ANALYSIS OF GLOBAL LUNAR IRON ABUNDANCES: A SYSTEMATIC COMPARISON OF LUNAR PROSPECTOR AND CLEMENTINE DATA. J. J. Hagerty[1], D. J. Lawrence[2], J. T. S. Cahill[2], R. L. Klima[2], and J. J. Gillis-Davis[3], [1]U.S.G.S. Astrogeology Science Center, Flagstaff, AZ 86001 (email: jhagerty@usgs.gov), [2]The Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, [3]University of Hawai'i, Hawai'i Institute of Geophysics and Planetology, Honolulu, HI.

Introduction: Multiple algorithms have been derived to estimate the abundance of iron from two portions of the electromagnetic spectrum (gamma-ray and ultraviolet-visible/near-infrared spectral reflectance). These algorithms have been applied to Lunar Prospector gamma-ray spectrometer (LP-GRS) and Clementine spectral reflectance (CSR) data sets to yield maps of global lunar Fe abundance [e.g., 1 – 7]. While these two data products are in agreement for a large portion of the lunar surface, there are significant discrepancies between the two data sets for many locations [5, 8]. In some cases, these discrepancies are large enough (i.e., up to 11 wt.% different) to lead to different conclusions regarding the petrogenesis of lunar surface materials.

We have tentatively identified four potential sources for the discrepancies between the iron data products: 1) Footprint/resolution issues (i.e., Clementine footprint is 100-200 m/pixel and Lunar Prospector GRS footprint is >50 km/pixel); 2) Spectral algorithm limitations; 3) Sampling depth; and/or 4) Mineralogy/lithologic mixing. To address these issues we are more closely examining the influence of neutrons on gamma ray data, reevaluating spectral algorithms relative to mineral absorption coefficients, and conducting forward modeling of LP gamma ray data. In this abstract, we focus on the forward modeling of LP-GRS iron data from three key regions that demonstrate discrepant iron abundances: Plains materials south of Apollo basin, basalt ponds in South Pole-Aitken (SPA) basin, and Tycho crater.

Geologic Background: *Plains South of Apollo Basin*: Most of the SPA basin has significant discrepancies between the LP and CSR FeO data sets [5]. One of these regions, the plains south of Apollo basin (contained within SPA), shows significant differences between the two FeO data sets (i.e., as much as 11 wt.% FeO) [e.g., 5]. The plains materials appear to consist of gabbroic lithologies [e.g., 9], which can have between 7 and 17 wt.% FeO, with a mean of 10 wt.% FeO [10]. The CSR FeO data for this area show FeO abundances as high as 22.5 wt.%; whereas, the LP FeO data only show a maximum of 11.8 wt.% FeO. Determining which of the two FeO data sets is more accurate will help to confirm or eliminate the presence of gabbroic lithologies, which in turn has implications for determining the composition of the SPA basin.

Basalt ponds in SPA Basin. Lawrence et al. [5] showed that for many of the Ti-rich and Th-poor basalt ponds in SPA basin, the maximum FeO value varies from 19 wt.% for the unsmoothed CSR data set to 11 wt.% for the LP-GRS data set. Constraining the iron abundances for these basalts will be important for understanding the composition and evolution of the far side lunar mantle. More specifically, recent research by Hagerty et al. [11] indicates that the basalt ponds in SPA basin have seen little contamination or assimilation during their ascent to the lunar surface, and therefore the compositions of the basalt ponds reflect the compositions of source regions in the far side mantle.

Tycho crater: CSR data indicate that ejecta surrounding Tycho crater has an average FeO abundance of 7–9 wt.%. Lawrence et al. [5] suggested that the CSR data are over estimated at Tycho by 1 – 4 wt.%, an assertion supported by LP-GRS data, which indicate that Tycho possesses very low abundances of 3–4 wt.% FeO [5]. Unlike the other locations discussed above, Tycho crater has also been studied with LP neutron data [5], which are sensitive to iron. Thermal, epithermal, and fast neutron data indicate relatively low iron at Tycho crater [5]. Thus, three different measurements from LP instruments consistently indicate that the FeO abundances at Tycho are very low. Accurately determining the iron abundances of the 100 million year old Tycho crater will assist in placing constraints on the bulk composition of the unique crustal materials that have been excavated by the crater [e.g., 5, 12, 13].

Forward Modeling: As was indicated above, one of the major issues limiting the LP-GRS data is the low resolution compared to CSR. However, as we have shown in previous work [e.g., 11, 15, 16], it is possible to essentially increase the resolution of the data by controlling the Fe abundances of specific geologic features as part of our forward modeling methodology. We select our regions of interest using a combination of existing geologic maps, orbital imagery, spectral reflectance data, and gamma-ray and neutron data. We then use these data to define specific geologic features and lithologies in the region of interest.

After identifying major geologic units in our model, we assign Fe abundances to each of those units using the procedures outlined in our previous work [e.g., 11, 15, 16]. We propagate the expected gamma-ray flux from these geologic features through the LP-GRS spatial response, which produces a simulated Fe distribution. We then compare the simulated Fe distribution to the measured Fe data and iteratively adjust the simulated distribution until we achieve a match with the measured data. Once a match is achieved, we use the modeled Fe distribution to determine the Fe abundance of any given feature of interest.

Results: The robustness of our approach has been confirmed by other deconvolution methods [e.g., 17] and by independent, high-resolution data sets [e.g., 18]. Therefore, we have opted to treat the forward modeling results as a baseline for comparing the two global iron data sets. If the initial estimated iron abundance for a given data set for a specific unit approaches 0-3 wt.% of the forward modeling result, we deem that data set to be successful at estimating the iron abundance for that region of interest.

Plains South of Apollo Basin: Using the approach described above, we find that the LP-GRS data provide a better estimate of the iron abundances in non-mare terrain; whereas the CSR data provide better estimates of the mare basalts. Both data sets had difficulty estimating the abundances of iron in heavily cratered highlands in the plains south of Apollo basin.

Basalt ponds in SPA basin: The CSR data set provided better estimates of iron abundances than the LP-GRS data for all uncontaminated exposures of basalt within the basin. The only exceptions are the ponds in the southern portion of Apollo basin, where both data sets precisely estimated the iron abundances.

LP-GRS data more precisely estimated the iron abundances of both non-mare materials and large craters in the regions of interest. This is likely due to issues with spectral reflectance data reduction algorithms, which overestimate FeO abundance in highly mafic regions [19]. It should be noted, however, that no single mafic mineral appears to be the source of the discrepancy [19]. As was the case for the plains south of Apollo basin, neither data set did well at estimating iron abundances in heavily cratered highlands terrain.

Tycho Crater: With the exception of two minor units, the LP-GRS data provide the best estimates for iron abundances in the Tycho region. The CSR data seem to suffer from albedo and/or lighting issues in this region more so than any other regions in this investigation. The CSR data may also be influenced by the rocky, pyroxene-rich ejecta blanket of Tycho crater [e.g., 5, 12, 13], but more research remains to be done.

Conclusions: Initial results from our investigation indicate that CSR data provide better estimates of the iron abundances in basaltic terrains, LP data provide better estimates of iron abundances for non-mare lithologies, and both data sets have difficulty estimating the iron abundances of areas that have complex lithologic mixtures or those regions that are heavily cratered.

LP-GRS data likely have difficulty estimating the iron abundances of basalts within SPA basin due to the lack of significant exposures of uncontaminated basalts (i.e., the low resolution data cannot resolve the small exposures of basalt). However, the Ti-rich, Th-poor compositions of SPA basalts may also lead to issues with accurately interpreting the influence of neutron absorption systematics on the GRS iron data [e.g., 20].

As pointed out in our previous work [19], but confirmed here, the CSR FeO estimates appear to be affected by limitations of multispectral data reduction algorithms. In particular, spectral reflectance data reduction algorithms overestimate FeO abundance in highly mafic, nonmare regions. However, no single mafic mineral appears to be the source of the discrepancy [19].

Based on our results, it is apparent that the LP-GRS results have fewer issues to overcome than do the spectral data. However, the one major limitation on the LP-GRS and neutron spectrometer data (i.e., low resolution) is significant. Fortunately this issue can be overcome through the use of forward modeling, but this process is time intensive and requires input from several other data sets to be truly successful.

At present, it is not possible to put together a comprehensive global iron data set that effectively combines the strengths and eliminates the weaknesses of each of the global iron data sets. Neither data set can be used exclusively to obtain accurate iron abundances for every single portion of the lunar surface. Until the resolution of neutron and gamma ray spectrometers can be significantly improved, one must combine the data sets (while accounting for the known caveats of each data set) to investigate individual regions of the Moon on a case-by-case basis.

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