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Detection of frictional heat in seismic faults by vitrinite reflectance :Insights from high-velocity friction experiment

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Quantitative assessment of heat generation along faults during fault movement is of primary importance in understanding the dynamics of earthquakes. Last several years localized heat anomaly in a fault zone due to rapid seismic sliding has been detected by various analyses of fault zone materials, such as ferromagnetic resonance signal (Fukuchi et al., 2005), trace elements and isotopes (e.g., Ishikawa et al., 2008) and mineralogical change of clay (e.g., Hirono et al., 2008) and vitrinite reflectance (e.g., Sakaguchi et al., 2011). Among them, vitrinite reflectance method has been used as a geological thermometer for a long time because of its simple and easy way. However, a conversion equation from vitrinite reflectance (R_o) to temperature (e.g., Baker 1988) can not apply for R_o measured in the fault zone as frictional heating duration is quite short and the parallel chemical reaction (or stabilization of kerogen thermal maturation) must not be reached.

Thus, in order to describe a kinetic model of vitrinite thermal maturation at coseismic conditions, we deformed a simulated gouge (a mixture of 90 wt% quartz and 10 wt% vitrinite) at slip velocities of 0.0013 m/s to 1.3 m/s, normal stress of 1.0 MPa and displacement of 15 m under anoxic, nitrogen atmosphere, while measuring temperature in the gouge zone by thermocouples. At velocity of 1.3 m/s, R_o increases from ~1.0 to ~6.0% as a result that temperature in the gouge zone increases gradually with displacement to ~270°C. In contrast, at velocity of 0.0013 m/s, temperature keeps nearly room temperature, most of Ro does not change except for few grains in the slip localized zone. Such grains with high R_o at low velocity may be due to flash temperature at asperity contacts and/or mechanochemical effects that could mature vitrinite. A dynamic kinetic model of vitrinite maturation at different coseismic slip conditions is needed for precise estimation of temperature anomaly along seismic faults and for development of a fault thermometer.

Keywords: fault, frictional heat, Vitrinite reflectance, carbonaceous material