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Strong faults in a strong crust

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Mature faults are characterized by high displacement/fault thickness ratios resulting by localized repeated slip along a principal or few discrete weakness horizons (weak faults in a strong crust). A contrasting end-member is a fault where successive slip increments migrate to different subparallel slip horizons thus resulting in a fault zone with a low displacement/fault thickness ratio (strong fault in a strong crust?). These "strong" faults develop within rocks characterized by a pre-existing anisotropy (foliation, joints, etc.). They involve hardening and welding of fault rocks, causing continuous migration of slip to new surfaces in the host rock.

The Gole Larghe Fault Zone is a dextral strike-slip fault crosscutting the tonalites of the Adamello batholith (Southern Alps). The fault zone is 550 m thick and accommodates a total displacement of about 1000 m. Fault rocks are tough green cataclasites (cemented by precipitation of K-feldspar and epidote) associated with pseudotachylytes (solidified friction melts produced during seismic slip). Most faults record the same succession of events, with cataclasites (recording seismic/aseismic slip) overprinted by final production pseudotachylyte.

The fault zone consists of two sets (rank 1 and 2 faults) of cataclastic horizons. Rank 1 faults exploit precursor sub-parallel cooling joints, and consist of about 200 faults, spaced 1 to 10 m apart, accommodating < 20 m of slip each. Rank 2 faults form a network of minor fault-fractures produced during slip on rank 1 faults and accommodate < 1 m of slip.

Mesostructural and microstructural data (attitude of the rank 2 faults-fractures, orientation of micro-veins in the cataclasites, etc.), are consistent with a principal maximum horizontal stress oriented at about 30-35^o from the rank 1 faults. The presence of tough cataclasites and abundant pseudotachylytes suggest a Byerlee friction coefficient (0.7) and low fluid pore pressure during initial seismic slip. The overall observations support the idea of a strong fault embedded in a strong tonalite host rock.

The solidification of seismic melts welded the fault surfaces and promoted migration of slip to newly activated slip planes (precursor joints) in the host rock. Cementation of the cataclasites by precipitation of hard minerals (K-feldspar, epidote) also concurred to welding of the fault surfaces. This resulted in progressive thickening of the fault zone and in its low displacement/thickness ratio ($\sim$ 2).

Given the similarity of the Gole Larghe Fault Zone structure with other pseudotachylyte-bearing, low displacement/thickness ratio faults (e.g., Ikertôq Brittle Zone in Greenland; Fort Foster Brittle Zone in Maine), this class of faults should be considered as “strong-type” faults in absolute (i.e., high rupture values for friction to produce pseudotachylytes) and relative sense (i.e., deformation de-localizes in new strands of the fault zone).