# Scanning ESR microscopic analysis of multiplex frictional heating events in the Nojima fault zone

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It is very significant to clarify whether or not the high temperature rise due to frictional heating in a fault zone universally occurs in connection to the earthquake energy budget or the San Andreas fault heat flow paradox. One of the few effective criteria for the high temperature rise is considered to be the pseudotachylyte vein showing melting textures. Generally, the frictional heat temperature increases with the fault slip rate, and the high-speed shear tests by Spray (1995) indicated that the ratio of melt per fragment in pseudotachylyte veins increases with the fault slip rate (or strain rate). Hence, the pseudotachylyte veins without the melting textures due to the frictional heating below the melting point, extremely low ratio of melt per fragment, devitrification or alteration are inapplicable to the assessment of the frictional heat temperature rise. On the other hand, black ultra-cataclasite or foliated cataclasite produced by frictional shearing as well as pseudotachylyte may have been subjected to high frictional heat. Thus, in stead of pseudotachylyte, ferrimagnetic resonance (FMR) signals are available as indicators of the frictional heat temperature rise [Fukuchi, 2003; Fukuchi et al., 2005; 2007]. Magnetite ($Fe_3O_4$) or maghemite (gamma-$Fe_2O_3$) is produced by thermal decomposition of iron-rich minerals (biotite, chlorite, limonite, lepidocrocite, etc.), and the FMR signals derived from these ferrimagnetic minerals are easily detected by the ESR (electron spin resonance) technique. Since the FMR signal intensity regularly increases with heat, its growth line as a function of temperature and time is obtained by the Arrhenius plot of the ratios of increase of FMR signal intensity, which are experimentally measured at various temperatures. In combination of this growth line with one-dimensional equations of thermal conduction on frictional heat [McKenzie & Brune, 1972; Cardwell et al., 1978], ancient frictional heat temperatures may be reconstructed by inversion [Fukuchi, 2003; Fukuchi et al, 2005]. When we attempt to reconstruct the frictional heat temperature using fault rocks, the FMR signals must be continuously measured because the temperature usually changes in a unit of 1 mm. This time, I carried out 1- and 2-Dimensional ESR continuous measurements of the Nojima fault rocks using a newly improved scanning ESR microscope. The basic model of the cavity of the scanning ESR microscope is a $TE_{111}$ mode cavity with a slit of 3x10mm designed by Yamanaka et al. (1993), and I attached a brass plate with a pinhole of 2.6mm phi on the cavity. The resolution for detection is about 0.25mm. As a result of 2-D ESR imaging, I have detected a pseudotachylyte vein with especially strong magnetic susceptibility (i.e. ESR absorption intensity) among multiple Nojima fault gouge and pseudotachylyte layers with a 2-3mm width. Furthermore, I have succeeded in detecting and separating multiplex frictional heating events recorded in the fault rocks by 1-D detailed measurement. Using the ESR absorption intensities showing the multiplex frictional heating events, I attempted to reconstruct ancient frictional heat temperatures by inversion. The results from computer simulations indicate that the instantaneous temperature rise over 600 degree C due to frictional heating has universally occurred in the Nojima fault zone and the maximum temperature may have attained 900-1000 degree C.

References

R. K. Cardwell, D. S. Chinn, G. F. Moore & D. L. Turcotte (1978) Geophys. J. Roy. Astr. Soc., 52, 525-530.
T. Fukuchi (2003) J. Geophys. Res., 108, B6, 2312, doi:10.1029/2002JB002007.
T. Fukuchi, K. Mizoguchi & T. Shimamoto (2005) J. Geophys. Res., 110, B12404, doi: 10.1029/2004JB003485.
T. Fukuchi, J. Yurugi & N. Imai (2007) Tectonophys.,443, 127-138, doi:10.1016/j.tecto.2007.01.020.
D. McKenzie & J.N. Brune (1972) Geophys. J. Roy. Astr. Soc., 29, 65-78.
C. Yamanaka, M. Ikeya & H. Hara (1992) Appl. Radiai. Isot.,44, 77-80.