



Detailed statistical analysis of the Gole Larghe Fault Zone fracture network (Italian Southern Alps) improves estimates of the energy budget for intraplate earthquakes in basement rocks

Andrea Bistacchi¹, Silvia Mitterpergher², Steve A.F. Smith³, Giulio Di Toro⁴, and Stefan Nielsen⁵

¹Università degli Studi di Milano Bicocca, Dipartimento di Scienze dell'Ambiente e della Terra, Milano, Italy
(andrea.bistacchi@unimib.it)

²Università degli Studi di Modena e Reggio Emilia, Dipartimento di Scienze Chimiche e Geologiche, Modena, Italy.

³University of Otago, Dunedin, New Zealand.

⁴Università degli Studi di Padova, Dipartimento di Geoscienze, Padova, Italy.

⁵Durham University, Department of Earth Sciences, Durham, United Kingdom.

We present a study on the paleoseismic Gole Larghe Fault Zone (GLFZ), composed of hundreds of sub-parallel faults hosted in tonalites of the Adamello Massif (Italian Southern Alps), where we collected a complete transect across the fault zone, including the background host rocks, over a thickness of >1km.

Along this transect, we studied the correlation between fracture spacing (for “fracture” here we mean joints, veins, faults, shear fractures, and all other brittle structures) and position with a robust non-parametric approach. This analysis, new for fracture distribution studies, allows detecting volumes of the fault zone with clustering or a trend in spacing, versus volumes where the spatial distribution is stationary. The analysis reveals that the GLFZ can be subdivided in “stationary volumes” where fractures shows stationary statistical properties. Each one of these volumes can be completely characterized with scanline and/or scanarea surveys to obtain a complete and statistically sound estimate of all fracture parameters (spacing, intensity, density, length, height, orientation, topology, etc.).

Within the GLFZ we have two main classes of structures: (i) “master” faults that are sub-parallel to the fault zone and are always characterized by pseudotachylytes and/or cataclasites, and (ii) minor “fractures” (e.g. Riedel fractures, joints, veins, etc.) that are oblique to the fault zone and interconnect the former. Out of the GLFZ we observe a background fracturing that is associated to the cooling of the Adamello tonalites under deviatoric tectonic stress (“cooling joints”).

By comparing fracture statistics within and outside the fault zone, we demonstrated that master faults within the GLFZ were almost completely inherited from the “cooling joints” of the host rocks. The cooling joints just grew in length and became completely interconnected at the scale of the seismic rupture. This means that, at least in the case of the GLFZ, the large faults and fractures along which seismic ruptures were running do not add significantly to the earthquake energy budget, because they were already present in the system before the onset of seismic activity. The

only fractures to be considered in this budget are the minor interconnecting fractures (e.g. Riedel fractures, joints, veins, etc.) that are coated with pseudotachylytes.

These observations confirm once again the classical assumption that seismic ruptures propagate along pre-existing discontinuities and do not, in general, tend to fracture intact rocks.