Estimation of thermal structure around the Median Tectonic Line in Shikoku, SW Japan

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It is important to estimate the thermal structure around the fault zone for understanding fault slip behavior and its strength, because a thermal diffusion during an earthquake is recorded by rocks around the fault zone. (Mori et al.,2015; Kaneki et al.,2018). Recently, various temperature proxies as vitrinite reflectance (Sakaguchi et al.,2011), biomarker maturity (Savage and Polissar, 2019) and carbonaceous materials (CM) (D.G. Henry et al.,2019) have been used to estimate the thermal structure around the fault zone. Especially, Raman spectroscopic analysis on CM is intensively used because CM and graphite commonly exist in sedimentary and metamorphic rocks. In this study, we conducted Raman spectroscopic analysis on CM to estimate a thermal structure around the Median Tectonic Line (MTL).

The MTL extending over 1000 km-long is a geological boundary fault that divides southwest Japan into Inner (mainly the Late Cretaceous Izumi Group and Ryoke granitic to low-P/T metamorphic rocks) and Outer (mainly the Cretaceous Sanbagawa high-P/T metamorphic rocks) zones. The MTL from Shikoku to western Kii Peninsula are dextral active faults revealed by geomorphological and paleo-seismological surveys (e.g., Ikeda et al., 2017). However, the movement history is complex because the MTL is a long-lived fault system from the Middle Cretaceous.

We estimated thermal structure around the MTL using a geological core sample (125 m-long) penetrating the inactive zone of the MTL in Saijyo City, Ehime prefecture (Uchida et al., 2019 JPGU). For Raman spectroscopic analyses, we prepared thin sections which consist of 9 samples from host rock and cataclasite of the Izumi Group at depths of 20–105 m, 8 samples from fault gouge and breccia of the MTL fault zone at depths of 106–110 m and 3 samples from host rock of the Sanbagawa metamorphic rocks at depths of 111–125 m. For each thin section, we measured at 20 ˜ 30 points and adopted the averaged results. We adopted equations proposed by Aoya et al (2010) and Kouketsu et al (2014) to estimate the metamorphic temperatures. We then estimated organic matter maturity of the Izumi Group using equation of Henry et al (2019) and estimated temperature of the Izumi Grougp using equation of Barker (1988).

Our results demonstrate that the averaged peak temperatures of the Izumi Group are calculated to be 195 to 211 ±30℃ and those of the Sanbagawa metamorphic rocks are estimated to be 440 to 455 ±30℃. The estimated temperatures (from 218 to 223 ±30℃) of fault breccia in the MTL fault zone are similar to those of the Izumi Group. However, CM of fault gouge in the MTL fault zone show a wide variety of temperatures from 206 to 360 ±30℃. Moreover, estimated temperatures of cataclasite (from 332 to 371 ±30℃) in the MTL fault zone are significantly lower than those of host rocks from the Sanbagawa Metamorphic rocks.

The temperatures during coseismic slip generally equal to or higher than those of host rock due to frictional heating. However, our results conflicted with the property that Raman spectra of CM can preserve the maximum temperature. Nakamura et al (2015) suggested that the crystal structure of CM is destructed by shearing during brittle deformation. The changes of R1 ratio (Intensity $_{D1\ band}$ / Intensity $_{G\ band}$) and the G band full width at half maximum of Raman spectra in this study could be explained by destruction of CM crystallinity by shearing. Thermal anomaly due to shear heating was not detected in the Izumi Group to a distance of 70 m from the MTL fault plane at least, while we detected signals of mechanical damage by shearing of the MTL.

Our findings about thermal anomaly and mechanical damage around the MTL can contribute to understanding fault slip behavior of a large crustal fault such as the MTL.

Keywords: thermal structure, Median Tectonic Line, Raman spectroscopic analysis, fault rocks