3D hydraulic and mechanical constraints on the 5 magnitude earthquake of 11 November 2019 at Le Teil (France)

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On 11 November 2019, a 5 magnitude earthquake occurred in southeast France at Le Teil, close to the Rhone river. This seismic event is the strongest earthquake ever felt in France since the Arette (Pyrenees) earthquake in 1967.

By using an updated 3D geological model, we focus this work on the comparison of the effect of hydraulic recharge linked to the infiltration of meteoric water in the period preceding the earthquake and the effect of the exploitation of a large limestone quarry in the vicinity of the epicenter.

First, we describe the fault system from the updated geological model and the boundary conditions that are used to calculate the pressure variations at depth using a three-dimensional (3D) double porosity double permeability model. The movement of moisture in partially-saturated media is then simulated by the BRGM Compass code using the surface soil moisture data acquired by the SMOS satellite between 2010 and 2019 as surface boundary conditions and the Rhône river as edge boundary conditions.

The main result of these simulations is that at the intersection of the faults, the calculated increase in pore fluid pressure is maximum just before the earthquake of November 11, 2019. A sensitivity study carried out on the hydraulic parameters allows us to estimate that at about 1200 m depth, the overpressure linked to the hydraulic recharge of the fault system is between 0.4 and 0.6 MPa. Finally, we compare the variation in normal stress linked to a mechanical discharge from the surface quarry and the hydraulic overpressure linked to a meteoric water recharge, by choosing the same structural model.

The comparison shows that if this event is triggered, a hydraulic triggering by heavy rainfall is much more likely than the hypothesis of a mechanical triggering due to the mass withdrawal.

Mots-Clés : Le Teil, earthquake, hydraulic recharge, fault system, Compass, 3-DEC, Surface Soil Moisture, SMOS, quarry

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