

1 **Comment on “Coincident locations of rupture nucleation during the 2019 Le Teil**
2 **earthquake, France and maximum stress change from local cement quarrying” by De**
3 **Novellis et al.**

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5 Chao Liang¹ and Jean-Paul Ampuero^{1*}

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7 ¹ Université Côte d’Azur, IRD, CNRS, Observatoire de la Côte d’Azur, Géoazur, France

8 * Corresponding author, ampuero@geoazur.unice.fr

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10 In a recent article, De Novellis et al. (2020, hereafter referred to as DN20) studied the effect
11 of mass extraction from a quarry on the occurrence of the M_w 4.9 Le Teil, France, earthquake
12 of November 11 2019. This topic is of great importance regionally due to the damage caused
13 by the earthquake in its vicinity, and globally due to its implications on hazard assessment in
14 low seismicity regions. This topic is also the focus of the French working group mandated by
15 CNRS INSU (“Groupe de Travail Teil” of Institut National des Sciences de l’Univers du
16 Centre National de la Recherche Scientifique) to assess the possibility of an anthropic origin
17 of the Le Teil earthquake. Their report was made public in the month after the earthquake
18 (Delouis et al, 2019, hereafter D19; the corresponding author of this comment is the current
19 chair of that expert group; both authors contributed stress change calculations to D19).

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21 The conclusions of these two independent research efforts, despite using similar data and
22 methods, are contrasting. While both D19 and DN20 concluded the earthquake was possibly
23 a triggered event (i.e. its initiation was possibly promoted by the quarry activity but its further
24 rupture growth was primarily enabled by natural pre-existing stresses), DN20 deemed
25 realistic the hypothesis that the earthquake was an induced event (i.e. both the earthquake
26 initiation and its further growth, up to its final size, were caused by the quarry activity). This
27 distinction is critical for our understanding of future anthropogenic hazards in the region and
28 in similar settings elsewhere, and may have significant social, economical and legal
29 repercussions. Here, we show that a severe error in the modeling done by DN20
30 undermines their conclusion.

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32 The volume of material extracted from the quarry that is reported in DN20 is about 7 times
33 smaller than the volume the authors used in their computations of the Coulomb stress
34 changes induced by the quarry on the local faults involved in the 2019 Le Teil earthquake.
35 The latter are documented in the code and input files provided to us by the authors upon
36 request, with which we have reproduced the stress values reported in their figures 3C and
37 3D. Table 1 reports the differences between the extracted-volume values published in the
38 Supplementary Table 4 of DN20 and those used for the stress computations in figures 3 and
39 4 of DN20.

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41 As a consequence of the error in source volume described above, the Coulomb stress
42 changes reported in DN20 (e.g. their figure 3) are overestimated by a factor of about 7. After
43 re-scaling the volumes of the computation input files of DN20 to match the total volumes for
44 each period reported in their Supplementary Table 4, and re-running the computation with
45 their code, the resulting stress change values (Figure 1-bottom) are similar to those reported
46 by Delouis et al (2019; see their figures QC2 and QC3).

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48 The large overestimation of stress values by DN20 undermines their core argument to
 49 qualify the Le Teil earthquake as an induced event rather than a triggered event. DN20 use
 50 their erroneous stress estimates to argue the time-advance caused by the quarry is
 51 comparable to the natural recurrence of earthquakes in the area, which in turn they claim
 52 supports the induction hypothesis. This conclusion hinges on comparing the values of
 53 Coulomb stress change and earthquake stress drop, which DN20 report to be similar.
 54 However, the corrected values of Coulomb stress changes (Figure 1-bottom) are not similar
 55 to the earthquake's stress drop (of order 1 MPa), but about one order of magnitude smaller.
 56 Thus, the stresses induced on the faults by the exploitation of the quarry are not sufficient to
 57 account for the stresses released by the earthquake. Based on this evidence, even though
 58 the event could have been triggered, it cannot be qualified as induced.

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 60 DN20 also “suggest that further mass removal in the area might lead to even stronger
 61 earthquakes, by activating deeper sectors of the same fault plane” under “the hypothesis of
 62 a linear increase of the fault strength with depth and especially if on deeper portions of the
 63 fault there is near-critical preexisting tectonic stress”. It is fair to note that, given the current
 64 state of knowledge, the opposite scenario is also mechanically plausible: the same material
 65 properties that led to the 2019 rupture not propagating deeper, possibly associated to the
 66 ductile behavior of the marly layers at the base of the rupture (Ritz et al., 2020; Cornou et al.,
 67 2020), could buffer the deeper fault portions from the effects of quarry activity. This important
 68 question is one of the subjects of current investigations by the CNRS/INSU Working Group
 69 Teil.

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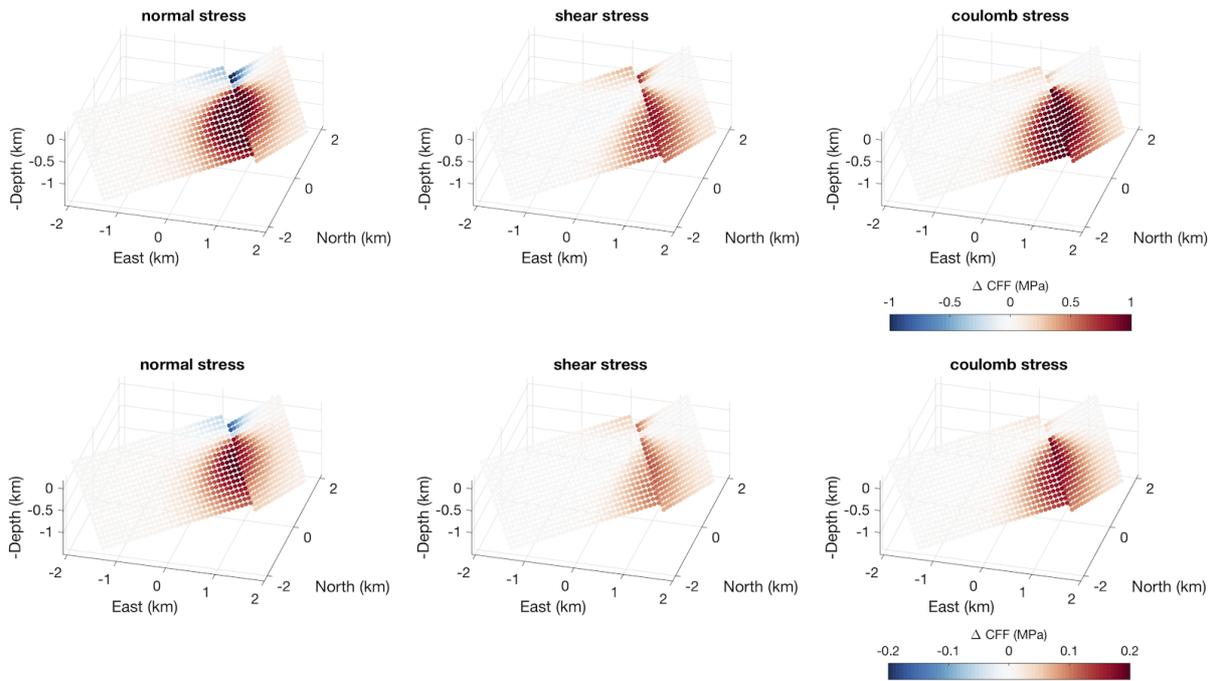
Time period	Volume removed as reported in Supplementary Table 4 of DN20 (10 ⁶ m ³)	Volume removed used for stress calculations by DN20 (10 ⁶ m ³)	Ratio between used volume and reported volume
1833 - 1946	11.3	54.1	4.8
1946 - 1979	8.3	75	9
1979 - 2007	18.5	115.5	6.2
2007 - 2011	4.1	54.7	13.3
1833 - 2011	42.3	299.4	7.1

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72 Table 1. Two estimates of volumes removed from the quarry, reported by DN20 and actually
 73 used in their stress calculations, and their ratio for 4 different time periods and their sum.

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78 **Figure 1.** Normal stress, shear stress and Coulomb stress changes on the causative faults
 79 of the 2019 Le Teil earthquake using the fault geometry, friction coefficient of 0.4 and density
 80 of 2300 kg/m³ assumed by DN20, using (top) the extracted-volume values used by DN20 in
 81 their calculation as shown in Fig. 3 of the main text, and (bottom) those values re-scaled to
 82 match the volumes reported in the Supplementary Table 4 of DN20.

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84 **Author contribution statement**

85 JPA designed the study and drafted the manuscript. CL conducted the calculations,
 86 prepared the figure and reviewed the manuscript.

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88 **References**

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