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Mineralogy of the lunar highland crust based on the Kaguya reflectance spectra

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Introduction: The composition of the lunar highland crust is among the most important information for understanding the formation mechanism of the lunar highland crust and the composition of the lunar magma ocean. Previously, the composition of the lunar highland crust was estimated mainly based on measurements of the lunar returned samples. Measurements of returned lunar samples and meteorites indicate that the lunar highland crust typically consists of plagioclase and low-Ca pyroxene with minor amounts of other mineral phases. However, it is not clear if the low-Ca pyroxene really is a major mafic silicate component of the highland crust because the returned samples may not be a representative material of the entire highland crust. Therefore, this study investigated the mafic silicate phase and estimated its composition within the highland crust by using remote sensing reflectance spectra of the lunar surface.

Method: We used reflectance spectra acquired by the Kaguya Spectral Profiler (SP), which has a spectral coverage of 500 to 2600 nm in 300 bands and a spatial resolution of 500 x 500 m. Among the global SP data, all of the 570 purest anorthosite (PAN) [1] spectra identified and reported by [2] were analyzed by using the modified Gaussian model (MGM) [3]. Several MGM parameters, a number of fitted peak and peak parameters (center wavelength, width, and strength) of each peak at the starting point were tried, and the results were cross evaluated. The compositions of silicate mafic minerals were estimated by comparing the peak fit results and the known correlation between absorption center wavelength and mineral composition.

Results: Most (93%) of peak, which corresponds to the mafic silicate phase, has a center wavelength shorter than 980 nm, suggesting that these mafic silicates in the PAN rocks are low-Ca pyroxene (65% are shorter than 950 nm). Note that the low-Ca pyrox-ene in this study implies pyroxene having less than a 0.2 molar ratio of Ca/(Ca+Mg+Fe) smaller than 0.2. Data points having a center wavelength shorter than 980 nm had a strong absorption band and were not a product of weak ambiguous absorption spectra. Six percent of the data have center wavelengths between 980 nm and 1040 nm, which correspond to the high-Ca pyroxene composition. The remaining 1% of the data with longer center wavelengths around 1050 nm possibly corresponds to olivine or glass. No apparent phase difference (low-Ca and high-Ca pyroxene difference) is observed between the nearside and the farside.

Discussion: Our results indicate that the majority of the PAN layer in the lunar highland crust globally consists of anorthite and small amounts of low-Ca pyroxene, the major mafic silicate component, rather than high-Ca pyroxene or olivine. This result is consistent with the previous work based on measurements of the lunar material from the lunar surface mixing layer with limited global coverage and confirms the homogeneous modal abundance within the lunar highland crust. The short center wavelengths of the PAN rocks at Jackson crater, which located at the farside highland suggest relatively higher Mg# (Mg/(Mg + Fe) in mole per cent) (around 70) in this region than the near side. This evidence is in good agreement with previous work [4], which suggests the presence of magnesian anorthosite in the farside highland.

References: [1] Ohtake, M. et al. (2009) Nature, 461, 236-240. [2] Yamamoto, S. et al. (2012) Geophys. Res. Let., 39, L13201. [3] Sunshine, J. et al. (1990) J. Geophys. Res. 95, 6955-6966. [4] Ohtake, M. et al. (2012) Nature GeoSci. 5, 384-388.

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