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Earthquake rupture directivity frozen in pseudotachylyte-bearing faults

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Introduction. Pseudotachylytes, or solidified friction-induced melts (Mc Enzie & Brune, 1972; Sibson, 1975), are the most certain fault rocks indicator of seismicity on ancient faults (Snoke et al., 1998). In this study, we show how the asymmetry in the distribution and the orientation of pseudotachylyte-filled secondary fractures around an exhumed fault can be used to reconstruct the earthquake rupture directivity, rupture velocity and fracture energy G, by comparison with the calculated asymmetrical dynamic stress field around a propagating fracture.

Observations. Solidified friction melts, produced during earthquakes, decorate faults and branching fracture networks of the well exposed East-West striking Gole Larghe Fault Zone (Italian Alps) (DiToro & Pennacchioni, 2004). Faults and secondary fractures have peculiar features in their shape, attitude and branching patterns. Most of the branching of secondary fractures consists either of tension cracks, up to several cm thick, laying perpendicular to the main fault line, or thin fractures, laying roughly at 30^o to the fault (consistently with the inferred orientation of the principal horizontal stress). Most interestingly, secondary fractures take off preferentially on one side of the fault, i.e., into the southern block.

Model and interpretation. Recent theoretical studies investigated the possible patterns of fault branching that seismic rupture may leave in its trail (Poliakov et al., 2002; Kame et al., 2003; Rice, et al., 2004). In particular, the damage and fractures associated to an earthquake, are expected to be asymmetrically distributed on either side of the fault, and to depend on the direction in which the rupture is propagating. In a specific dynamic rupture model reproducing the local stress and rock properties, we predict the asymmetrical creation of secondary fractures and tension cracks, based on the near-field, dynamic stress radiation. The observed distribution of pseudotachylyte-bearing fractures is compatible with unchanged propagation direction during repeated seismic ruptures, subsonic fracture velocities (close to Rayleigh wave velocity) and G values in the range 8.0x10^6-6.7x10^7 J m^{-2}.

Reference list.

McKenzie, D. & Brune, J.N. Melting on fault planes during large earthquakes. Geophys. J. R.. Astron. Soc. 29, 65-78 (1972).

Sibson, R.H. Generation of pseudotachylyte by ancient seismic faulting. Geophys. J. R.. Astron. Soc. 43, 775-794 (1975).

Snoke, A.W., Tullis, J. & Todd, V. Fault-related Rocks; a Photographic Atlas (Princeton University Press, Princeton, New Jersey, USA, 1998).

Di Toro, G., Pennacchioni, G. Superheated friction-induced melts in zoned pseudotachylytes within the Adamello tonalites (Italian Southern Alps). Journal of Structural Geology 26, 1783-1801 (2004).

Poliakov, A.N.B., Dmowska, R., Rice, J.R. Dynamic shear rupture interactions with fault bends and off-axis secondary faulting. Journal of Geophysical Research, 107 (B11), 2295 (2002).

Kame, N., Dmowska, R., Rice, J.R. Effects of pre-stress and rupture velocity on dynamic fault branching. Journal of Geophysical Research 108 (B5), 2265 (2003).

Rice, J.R., Sammis, C.G., Parsons, R. Off-fault secondary failure induced by a dynamic slip-pulse. Bulletin of the Seismological Society of America, (in press 2004).