Did seismic slip occur in a mm-wide shear zone

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This study probes the question posed in the title on the basis of the field occurrences and meso- and micro-structures of pseudotachylytes and fault gouges occurred in the Genoa fault, eastern Sierra Nevada, and in the Nojima fault, Japan. Meso- and micro-structures and petrological characteristics strongly suggest that (1) the fault gouge and pseudotachylytes formed by cataclastic crushing with little frictional melting; (2) each thin layer records at least one seismic faulting event and, therefore, the1.5-cm thick pseudotachylyte vein has recorded more than 9 seismic events during its formation, and (3) the major seismic slip occurred in a narrow zone less than a few mm wide.

The process of earthquake rupture propagation within a seismogenic zone is inherently complex at all scales, but a lack of adequate geologic data inhibits any detailed investigations into the actual process of rupture and slip (Scholz, 1990). Cataclastic rocks such as fault gouge (e.g. Lin et al., 1994, 1998a; Lin, 1996), pseudotachylyte (e.g. Sibson, 1975; Lin, 1994a, b; 1999), fault breccia (e.g.Sibson, 1986) and cataclasite veins (Cheaster and Chester, 1998), occurred as simple veins and injected networks in fault zones are widely considered to record "fossil" earthquake, i.e. events of seismic slip along faults. Occurrences of incohesive cataclastic injection veins along particular faults suggest that the associated fractures were related to dynamic rupture propagation and slip during incremental coseismic displacement (Lin, 1996). The study of cataclastic veins and fault structures, therefore, can provide, by direct observation, a unique view of the process of earthquake rupturing at shallow crustal levels that cannot be obtained through indirect seismic studies.

This study probes the question posed in the title on the basis of the field occurrences and meso- and micro-structures of pseudotachylytes and fault gouges occurred in the Genoa fault, eastern Sierra Nevada, and in the Nojima fault, Japan, along which the M7.2 1995 Kobe earthquake occurred. The fault gouges and pseudotachylytes are characterized by a distinct layered structure, which is characterized by alternating from gray, brown, dark-gray, dark-brown to black colored bands. These layers vary from a few tens of

to a few mm in thickness, and show injection relations. Petrological and powder X-ray diffraction analyses show that the pseudotachylytes are mainly composed of fine-grained angular clasts that originate from the granodiorite host rock. Meso- and micro-structures and petrological characteristics strongly suggest that (1) the fault gouge and pseudotachylytes formed by cataclastic crushing with little frictional melting; (2) each thin layer records at least one seismic faulting event and, therefore, the1.5-cm thick pseudotachylyte vein has recorded more than 9 seismic events during its formation, and (3) the major seismic slip occurred in a narrow zone less than a few mm wide. The analyses and interpretations of layered structures in pseudotachylytes and fault gouge may be useful for evaluating seismic rupturing and frictional melting mechanisms and inferring the dynamic behavior of fault zones in the upper crust.