GLOBAL DISTRIBUTION OF MG-SPINEL ON THE MOON REVEALED BY SELENE SPECTRAL PROFILER

Satoru Yamamoto[1], Ryosuke Nakamura[2], Tsuneo Matsunaga[1], Yoshiko Ogawa[3], Yoshiaki Ishihara[2], Tomokatsu Morota[4], Naru Hirata[3], Makiko Ohtake[5], Takahiro Hiroi[6], Yasuhiro Yokota[1], and Junichi Haruyama[5], [1]National Institute for Environmental Studies, Japan (yamachan@gfd-dennou.org), [2]National Institute of Advanced Industrial Science and Technology, Japan, [3]The University of Aizu, Japan, [4]Nagoya University, Japan, [5]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, and [6]Brown University, USA.

INTRODUCTION

The studies using the spectral data obtained by Spectral Profiler (SP) and Multiband Imager (MI) onboard the Japanese lunar explorer SELENE/Kaguya revealed the global distributions of the purest anorthosite (PAN), olivine-rich materials, and orthopyroxene-rich materials over the entire Moon [1,2,3,4]. These results were based on the diagnostic bands of these lunar major minerals in spectral data with wavelength $\lambda <\sim 1.7\,\mu$m. Recently, a prominent Mg-spinel-rich material (hereafter, Mg-spinel) on the lunar surface has been identified by Moon Mineralogy Mapper (M^3) onboard Chandrayaan-1 [e.g. 5,6]. However, the global distribution of Mg-spinel has been unclear so far. Since the Mg-spinel is characterized by a strong absorption band around $2\,\mu$m without a prominent band around $1\,\mu$m, the spectral data with $\lambda > 1.7\,\mu$m are needed to find the Mg-spinel by remote-sensing spectral data [7]. We have recently updated the radiometric calibration for SP NIR 2 data with $\lambda > 1.7\,\mu$m. Based on the entire data set of SP, including the SP NIR 2 data, we conducted the global survey to find the Mg-spinel on the Moon. Here, we report the global distribution of the Mg-spinel sites based on this survey.

METHOD

SP has obtained continuous spectral reflectance data for about 70 million points (0.5 by 0.5 km footprint) on the Moon in $\lambda = 0.5$-$2.6\,\mu$m and a spectral resolution of 6-8 nm during the mission from November 2007 to June 2009 [e.g. 8,9]. Analyzing the 70 million spectral data with the global survey algorithm used in [2,3,4], we pick up the spectra which show a clear $2\,\mu$m band. We then selected only the spectra whose absorption depth ratio of $1\,\mu$m to $2\,\mu$m is less than 0.5. Fig. 1 shows example spectra identified by this survey, which show a clear $2\,\mu$m band as compared to $1\,\mu$m band. We consider that these spectra indicate the existence of Mg-spinel.

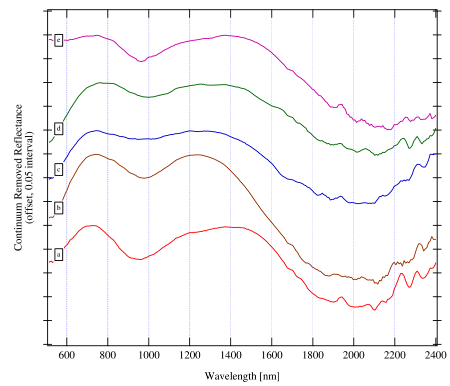

Figure 1: The continuum-removed reflectance spectra measured at SP observational points in (a) Humboldtianum, (b) Smythii, (c) Moscoviense, (d) Nectaris, and (e) Insularum basins. All spectra have been vertically offset for clarity, and the thick intervals of the vertical axes are 0.05. Note that the wavelike features in $\lambda > 2.2\,\mu$m may be due to the inherent spectral feature in the radiometric calibration coefficients (RCCs) [9].

RESULTS

We identified 19 observational points that show Mg-spinel spectra among 70 million spectral data. These detected points include Moscoviense and Nectaris basins, where the Mg-spinel sites are found by M^3 [5,6]. In Moscoviense, we identified Mg-spinel spectrum at slightly south from the sites reported by [5]. Fig. 2(a) shows the close-up image of the detected point in Moscoviense basin. We do not see any clear geological feature at the detected point. This feature is the same as other Mg-spinel sites in Moscoviense reported by M^3. [5] reported that there is nothing in the local morphology to distinguish the OOS (orthopyroxene, olivine and Mg-spinel) from the surroundings. In Nectaris, our detected point is at the central peaks of the Theophilus crater (Fig. 2(b)), which is the same as that by M^3 [6].

Fig. 3(a) shows the close-up images of Mg-spinel sites in Smythii basin, where Mg-spinel is found on the central peak of Neper crater. This may suggest that the Mg-spinel rocks originated from beneath the surface, and the impact that formed Neper crater exposed the materials to the surface. In Humboldtianum, Mg-spinel spectrum is identified on a small crater on the rim of Endymion crater (Fig. 3(b)). Fig. 3(c) shows the close-up image of the Mg-spinel in Insularum. In this close-up image, SP detected Mg-spinel spectra at three points, but they are not associated with any clear geological features. This exposure trend is the same as that in Moscoviense.

Our survey does not identify Mg-spinel spectra at the Copernicus and Tyco [e.g. 10]. [10] reported that Mg spinel bearing lithology occurs as a small hill on the floor of Copernicus crater. The absence of Mg-spinel site in these craters in our survey may be due to smaller exposures than SP footprint size.

Note that there are two types of the spectral features for these Mg-spinel rocks. First type shows a simple shape of the 1 μm band with a maximum reflectance at $\lambda \sim 1.25\,\mu$m, as shown in (b), (c), and (d) in Fig. 1. Second type shows more complex shape of the 1 μm band with a maximum reflectance at $\lambda \sim 1.4\,\mu$m, as shown in (a) and (e) in Fig. 1. We also found that there is a correlation between the spectral type and the impact basin. The first type is found in Smythii, Moscoviense, and Nectaris basins, while the second type is found in Humboldtianum and Insularum basins.

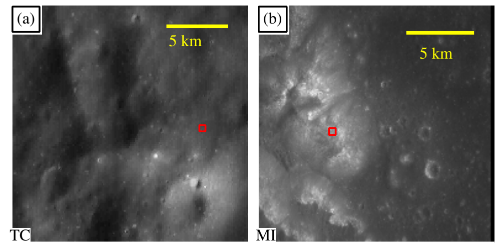

Figure 2: The close-up images of the Mg-spinel sites in (a) Moscoviense and (b) Nectaris. The close-up images shown here are obtained by the MI and Terrain Camera (TC) [11]. Mg-spinel points are plotted as red rectangles with 5 km scale bars.

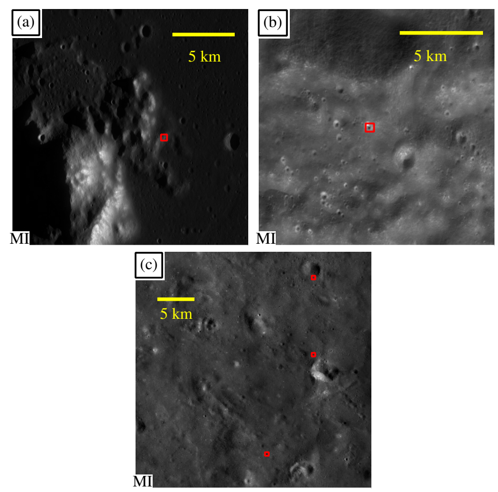

Figure 3: The close-up images of the Mg-spinel sites in (a) Smythii, (b) Humboldtianum, and (c) Insularum basins. Mg-spinel points are plotted as red rectangle with 5 km scale bars.

DISCUSSION

What is the origin of these Mg-spinels? All the Mg-spinel sites are associated with large impact basins. [5] and [6] proposed that the Mg-spinels originated from magmatic intrusions into the lower crust, which was excavated by the formation events of Moscoviense and Nectaris. We propose another explanation. Most of the basins with Mg-spinels possess the PAN and olivine-rich sites [1,2,3]. The formation of the impact basins melted the olivine-rich materials in the upper mantle and PAN in the crust, producing the spinel-rich materials [12]. In every cases, the distribution of Mg-spinel sites is related to the formation of impact basins. Our new data would provide important constraints for the composition and the evolution of the lunar crust and mantle.

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