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Origin of the temporal evolution of elastic properties during laboratory seismic cycle.

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Recent seismological observations highlighted that earthquakes are associated to drops in elastic properties around the fault zone (Brenguier et al., 2008). This drop is often attributed to co-seismic damage produced at the rupture tip, and can mostly be observed at shallow depths. However, it is known that in the upper crust, faults are surrounded by a zone of damage (Caine, Evans, & Forster, 1996). Because of this, the origin of the velocity change associated to earthquakes, as well as its recovery in the months following the rupture remains highly debated.

We conducted stick-slip experiments to explore the evolution of elastic waves velocities during the entire seismic cycle. The tests were run on saw-cut La Peyratte granite samples presenting different initial degrees of damage, obtained through thermal treatment. Three types of samples were studied: not thermally treated, thermally treated at 650 °C and thermally treated at 950 °C. Seismic events were induced in a triaxial configuration apparatus at different confining pressures ranging from 15 MPa to 120 MPa. Active acoustic measurements were carried through the whole duration of the tests and P-wave velocities were measured.

The evolution of P-wave velocity follows the evolution of the shear stress acting on the fault, showing velocity drops during dynamic slip events. The evolution of the P-wave velocity drops with increasing confining pressure shows two different trends; the largest drops can be observed for low confining pressure (15 MPa) and decrease for intermediate confining pressures (up to 45 MPa), while for confining pressures of 60 MPa to 120 MPa, drops in velocity slightly increase with confining pressure.

Our results highlight that at low confining pressures (15-45 MPa), the change in elastic velocity is controlled by the sample bulk properites (damage of the medium surrounding the fault), while for higher confining pressures (60-120 MPa), it might be the result of co-seismic damage.

These preliminary results bring a different interpretation to the seismic velocity drops observed in nature, attributed to co-seismic damage. In our experiments co-seismic damage is not observed, except for high confining pressures (laboratory equivalent for large depths), while the change in P-wave velocity seems to be highly related to combined stress conditions and initial damage around the fault for low confining pressures (laboratory equivalent for shallow depths).