Microstructural character of active fault zones, southwest Honshu, Japan

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Detailed examination of the microstructures of active faults in southwestern Honshu, Japan has been made at three types of occurrence: (1) surface exposures of the Rokko fault and adjacent damage zone of the Arima-Takasuki Tectonic Line (ATTL); (2) a trench excavated across the same fault; and (3) drill core acquired from the Nojima fault, source of the 1995 Hanshin-Awaji earthquake. A primary objective was to characterize the mineralogical and textural nature of the ultra-fine-grained (typically less than 1 μm) component of the fault rocks. Laboratory techniques include optical petrography, SEM characterization, X-ray diffraction, micro-X-ray fluorescence, and transmission electron microscopy. The damage zone of the ATTL comprises a broad zone of crushed, comminuted, and pulverized granite/rhyolite containing cm-scale slip zones and highly comminuted injection veins. The fault and injection gouges have mixed mineralogy typical of the host material and form during several faulting events, as evidenced by overprinting. Damage zone material exhibits generally random textures whereas slip zones are macroscopically foliated, and compositionally layered, notwithstanding a fairly homogeneous protolith. The latter reflects fluid-rock interaction during both coseismic and interseismic periods. The slip zones are microstructurally heterogeneous at all scales, comprising not only cataclasites and phyllosilicate (clay)-rich gouge zones, but Fe/Mn pellets or clasts that are contained within gouge. The sub-structure of these growths can resemble crack-seal growths at 10–100 nm-scale that could reflect diffusion and growth over even shorter time periods. A central question related to earthquake recurrence along existing faults is the nature of the gouge. Notwithstanding the evidence for rapid comminution and particulate flow, fluidized particulate flow, fluidized injection, and fluid-rock reactions, there remain ambiguous aspects of gouge behaviour. In both near-surface exposures and drill core, “plastic” or “viscous” gouge zones comprise ultra-fine-grained clay-siliciclastic particles that would not necessarily respond in a simple frictional manner.

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