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Seismotectonic implications of fault-fracture networks: An example from the active Nojima fault, Japan

Aiming Lin[1]

[1] Graduate School,Shizuoka Univversity

http://www.ipc.shizuoka.ac.jp/%7eslin/index.html

Most large intraplate earthquakes are the result of slip on mature active faults, thus, investigations of the seismic faulting process require information about the nature of seismogenic fault zones. Detailed structural analysis of the fault-fracture networks developed in the seismic fault zone will help to develop predictive solutions to problems involving seismic hazards, brittle deformation mechanisms within and near the main fault zone, and hydrocarbon migration and trapping. Mature fault zones within the upper crust are generally composed of fault-fracture systems including fault core containing major slip planes and adjacent damage zones including numerous fractures, and undeformed protoliths. The core zone of the active fault accommodates that majority of accumulated fault displacement, and contains major slip planes, fault gouge, cataclasite, foliated cataclasite, and fault breccia (Lin, 1999, 2001). The damage zones, developed in either side of the core zone, are generally characterized by structures subsidiary to the main fault zone, including localized cataclasites, sub-faults and fractures linking the core zone and undeformed protolith (Chester et al., 1987, 1993; Lin et al., 2007). The damage zones record much lower bulk shear strain than the fault core zone.

The fault-fracture networks are well observed in the 1800 m drill core through the Nojima Fault zone, Japan, which reveals structures modes of subsidiary fault and fracture networks developed in the fault zone that triggered the 1995 Ms 7.2 Kobe earthquake. The subsidiary fault zones contain a fault gouge of less than1 cm thick bounded by thin zones of foliated cataclasite or breccia. Fractures are mostly filled with calcite veins, calcite-cemented breccias, clay minerals, and iron-oxide and carbonate alternation of the granitic host rock. These features are typical of extensional cracks that form the conduit network for fluid flux close to a major fault zone, which are mostly filled by fine-grained materials including some clay minerals and calcite veins. The zone of deformation about the main fault is 50 m in width, and the dip of the Nojima fault at a depth of larger than1 km is 75 degree.

Geological, petrological and stable isotopic data suggest that these fault-fracture networks associated with the Nojima fault zone are coseismic, and were filled with carbonate and fine-grained material during repeated seismic-related infiltration of the fault zone by carbonate-bearing subsurface water.