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Seismogenic shear-induced thermal turbulence in Nojima fault gouges: micro-textural and rock magnetic considerations

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Nojima fault gouges exhibit a characteristic flow microtexture of laminated slip zones, billow-like wavy folds and turbulent disordered structures. Power spectral analysis of the wavy folds indicates that the geometry roughly obeys a power-law of -1.9, agreeing well with the previously measured value of Kelvin-Helmholtz (KH) turbulence in natural environments. 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 in Nojima fault gouges 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. 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 ℃. Therefore, we suggest that the KH wave is generated through KH instability in a high-temperature (>400 ℃) granular dense layer with different densities and different slip velocities. This result suggests that shear-induced thermal turbulence in the fault gouge plays an important role to weaken a frictional strength during earthquake slip dynamics.