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Creep versus Earthquake Slip: New insights from rock magnetic data

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Pseudotachylyte is generally believed as the best evidence of high-friction heating during earthquake. However, in clay-rich derived gouge, the temperature elevation is limited to large-scale endothermic dehydration reaction (Brantut et al., 2011). In such a context where melting is likely, it has been suggested that the characterization of neoformed mineral may be a diagnostic clue to distinguish between creep process and earthquake slip zone. Here we show evidence of neoformed magnetic mineral in the active Chelungpu fault gouge that hosts the Chi-Chi slip zone (Taiwan, Mw 7.6, 1999). Thanks to boreholes of Taiwan Chelungpu-fault Drilling Program and the recovery of fresh gouge, we get new evidence of neoformed magnetic minerals. Both rock magnetic investigation and transmission X-ray microscope image show the occurrence of neoformed 5 μm goethite (α-FeOOH) within the Chi-Chi 16 cm thick gouge. Goethite forms post-seismically from the cooling of >350°C fluids. In addition to goethite, we detect occurrence of neoformed pyrrhotite (Fe7S8). The pyrrhotite forms at the expense of pyrite, in response to elevation of temperature >500°C. Within the mm-thick Chi-Chi principal slip zone, we do not detect evidence of goethite, nor pyrrhotite. Instead, we detect magnetite (Fe3O4). We suggest that a part of magnetite formed during friction-induced temperature elevation. We propose a simple model of evolution between goethite and magnetite within the entire gouge. If confirmed elsewhere, the recognition of the assemblage of iron oxide (magnetite), iron hydroxide (goethite) and iron sulfide (pyrrhotite) is possibly a diagnostic evidence of earthquake slip rather than creep process.