

A possibility of a CM fault thermometer Part2: Raman spectra

OKAMOTO, Shiori^{1*} ; KOUKETSU, Yui² ; SHIMIZU, Ichiko³ ; HOSHINO, Kenichi⁴

¹Fac. Sci., Hiroshima Univ., ²Univ. Tokyo, Grad. Sch. Sci., ³Univ. Tokyo, Grad. Sch. Sci., ⁴Grad. Sch. Sci., Hiroshima Univ.

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Key words: carbonaceous matter, thermometer, fault, Raman spectra

Parameters of Raman spectra of carbonaceous matters (CMs) have been widely used to estimate geological temperatures (e.g., Beyssac et al., 2002). Huang (1996) and Muirhead et al. (2012) proposed empirical power rate laws for CM maturation represented by reflectances in oil (%Ro) and R1 ratios of Raman spectra, respectively, from pyrolytic experiments of bare CM fragments extracted from rocks and meteorites, respectively.

To investigate a possibility of a fault thermometer by thermal maturations of CMs indicated by their Raman spectra, we conducted heating experiments of pelitic rock samples taken from Aki Group of the Shimanto accretionary belt in Kochi Prefecture, whose diagenetic temperature is estimated as ~180C by vitrinite reflectances (Kitamura et al., 2014). The samples were heated at temperatures, 300, 350, 450, 550, 600 and 750C for 2, 5, 13 and 34 minutes (see details in the previous presentation, Part 1).

It was indicated by comparing the spectra of CMs on surfaces of heated samples and those inside the sample that maturations of the former proceeded faster than the latter during heating. Therefore, in order to apply the thermal maturation of CM to a fault thermometer, it is needed to analyze CMs inside the samples.

It should be mentioned that micro-XRD analyses of CMs after the highest and longest heating run show no graphite peak. Hence, the maturation process during the present experiments is not graphitization but coalification.

Raman spectra of CMs show two major peaks, so-called G-band and D1-band peaks. Analytical results of the peaks indicate that certain parameters of Raman spectra of CMs remarkably vary even after low temperature (300 - 450C) heating runs, whereas reflectances of CMs do not increase (see Part 1). The positions of G-band peak (Gp) and D1-band peak (Dp) tend to shift toward higher wave numbers with increasing heating durations in the all temperature runs. However, they do not shift monotonically with heating temperatures. Their wave numbers increase with the heating temperatures up to 450C, then decrease at 550C, and again increase up to 750C.

Differences between Gp and Dp (Gp-Dp) also vary with heating temperatures and durations. Although they become smaller as the temperature is higher for the longest runs (34 minutes), this temperature dependency could not be seen for the other heating durations.

The ratio of intensity to full width at half maximum of the G-band peak (Gif) and that of the D1-band peak (Dif) decrease with increasing temperatures from 300C to 450C and from 550C to 750C, but increase from 450C to 550C. The both Gif and Dif do not show monotonic change with the heating durations.

As stated in the above, a simple indicator varying monotonically with heating temperatures and durations has not been found yet. However, we conceive that the sensitivities of the above indices of the Raman spectra to the thermal maturation of CM may show their potentials as a fault thermometer. Size dependencies of variations in some of the above indices with heating temperatures and durations and similarities of those of small-grained CMs and rims of large-grained ones also show a possibility to estimate both heating temperature and duration simultaneously by a size dependent thermometer, that is, a thermo-chronometer.

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