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Energy balance from a mantle pseudotachylyte, Balmuccia, Italy

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In the Balmuccia massif (NW Italy), a pseudotachylyte vein network (N068) found in a spinel lherzolite is interpreted as the product of frictional melting during a single Mw > 6 earthquake. The subvertical fault underwent a metric dextral co-seismic displacement, dipping 60°SW. The average width of the main slip surface is $\sim$ 5 mm. A dense network of thin (20-200 μm) injection veins and ultramylonitic shear zones decorates the fault walls. In the injection veins, Raman microspectrometry mapping reveals pockets of amorphous silicate still preserved, containing $\approx$1% of structurally bound H_2O. In the ultramylonitic shear zones, EBSD mapping reveals that microgranular (0.2-2 μm) olivine grains exhibit a strong fabric with (010) planes parallel to the shear plane, consistent with temperatures above 1250°C during deformation and suggesting fast recrystallization from the frictional melt during "afterslip". The ultramylonitic shear zones also exhibit pyroxene and recrystallized spinel, which proves that the earthquake occurred at a minimum depth of 40 km. Energy balance demonstrates that complete fault lubrication must have occurred during co-seismic sliding (i.e. dynamic friction coefficient « 0.1). Because of the viscosity of slightly hydrated ultramafic liquid ($\approx$ 1 Pa s), we argue that lubrication was only transient, as the melt could rapidly flow into tensile fractures, which led to rapid cooling and may have promoted strength recovery and sliding arrest. Combined together, our observations suggest that this pseudotachylyte corresponds to the frozen record of a deep (> 40km) earthquake of 6 < Mw < 7, its focal mechanism being deciphered by EBSD.