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Insights on fault reactivation during the 2019, M_w4.9 Le Teil earthquake in southeastern France, from a joint 3D geology and InSAR study

Léo Marconato[1], Philippe-Hervé Leloup[1], Cécile Lasserre[1], Séverine Caritg[2], Romain Jolivet[3], Raphaël Grandin[4], Olivier Cavalié[5], Marianne Métois[1], and Laurence Audin[6]

[1]Univ Lyon, Univ Lyon 1, ENSL, CNRS, LGL-TPE, F-69622, Villeurbanne, France
[2]Bureau de Recherches Géologiques et Minières (BRGM), France
[3]Laboratoire de Géologie, Département de Géosciences, École Normale Supérieure, PSL Université, CNRS UMR 8538, Paris, France
[4]Université de Paris, Institut de physique du globe de Paris, CNRS, F-75005 Paris, France
[5]Université Côte d'Azur, IRD, CNRS, Observatoire de la Côte d'Azur, Géoazur, France
[6]ISTerre, Univ. Grenoble Alpes, CNRS, IRD, Grenoble, France

The 2019, M_w4.9 Le Teil earthquake occurred in southeastern France, causing important damage in a slow deforming region. Field based, remote sensing and seismological studies following the event revealed its very shallow depth, a rupture length of ~5 km with surface rupture evidences and a thrusting mechanism. We further investigate this earthquake by combining geological field mapping and 3D geology, InSAR time series analysis and coseismic slip inversion.

From structural, stratigraphic and geological data collected around the epicenter, we first produce a 3D geological model over a 70 km^2 and 3 km deep zone surrounding the 2019 rupture, using the GeoModeller software. This model includes the geometry of the main faults and geological layers, and especially a geometry for La Rouvière Fault, an Oligocene normal fault likely reactivated during the earthquake.

We also generate a time series of the surface displacement by InSAR, based on Sentinel-1 data ranging from early January 2019 to late January 2020, using the NSBAS processing chain. The spatio-temporal patterns of the surface displacement for this limited time span show neither clear pre-seismic signal nor significant postseismic slip. We extract from the InSAR time series the coseismic displacement pattern, and in particular the along-strike slip distribution that shows spatial variations. The maximum relative displacement along the Line-Of-Sight is up to ~16 cm and is located in the southwestern part of the rupture.

We then invert for the slip distribution on the fault from the InSAR coseismic surface displacement field. We use a non-negative least square approach based on the CSI software and the fault

surface trace defined in the 3D geological model, exploring the range of plausible fault dip values. Best-fitting dips range between 55° and 60°. Such values are slightly lower than those measured on La Rouvière Fault planes in the field. Our model confirms the reactivation of La Rouvière fault, with reverse slip at very shallow depth and two main slip patches reaching 30 cm and 24 cm of slip at 400-500m depth. We finally discuss how the 3D fault geometry and geological configuration could have impacted the slip distribution and propagation during the earthquake.

This study is a step to better quantify strain accumulation and assess the seismic hazard associated with other similar faults along the Cévennes fault system, in a densely populated area hosting several nuclear plants.