TRACE ELEMENT ANALYSIS OF LUNAR SOILS BY ICP-MS. M. C. Ranen and S. B. Jacobsen, Department of Earth and Planetary Sciences, Harvard University, 20 Oxford St. Cambridge, MA 02138, USA, (ranen@fas.harvard.edu)

Introduction: The average composition of the lunar surface is still not well known for many elements. Orbiting missions such as the Lunar Prospector and Clementine missions were able to produce global maps of Th, K, and FeO using gamma ray spectroscopy and UVVIS with a recent recalibration by [1]. Jolliff et. al. [2] called for the lunar crust to be made of three major crustal terranes, the Procellarum KREEP Terrane (PKT), Feldspathic Highlands Terrane (FHT) and the South Pole-Aitken Terrane (SPAT). The FHT makes up almost 85% of the crust, yet there is still little known about the trace element and isotopic composition of the ancient highland crust or the average crust in general. Together, the FHT and the PKT make up approximately 95% of the lunar crust. Measuring elemental concentrations from both the FHT and PKT will allow for a better estimate of the bulk composition of the lunar crust for a variety of elements. The Apollo 14 mission sampled material with the highest concentration of KREEP-like material while the Apollo 16 mission was the only mission to land in the highlands [3]. Samples of the lunar regolith should best show an average composition for the area because meteoritic impacts continually "stir" the regolith. Even though each sample will have a small degree of meteoritic contamination as well as components from other sites brought to the sampling site by meteoritic impact a composite of soils will provide an average composition for that area.

In a separate study, the Sm-Nd and Hf-W isotopic compositions of these same lunar soils will be measured in order to provide clues to the formation and evolution of the lunar crust and mantle. Here we report minor and trace element concentrations to learn as much as we can about each soil sample in terms of its bulk composition, volatile depletion, meteoritic component, and possible mixing relationships between the three Terrane end members.

We report on 14 samples of lunar soils. All samples weigh approximately 100 mg. Samples were carefully selected to provide a range of Sm concentrations representing end members of the FHT as well as the PKT.

Previous large scale trace element studies of lunar soils include a study of 25 elements on Apollo 16 soils by Korotev [4] and 36 elements on Apollo 14 bulk fines [5]. Both of these studies used Instrumental Neutron Activation Analysis which may require a large sample size (100 mg to 1 g). Here we show that a more complete list of elements can be measured on a much smaller sample size.

Methods: Measurements were made using a GV-Platform-XS Quadrupole ICP-MS. The instrument combines a hexapole with a quadrupole for maximum sensitivity. We used a silica glass nebulizer with a 40 µL/min flow rate in free aspiration mode. A 1 mg aliquot was taken from the original 100 mg sample once dissolved. All samples were run in duplicate with blanks as well as a suite of terrestrial rock standards for precise calibration for each element. Only 200 µg of sample is required for each run. Figures 1 and 2 show the absolute sensitivity and the stability of the GV-ICP-MS-Platform.

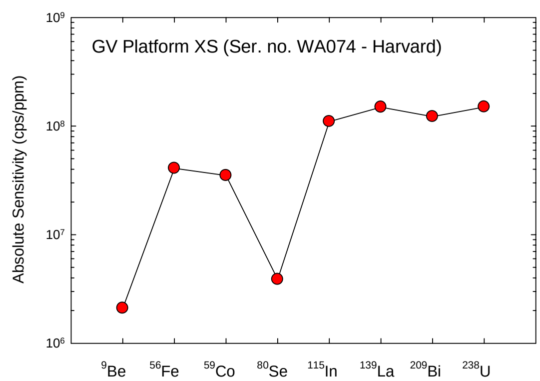

Figure 1. Absolute Sensitivity of Platform

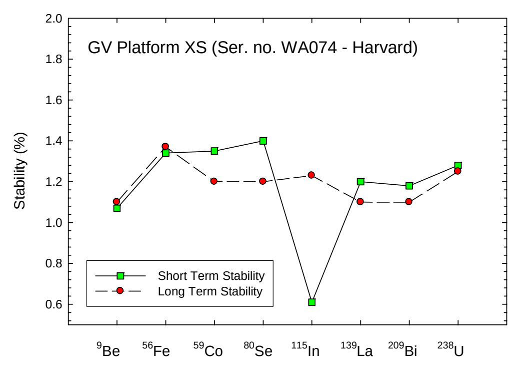

Figure 2. Stability of Platform

Results: Complete results of all elements studied are shown in Figure 3 while Figure 4 shows a close up of just the Rare Earth Elements. Figure 5 shows data for various Platinum Group Elements calibrated with a 10 ppb mixed PGE solution. The results are a combination of three runs on 2 different dilutions, both a 1:1000 dilution and a 1:5000 dilution. Oxide and doubly charged ion production was externally monitored and corrections were applied to the raw data.

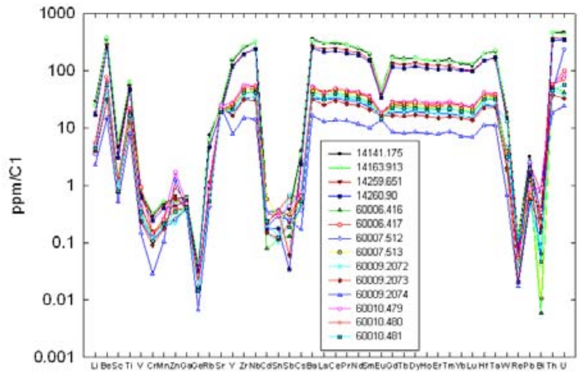

Figure 3. Elemental Analysis of Lunar soils

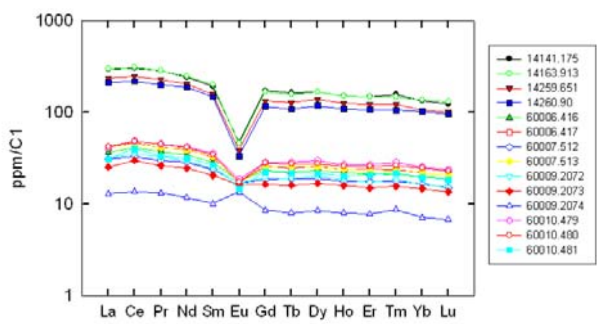

Figure 4. REE concentrations of Lunar soils

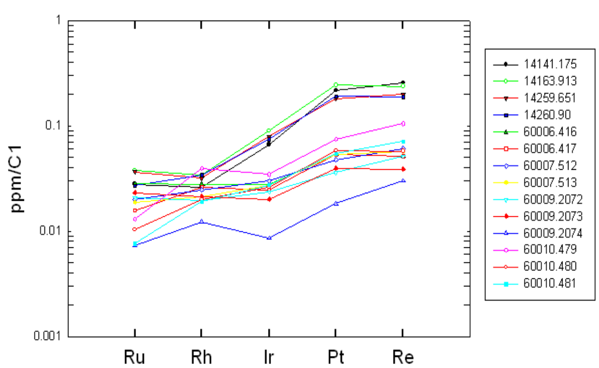

Figure 5. PGE concentrations of Lunar soils

Discussion: Sample 60009,2074 is the only sample to exhibit a positive Eu anomaly making it the most pristine highland sample and our end-member for any mixing relationships between the FHT and the PKT. All four Apollo 14 soils have the trace element pattern similar to other KREP samples [5]. The FHT is projected to have a positive Eu anomaly because of the high plagioclase composition. Since the other Apollo 16 soils have negative Eu anomalies these all exhibit a mixing trend between pure FHT and the PKT. All samples have expected volatile depletions in Ge and Bi while sample 60009,2074 is depleted in Cr and Y. The PGE pattern is consistent with a one to two percent meteoritic component in the highlands regolith. However, the low concentration of PGE's means that there could be considerable contribution to the mass measured for PGEs from REE oxides. This data shows that the KREEP rich soils from Apollo 14, which have elevated REE concentrations, also have high PGE concentrations, particularly on Ir, Pt, and Re which may indicate that our oxide corrections are not accurate. We were looking into the accuracy of the PGE results. However, we were able to measure a large number of elements accurately on a sample size of only 200 μg.. While we studied bulk samples with slight modifications it should be possible to study individual particles. Trace element data can be used to characterize lunar soils as being representative of the FHT (such as 60009,2074) or as being representative of the PKT (all four Apollo 14 samples studied).

References: [1] Gillis, J. J. et al. (2004) *GCA*, *68*, 3791-3805. [2] Jolliff, B. et al. (2000) *JGR*, *105*, 4197-4216. [3] Korotev, R. L. (1999) *LPS XXXI*, Abstract # 1302. [4] Korotev, R.L. (1991). *Proc. 21st Lun. Plan. Sci. Conf.*, 229-289. [5] Brunfelt, A.O. et al. (1971) *EPSL*, *11*, 351-353.