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When an earthquake in southern France caused the ground to rupture—a phenomenon not known during the last 25 years in the region—the earthquake science community worked together to determine the implications for hazard assessment. Now we must maintain that spirit of co-operation for the future.

In the most destructive French earthquake since 1967, the ground ruptured at the surface (Fig. 1)—just a few kilometers from a nuclear power plant. The event occurred near the small town of Le Teil, southeastern France on November 11, 2019, and constitutes a phenomenon that had not previously been described in France. At Mw 4.9, the quake was only moderate in magnitude, but occurred at a depth between 1 and 2 km, then lead to the ground rupture.

The event captured our interest along with that of the French scientific community, and we published an early account that identified and described this surface rupture in *Communications Earth & Environment* in late August 2020[1]. French society, unaccustomed to such destructive earthquakes in metropolitan France joined the conversation.

Bridging disciplines

In the wake of the quake, the community of geologists interested in earthquakes and in the characterization of faults in France has come together to take action. Two PhD theses have been assigned to investigate the Cévennes Fault that was responsible for the Le Teil earthquake, supported by industrial and governmental agencies. In a separate project, existing data are being made available at the national level, beyond the existing synthesis[2], and updated with regional input. Interdisciplinary cooperation has sprung up between geologists, seismologists and geophysicists from academic circles, to develop temporary instrumental networks and propose analyses of the earthquake and consequences[3–7].

Field geologists have continued to investigate where possible, despite the lockdowns and curfews resulting from the COVID-19 pandemic, and the motivation of our group has remained strong. Importantly, we were able to excavate a dozen paleoseismological trenches that demonstrate earlier incidences of ground rupture. Some trenches are still open for 2021/2022 scientific conferences, field trips and for teaching: they are a crucial resource in a country were such events and research opportunities are not so common. All this was made possible thanks to the positive and enthusiastic response of land owners, a welcome behavioral trait in freshly earthquake-shaken areas.

We have adapted our way of working to meet pandemic-related health requirements, an easier task in outdoor activity. We also had to satisfy the needs of co-working: we concentrated field efforts, as well as external media visits when restrictions allowed, and moved online conferences to exchange ideas to the phases of lockdown. Ultimately, we found that these adaptations allowed us to continue to carry out our time-sensitive work effectively.

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Fig. 1 This tiny scarp on the La Rouvière tar road was the first evidence of Le Teil earthquake-related ground rupture uncovered by the field team (2 days after the event). The equipment is a laser scanner to image accurately the offset.

Fig. 2 Detail picture of a trench wall excavated across the causative fault. This is from the first trench out of a dozen that was dug during the 2020 spring; notice the fracture in the colluvium related to a pre-historical activity, with the two authors for scale.

Change in focus

Our own careers and personal trajectories have been affected as well as those of our colleagues. The Le Teil earthquake has turned the research community's attention and activity to seismic hazard and seismicity in intraplate areas and particularly in France. A few fundamental scientific questions now need to be addressed.

Identification of other unknown but potentially active faults. We have had to adapt our usual reconnaissance strategy: the Le Teil earthquake source was only 5 km long, previously not known to be active, and located in an area a priori unfavorable for morphological analyses. Following our ambitious and successful field campaign, it is now clear that the fault in question has been active in the Quaternary, probably in the form of repeated reactivation of an originally Oligocene age structure[8] (Fig. 2). It is worrying to think that other faults not yet studied, could, in fact, be just as active. There is potentially a lot of work to be done in the longer term. We need to build a clear picture of seismic hazard. The paramount lesson that we learned this year is that paleoseismological investigation, namely trenching, is a powerful tool to document past fault activity, even in unexpected areas.

Potential threats from surface rupture and their mitigation. The le Teil earthquake has focused the attention on surface faulting and the acute risks it poses to infrastructure: it occurred not only just a few kilometres from a nuclear power plant, but also in one of the most industrialized regions of France. Methodologies to evaluate the surface faulting risk to infrastructure have been improving for a few years in an international framework[9–11]. This hazard has become a concern for sensitive facilities[12, 13], and has only now erupted onto the French scene. If other sensitive sites are threatened by earthquake-related surface ruptures, we need to identify and mitigate these risks.

Causes of intraplate seismicity. Plate tectonics classically leads to the assumption that the cyclic buildup of stress on faults leading to earthquakes is essentially controlled by distant tectonics, i.e. in the case of France, the convergence of Africa and Eurasia, the counterclockwise rotation of the Adria microplate and extension in the Atlantic Ocean. This is still a commonly accepted model for active areas, including in the French Alps[14]. However, alternatives have been suggested for intraplate areas that involve different internal and external geodynamic processes at regional and local scales, such as climatic or even anthropogenic factors[15–18]. Geological and paleoseismological data—the only data that can provide long-term constraints on the timing of tectonic deformation—will be essential for gaining a clearer picture of the responsible driving forces.

Build on the insights

Substantial media coverage of the earthquake and its impact put us and our colleagues in the spotlight, following the publication in *Communications Earth & Environment*. We had media interest from national television and radio reports and live broadcasts on the anniversary of the earthquake, national or regional press articles, as well as specialized magazine reports. Aftershock activity has been weak, seismologically speaking, but the media reverberated.

Public and scientific interest in seismic risk has thus been revived and, two years after the quake, we have made good progress. However, the acquisition of the data necessary to inform seismic risk requires long-term commitment, and we must remain determined to ensure that this initial impetus is maintained in the years to come.

Acquiring paleoseismological data in a short time and at the scale of the country is a daunting task and further steps to achieve scientific goals will require close collaboration between geologists, geophysicists, geodynamicists, and modelers. As a scientific community that mobilized so effectively after the Le Teil Earthquake, we must now work to keep up the collaborations we have forged. The FACT ("*Failles Actives*") task force of the now well-established ATS group ("*Action Transverse Sismicité*") from the RESIF national network of Geodesy and Seismicity[8,19] is the relevant framework to address this challenge.

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Author contributions

S.B. and J.-F.R. contributed equally to the conceptualization. S.B. led the writing of the paper, with strong support of J.-F.R.

Competing interests

The authors declare no competing interests.

Additional information

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