Raman Spectroscopy of Carbonaceous Material record in pseudotachylytes: heating or deformation?

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The Raman Spectroscopy of Carbonaceous Material (RSCM) allows quantifying the degree of crystallinity of carbonaceous material, which increases upon geological heating. Evolution of crystallinity of CM is now routinely used as a reliable geothermometer. Recently, RSCM approach has been used to evidence frictional heating during seismic events. This new application assumes that CM spectra reflect only the thermal record irrespectively of the potential impact of geological strain on CM crystallinity.

The aim of this study is to reconsider this postulate by using analyses of Raman spectra in order to understand the effects of seismic deformation on the CM structure. For this purpose, we analyzed six pseudotachylyte veins from the Shimanto Belt (Japan) and the Kodiak Accretionary Complexes (USA), through high-resolution cross-sections. Samples are composed of foliated tectonic mélanges cut by millimetric shear planes filled by black vitreous material accompanied by injection veins, and present most of features described in the melt-origin rocks. The Raman peak area ratio as well as the intensity ratio show a drastic increase within the pseudotachylyte compared to the host rock. In addition, these parameters show a very sharp evolution in few microns along cross-sections across the PST boundaries, which is at variance with thermal diffusivity models applicable for others intrusive bodies. In order to understand such an evolution of the Raman parameters, 1D thermal diffusion and kinetics of RSCM evolution based on static heating experiments modellings were applied. Diffusion models show that the temperature of the pseudotachylyte materials and the surrounding rocks drops down very quickly after few milliseconds and returns to the background temperature after few seconds. Additionally, the kinetics modelling shows that a very large temperature must be applied for at least 1.0×10^2 ms to increase the intensity ratio. Furthermore, the cooling down of a molten layer is not able to reproduce the sharp evolution in RSCM parameters across the PST boundaries.

Therefore, these results are not consistent with observation made on natural samples. It suggests that deformation is the main factor controlling CM crystallinity in fault cores. These results therefore also question the maximum temperature reached in fault zones, possibly much lower than previously estimated.

Key-words: Raman Spectroscopy, Carbonaceous Material, Pseudotachylyte, Seismic deformation, Modelling