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Compositional trend within the lunar highland crust

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1. Introduction

A global distribution of rocks of very high plagioclase abundance (approaching 100 vol.%; purest anorthosite) has been detected at central peaks, crater walls, and ejecta using an unambiguous plagioclase absorption band recorded by the SELENE Multiband Imager (MI) [1].

Recent study [2] suggests possible generation of high plagioclase abundance anorthosite rocks as reported in [1] by a combined process of segregating liquid from solid by compaction and melt migration, and segregating solids by granular shearing. Their model [2] predicts decrease of mafic abundance with depth in the crust. Therefore, to understand the vertical compositional trends (if any) of lunar highland crust is important for addressing the crustal generation mechanism

In this study we investigated spatial and vertical compositional (modal abundance) trends of the high plagioclase abundance anorthosite rocks over the entire lunar surface within the upper crust by using continuous reflectance spectra derived by the SELENE Spectral Profiler (SP) [3] and images derived by the SELENE Multiband Imager (MI) [1].

We also investigated compositional trend within the deeper area than a central peak excavation depth (possibly lower crust) based on a composition of Orientale ejecta. Orientale is selected because it is young and least disturbed by later impact event.

2. Data

SP is a line-profiling sensor with spectral coverage from 0.5 to 2500 nm and a spectral resolution of 6 nm at visible wavelengths range and 10 nm at near-infrared wavelengths. It has a foot print of 500 m x 500 m and observed the illuminated side of the Moon every orbit (about 7000 orbits) throughout the SELENE mission periods except checkout. All of the observed SP data except data for calibration were used as input for this study (roughly 10,000 spectra are acquired per orbit).

3. Dada analyses

Data with phase angles exceeding 75 degrees were omitted from the data sets because of the larger errors in the photometric function correction. SP spectra with reflectance at 750 nm below 5% were also omitted from the data sets because of the lower S/N of these data.

3.1 Trends of the high plagioclase abundance anorthosite rocks

The absorption depth of each wavelength was calculated after the continuum was removed. Spectra with the greatest absorption depth around 1250 nm (absorption generated by plagioclase) and a ratio of absorption depth at 900 nm (absorption generated by mafic minerals) to the absorption depth around 1250 nm of less than 0.9 were ultimately selected to detect the high plagioclase abundance anorthosite. The high plagioclase abundance anorthosite spectra can be detected by this method because only rocks with high plagioclase abundance have this spectral feature caused by the plagioclase absorption band generated by a minor amount of Fe^{2+} (0.1 wt% FeO) contained in the plagioclase.

The location and geologic context of SP spectral data were derived by matching each SP signal to corresponding pixels in MI images. Thus, the original burial depth of each high plagioclase abundance anorthosite rock outcrop was estimated from a crater scaling law [4] using the crater diameter of each outcrop observed in MI data.

3.2 Trends of the Orientale ejecta

All available (based on the above criteria) SP spectra were averaged to 1 x 1 degree and then the absorption depth of each wavelength was calculated after the continuum was removed. Modal abundance of each pixel (1 x 1 degree) was estimated as proxy by comparing absorption depth at 920 nm of the each observed spectrum to modelled spectra (spectral modelling is based on a method described in [5]) assuming a low-Ca pyroxene and plagioclase (with constant 0.1 wt% FeO content) mixture. Then concentric circle averages of modal abundance were calculated based on a distance from the center of the Orientale basin.

Material excavated from deeper area fall on to the near basin location than the material excavated from shallower area. Therefore compositional trend within the crust (in this case, it is possibly deep enough to be lower crust based on the basin size) is observed as the compositional trend related to a distance from the Orientale basin.

4. Results

The detected high plagioclase abundance anorthosite rocks are distributed globally and relatively homogeneously within the highland region. There is no apparent spatial dependence in the absorption depths of each anorthosite rocks distribution.

However, Fig. 1 indicates that the majority of the derived absorption depth (strength) ratios (900/1250 nm) of the detected high plagioclase abundance anorthosite rock spectra appear to form a trend that increases as their estimated original burial depths increase within the crust (the trend is observed at original burial depth of up to 30 km).

Modal abundances of the Orientale ejecta suggest no increase of mafic mineral abundance toward the basin rim as indicated in Fig. 2, which suggests no evidence of increase of mafic mineral abundance in the crust excavated by the Orientale basin.

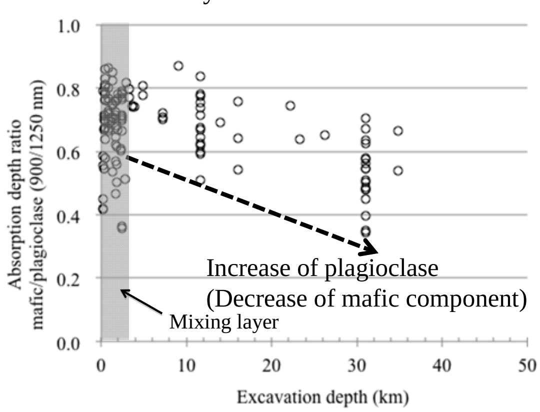

Fig. 1 Correlation of the absorption depth ratio of mafic minerals to plagioclase (900 nm/1250 nm) to the excavation depth.

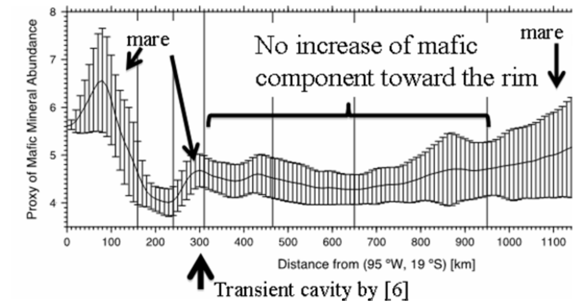

Fig. 2 Correlation of the mafic abundance to the distance from the center of Orientale basin.

5. Discussion

Although we requires further study, these evidence may indicate a decrease in the mafic mineral abundance within the already very mafic-poor rock and/or an increase in the Fe^{2+} content of plagioclase with depth up to 30 km and then the modal abundance remains nearly constant up to several tens of km (though actual excavation depth of the Orientale basin is not known).

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