is still dominated by volume scattering. The broad feature near 3 μm is due to adsorbed water, presumably terrestrial, which cannot be eliminated even after the sample has remained in a purged environment for more than 24 hours. The continuum increases until ~4.5 μm, where the wings of the strong molecular RB absorptions of the midIR begins to affect the spectrum at longer wavelengths.

<u>Mid-infrared (7 - 25 μm)</u> Although reflectance data are shown here, remote measurements of the Moon would be emission radiation. [With certain geometric assumptions, an emission spectrum is 1 - Reflectance (5).] The RB molecular absorptions between 9-12 μm are so strong they result in reflectance peaks and surface scattering dominates (5). The Transparency Feature TF (5) can be observed near 12.5 μm for the bulk soils and the finest fraction. Although the TF is most prominent for the feldspathic Apollo 16 soil, it does not shift in wavelength with composition. The CF of the bulk soils (near 8.5 μm), however, does shift to shorter wavelengths with feldspathic content. The properties of the bulk soil are clearly dominated by the finest particles. Larger particle sizes exhibit a distinctly shorter CF than the bulk soil and fine fractions, a property similar to that noted for Antarctic sediments (6). For such fine particles, this may be an apparent shift due to the weaker effects of the RB absorptions and their wings at shorter wavelengths. Although these RB features of soils between 9 - 12 μm appear to be regular, their assignment and the relative abundance of specific species has not been determined with confidence.

References. 1. Nash D. B. (1991) *Geophys. Res. Lett.*, 18, 2145; 2. Pieters CM et al. (1991), *LPSXXII*, 1069; 3. Pieters et al (1993) *JGR* 98, 20817; 4. Burns RG (1993) 2d ed., Cambridge U. Press, 551 pp; 5. Salisbury JW (1993) Ch 4 in *Remote Compositional Analyses* (Pieters & Englert, Eds), 79; 6. Bishop et al (1995) *GCA* in press.

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