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Kelvin-Helmholtz wave texture in Nojima fault gouges and its rock magnetic constraint to temperature rise

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Nojima fault gouges exhibit a characteristic flow microtexture of a wavy boundary plane, a folding structure and a Kelvin-Helmholtz (KH) wave texture. The flow microtexture has been evident as a product of frictional melting slide (Otsuki et al. 2003) or of steady-state frictional non-melting slide (Mochizuki et al. 2009). It is important to constrain the formation mechanism (melting or non-melting) from these flow microtextures of a natural gouge sample. Ishikawa et al. (2008) proposed the coseismic presence of high temperature fluids during earthquake, resulting in dynamic fault weakening. Such high temperature fluid might liquefy a gouge or thermally pressurize a fault gouge to cause instability of friction. We found a distinct KH instability-promoted wave texture in a granular material of Nojima fault gouge. The well-known example of KH instability is a cloud that the cloud-atmosphere interface becomes an unstable vortex sheet that rolls up into a spiral. The instability occurs at the interface between two fluids of different densities shearing at different velocities (Thorpe 2005). The KH wave was found along a slip plane in a blackish cohesive gouge (pseudotachylyte-like gouge), resulting in the presence of instability at the slip interface during ancient earthquake or creep. The wave instability occurred at c.a. 1.5mm apart and c.a. 0.7mm height. Thin section observations showed the blackish cohesive gouge consisted of granular materials for both sides of the interface and the KH wave occurs in a denser granular material along an earthquake-originated sharp slip plane. Our scanning Magneto-impedance magnetic microscope observation shows the KH wave dense layer is only magnetized in isothermally-magnetized thin section, revealing the production of magnetic mineral in KH wave. Because the Nojima fault gouge contains iron-carbonate (siderite), the thermal decomposition of siderite produces magnetite more than 400 degree C. Therefore, we suggest that the KH wave is generated through KH instability in a high-temperature ($>$400C) granular dense layer with different densities and different slip velocities. This result constrains our understanding of earthquake slip dynamics.