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Reflectance spectroscopy of lunar meteorite Y981031: Implications for lunar remote-sensing observation

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We report Modified gaussian model (MGM) deconvolution analyses of reflectance spectrum of Yamato (Y) 981031. Absorption features derived from the MGM deconvolution are compared with the petrological characteristics of Y981031, and implication for lunar remote-sensing observation are discussed.

Y981031 is a polymict regolith breccia. The mineral fragments are composed of major pyroxene, plagioclase and olivine including minor iron oxide and Ca-phosphate. The lithic clasts are mainly composed of mafic mare clasts, and some minor highland-origin lithic clasts are observed. These mineralogical evidences suggest that Y981031 was derived from extensive mixing area of mafic mare and highland components. Since chemical compositions of the fusion glass resemble bulk rock compositions of Y981031 (TiO_2=0.50-0.77 wt.%, Al_2O_3=14.7-18.3 wt.%), the glass chemical compositions represent well-mixed bulk rock compositions, suggesting mixing of mafic VLT affinity and feldspathic highland materials.

Based on the MGM deconvolution analyses of the reflectance spectrum of Y981031, absorption bands are observed at 0.78, 0.90, 1.01, 1.22, 1.92, and 2.24 um in wavelength. 1um absorption bands due to Fe^{2+} absorption in mafic silicates would correspond to 0.90 and 1.01um bands, and 2um absorption bands correspond to 1.92 and 2.24um. Two absorption bands of 1um (0.9 and 1.01um) show existence of Mg-rich low-Ca pyroxene and augitic to ferroaugitic high-Ca pyroxene, and tendencies of 1um bands consistent with those of two 2um absorption bands (1.92 and 2.24um). Such Mg-rich low-Ca pyroxene and augitic to ferroaugitic high-Ca payroxene are observed in Y981031. Although slight disagreements are observed, 0.90 and 1.92um bands are of pigeonitic low-Ca pyroxene (up to $Wo_{10}En_{63}Fs_{27}$). 1.01 and 2.24um absorption bands are of the augitic to ferroaugitic high-Ca pyroxene mineral fragments. High-Ca pyroxene in Y981031 show a compositional trend ($Wo_{43}En_{40}Fs_{17}$ to $Wo_{29}En_{23}Fs_{48}$). This compositional trend is near parallel to the absorption contours around this region in pyroxene quadrilateral. Therefore, 1.01 and 2.24um bands would be of the compositional trend of high-Ca pyroxene rather than one pyroxene composition. These observations indicate that Y981031 has predominantly high-Ca pyroxene and Mg-rich low-Ca pyroxene. Chemical compositions of pyroxene in mafic mare clasts are included in the high-Ca pyroxene compositional trend. Therefore, 1.01 and 2.24um bands show characteristics of the VLT affinity as mafic components in Y981031. Relatively wide exsolution lamellae is observed in Mg-rich low-Ca pyroxene fragments under the microscope, and Ti# (Ti/(Ti+Cr), atomic ratio)-Mg# (Mg/(Mg+Fe), atomic ratio) relation of the low-Ca pyroxene fragments resemble those of highland pyroxene. Therefore, Mg-rich low-Ca pyroxene was derived from highland materials. We can observe separately absorption features derived from mafic VLT and mixed highland materials in Y981031 by the MGM analyses. This result suggest that we can separately identify some mixing end members even if in mare-highland mixing area such as mare-highland contact using hyperspectral remote sensing data and the MGM analyses. Therefore, if we carry out petrological observations in detail and measure reflectance spectrum of a lunar meteorite, we can not only understand source region of the meteorite from remote sensing data but also use the meteorite as ground truth of the remote sensing data around the source region. TiO_2 and FeO concentrations of the fusion glass and bulk rock resemble those of Mare Frigoris and adjacent maria that were derived from Clementine images using Lucey et al. algorithms. Therefore, Y981031 may be launched from a region in these maria. If we observe these maria by ground-based telescopic or future hyperspectral remote sensing observations, we can identify source region of the meteorite having same absorption characteristics.