Geophysical Research Abstracts
Vol. 19, EGU2017-7464, 2017
EGU General Assembly 2017

Sliding history and energy budget recorded in a frozen mantle earthquake

Thomas P. Ferrand (1), Loïc Labrousse (2), Nadège Hilairet (3), and Alexandre Schubnel (1)

(1) Ecole Normale Supérieure, CNRS UMR 8538, PSL Research Univsersity, Paris, France, (2) Institut des Sciences de la Terre de Paris, CNRS UMR 7193 UPMC, Sorbonne Universités, Paris, France, (3) Unité Matériaux et Transformations, CNRS UMR 8207, Université Lille 1, Villeneuve d'Ascq, France

In the Balmuccia massif (NW Italy), pseudotachylytes (PST) are found within a spinel lherzolite. Coming from the solidification of the melt generated during seismic rupture, these rocks constitute a geological record of fossilized earthquakes. Here, combining field observations, Raman spectrometry and Electron Back-Scattered Diffraction (EBSD), we decipher the sliding history of an ancient Mw >6 earthquake.

The earthquake fault displays a 1-1.2 m strike-slip component. The average width of the principal fault plane is about 5 mm. A dense network of thin (20-200 μm) faults and injection veins decorates this principal slip surface. Ultramylonitic faults, filled with olivine (0.2-2 μm), pyroxenes and Al-spinel exhibit strong olivine fabric, with (010) planes parallel to the sliding of the fault and [100] direction parallel to the slip direction. The EBSD pole figure for the [100] direction shows an angle of about 40° with respect to Z-axis, indicating a non-negligible dip-slip component of 1.2-1.5 m, i.e. a probable total relative displacement of 1.6-1.9 m. The olivine fabric is consistent with partial melting and/or high temperature (> 1250 °C) diffusion-accommodated grain boundary sliding, which proves: 1) that the ultramylonite originates from a recrystallized melt; 2) that the earthquake occurred at a depth greater than 35 km (stable Al-spinel, no plagioclase). Raman spectrometry in micrometric injectites reveals amorphous material, with water content of 1-2 wt%, structurally bounded. Assuming a peak temperature of 1600-1800°C during sliding, the melt viscosity was < 1 Pa s.

Fracture surface energy and thermally dissipated energy are estimated from fracture density and melt volume (including injected volume) around 50 kJ/m2 and 50 MJ/m2 respectively. Considering a metric displacement, an average melting width of 1 cm and high normal stress, > 1 GPa, this yields a dynamic friction coefficient « 0.1, which demonstrates that complete fault lubrication occurred during co-seismic sliding. We argue however, that lubrication is transient, as the melt could rapidly flow (2-10 m/s) into tensile fractures. Melt injection within the fracture led to rapid cooling and may have promoted strength recovery and sliding arrest. Post-seismic slip is nevertheless recorded in the main PST axes, which are mylonitized, contrary to the thin fault network. Finally, the finding of water fossilized in a frozen mantle earthquake strongly suggests that fluid and/or hydrous minerals were present and emphasizes the need for a better understanding of their role in the mechanics of earthquakes.