**Strategy for Lunar Mantle Rock Identification in SLIM Project.**

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**Introduction:** Smart Lander for Investigating Moon (SLIM) project is on going at JAXA. It was approved in 2016 and will be launched in fiscal year 2021 as Japan's lunar-landing mission [1]. The main purpose of this project is to demonstrate various techniques for pinpoint landing within a hundred meters in radius on the moon. Demonstration of the SLIM landing technology will cause a paradigm shift from "exploring where it is easy to land" to "exploring where we want to land." After landing, the SLIM project plans to operate Multi-Band Camera (MBC) to observe around the landing site. The observational mission is positioned as "extra success". We are now testing an engineering model of MBC (see Nakauchi et al. in this conference).

As a landing site for SLIM mission, one of the small fresh craters just outside of the Theophilus crater is selected. This crater (diameter ~200 m) locates 13.3º S, 25.2º E outside the southwest rim of Theophilus and named "Shioli". The reason we select there as a landing site is because there is olivine-rich lithology, which is probably mantle (or the lower part of the crustal) origin excavated by the Nectaris basin forming impact [2] as suggested by the global distribution of the olivine-rich sites [3], well before the formation of the Theophlius.

In order to identify this unknown lithology and estimate its origin, MBC has a spatial resolution (1.3 mm/pixel at 10 m) that distinguishes plutonic rock texture and a band combination (10 bands. see Table.1) that identifies mineral species. And most importantly, MBC has plan to estimate Mg # (=Mg/(Mg+Fe) atomic ratio) of olivine. In this study, we explain how to detect subtle absorption peak shift due to Mg / Fe ratio change in olivine from 10-bands discrete spectral information.

**Methods:** In order to detect peak wavelength of absorption band from discrete spectral data obtained by band-pass filters, we intend to use spline fitting method. The effectiveness of this method was tested in the following manner. The spectral data of olivine with various chemical compositions of RELAB were used as source data. First, the continuous spectrum data is converted into discrete data cut out by 10 bands of MBC. Next, the continuum connecting the reflectance of 750 nm and the reflectance of 1550 nm was removed. The 10-bands spectrum after the continuum removal is fitted with a spline function, and the position of the lowest reflectance near 1100 nm is set as the absorption peak wavelength (Fig.1). To see the durability against noise, we added random noise in the range of ± 0.5% and ± 1% to the reflectance after continuum removal. One hundred sets of spectral data were generated for each noise amount. After that, we spline-fitted each spectrum and determined the absorption peak position for each spectrum.

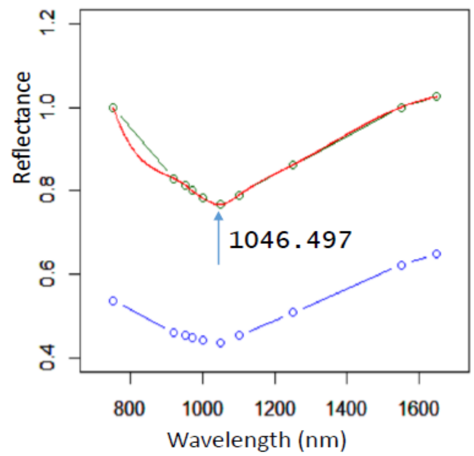


Fig.1 Examples of 10-bands spectrum (blue), continuum removed spectrum (green), and spline-fitted spectrum (red).

**Results:** The results are shown in Fig.2 and Fig.3. The Fo value indicates the amount of forsterite in olivine solid solution and can be interpreted as 100 times the value of Mg#. Concerning Mg-rich part of olivine (Fo≥40), it can be seen that the original absorption peak position was roughly restored by spline fitting. Decomposition of the iron-rich group (Fo < 40) is poor, but the mantle olivine is likely to have a Fo value of over 70, so it is considered that peak decomposition is possible if the target is mantle rock. Spectroscopic observations of rocks on the lunar surface are more difficult than observations of olivine powder at laboratory. Our preliminary experiments have shown that ideal olivine absorption peaks appear in confined areas such as rough rock surfaces and the edges of large olivine grains. In the lunar observations by MBC, we use high spatial resolution to find where the olivine absorption peak appears.

**Ongoing work:** For successful spectroscopic observations on the moon, it is important to conduct operational tests under observation conditions that are close to actual conditions. We plan to observe natural rocks with the Engineering Model of MBC. Furthermore, in order to advance basic research on spectroscopic observation of rocks, we have developed a line spectrometer using the same image sensor as MBC. The block diagrams and specifications of MBC and Line Spectrometer are shown in Fig. 4 and Table1.

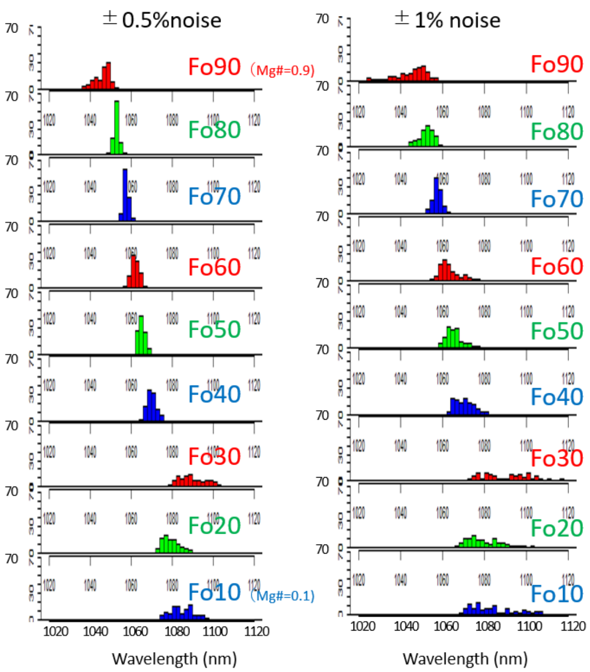


Fig.2 Absorption peaks detected from the noise-added spectra by the spline function

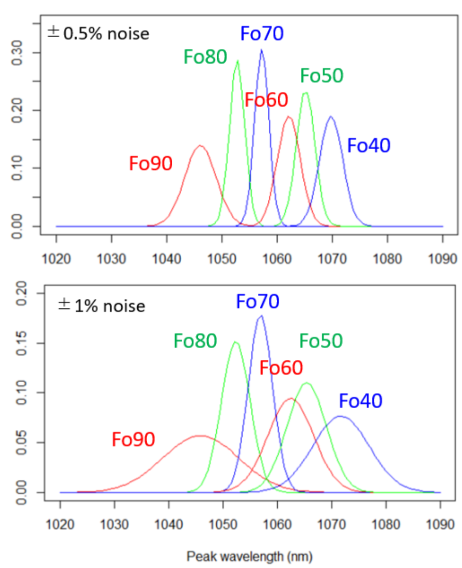


Fig.3 Histogram of absorption peak position distribution for Mg-rich (Fo≥40) olivine converted to normal distribution.

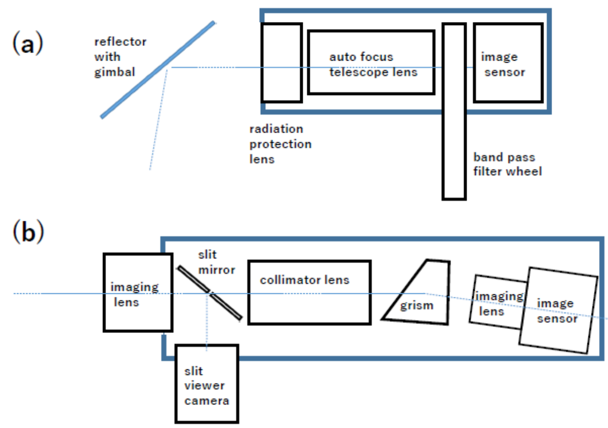


Fig.4 Block diagrams of Multi-Band Camera (a) and Line Spectrometer (b).

Table 1. Specifications of MBC and Line Spectrometer.

| | Multi-Band Camera | Line Spectrometer |
|---|---|---|
| type of Spectrometer | Band Pass Filters 750, 920, 950, 970, 1000, 1050, 1100, 1250, 1550, 1650 (nm) | Grism 750 ~ 1700 nm |
| band width | 30 nm | 5.8 nm / 3 pixels |
| image sensor | Xenics FPA0.9-1.7_640_4_TE1 pack sensor | The same as MBC (installed in Bobcat-640V-GigE) |
| purpose | onboard SLIM | laboratory experiments |
| Focus | auto focus | manual focus |

Line Spectrometer can observe continuous spectra and also have one-dimensional spatial information. By observing various rock samples with this spectrometer, we would like to succeed in deriving the detailed mineralogy of the olivine-rich exposure in the lunar spectroscopic observation at the SLIM project.

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**References:** [1] Sakai S. et al. (2015) *Low-Cost Planetary Mission Conference.* [2] Ohtake M. et al. (2019) *50th LPSC*, #2342. [3] Yamamoto S.et al. (2010) *Nat. GeoSci.*, 3, 533-536.