

QUANTITATIVE MINERALOGY OF SOUTH POLE-AITKEN BASIN, P. G. Lucey¹, J. J. Gillis¹, J. T. Cahill¹, ¹Hawaii Institute of Geophysics and Planetology, University of Hawaii, 1680 East-West Road, Honolulu, HI 96822. lucey@higp.hawaii.edu

Introduction: The South Pole-Aitken (SPA) Basin is a major topographic and geochemical province on the Moon, and is currently unsampled. This large impact feature almost certainly exposes lunar material with very deep origin, almost certainly the lower crust and possibly the lunar mantle. The importance of this feature in understanding the Moon and by inference the terrestrial planets was underscored by the recommendation by the National Research Council that returning a sample from this basin be a high priority for NASA solar system exploration.

The proposed Moonrise SPA sample return mission (Michael Duke, Principal Investigator) is one of two finalists in the NASA New Frontiers mission, so a SPA sample return in the relatively near future is a strong possibility. Selection of the sample sites for this mission will likely be based on data currently in hand, and it has already been argued that such data are adequate to make such selections [1].

Recently we developed a methodology to extract quantitatively the major mineralogy and chemistry from Clementine reflectance spectra of the moon [2,3]. In this abstract we apply this method to the SPA basin to examine the distribution of mineralogically and chemically defined units.

Data: Clementine collected 11-band multispectral data (415, 750, 900, 950, 1000, 1100, 1250, 1500, 2000, 2620, and 2792 nm) at 100-200 meter per pixel spatial resolution for most of the lunar surface. We used global mosaics processed by the USGS [4]. The data used in this work are resampled to 1km resolution.

Analysis Model: The mapping approach uses a radiative transfer model to precompute a large number of mixtures covering the full range of lunar mineral compositions, and includes the effects of mineral chemistry and space weathering. These computed mixtures are then used as a lookup table against which the Clementine spectra are compared. The radiative transfer model integrates empirical measurements of the complex optical constants of lunar component materials with a radiative transfer treatment widely used in planetary science [5]. The model used was developed for [6]. This methodology for lunar spectral studies was validated by [7] and [8]. This model includes varying the chemistry of the minerals, an essential capability for modeling lunar spectral properties.

The precomputed mixtures include 858 different lunar compositions at 10% intervals covering the system plagioclase-olivine-clinopyroxene-orthopyroxene, in which lunar highlands rocks are classified [9], and ilmenite at 0, 10 and 20% by volume. The 858 composi-

tions were also modeled at 10 intervals of mineral chemistry. Mineral chemistry is parameterized in the form of the Mg-number, the ratio of Mg to the sum of Mg and Fe on an atomic basis. Mg-number is varied from 50 to 95 at intervals of 5. For each composition and chemistry spectra were computed at ten levels of intensity of space weathering. Space weathering effects were included in the form of submicroscopic iron and iron bearing glass. Space weathering was parameterized by the optical maturity [10] and spectra were computed in the range of optical maturity from 0.3 to 0.5 corresponding to very immature surfaces by appropriate addition of submicroscopic iron and iron-bearing glass. This process results in just over 85,000 model spectra forming a large lookup table against which the lunar multispectral measurements are compared. The mapping methodology is to compare each measured lunar spectrum to this lookup table, and assign the composition of the closest match using total absolute difference between model and measured spectra as a criterion, provided the average error is less than 0.5%.

The data analyzed are also restricted in degree of maturity because noise in the Clementine data limit the ability to interpret spectra of mature surfaces. The OMAT parameter of [10a] is used for this restriction and only locations with values above 0.3 are used. This restriction means that only about 5% of the surface area of the basin is analyzed, though the regions are randomly distributed. The model data set is similarly limited to contain only spectra featuring OMAT values above 0.3.

Results: We find most locations in the basin to be mafic, with essentially basaltic compositions (Figure 1). High Ca-pyroxene is the most abundant phase with abundances of 60-70% by volume being typical. Noritic material is rare with true norites occurring infrequently but notably in Antoniadi, Minnaert, and the central peaks of Lyman, Alder and Finsen craters. A low abundance of olivine is found at many locations, but high abundances appear to be absent. Few occurrences of anorthosite are found, mostly as single pixel detection scattered throughout the basin.

Discussion: The zero order results of this analysis are strikingly different than previous studies of the mineralogy of the basin [11, 12] in that the abundance of high Ca pyroxene detected is much higher than previously reported. This difference is due to the quantitative interpretation of the Clementine spectra, which of course could suffer from systematic error.

The major difference is in the model abundance of high-Ca pyroxene. High abundances are derived from

the model because the center of the absorptions of most basin spectra is so long that little low-Ca pyroxene can be accommodated. The model does not always require abundant high-Ca pyroxene, several restricted locations within the basin, such as Lyman crater, do not exhibit any high-Ca pyroxene in the modeled results.

If the distribution of individual minerals is examined, there is a very close correspondence between the abundance of orthopyroxene and previous reports of the distribution of noritic terrains, especially the results of the “band curvature” parameter of [11]. The question is to what abundances to these parameters correspond. Previous studies have not used methodologies quantitatively linked to mineral spectral properties.

Despite this linkage, there are several possible sources for overestimate of a given mineral. First, if there is a systematic difference in Mg-number between high and low Ca pyroxene, this affects the relative band strengths and hence the model results. To overestimate high-Ca pyroxene that mineral would have to have a significantly lower Mg-number than the low Ca pyroxene present. This could occur, for example in cases where the high-Ca pyroxene in a soil was contributed by mare basalt. Second, the spectral properties of pigeonite are not represented in this model. If pigeonite has spectral properties more similar to high Ca pyroxene than low Ca pyroxene, its presence may be interpreted to be augite. Finally, there could be systematic errors in the mineral database, though these spectra and analyses were all done by the same individual.

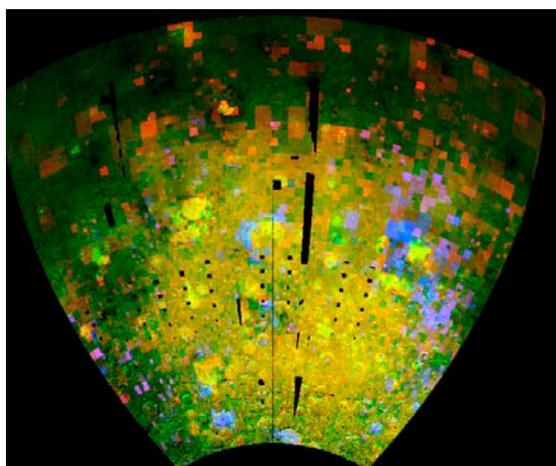


Figure 1. Color composite of mineral images of South Pole-Aitken Basin. Red: Clinopyroxene, Green: Iron, Blue: Orthopyroxene. Yellow tones indicate clinopyroxene rich terrains, blues are norites and greens are anorthosites.

Conclusions: If these model results are correct, mare basalt is likely far more extensive than previously believed based on the high abundance of high-Ca pyroxene, complicating the task of sampling the SPA melt sheet. However, the model results remain to be validated using an appropriately prepared lunar sample data set.

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