MAFIC MINERALS IN THE NON-MARE REGIONS OF THE SOUTH POLE-AITKEN BASIN. X. Y. Zhang[1], M.-H. Zhu[1], Y. Z. Wu[2, 1], W. Cai[2], Z. C. Wang[3], T. Y. Xu[1], [1]Space Science Institute, Macau University of Science and Technology, Macau, China (xyzhang@must.edu.mo), [2]Key Laboratory of Planetary Sciences, Purple Mountain Observatory, CAS, Nanjing, China, [3] School of Geographic and Oceanographic Sciences, Nanjing University, Nanjing, China.

Introduction: The South Pole-Aitken (SPA) basin is the largest and oldest recognized impact structure on the lunar surface [1, 2]. Its formation was thought to excavate the deep crust or mantle [1, 3]. Compared with the lunar highlands, the non-mare regions of the SPA basin is dominated by low-Ca pyroxene [4, 5, 6], which suggests that they are a result of the SPA formation as either impact melt [7] or the deep materials excavated from the lower crust and/or upper mantle [4, 5, 6]. However, the mineralogical and geological understanding of these orthopyroxene (Opx)-dominated materials remains limited. Therefore, this study aims to investigate the relative content and distribution of mafic minerals in the non-mare regions of the SPA basin based on the spectra extracted from small fresh craters and discuss their geologic contexts.

Methods: The Moon Mineralogy Mapper data with wide band coverage and high resolution is an ideal data for mineral identification [8]. Most spectra were extracted from small fresh crater about 1 km in diameter with strong absorption features of mafic minerals to avoid the space weathering effect [9]. After careful selection, 285 craters from the non-mare regions were extracted (Fig. 1), defined by the outer structure of the SPA basin [2]. To analyze the relative content of olivine and pyroxene in composition, the 1 μm absorption band (Band I) center and the Band Area Ratio (BAR), defined as the ratio between 2 μm and 1 μm absorption features, are estimated based on several spectral processes (e.g., smoothing, continuum removal, and measurements of the band areas and band centers) documented in Zhang et al. [11].

Results: Fig. 2a presents the BAR values and Band I centers of the spectra extracted from the non-mare regions in the SPA basin. Most data points of these spectra mainly fall into the regions that represent the composition varying from olivine (Ol)-clinopyroxene (Cpx) mixtures to Opx-dominated materials. Five representative spectra with different BAR values are shown in Fig. 2b and 2c (raw spectra and continuum-removed spectra). Generally, the spectra with medium BAR values (the green ones) display a similar Band II absorption but a relatively weaker Band I absorption than the spectra with the lower BAR values (the red ones), consistent with the presence of more Opx. In contrast, compared with the spectra with the higher BAR values (the dark blue ones), the spectra with the medium BAR values show a similar Band I absorption but a much weaker Band II absorption, consistent with a higher Cpx fraction. Therefore, the spectra of the non-mare regions with the lower BAR values are interpreted to have higher Cpx/Opx ratios, and vice versa.

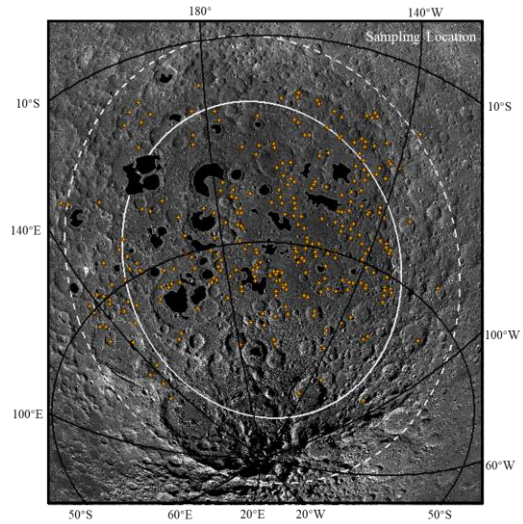

Fig. 1. Locations of the extracted spectra (yellow dots) superimposed over a Lunar Reconnaissance Orbiter Camera -Wide Angle Camera (LROC-WAC) mosaic [10]. The black areas denote the identified maria, and the white ellipses indicate the inner and outer structures of the SPA basin [2].

To analyze the distribution of Cpx and Opx in the non-mare regions, an interpolation surface of the BAR values was generated based on the Simple Co-Kriging method (Fig. 2d). For the spectra with the lower BAR values, shown as red and yellow hues, they are mainly located in the central (around the Bose crater) and northwestern (around the Birkeland crater) portions of the SPA basin. It is consistent with the previous interpretations that these regions are dominated by Cpx [4, 5, 6]. For the regions with medium and higher BAR values (i.e., green, light blue, and dark blue hues), previous studies used to interpret these areas as an Opx-dominated layer [4, 5, 6]. However, based on the distribution of the BAR values, at least two types of Opx-dominated materials can be identified. One type is the Opx-dominated materials with medium BAR values (Opx-M), which is not associated with one region or

one size of crater and distributed as an expanse of the relatively homogeneous layer from the center to the edge in the non-mare regions (i.e., green hues in Fig. 2d). The other type is the Opx-dominated materials with the highest BAR values (Opx-H), which is shown in dark blue hues in Fig. 2d and generally located in the areas associated with plagioclase-rich materials [4, 5]. The Opx-H materials mainly occur in the large impact craters, such as the Apollo basin and Poincaré basin, and the south and edge of the SPA basin. These regions are approximately consistent with the distribution of the plagioclase-rich materials identified in the previous study [5].

Discussion: The SPA edge (i.e., the areas between the inner and outer structures in Fig. 1) is considered the plagioclase-rich highlands heterogeneously mixing with the Opx-dominated ejecta from the SPA impact [4, 5]. The plagioclase-rich areas in the SPA inner structure are interpreted as the residual crust that escaped the excavation by the SPA impact and was exposed by the post-SPA impact events [5]. Therefore, it is reasonable to consider that the Opx-H materials in these areas are from the lower crust and/or upper mantle. In contrast, the Opx-M materials found on the northwest of the Bose crater, which are within the transient cavity of the SPA impact [7, 15], are thought to be the impact melt of the SPA basin.

Conclusion: The Opx-dominated materials in the non-mare regions of the SPA basin are classified into two types based on their distribution and different ratios of Cpx and Opx in composition. One is distributed as a homogeneous layer across the SPA basin and interpreted as the SPA impact melt. The other has a lower Cpx/Opx ratio and is generally located in the plagioclase-rich regions, considered the materials from the lower crust and/or upper mantle.

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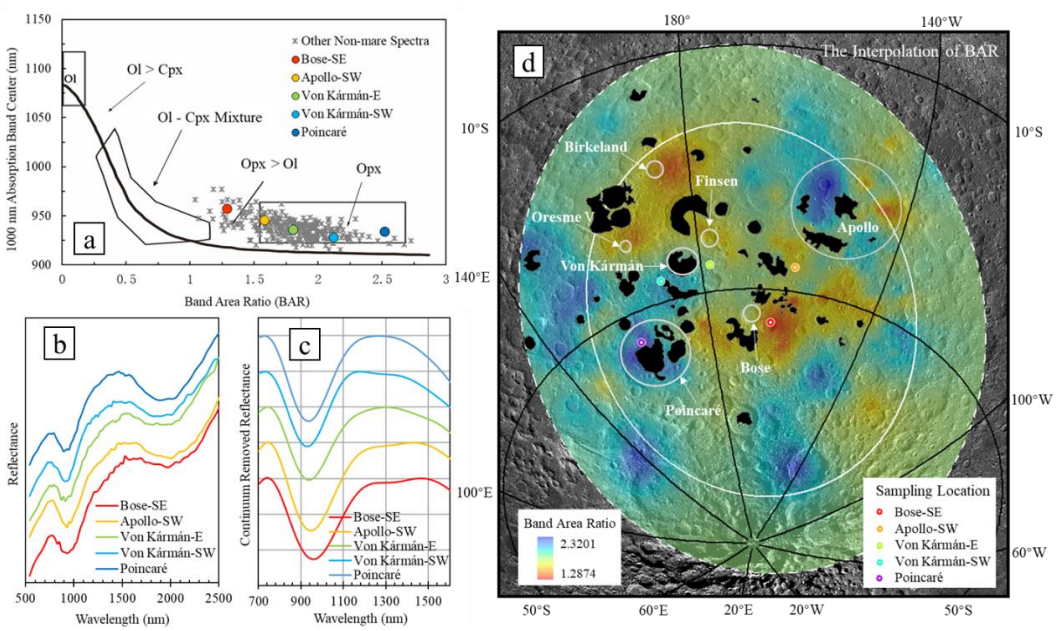

Fig. 2. (a) Plot of the BAR versus Band I center. The Ol-Opx mixing line from Cloutis et al. [12] and some compositional groups from Gaffey et al. [13] are drawn as a reference. (b) and (c) are the raw spectra (without smoothing) and continuum-removed spectra (in Band I with smoothing) of five craters (vertically offset for clarity). (d) Interpolation map for the BAR values superimposed over a LROC-WAC mosaic [10]. In general, a lower BAR value (redder) indicates the localized mafic material with a higher Cpx/Opx ratio. The small white circulars indicate the crater/basin rims or walls. The color dots represent the locations of spectra shown in this figure.