Characteristics of ESR signals detected from black fault gouge in the 1137m fault zone of TCDP drill core samples

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By Taiwan Chelungpu-fault Drilling Project (TCDP), deep boring core samples penetrating through the Chelungpu fault were obtained from two boreholes, Holes A and B. In the boring core samples from Hole B, there is a main fault zone around 1137m in depth that may have been active in the 1999 ChiChi Earthquake. This fault zone contains a 25cm wide fault gouge zone whose central part has changed into black gouge over about 10cm in width. High-speed shearing tests revealed that fault gouge may change into a darkened material due to the production of ferrimagnetic minerals by frictional heating (Fukuchi et al., 2002; Fukuchi et al., 2005). Therefore, the black fault gouge in the 1137m fault zone may have been produced by seismic frictional heating. We have carried out ESR measurements of the black gouge and its source materials, white gray gouge and siltstone, to investigate the characteristics of ESR signals detected from these fault materials and consequently to estimate the degree of frictional heat generation along the Chelungpu fault.

The black gouge has a ferrimagnetic resonance (FMR) signal (g=2.1) derived from maghemite, paramagnetic organic radical (g=2.0031-2.0035) and E' center (g=2.001) that is an intrinsic paramagnetic signal of quartz. According to step-by-step heating experiments from 100 to 500 degree C (heating duration: 5 minutes), the FMR signal indicates that the black gouge may have been subjected to heat over 350 degree C, however the heating temperature may not have reached 400 degree C. Lepidocrocite (gamma-FeOOH) in the fault gouge transforms into maghemite (gamma-Fe2O3) by thermal dehydration in frictional heating, however maghemite can return to lepidocrocite due to hydrothermal reaction in the fault gouge. Consequently, the FMR signal may decay with time. To elucidate this matter, detailed hydrothermal reaction experiments are needed.

On the other hand, organic radicals detected from the white gray gouge and siltstone do not disappear even by heating at 500 degree C, whereas the organic radical from the black gouge decays by heating over 350 degree C and completely disappears over 400 degree C. Generally, organic radicals detected from mudstone or coal once increase, then decay and disappear by heating. This means that the organic radical in the black gouge has begun to decay. The E' center detected from the black gouge has extremely decayed rather than ones from the white gray gouge and siltstone. The results from step-by-step heating experiments indicate that the black gouge has been subjected to heat over 450 degree C. If considering our experimental results, the black gouge may have been produced by multiple ancient fault slips, and subjected to frictional heat equivalent to 5 minutes heating at 400-450 degree C in past fault slips and furthermore to that at 300-350 degree C during a recent slip.

References

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