LRO DIVINER SOIL COMPOSITION MEASUREMENTS – LUNAR SAMPLE "GROUND TRUTH".

Carlton C. Allen[1], Benjamin T. Greenhagen[2], and David A. Paige[3] [1]NASA Johnson Space Center, Houston, TX 77058 carlton.c.allen@nasa.gov, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109 benjamin.t.greenhagen@jpl.nasa.gov, [3]University of California, Los Angeles, CA 90024 dap@mars.ucla.edu.

Introduction: The Diviner Lunar Radiometer Experiment on the Lunar Reconnaissance Orbiter [1,2] includes three thermal infrared channels spanning the wavelength ranges 7.55-8.05 μm, 8.10-8.40 μm, and 8.38-8.68 μm. These "8 μm" bands were specifically selected to measure the "Christiansen feature". The wavelength location of this feature, referred to herein as CF, is particularly sensitive to silicate minerals including plagioclase, pyroxene, and olivine – the major crystalline components of lunar rocks and soil. The general trend is that lower CF values are correlated with higher silica content and higher CF values are correlated with lower silica content. In a companion abstract, Greenhagen *et al*. [3] discuss the details of lunar mineral identification using Diviner data.

Apollo and Luna sites: The Apollo astronauts collected numerous soil samples at all six landing sites, and the Soviet Luna 16, 20, and 24 robotic landers each returned a single drill core soil sample. The modal abundances of grains in all of these samples have been determined by point counting [4].

To a first approximation, the minerals in lunar soil samples match those in the local bedrock [5]. Lunar soils are, however, complex mixtures of rock fragments, mineral grains, impact-derived glass, and pyroclastic glass. The lunar surface is constantly bombarded by micrometeorites, the solar wind, and cosmic rays leading to mineralogical and physical changes in the soil collectively termed "maturity".

Diviner observations: We have employed the Diviner 8 μm observations to derive characteristic CF values specific to the six Apollo and three Luna landing sites. The observations were made during the lunar early afternoon, midday, and late morning. Table 1 lists the best quality CF values and the date for each observation. In all cases the values for a region approximately 2 x 2 km around the landing site location were averaged. The two measurements of the Apollo 15 site, taken approximately one lunar cycle apart, have average values that differ by only 0.023 μm, an indication of the stability of the measurements.

Site	Date	Mean CF (μm)
Apollo 11	10/29	8.358
Apollo 12	10/5	8.337
Apollo 14	11/1	8.267
Apollo 15	9/6	8.325
Apollo 15	10/3	8.348
Apollo 16	9/5	8.129
Apollo 17	9/4	8.331
Luna 16	10/26	8.388
Luna 20	9/2	8.230
Luna 24	10/26	8.389

Table 1. Mean CF values at Apollo and Luna landing sites

The mean CF values for sites dominated by mare soil components (Apollo 11, 12, 15, 17, Luna 16, 24) range between 8.325 μm and 8.389 μm (Table 1). The highland-dominated Apollo 16 and Luna 20 soils have distinctly lower mean CF values of 8.129 μm and 8.230 μm, respectively. The Apollo 14 site, dominated by basin ejecta, has an intermediate mean CF value of 8.267 μm. The values for mare-dominated sites are higher than those for highland-dominated sites, reflecting the higher modal abundances of olivine and pyroxene in mare materials and the higher abundance of plagioclase in highland materials.

Diviner data swaths across the Apollo and Luna landing sites demonstrate the lateral homogeneity of CF values. Figures 1 and 2 compare visible-light images of the Apollo 15 and Apollo 17 sites with sets of Diviner CF values calculated from single data swaths. In both cases, the areas near the landing site are composed of mare-dominated soil with a consistent CF value near the values in Table 1. Kilometer-scale areas with slightly lower CF values roughly correspond with the locations of impact craters near the landing sites. Nearby highland massifs have distinctly lower CF values, due to a combination of composition and slope effects.

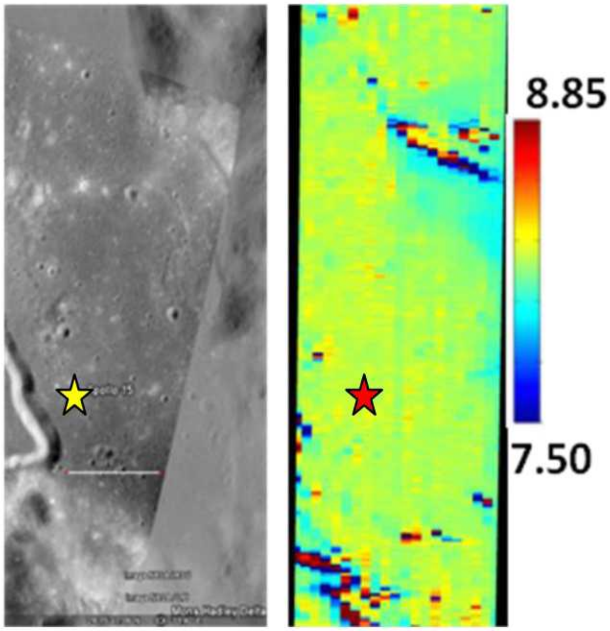

Figure 1. Apollo 15 landing site region and corresponding CF values (north is up; star = landing site location; scale bar = 5 km; calculated mean CF values at landing site = 8.325 and 8.348)

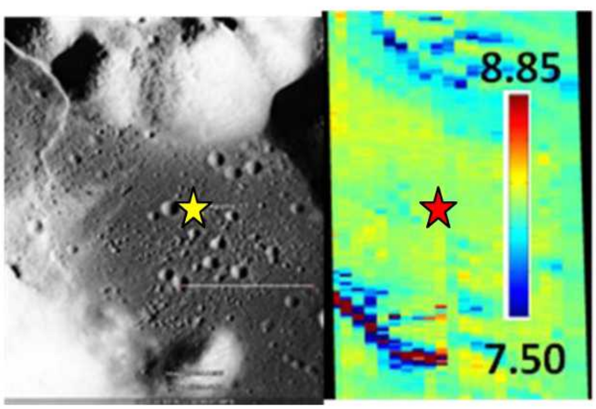

Figure 2. Apollo 17 landing site region and corresponding CF values (north is up; star = landing site location; scale bar = 5 km; calculated mean CF value at landing site = 8.331)

Summary: Initial Diviner observations of the Apollo and Luna landing sites support the use of CF values as indicators of soil composition. The mean CF values consistently distinguish between mare-dominated and highland-dominated soils. The CF values of lunar soils are laterally consistent on a scale of kilometers, but are apparently affected by impact cratering and slopes. The optical properties of lunar soils can also be affected by maturity, sun angle, and temperature. Continuing analysis of the Diviner CF data sets, laboratory experiments, and comparison to Apollo and Luna soil samples are underway to quantify these effects. The ultimate goal of these observations and experiments is to derive the compositions of soils across the lunar surface, based on "ground truth" provided by the Apollo and Luna samples.

References: [1] Paige, D.A. *et al*. (2009), *Space Sci. Revs*, DOI 10.1007/s11214-009-9529-2. [2] Paige, D.A. (2010) This meeting. [3] Greenhagen, B.T. *et al*. (2010) This meeting. [4] Simon, S.B. *et al*. (1981) *J. Geophys. Res., 91*, E64-E74. [5] McKay, D.S. et al. (1991) *Lunar Sourcebook*, Cambridge.