Mg# ESTIMATION OF POSSIBLE MANTLE OLIVINE ON THE MOON.

M. Ohtake[1], S. Yamamoto[2], T. Morota[3], and S. Kato[3]. [1]Japan Aerospace Exploration Agency (JAXA) (ohtake.makiko@jaxa.jp), [2]National Institute for Environmental Studies, [3]Nagoya University.

Introduction: Recent remote-sensing data obtained by the SELENE (Kaguya) Spectral Profiler (SP) found exposures with olivine-rich spectral features, globally distributed on the lunar surface [1]. Their being surrounded by large basins, their spectral characteristics indicating olivine-rich (pyroxene-poor) composition, and the distribution of the olivine-rich unit at relatively recent crater walls and ejecta suggest that these olivine-rich exposures possibly originated from the mantle that is excavated from depth by basin-forming impacts. [1]

Previous lunar sample analyses indicate that olivine-rich rocks on the Moon have three major origins: 1) mantle material, 2) olivine-rich volcanic material, and 3) olivine-bearing crustal intrusion (troctorite) [2], but our recent work [3] revealed that roughly 60% of the olivine-rich sites are mantle origin, 5% are volcanic, 30% are crustal, and 5% are of unclear origin based on their iron content, geologic setting, and distribution.

In this study, we tried to estimate Mg# (Mg/(Mg+Fe) in mole per cent) for these olivine-rich spectra to further asses their origin and to discuss Mg# of the lunar material.

Methods: All of the latest 70 million calibrated reflectance spectra (version 03) obtained by Kaguya SP were used to re-identify olivine-rich exposures on the lunar surface (http://l2db.selene.darts.isas.jaxa.jp/index.html.en) by finding diagnostic absorption features of olivine around 1050nm as described in [1]. About 150 SP reflectance spectra were re-identified as having unambiguous olivine-rich absorption features. Examples of the identified spectra from two sites are presented in Fig. 1. It is clear that these identified spectra have maximum absorption around 1050nm with shoulders at 850 and 1250nm. Spectral fitting was calculated using a Modified Gaussian Model [4] for each of the identified spectra (Fig. 2 presents one of the MGM results). About 30 sets of different fitting conditions (different fitting peak number, different initial parameters, etc.) were performed for all of the identified spectra. However, currently no correlational constraint among fitting parameters (for example, correlation of center wavelengths among three fitted absorption peaks) were adapted. The derived center wavelengths of the olivine absorptions were therefore compared to the previously derived correlation between a center wavelength of olivine absorption and their Mg# [5]. In this study, we assumed pure olivine composition for all of the identified

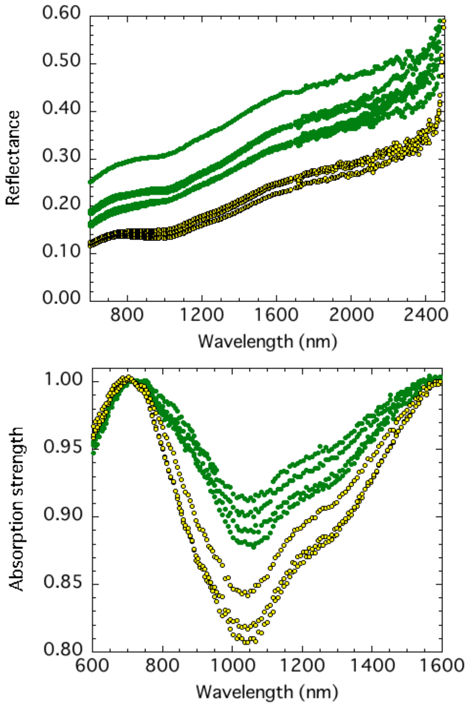

Fig. 1 Example of olivine-rich spectra.
a) Reflectance. b) Absorption strength after continuum removal. Green and yellow symbols correspond to spectra of possible mantle and volcanic origin respectively.

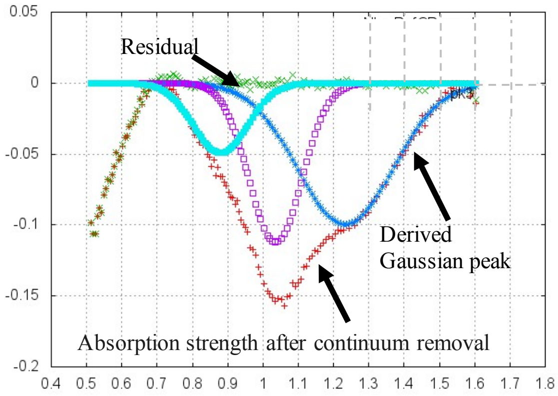

Fig. 2 Example of the MGM spectral fitting result.
Three absorption peaks with three parameters (strength, width, and absorption center wavelength) for each peak were fitted in this result.

spectra. Therefore, all of the fitted peaks were interpreted to be olivine absorption without any mixing with other minerals (pyroxene or plagioclase).

Results: Figure 3 demonstrates one example of MGM analyses results. Though center wavelength of most of the absorption around 1050nm appear to cluster, some of the data are scattered over a wavelength range much wider than the realistic wavelength range for a pure olivine absorption center. This tendency is more evident in absorptions around 850nm and 1250nm. Moreover, laboratory measurements and MGM spectral fitting of olivine [5] indicate that the absorption strength is maximum at the longest wavelength. However, many of the fitted results in this study have greater absorption strength at around 1050nm. Based on these observations, we interpret that these scatterings are caused by spectral fitting errors.

Discussion: Discussion

Based on the poor spectral fitting results without any correlational constraint among fitting parameters, we tried to adapt spectral fitting with correlational constraints developed by [6] (for example, the center wavelengths of three olivine absorptions are coupled as observed in the previous laboratory measurement [5]). In this new approach, modal abundance of olivine, pyroxene, and plagioclase were estimated with Mg# of olivine and pyroxene. Figure 4 presents the preliminary results of such an approach. Although there are still problematic fitting results having large Mg# estimation errors, many of the data suggest better fitting results (Mg# estimation errors are smaller than 10). However, most of the spectra of possible volcanic origin (yellow) and many of possible mantle origin (green) have much lower fitting errors. When we compared the results having smaller errors, Mg# of the volcanic origin is much lower than that of the mantle origin. The estimated Mg# range of the volcanic origin is consistent with the sample analyses of the returned lunar basalt samples [7]. Spectra of the possible crustal intrusion origin (white) tend to have greater fitting errors and need more detailed analyses. Therefore, comparing Mg# between the crustal and mantle origin is currently difficult, though crustal origin spectra with lower fitting errors appear to be lower than that of the possible mantel origin.

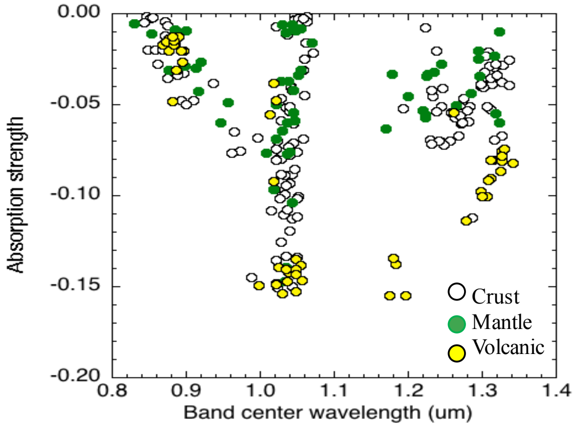

Fig. 3 Example of summary of the MGM spectral fitting. One example of series of MGM analyses sets of the all identified olivine-rich spectra are presented in this diagram.

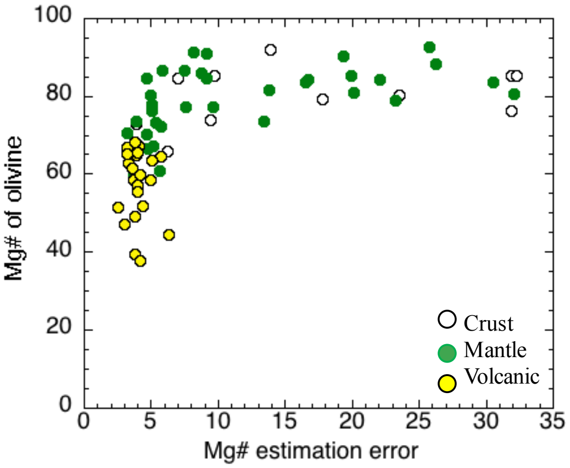

Fig. 4 Preliminary results of a new MGM spectral fitting. Although, there are still problematic fitting results having large Mg# estimation errors, many of the data suggest a better fitting results

References: [1] Yamamoto et al. (2010), *Nature GeoSci.* 3, 533-536. [2] Shearer et al. (2015), *Meteorit. Planet. Sci.*, 50, 1449-1467. [3] Ohtake et al. (2017), *48th LPSC, abstract* #1651. [4] Sunshine et al. (1990), *J. Geophys. Res.*, 95, 6955-6966. [5] Sunshine and Pieters (1998), *J. Geophys. Res.*, 103, 13675-13688. [6] Nimura et al. (2006), *37th LPSC, Abstract* #1600. [7] Kato et al. presentation in this meeting. [8] Lucey et al. (2006), in *New Views of the Moon.*