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Influence of injection-rate on the onset of fault reactivation

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Fluid injections are known to induce earthquakes. To reduce induced-seismicity, regulators plan to decrease the injection-rate in the seismically active areas, such as Oklahoma. However, the influence of injection rate on fault reactivation remains poorly documented up to now. From a static point of view, elevated pore pressure can lead to slip reactivation on pre-existing fractures and faults when the coulomb failure point is reached. For instance, the reactivation of fault submitted to a background stress ($\tau 0$) is a function of the peak strength of the fault, i.e. the quasi-static effective friction coefficient (μeff).

In this study, we present new results about the influence of the injection rate on the onset of fault reactivation. Experiments were conducted on a saw-cut sample of westerly granite. The experimental fault was 8 cm length. Injections were conducted through a 2 mm diameter hole reaching the fault surface. Experiments were conducted at four different order magnitudes fluid pressure injection rates (from 1 MPa/minute to 1 GPa/minute), in a fault system submitted to 50 and 100 MPa confining pressure. Our results show that the peak fluid pressure leading to slip depends on injection rate. The faster the injection rate, the larger the peak fluid pressure leading to instability. Monitoring continuously the elastic wave speed across the fault during fluid injections allow us to image that large injection-rate induces local but intense fluid overpressures, which allow the reactivation of the entire fault. These results suggest that increasing the injection rate enhances fluid pressure heterogeneity in the fault system. Finally, the slip rate at the onset of slip increases drastically with the injection rate. These results suggest that the intensity of the fluid pressure perturbation rather than its size enhances the slip-rate, and could promote the nucleation of instability. Our experimental results demonstrate that reducing the injection rate promote a better homogeneity of the fluid pressure in the fault system, which could allow a better control of the resulting seismicity.