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How hot is a lab-earthquake?

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Frictional heating in faults during seismic slip induces a temperature increase on the rubbing contacts and within the slipping zone which activates deformation processes and chemical reactions resulting in dramatic decrease of the frictional resistance and, in turn, decrease of the frictional heating itself, in a negative feedback loop.
An independent measurement of temperature is required to correlate frictional strength with temperature and to constrain the deformation processes and associated chemical reactions activated during seismic slip. So far, in-situ temperature measurements performed at high acquisition rates (from kHz to MHz) and high spatial resolution (« 1 mm^2) to detect, for instance, flash heating and weakening mechanisms (micro- to milli-second in duration over contact areas « 1 mm^2) were impossible to achieve due to the low acquisition rate and large thermal inertia of traditional techniques (i.e. thermocouples). As a consequence, temperatures in the slipping zone sheared at seismic slip rates (1 m/s) were often modelled numerically using the frictional power (shear stress x slip rate) dissipated on the slipping zone as an input parameter, but by making poorly constrained estimates about (1) the partitioning of the dissipated power between frictional heating and wear processes or, worse, (2) other energy sinks that would result in the buffering of the temperature increase (e.g., endothermic reactions).
Here we reproduced earthquake slip in the laboratory via rotary shear experiments performed on Carrara marble rock samples, slid at 10 and 20 MPa effective normal stresses, 1 and 3 m/s slip rates, and 10 and 5 m of total displacement, respectively. During the experiments, the bulk temperature of the slipping zone was measured at acquisition rate of 1 kHz with an optical fiber conveying the radiation from the hot rubbing surfaces to electric signals using a two-color pyrometer. The measured temperatures were synchronized with the friction coefficient measurements. In the experiments, the friction coefficient dynamically decreased to a minimum (μ = 0.1-0.03) and at the same time the bulk temperature increased up to ca. 500-600 °C, in a time interval of 250-500 ms. At this stage the slipping zone of the Carrara sample was already decarbonating.
Our data provide the first direct measurements of decarbonation reaction temperatures during seismic slip in carbonate-built rocks. These and future similar experiments will shed light on the mechanics of carbonate-hosted earthquakes, a main hazard in the Mediterranean and other areas worldwide.