Japan Geoscience Union Meeting 2013
(May 19-24 2013 at Makuhari, Chiba, Japan)

MTT38-P01 Room:Convention Hall Time:May 22 18:15-19:30

Carbon isotope analysis of carbon dioxide using Raman Spectroscopy: Application to fluid inclusions in mantle xenolith

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Carbon is often observed in mantle rocks, and its isotopic composition is used to discuss the carbon cycle inside the earth. Some carbon exists as fluid inclusions mainly composed of carbon dioxide in rocks. Generally carbon isotopes in rocks have been measured by mass spectroscopy analyzing gas extracted when heating or crushing. Arakawa et al. (2007, Applied Spectroscopy) suggested a possibility that micro-Raman spectroscopy is applicable for determining carbon isotopic composition of carbon dioxide.Development of this method will become easier to conduct non-destructive measurement of carbon isotopic composition for individual fluid inclusions.

In this study, we attempted to solve a problem raised by Arakawa et al. and to examine applicability of the method to natural samples. We analyzed a fluid inclusion in natural olivine by micro-Raman spectrometer installed at Department of Earth Sciences, Kanazawa University. After we carried out original peak fitting on spectrum of 1240-1514 cm^{-1} as Raman shift including a fermi diad, hot bands and a "collision induced" band of carbon dioxide, we calculated intensity ratio of peaks originated from $^{13}CO_2$ and $^{12}CO_2$.

The most serious problem pointed out by Arakawa et al. was caused by positional relationship between a grating and a detector. We solved it by using a high-resolution spectrometer (0.27 cm^{-1}/pixel). On the other hand, we found a problem characteristic of natural samples that both accuracy and precision has deteriorated when we obtain intense Raman peaks other than carbon dioxide. In case of absence of such peaks, we can determine carbon isotopic composition (delta^{13}C) with an uncertainty of +/-2.5 per mil (1 sigma). Further development of the micro-Raman mass spectroscopy enables us to discuss the origin and cycle of carbon inside the earth.

Keywords: Raman spectroscopy, Carbon dioxide, Carbon isotope, Fluid inclusion, mantle xenolith