DIFFERENTIATIAION OF IMPACT-GENERATED MAGMA SEAS ON THE MOON AS REVELAED BY SPECTRAL PROFILER ONBOARD KAGUYA.

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Introduction: It is widely accepted that a huge impact on the Moon, such as the South Pole-Aiken (SPA) basin forming event, entirely removed the feldspathic crust and melted the mantle below [1]. The tremendous amount of impact melt must have formed a "magma sea" in the excavated basin. Such magma seas likely have experienced a significant differentiation as global magma ocean [2]. In this paper, we summarize recent results of global hyperspectral mapping of the Moon by Spectral Profiler (SP) onboard Kaguya [3, 4] and discuss the implications on the differentiation processes of magma seas.

Data mining: Figure 1 shows laboratory spectra of representative minerals on the Moon. Plagioclase and olivine have the absorption band centered around 1.2 μm and 1.05 μm, respectively. Pyroxene has two absorption bands around 1μm and 2μm whose central wavelengths shift with the calcium content. We have developed a decision tree algorithm which accurately picks up the spectra with the characteristic absorption features of these minerals. The data mining procedure was applied to approximately 70 million spectra acquired during 1.5 years mission period of Kaguya [3, 4].

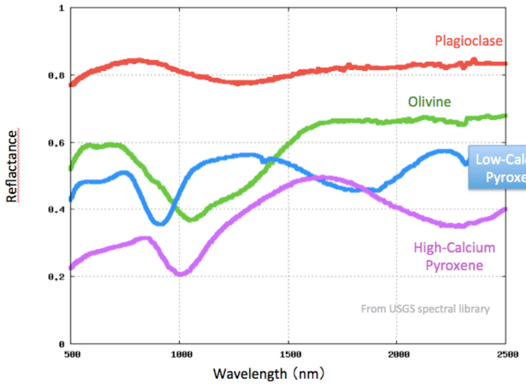

Figure 1. Visible and near-infrared spectra of typical lunar minerals measured in USGS laboratory

Reults and discussions: Figure 2 indicates the global distribution of the outcrops dominated by low-calcium pyroxene (LCP). The exposures are concentrated around the South Pole-Aitken (SPA), Imbrium and Procellarum basins, strongly suggesting an impact origin for the Procellarum basin [5]. LCP could be naturally formed as differentiated cumulates of magma seas if the parent magma was produced by impact-induced melting of crust-mantle mixture [6]. As olivine and plagioclase would be crystallized before/after LCP from the same magma, we examined the correlation of spatial distributions of olivine [7] and Pure Anorthosite (PAN) [8] with that of LCP (figure 3). The three types of exposures are adjacently located around mare Nectaris, Schroedinger crater [9] and north-eastern rim of the Imbrium basins. Olivine and PAN exposures can be found around Mare Moscoviense, Crisum and Humboldtianum with relatively thinner crust, but LCP-rich exposures are absent in these areas. Those impact events could be large enough to excavate the olivine-rich mantle, but too small to produce huge impact melt seas which subsequently underwent fractional crystallzation.

The current crust in the Procellarum and SPA wouldn't be a remnant of the primordial crust solidified from global magma ocean, but a secondary cumulates from impact-induced magma seas. The possible ''late'' generation of some anorthositic highland and Mg-suite lithologies from such secondary magma seas has been proposed in many previous works [6, 10]. The secondary formation would account for the young age (positive e_{Nd}) for some Apollo ferroan anorthosite samples [11,12] and the presence of PAN in the central part of the Procellarum basin (Figure 4) where original crust were completely removed [8].

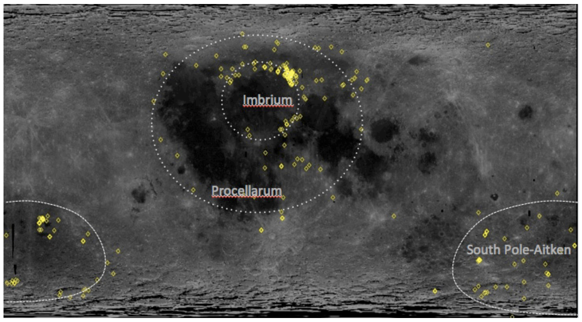

Figure 2 The yellow diamonds show the location of LCP-rich exposures on the Moon [5]. The dotted lines encircles the three biggest impact basins on the Moon, i.e., SPA, Imbrium and Procellarum. The prevalance of LCP might be resulted from common differentiation process in lunar magma seas and Vestan magma ocean [13].

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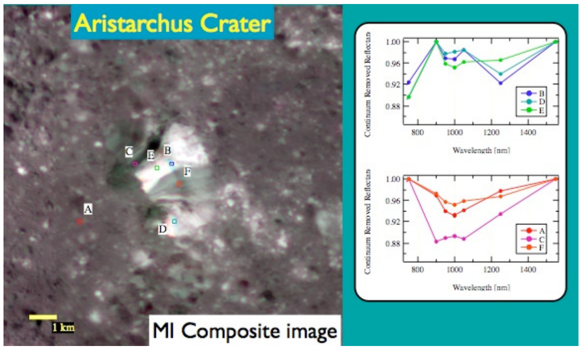

Figure 4 Multiband image (left) and continuum-removed spectra (right) of the central peak of Aristarchus crater obtained by Kaguya Multiband Imager [8] . Aristarchus is located around the center of the Procellarum basin, but the bright part of the central peak is composed of PAN. This site is not detected in global survey by Spectral Profiler possibly due to the small size.

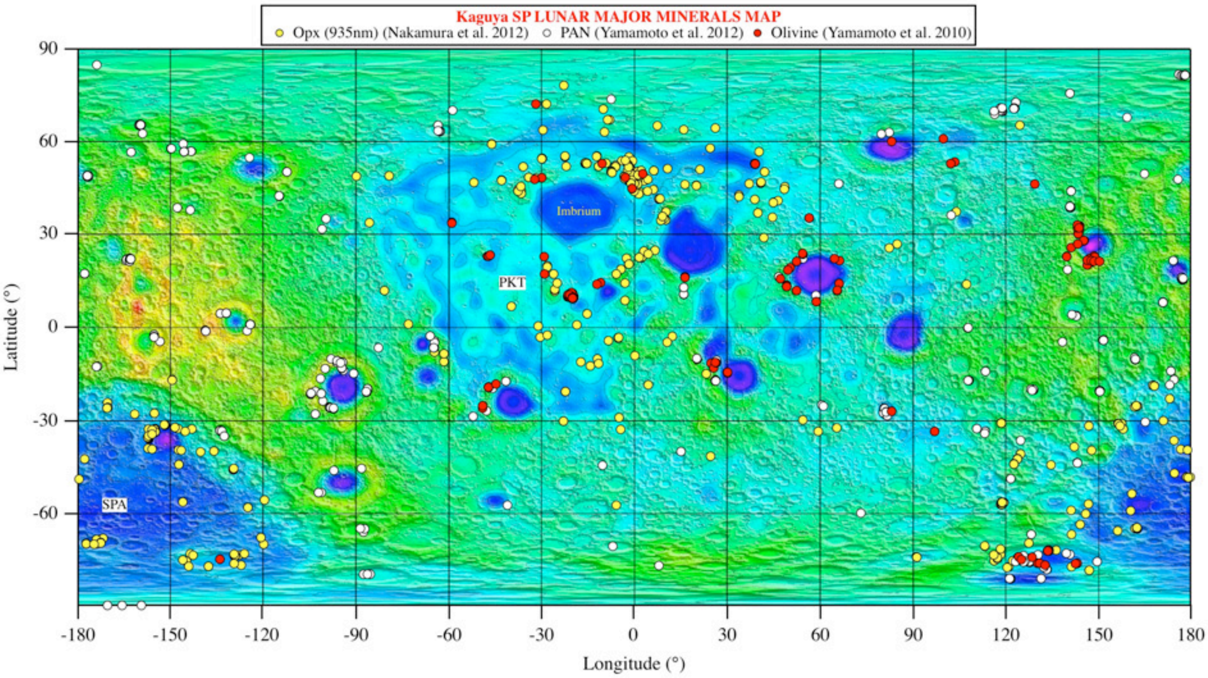

Figure 3. Global distribution of olivine (red) [7], PAN (white) [8] and low-Ca pyroxene (yellow) [5]. The backgournd image shows the crustal thickness derived from KAGUYA gravity measurements and altimetry [14].