AN ATTEMPT OF RESTRICTING OLIVINE BANDS IN THE MODIFIED GAUSSIAN MODEL.

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Introduction: In the surface reflectance spectra of planets, we often find a composite absorption band around 1 μm in wavelength due to the component silicates. As a method of deconvolving this complex absorption band into those of its component minerals, MGM (modified Gaussian model) is used as a standard way [1]. However, each mineral species usually has multiple bands around 1 μm which overlap with one another and those of other minerals, making it difficult to assign the deconvolved bands into individual mineral components. Because the relationship between the chemical composition and absorption band characteristics of some minerals are known to some extent, it is expected that the above problem can be solved by utilizing such knowledge. Especially, three absorption bands of olivine are studied relatively well [2].

MGM: In MGM, natural log of each reflectance spectrum is modeled as:

$$\ln R(\lambda) = c_0 + c_1/\lambda + \sum_i^N s_i \exp\left[-\frac{(\lambda-\mu_i)^2}{2\sigma_i^2}\right] \quad (1)$$

where λ denotes wavelength, R(λ) reflectance at wavelength λ, and s, μ, and σ band strength, center, and width, respectively. Defining each absorption band requires those three parameters. The suffix (i = 1~N) indicates the band number. In the case of olivine, there are three bands, making the number of parameters 11 (3 × 3 + 2) in Equation (1). In this study, we investigate a relationships between the Fa value (Fe content in olivine) and band center, band width and relative strength of olivine based on data in [2], and utilize them in our MGM calculations.

Experimental: Reflectance spectra of olivine samples (<45 μm) described in [2] were taken from the RELAB database (http://lf314-rlds.geo.brown.edu/). A sample of Alta'ameem LL5 chondrite was ground into power fraction of <45 μm in size, and its reflectance spectrum was measured at 0 degree incidence and 30 degree emergence angles, using a Jasco UV-Vis-NIR bidirectional spectrometer at JAXA Institute of Space and Astronautical Science.

Constraints: Shown in Fig. 1 is the relationships between the Fa value and the band centers of three absorption bands. We model each relationship using a linear function:

$$\mu_i = M_i \cdot Fa + N_i \quad (2)$$

where M_i and N_i are constants, and the subscript i indicates the band number. Equation (2) enables us to obtain three band center values from just one Fa value.

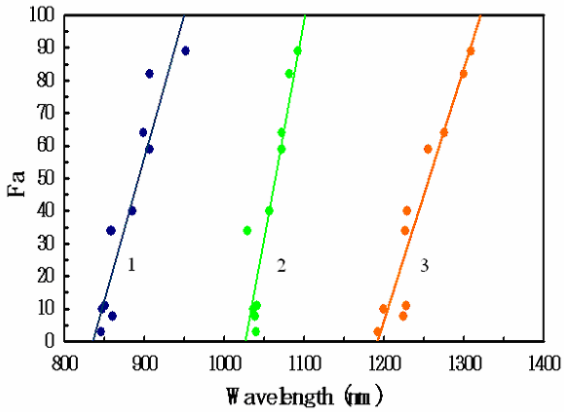

Fig. 1. Center wavelengths of three olivine absorption bands. Bands 1 and 3 are assigned to the M1 site, and the band 2 the M2 side [2].

Band widths of the three absorption bands are plotted in Fig. 2. Numbers on the plot indicate Fa values. These data points seem to show little correlation between the Fa values and band width values for each band. All the band width values for each band are averaged to be used in our model calculations.

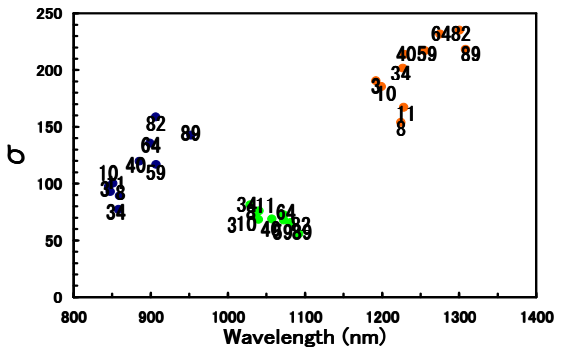

Fig. 2. Widths of three olivine absorption bands. Colors indicate the same as in Fig. 1.

Shown in Fig. 3 are the relative strengths of the three absorption bands. As addressed earlier [2], the band 1 strength relative to the band 3 strength seems to be modeled well as a constant (plotted in blue), while

the band 2 strength (plotted in green) relative to the band 3 strength seems to change linearly along with the Fa value. Thus, we can model as:

$$\frac{s_2}{s_3} = A \cdot Fa + B \quad (3)$$

and

$$\frac{s_1}{s_3} = C, \quad (4)$$

where A, B, and C are constants. Equations (3) and (4) show that three strength parameters can now be expressed by one for a given Fa value.

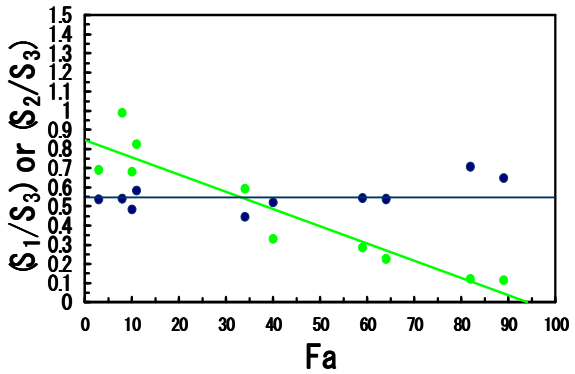

Fig. 3. Fa value vs. relative strengths of three olivine absorption bands. Blue color indicates the s_1/s_3 ratio, and blue the s_2/s_3 ratio.

Based on Equations (1)~(4), we can model each olivine spectrum using, instead of 11 variables, only 4 variables c_0, c_1, Fa, and s_3, and 12 constants M_i, N_i, and σ_i (i = 1~3), A, B, and C.

Tests: These new constraints in Equations (2)~(4) were applied to the MGM calculations of the same olivine spectra used above again. Shown in Fig. 4 is the relationship between the actual Fa values and those derived by MGM fits with these constraints. In the low and high Fa value ranges, MGM fits with these constraints have larger errors than the middle Fa value range. This scheme was also applied to the spectrum of the Alta'ameem sample (Fig. 5). While the normal MGM cannot give the correct features of olivine absorption (Fig. 5a), this scheme of MGM can produce the correct features (Fig. 5b).

Conclusion: This preliminary study of putting constraints on olivine bands in the MGM calculations has shown a potential usefulness, although there still remain issues to address, such as accuracy.

References: [1] Sunshine J. M. et al. (1990) *JGR*, 95, 6955-6966. [2] Sunshine J. M. and Pieters C. M. (1998) *JGR*, 103, 13675-13688.

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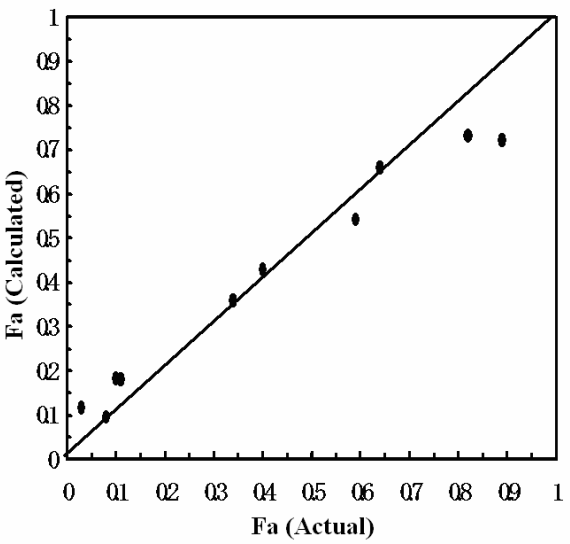

Fig. 4. Comparison between the actual Fa values and the calculated Fa values from MGM fits with the constraints in Equations (2)~(4).

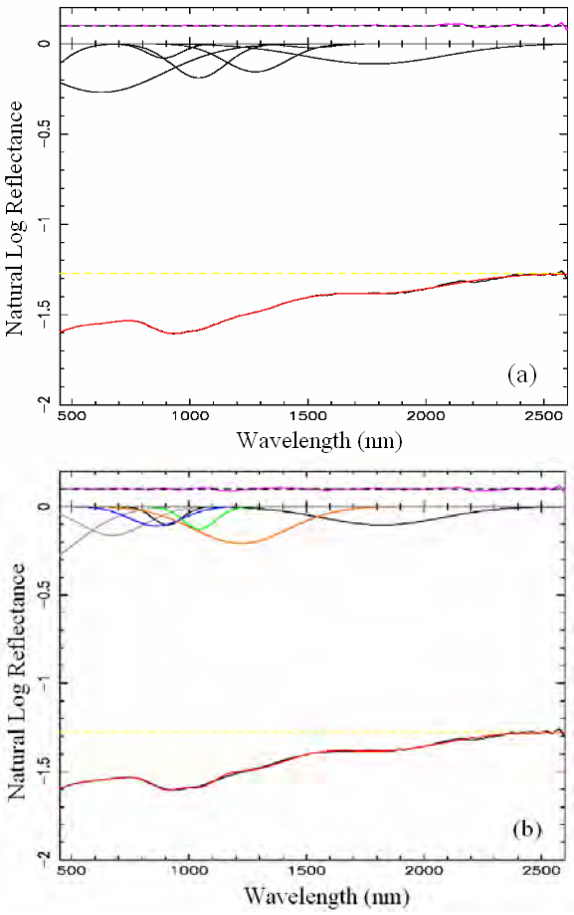

Fig. 5. MGM fits of Alta'ameem (LL5) ordinary chondrite sample (a) without and (b) with the constraints in this study.