COMPOSITION DISTINGUISHMENT OF OLIVINE UNDER THE CONSIDERATION OF GRAIN SIZE

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Introduction: For the lunar mineralogy, previouse research pointed that the extraction of Fe, Ni, S-rich liquid to form a core and gravitational sinking of Mg-rich olivine and minor amounts of heavy complex oxides to form a mantle [1]. Especially, a hypothesis that materials in the olivine-rich sites originated in the upper mantle was proofed by [2]. Many studies focus on the composition of olivine [3-6]. In other words, determination of the components olivine is significant in the expliation of olivine-rich material originate.

On the one hand, the imaginary part *k* of materials' complex indices of refraction in the visual and NIR region directly effects absorption coefficient α(λ). On the other hand, the reflectance of a mineral varies, sometimes significantly, with the grain size.

In order to distinguish the olivine's composition, we discussed the spectral characteristics of Mg-rich olivine and Fe-rich olivine based on the reflectance which calculated by Mie theory and Hapke's radiative transfer model in this study.

Dataset: Lunar spectral sample data, LR-CMP-255 and LR-CMP-169 which sampled from lunar sample of 72415 and 15555, were studied first to revise the properties of samples. The sample 72415 is a cataclastic dunite made up of 93% olivine (Fo_{86-89}), and the sample 15555 was reported as containing two kinds of olivine: large (1mm), normal-zoned olivine phenocrysts with Fo_{67-29} and small (0.1mm) euhedral inclusions in plagioclase with Fo_{49-16}.

For the laboratory study, we taken San Carlos Olivine (SCO) and Sri Lanks Olivine (SLO) to represent Mg-rich olivine and Fe-rich olivine respectly. The complex indices of refraction of each mineral can be found in [7]. We took mean size weighted by cross sectional area to represent grain size in this study.

Method: The study including two steps: (1) revision particle numbers of LR-CMP-255 and LR-CMP-169; (2) simulated the spectral reflectance of SCO and SLO under different grain sizes.

In the first step, the mean size weighted by cross sectional area of LR-CMP-255 and LR-CMP-169 were calculated under the equation (4) in [8]. Since the mean size weighted by cross sectional area range from 0 to 125μm of these two samples were given by RELAB Database, the the mean size weighted by cross sectional area can be determined as 16μm in this study.

Then the number of particles can be determined via equation (1)-(23) in [8]. With the determined number and the mean size weighted by cross sectional area D, the effective study area can be calculated. As the the effective study area was determined, the number of particle in different size can be firmed too.

In the second step, the absorption and scattering coefficients, α and *s* respectively, can be calculated from Mie theory. Then, we can get the single-scattering albedo ω via equation (18)-(22) in [8].

Finally, the bidirectional reflectance of SCO and SLO in different grain size can be calculated, for bidirectional reflectance of LR-CMP-255 and LR-CMP-169 measured with a combination of the bidirectional reflectance spectrometer at i = 0°, e = 30°.

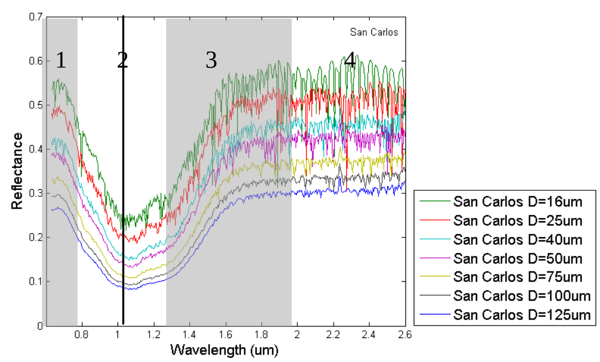

Fig.1. Revised reflactance of San Carlos Olivine in differenc the mean size weighted by cross sectional area at the wavelength from 0.6~2.6 μm. D varied in 16μm, 25μm, 40μm, 50μm, 75μm, 100μm , and 125μm.

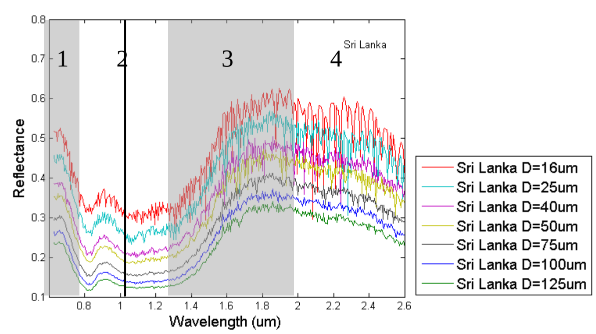

Fig.2. Revised reflactance of Sri Lanks Olivine in differenc the mean size weighted by cross sectional area at the wavelength from 0.6~2.6 µm. D varied in 16 µm, 25 µm, 40 µm, 50 µm, 75 µm, 100 µm , and 125 µm.

Result and Discussion: We taken reflectance with the mean size weighted by cross sectional area as 16 µm, 25 µm, 40 µm, 50 µm, 75 µm, 100 µm, and 125 µm as example, as Fig.1. and Fig.2. showed.

The simulated results showed that, spectral reflectance of Mg-rich olivine, like San Carlos, were higher than reflectance of Fe-rich.

SCO and SLO have similar refelectance shape at the wavelength from 0.6~0.8 µm and the wavelength from 1.3~2 µm, which marked in the zone 1 and 3 in Fig.1. and Fig.2.. The simulated reflectance showed that, SCO and SLO have a absorption depth around 1.05 µm in all sizes.

Reflectance at 1.05 µm ($R_{1.05}$) of SCO were analyzed by mean size weighted by cross sectional area. There is a logarithmic relationship between $R_{1.05}$ and mean size weighted by cross sectional area D ($D = -0.07\ln(R_{1.1}) + 0.4185$, $R^2 = 0.9909$).

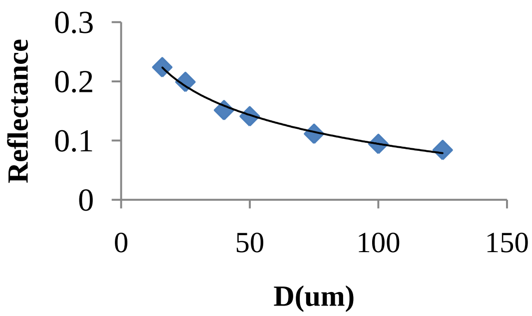

Fig.3. Logarithmic relatrionship between $R_{1.05}$ and mean size weighted by cross sectional area

As [7] pointed that individual values of k(λ) and the absorption cross section $Q_{abs}(\lambda)$ depend strongly on the content in transition metals like iron. Two samples showed a notable difference in zone 2 (0.8~1.3 µm).

We set a parameter, (R_a-R_b), which means the difference between reflectance at a µm and b µm, to distinguish Mg-rich olivine and Fe-rich olivine. For detail can be found in Table 1..

Table 1. The (R_a-R_b) feature of Mg-rich olivine and Fe-rich olivine

D(µm)	SCO		SLO	
	$R_{0.8}$-$R_{1.05}$	$R_{1.05}$-$R_{1.3}$	$R_{0.8}$-$R_{1.05}$	$R_{1.05}$-$R_{1.3}$
16	0.1677	-0.0376	0.0187	-0.0106
25	0.1684	-0.0634	0.0246	0.0102
40	0.1561	-0.0466	0.0232	-0.0239
50	0.1480	-0.0467	0.0163	-0.0135
75	0.1241	-0.0346	0.0053	-0.0098
100	0.1039	-0.0289	0.0029	-0.0070
125	0.0917	-0.0242	-0.0013	-0.0036

Conclusion: We analyszed reflectance of Mg-rich olivine and Fe-rich olivine, which simulated by Hapke's model under the consideration of grain size. The theoretical result indicated a logarithmic relationship between reflectance depth around 1.05 µm and grain size.

The reflectance of these two olivines showed notable difference at zone 2 (wavelength range from 0.8 to 1.3 µm). Especially, the reflectance difference between 0.8 µm and 1.05 µm can be used to distinguish olivine composition in all size, as Fig.4. shown.

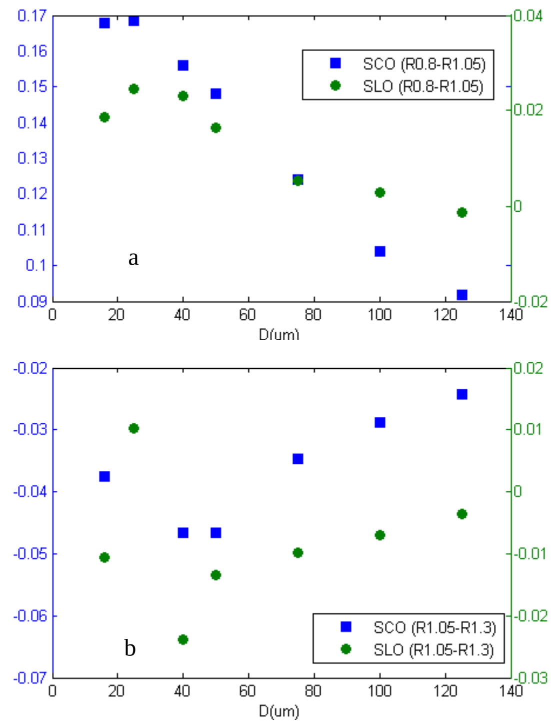

Fig.4. Difference between $R_{0.8}$ and $R_{1.05}$ were marked in (a) and difference between $R_{1.05}$ and $R_{1.3}$ were marked in (b).

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