

Investigating the effect of a heavy rainfall episode on the Mw4.9 earthquake of 11 November 2019 at Le Teil (France)

André Burnol, Antoine Armandine Les Landes, Daniel Raucoules, Hideo Aochi, Julie Maury, Cécile Allanic, Behrooz Bazargan-Sabet

▶ To cite this version:

André Burnol, Antoine Armandine Les Landes, Daniel Raucoules, Hideo Aochi, Julie Maury, et al.. Investigating the effect of a heavy rainfall episode on the Mw4.9 earthquake of 11 November 2019 at Le Teil (France). EGU 2023, Apr 2023, Vienne, Austria. , 2023, 10.5194/egusphere-egu23-8363 . hal-04058080

HAL Id: hal-04058080 https://brgm.hal.science/hal-04058080v1

Submitted on 4 Apr 2023 $\,$

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers. L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

BRGM (French Geological Survey)

Let's think a hydraulic triggering for this shallow earthquake using hydraulic simulations based on a new geological model !



The epicenter location suggested by Delouis (2021) and the surface ruptures evidences of Ritz (2020) are indicated with ten-pointed and five-pointed red stars, respectively. Also shown are the M201 seismic cross-section (dashed black line) and the vibration sensor in the Clauzel house to monitor the quarry blasts (pink triangle).

(2) Unwrapping of interferogram A059: two parallel surface ruptures



1) two surface ruptures represented by F1 and F2; 2) the distance between ruptures is small respect to their lengths. Red line is a profile on the original wrapped interferogram. Assuming that the displacement should be zero at $\pm \infty$, left part of F1 and right part of F2 can be unambiguously unwrapped (blue dashed line). However between F1 and F2, the unwrapping solution results ambiguous: on solution a) all the displacement is on F2, on solution b) all the displacement is on F1, intermediary solutions are possible (e.g. c).

Investigating the effect of a heavy rainfall episode on the Mw4.9 earthquake of 11 November 2019 at Le Teil (France) A. Burnol, A. Armandine Les Landes, D. Raucoules, H. Aochi, J. Maury, C. Allanic, and B. Bazargan-Sabet

POINTS

- shallow earthquake of 11 November 2019 at Le Teil
- of faults at shallow depth after a heavy rainfall episode



Interpretation of the faults and geological layers on M201 profile included in the geological model with true dip angles of LRF (La Rouvière), BRF (Bayne Rocherenard) and PF (Paurière) faults.



Officially accepted on 19 April 2023 for publication by MDPI Remote Sensing <u>https://doi.org/10.3390/rs15092270</u>

Impact of meteoric water transfer from ground surface on the

a possible rapid hydraulic triggering mechanism on a network

Geological layers used in the hydraulic model included the surface layer with the Apto-Albian clay layer (green) and the Barremian limestones (light blue).

Daily rain amount at Montélimar station compared to the effective saturation Se calculated by using *in situ* soil moisture at 30 cm depth (SM30) at Berzème station.

(a) Differential of pressure (ΔP) on the fault system between 11 November 2019 and 24 September 2019; (b) ΔP on LRF (looking southeast). The intersection lines of BRF and PF with LRF are indicated by a grey and white dotted line, respectively; (c) Spatial variation of ΔP along the intersection line between LRF and BRF. Red diamond is the node position along the line where ΔP is maximum (at Y = 1963 m); (d) Temporal pressure variation between 2015 and 2019 at the node where ΔP is maximum (blue line) and the pressure gradient for the previous 30 days (orange line).

Regional setting around Le Teil

- (a) The location/date of the seismic events from RéNaSS during 2010-2019 period are shown in both cells L1 and L2 (50 km x 25 km area). The soil moisture station (Berzème) is located in L1 and the rainfall (Montélimar) and hydrological (Viviers) stations are located in L2;
- (b) The daily rain amount and discharge of Le Rhône river are compared to the magnitude of seismic events during 2010-2019 period.

(5) **Reference cases using SM30 at 30 cm depth (Berzème)**

Reference case	Ref16	Ref20
Surface condition	SM30	SM30
Matrix Porosity θ_{m}	0.2	0.2
Matrix Permeability \mathbf{K}_m	10 ⁻¹⁸ m ² in Apto-albien	10 ⁻¹⁶ m ²
	10 ⁻¹⁶ m ² elsewhere	
Fault Porosity θ_{f}	0.1	0.1
Fault Permeability \mathbf{K}_{f}	10 ⁻¹¹ m ²	10 ⁻¹¹ m ²
Fault Width <i>W</i>	20 m	20 m
Maximum		
differential of	0.98 MPa	0.97 MPa
pressure (ΔP)		

Comparison of different epicenter location estimations of Le Teil earthquake:

- components are displayed (NS, EW, UD);

The simulated pore pressure gradient shows a local peak just before the **2019 earthquake at the intersection of two faults BRF and LRF, very close** to the hypocenter locations determined by other seismological studies.

Delouis, B.; Oral, E.; Menager, M.; Ampuero, J.-P.; Trilla, A.G.; Régnier, M.; Deschamps, A. Constraining the Point Source Parameters of the 11 November 2019 Mw 4.9 Le Teil Earthquake Using Multiple Relocation Approaches, First Motion and Full Waveform Inversions. Comptes Rendus Géoscience 2021, doi:10.5802/crgeos.78 Ritz, J.-F.; Baize, S.; Ferry, M.; Larroque, C.; Audin, L.; Delouis, B.; Mathot, E. Surface Rupture and Shallow Fault Reactivation during the 2019 Mw 4.9 Le Teil Earthquake, France. Communications Earth & Environment 2020, 1, 10, doi:10.1038/s43247-020-0012-z

Contact: a.burnol@brgm.fr







(a) Ref16 and Ref20 (stars) are the locations of maximum overpressures calculated by both reference cases (see Table). DL(main) and DL(af) are epicenter locations of mainshock and aftershock of 23 November 2019 (MI 2.8) from Delouis (2021). RZ (main) is the epicenter location from Ritz (2020); (b) Waveforms in displacement recorded by the vibration sensor at the Clauzel house (CLAU). The three

(c) Horizontal particle motion for the selected time window of the beginning of the signals (shown in panel (b) with green color) and the associated polarity (orange line).