DISTRIBUTION AND COMPOSITION OF THE LUNAR MANTLE MATERIAL AND ITS IMPLICATION. M. Ohtake[1], S. Yamamoto[2], K. Uemoto[3], Y. Ishihara[1], [1]Japan Aerospace Exploration Agency (JAXA) (ohtake.makiko@jaxa.jp), [2]National Institute for Environmental Studies, [3]Tokyo Univ.

Introduction: No sample originating directly from the lunar mantle is known among currently available lunar samples and lunar meteorites. Therefore, it is critical to understand the composition of the lunar mantle based on remote-sensing data of the exposures of mantle materials.

Recent remote-sensing data obtained by the Kaguya Spectral Profiler (SP) found exposures with olivine-rich spectral features globally distributed on the lunar surface [1]. Based on their being on or near rings of large basins, it is suggested that these olivine-rich exposures may have originated from the mantle. Therefore, these locations can be the data source for mantle material analyses. Another data source is the South Pole-Aitken basin, which is the largest clearly recognized basin on the lunar surface and thought to be excavated mantle material deeper than other basins [2].

We conducted detailed mineralogical and morphological analyses of these locations to identify if the origin of material observed there is mantle and if so, to estimate the composition of the lunar mantle materials.

Origin and composition of olivine-rich materials: We evaluated reflectance, space weathering, geologic context, distribution and size of the exposures, composition (FeO abundance), surface texture (roughness and rock abundance), and local slopes of the each olivine site and estimated and classified their origins as likely mantle, volcanic, crustal, or unclear. About 60% of the sites are estimated to be mantle, 5% are volcanic, 30% are crustal, and 5% are of unclear origin. Mantle origin sites surround large basins whereas volcanic origin sites are within mare, and crustal origin sites either surround or are far from large basins. FeO abundance of the estimated mantle origin sites ranges from 6 to 13 wt.%. Though the percentage of each origin is not necessarily proportional to the volumes (surface area) of each category, there are many olivine sites of mantle origin around Crisium, Imbrium, and Nectaris. The estimated excavation depth of these basins indicates it is likely to reach the mantle, which is consistent with the estimation of mantle origin for these olivine sites. The identified volcanic and crustal olivine-rich sites, which have not been reported previously, are aslo important for understanding the formation mechanism of olivine-rich magma and crustal intrusion (troctorite). Note that some of the locations classified as crustal possibly result from spacial mixting of crustal rock (purest anorthosite: PAN) with more mafic silicate-rich rock such as Mg-suite rock because exposures of the olivine-rich material are sometimes very small and surrounded by PAN rocks.

Distribution and composition of mantle material of the SPA basin: Recent computer simulation of SPA basin formation suggests that SPA generated impact excavated mantle material and the mantle material was ejected and mounded on the basin interior except the central part, where impact melt was pooled [2]. Remote-sensing observation of the reflectance spectra of the SPA basin suggests that low-Ca pyroxene dominant rock appears to be the ejected and mounded mantle material [3]. Detailed analyses of the central part of the basin also indicates that the SPA impact melt underwent magmagic differentiation and made at least two differentiated layers (upper high-Ca pyroxene and lower low-Ca pyroxene layers) several kilometers thick. Furthermore, the composition of the two observed layers compared to the prediction by a petrologic magmatic differentiation model [4] suggests that the observation is consistent if the lunar magma ocean were solidified into two mantle layers (olivine dominant and low-Ca pyroxene dominant layers) and mantle overturn occurred before the SPA basin formed [5].

Implication of the distribution and composition of mantle material: These mineralogical analyses of the big basins including SPA basin indicate that vertical heterogeneity (possibly two layers of olivine dominant and low-Ca pyroxene dominant) of the lunar mantle, which apparently correspond to the original depth rather than the results of lateral variation. Furthermore, the lunar mantle possibly overturned after the magma ocean solidified.

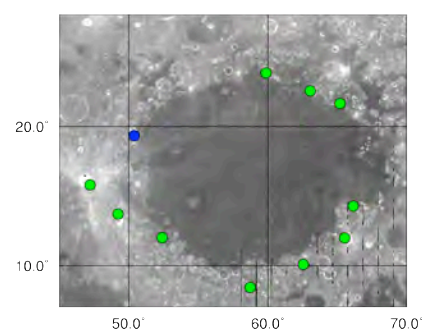

Fig. 1. Distribution of olivine-rich material at Mare Crisium. Green (blue) indicates the locations estimated to be mantle (crustal) origin.

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