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Thermal decomposition along natural faults during earthquakes

Cristiano Collettini (1,2), Cecilia Viti (3), Telemaco Tesei (1,2), and Silvio Mollo (2)

(1) Dipartimento di Scienze della Terra Università di Perugia., (2) Istituto Nazionale di Geofisica e Vulcanologia, Roma., (3) Dipartimento di Scienze della Terra Università di Siena

Earthquake slip is facilitated by a number of thermally activated physicochemical processes that are triggered by temperature rise during fast fault motion, i.e. frictional heating. Most of our knowledge on these processes is derived from theoretical and experimental studies. However additional information can be provided by direct observation of ancient faults exposed at the Earth's surface. Although fault rock indicators of earthquake processes along ancient faults have been inferred, the only unambiguous and rare evidence of seismic sliding from natural faults is due to solidified friction melts or pseudotachylytes. Here we document a gamut of natural fault rocks produced by thermally activated processes during earthquake slip. These processes occurred at 2-3 km of depth, along a thin (0.3-1.0 mm) principal slip zone of a regional thrust fault that accommodated several kilometers of displacement. In the slip zone, composed of ultra fine-grained fault rocks made of calcite and minor clays, we observe the presence of relict calcite and clay, numerous vesicles, poorly crystalline/amorphous phases and newly formed calcite skeletal crystals. These observations indicate that during earthquake rupture, frictional heating induced calcite decarbonation and phyllosilicate dehydration producing a viscous, fluid-rich, layer able to lubricate the slip zone and facilitate earthquake slip.