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Application of the Raman carbonaceous material thermometer to chondrites

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Introduction

Structure of carbonaceous material (CM) reflects the experience of thermal metamorphism which occurred on their parent bodies. Therefore, various applications of CM to geothermometer on both terrestrial metasediments and primitive chondrites have been reported so far. Raman spectroscopy is a promising method to investigate the structure of CM, because of the in-situ, non-destructive analysis. Raman spectra of CM have characteristic bands at around 1600cm^{-1} (G-band) and 1355cm^{-1} (D1-band). Recently, detailed analysis on Raman spectra of CM using four or five peaks on terrestrial metasediments extended the applicable range of thermometer to 150˜650 ℃ (Kouketsu et al., 2014). On the other hand, only two peaks are applied in the regression analysis on Raman spectra of CM in meteorites at present. In this research, we try to improve the Raman thermometer on CM in meteorite by applying the detailed peak fitting method.

Samples and Methods

In this research, 20 samples were chosen from carbonaceous chondrites, ordinary chondrites and R chondrites. Raman spectra were obtained on CM in 14 bulk meteorites, thin section of five samples and insoluble organic matter (IOM) extracted from one sample. Laser power at the sample surface was controlled in the range of 1˜2.5 mW, and acquisition time was 10˜30 s. For most of the samples, at least 30 data sets were acquired. After removing the background by a linear baseline, the obtained spectra were fitted by four pseudo-Voigt functions.

Results and Discussion

Four-peak spectral fitting (using G_L, D1, D3 and D4-band) was performed on each sample. The result suggested that there is a correlation between the full width at half maximum (FWHM) of D1-band and peak metamorphic temperatures (PMT). A calibration curve was obtained by using seven samples whose metamorphic temperature were already estimated to be 120˜550 ℃ in the previous study(Huss et al., 2006). The derived relationship between the FWHM of D1-band (Γ_{D1}) and PMT is represented by a liner function.

To verify whether the obtained thermometer is applicable to other chondrites, we observed the relationship between Γ_{D1} and other parameters. The relationship between intensity ratio I_{D1}/I_{GL} and Γ_{D1} showed that the value of Γ_{D1} has the lowest limit. This phenomenon was also identified in Kouketsu et al. (2014). From the obtained results, the upper limit of the thermometer was found to be (550 ℃).

Conclusion

This study revealed that Raman thermometer on CM is applicable to estimate the metamorphic temperature of primitive chondrites by using the FWHM of the D1-band. The relational is expressed by a linear function and the applicable temperature range is 200 to 550 ℃. There is a possibility to apply this thermometer to the low metamorphic region under 200 ℃ by increasing assay samples, although there is still room to optimize the fitting conditions.

Keywords: chondrites, carbonaceous material, Raman spectroscopy, thermal history