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Fracture Network Characteristics and Velocity Structure of a Seismic Fault Zone

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Fault zone structure over a wide range of scales strongly influences earthquake mechanics. In this work we quantify the hierarchical structure, fracture network characteristics, and velocity structure of the seismic Gole Larghe Fault Zone (GLFZ) in the Italian Alps using a range of digital fieldwork techniques and experimental facilities. The GLFZ is c.500m thick and accommodates a total displacement of c.1000m, distributed amongst hundreds of first- and second-order oblique-slip cataclasite- and pseudotachylyte-bearing faults. The GLFZ was exhumed from 8-10km depth, nucleated in an area of pre-existing joints in the Adamello batholith, and records thousands of seismic ruptures. The continuous, glacier-polished nature of the exposures allows systematic data and sample collection at scales of centimetres to kilometres. Main results to date are: 1) Joints outside the GLFZ formed predominantly at temperatures >500°C during cooling of the pluton, whilst cataclasite- and pseudotachylyte-bearing fault strands within the GLFZ were active at 200-300°C. The transition from jointed 'wall rock' to 'fault zone' is marked by an *abrupt* increase in macroscopic fracture density; 2) Second-order faults inside the GLFZ are strongly clustered around first-order faults. However, in around 70% of cases, second-order faults are *asymmetrically* distributed on the northern side of first-order faults. This damage asymmetry is not explained by lithological variation, but may reflect the fact that propagating earthquake ruptures preferentially follow one of the boundaries between a pre-existing joint cluster and relatively intact host rock; 3) P-wave velocities measured on 37 samples collected along a c.300m profile across the wall rock and fault zone *increase* from 3500-4500m/s in the wall rock to 5000-6000m/s inside the fault zone. Preliminary microstructural observations indicate that the increase in P-wave-velocities probably correlates with an increase in microfracture density. Microfractures are often sealed with epidote and K-feldspar, which may explain the observed velocity increase. The above field observations suggest that the GLFZ is markedly different from other seismic fault zones, where fracture density increases exponentially towards the fault zone. The relationship between P-wave-velocities and microfractures also highlights the importance of fluid-rock interaction processes during the seismic cycle, resulting in induration and effective healing processes due to fluid flow.