Grain Size Effects on Spectral Reflectance of Ol, Opx and Cpx Minerals - Applied to the Hull Quotient Method -

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For emphasizing absorption feature with mineral composition and grain size fraction, we applied to the hull quotient method [1,2] which is proposed that a hull is defined as a lowest convex curve lying above the spectral reflectance and a hull quotient is given by taking the ratio between the raw spectrum and the hull value (Fig. 1). We report the results of laboratory reflectance measurements for olivine(*ol*), orthopyroxene(*opx*), and clinopyroxene(*cpx*) which are of geologic importance throughout the solid part of the solar system. Used *ol*, *opx*, and *cpx* minerals are extracted from crushed spinel lherzolite (Kilbornhole, New Mexico). We measured the spectral reflectance of samples with a UV-VIS-NIR spectrophotometer (Beckman UV-5240) with an integrating sphere. Halon powder was standard. The details of sample preparation and measurement procedure were described in our previous works [3,4,5,6].

Reflectance and hull quotient spectra for *ol*, *opx* and *cpx* are shown in Fig. 2, 3 and 4. These spectra show how the absorption features of powdered minerals vary systematically with change in mineral compositions and grain sizes. The hull spectra of *ol* ($Fo_{83}Fa_{17}$) display more clearly asymmetrical absorption features of overlapping Fe^{2+} crystal field effect near 1000 nm than that of the raw spectrum (Fig. 2). The spectra of *opx* ($En_{84}Fs_{16}$) demonstrate two major absorption bands centered at about 900 and 1800 nm. The effects of particle size are the same as those of the *ol* except for near 300 nm absorption (Fig. 3). The hull spectra of *cpx* ($Wo_{51}En_{41}Fs_8$) have also two major bands centered at about 1000 and 2200 nm and have rather weak absorption near 600 nm caused by a small amount of Cr^{3+} (0.6wt% Cr_2O_3) located in M1 sites [7,8] (Fig. 4). The grain size effects are same as those of the *ol*.

Hull quotient method yield a consistent technique for emphasizing characteristic features of reflectance spectra, and hence we can easily identify the existence of small amount of transfer elements (e.g. Cr^{3+},Ti^{3+}). In this case, absorption feature near 600 nm caused by 0.6% of Cr_2O_3 can be easily seen. To demonstrate the size effects of hull spectra more clearly, intensities of absorption peaks (*a*:*ol* 1050 nm, *b*,*c*:*opx* 900 and 1800 nm, *d*,*e*:*cpx* 1030 and 2230 nm absorptions, respectively) of hull spectra are plotted in Fig. 5. We assume that absorption ratio for a smoothed surface spherical particle relates to R^3 (R is its particle radius) and the number of particles per unit area relates to R^{-2}, then absorption ratio per unit area is proportional to R. The results of our study consistent with this assumption. Work needs to study the relation between crystals field theory and the hull quotient method. And the next step in this study is to investigate the inversion problem for multi components mixtures.

References:(1)Yamaguchi Y. and Lyon R.J.P. *Proc. 5th Thematic Conf.*, 1986. (2)Green A.A. and Craig M.D. *JPL Pub.*85-41,111-119, 1985. (3)Azuma H. et al., *Proc.17th ISAS LPS.*,43-44, 1984. (4)Fujii N. et al., *Proc.18th ISAS LPS.*,50-51, 1985. (5)Fujii N. et al., *LPSC 17th*, 245-246, 1986. (6)Azuma H. et al., *Mem. Grad. Scl. of Sci. and Tech. Kobe Univ.*, 1988. (7)Singer R.B., *J.Geophys. Res.*, 86,7967-7982, 1981. (8)Adams J.B., *J.Geophys. Res.*, 79,4829-4836, 1974.

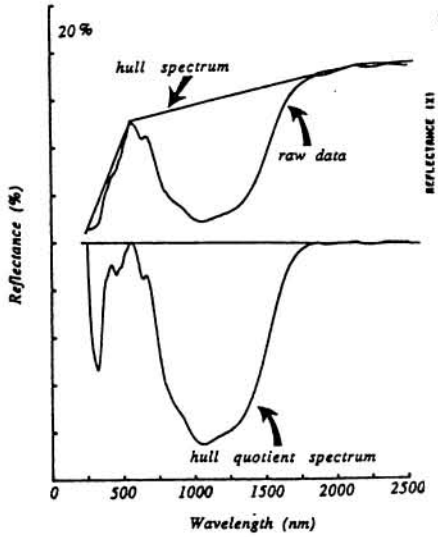

Fig. 1 Raw spectrum, hull and hull quotient spectrum.

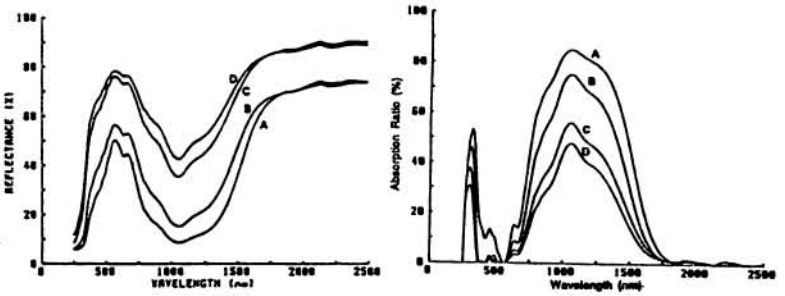

Fig. 2 Reflectance spectra (left) and hull quotient spectrum (right) for olivine. A:250-500, B:105-250, C:74-105, and D:44-74 microns grain size.

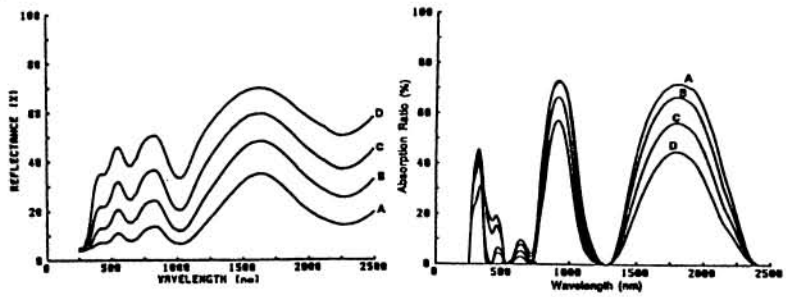

Fig. 3 Reflectance spectra (left) and hull quotient spectrum (right) for orthopyroxene. A to D are the same as Fig. 2.

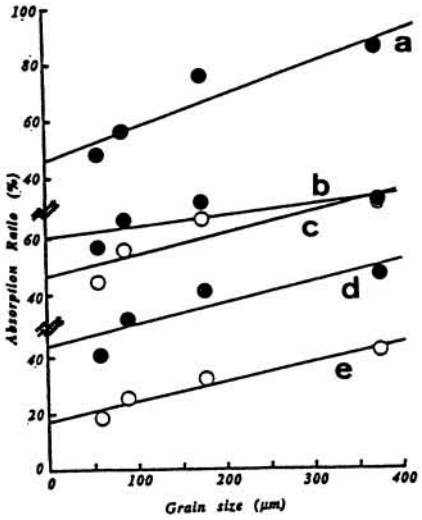

Fig. 5 Plot of intensities of absorption peak as a function of particle size for ol(a), opx(b,c) and cpx(d,e).

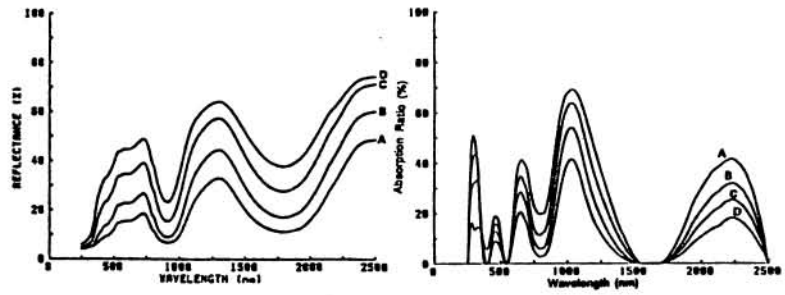

Fig. 4 Reflectance spectra (left) and hull quotient spectrum (right) for clinopyroxene. A to D are the same as Fig. 2.