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# Dynamic weakening in carbonate-built seismic faults: insights from laboratory experiments with fast and ultra-localized temperature measurements

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During earthquakes, seismic slip along faults is localized in < 1 cm-thick principal slipping zones. In such thin slipping zones, frictional heating induces a temperature increase which activates deformation processes and chemical reactions resulting in dramatic decrease of the fault strength (i.e., enhanced dynamic weakening) and, in a negative feedback loop, in the decrease of the frictional heating itself.

In the laboratory, temperature measurements in slipping zones are extremely challenging, especially at the fast slip rates and large slip displacements typical of natural earthquakes. Recently, we measured the temperature evolution in the slipping zone of simulated earthquakes at high acquisition rates (□ kHz) and spatial resolutions (<< 1 mm$^2$). To this end, we used optical fibres, which convey IR radiation from the hot rubbing surfaces to a two color pyrometer, equipped with photodetectors which convert the radiation into electric signals. The measured signals were calibrated into temperature and then synchronized with the mechanical data (e.g., slip rate, friction coefficient, shear stress) to relate the dynamic fault strength to the temperature evolution and eventually constrain the deformation processes and associated chemical reactions activated during seismic slip.

Here, we reproduce earthquake slip via rotary shear experiments performed on solid cylinders (= bare rock surfaces) and on gouge layers both made of 99.9% calcite. The applied effective normal stress is 20 MPa. Bare rock surfaces are slid for 20 m with a trapezoidal velocity function with a target slip rate of 6 m/s. Instead, the gouge layers are sheared imposing a trapezoidal (1 m/s target slip rate for 1 m displacement) and Yoffe (3.5 m/s peak slip rate, and 1.5 m displacement) velocity function. The temperature measured within the slipping zone, which in some experiments increases up to 1000 °C after few milliseconds from slip initiation, allow us to investigate the deformation mechanisms responsible for fault dynamic weakening over temporal (milliseconds) and spatial (contact areas << 1 mm$^2$) scales which are impossible to detect with traditional techniques (i.e., thermocouples or thermal cameras).

Importantly, thanks to FE numerical simulations, these *in-situ* temperature measurements allow us to quantify the partitioning of the dissipated energy and power between frictional heating (temperature increase) and wear processes (e.g., grain comminution), to probe the effectiveness of other energy sinks (e.g., endothermic reactions, phase changes) that would buffer the temperature increase, and to determine the role of strain localization in controlling the temperature increase. The generalization of our experimental data and observations will contribute to shed light on the mechanics of carbonate-hosted earthquakes, a main hazard in the Mediterranean and other areas worldwide.