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Raman spectroscopic analysis of carbonaceous material included in oil source rocks

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Carbonaceous material (CM) included in rocks is important material to produce resources of oil and gas. The quality and storage of these resources are evaluated by analyzing the chemical composition, crystal structure, and reflectance of CM. In the oil exploration, vitrinite reflectance is widely used to evaluate the maturity of CM. However, the spatial resolution of vitrinite reflectance measurement is about 10 μm and more than 100 point measurement is needed for quantitative evaluation. Therefore, the evaluation of maturity of CM is sometimes difficult in low vitrinite content rocks.

In the present study, we examined the maturity of CM using the Raman spectroscopy, whose spatial resolution is about 1 μm. Kouketsu et al. (2014_Island Arc) reported that the values of full width at half maximum (FWHM) of CM Raman spectra correlate with metamorphic temperature and proposed the Raman CM geothermometer. Applicable temperature range is 150 to 400 ℃ and the reflectance of vitrinite included in the calibrated samples is more than 1 %. We focused on the reflectance less than 1 % where the crude oil is started to produce and carried out the measurement of Raman spectroscopic analysis and reflectance for the samples containing vitrinite grains whose reflectance between 0.25 to 2.44 %.

In the Raman spectroscopic analysis, we used 514.5 nm Ar^{+} laser and set the laser power around 0.2 mW at sample surface to avoid the damage to CM. Measured spectra were divided into four peaks of D1-, D2-, D3-, and D4-bands within the 1000 to 2000 cm^{-1} range. Raman spectra of CM less than 1 % of reflectance show strong fluorescence background. Raman peaks of CM less than 0.4 % of reflectance cannot be detected. The values of FWHM of D1- and D2-bands vary less than 1 % of reflectance range and the correlation becomes unclear. The CM Raman spectra seem to be affected by the background and peaks are not separated properly. This result indicates that the conventional Raman CM geothermometer is difficult to apply to oil source rocks. On the other hand, the slope of Raman baseline becomes smaller with increasing reflectance, and the correlation is approximated by exponential function. The fluorescence related to the baseline of Raman spectra is considered to be caused by the polycyclic aromatic hydrocarbon that is the main component of oil and gas. Therefore, the baseline slope of CM Raman spectra will be a useful index to evaluate the maturity of oil source rocks.

Keywords: oil source rock, carbonaceous material, Raman spectroscopy, vitrinite reflectance