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Frictional control on aftershock rupture planes and implications for crustal strength

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Moderate to large mainshock-fault-ruptures nucleating in extensional and compressional intracontinental environments are well explained by 2D frictional fault reactivation theory (Sibson and Xie, 1998; Collettini and Sibson, 2001). Here we use a 3D slip tendency analysis (e.g. Morris, 1996; Lisle and Srivastava, 2004) to test whether also aftershocks are governed by frictional reactivation theory. We observe that aftershocks for two well-documented seismic sequences occurred in extensional and compressional environments, respectively the 1997 Mw=5.9 Colfiorito sequence (Central Italy) and the 1999 Mw= 7.6 Chi-Chi sequence (Taiwan), occur on planes favourably oriented for frictional fault reactivation within the regional stress field. In particular, 86.6% of 329 events and 87.5% of 115 events for the Colfiorito and Chi-Chi sequences respectively, are well explained by 3D fault reactivation theory. In addition, the percentage of well oriented aftershock rupture planes reaches 100%, if we consider a magnitude threshold of M=3.7 for the Colfiorito sequence and M=5.0 for the Chi-Chi one.

The consistency of the aftershock ruptures with frictional fault reactivation theory constrained from the regional stress field, suggests that stress drop induced by the mainshocks – usually in the range of 1-10 MPa with occasionally values as high as 100 MPa (Kanamori and Heaton, 2000)- is not enough to totally release the tectonic stress level, in other words the crust is strong. In addition, the 100% well-explained earthquakes above a magnitude threshold indicates that stress perturbations induced by the mainshock are capable of influencing only small structures.

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