

Point-to-point to comments on se-2021-75

Editor and referees' comments on "GPR signature of Quaternary faulting: a study from the Mt. Pollino region, southern Apennines, Italy" by Maurizio Ercoli et al., Solid Earth Discuss., <https://doi.org/10.5194/se-2021-75-RC2>, 2021

#editor and #referee1

Dear all,

as we've already replied during the discussion phase, we really thank you for your kind revision and suggestions. Some replies to your general comments were already addressed within the discussion, we have answers to more specific requests in the following document, as many points overlap with ones of #referee2. During the revision process, we have made an effort to improve and sharpen the introduction, interpretation, discussion and conclusions, providing more quantitative information but also clearly defining the limits of our workflow. You'll find all the answers here and the tracked corrections in the marked manuscript. We trust that this revision will make our paper a strong candidate for publication in Solid Earth.

#referee2

Dear #referee2,

Again, thank you for your detailed review and associated suggestions. We've made a considerable effort to address all your requests and suggestions and we think the manuscript has benefited with the changes. We hope this will be enough to consider the paper for publication in SE.

Ref#2 lines 13-15: evidence of late Quaternary faulting across the fault not across the basin. Please present the fault clearly... name, location and portion investigated with GPR. any fault in the area? see previous comment

Authors: we agree with the comments, we added such information in the text.

Ref#2 line 27: what do you mean for near-surface data: you have surface data but scarce is the knowledge of the subsurface? you need to be clear in any single words of the abstract

Authors: yes, correct, with near-surface we meant the portion of shallow subsurface (tens of meters) typically investigated with high-resolution methods (like the GPR).

Ref#2 lines 32-34: please revise the definition for seismic gap. It is not correct. To be added that the gap region is surrounded by regions struck by large earthquakes in historical or recent times....the presence of faults and of their seismic past activity, of their possible quiescence as well, is from morphological and paleoseismic data.... also gaps are candidate regions for the occurrence of large earthquakes in the near future ||| For the seismic gap definition you need to cite McCann et al., 1979. Galadini and Galli 2003 applied the theory in central apennines, but before in time Cinti et al 1997 recognize a seismic gap, silent area in the castrovillari zone....

Authors: thanks for the comments, very appreciated. We have changed the text following the advice and updated the citations.

Ref#2 line 37: provide some examples

Authors: citations were provided above so we have shortened the introduction.

Ref#2 lines 39: not clear. please rephrase

Authors: done.

Ref#2 lines 39-40 and references comments until line 47: As a general comment: too much info on this sequence, and it is not needed to confirm that paleoseismology is useful, and moreover paleoseismology is not the topic of this paper. Suggestion is to focus on the precious info from GPR on fault and also that it is complementary to trenching. And particularly the added value this technique provides to better understand the active faults in the Pollino range area.

Authors: we have significantly reorganized and shortened the text, updated the text to the most representative literature, aiming to highlight the central Italy sequence might be an analogue seismic gap for the southern Italy.

Ref#2 lines 54-59: you are referring to trenching. rephrase || unclear what you mean.

Authors: we have rewritten the text referring to trenching.

Ref#2 line 61: this is a quite dated paleoearthquakes inventory of Italy, is this you want to cite?

Authors: we have removed the citations as requested.

Ref#2 line 63: this is a report for Civil Protection Dept.

Authors: yes, we cite both reports referring to the project results and provide the URL in the reference list.

Ref#2 line 68: and what about southward?

Authors: we have rewritten the text.

Ref#2 line 70: there is confusion: Mercure and Campotenese basin are bounded by faults, the Castrovillari plain (I would not refer to it as a basin) is bounded by the Pollino fault and crossed by the Castrovillari fault systems. There is the signature of the faults in any case. Please attention to the description of faults setting in the gap area and to the morphology as well.

Authors: we have rewritten the text.

Ref#2 line 77: this is a submitted paper!

Authors: we have updated the citation; the pre-print is online and in revision in SE (<https://doi.org/10.5194/se-2021-76>) within the same special issue. URL: <https://se.copernicus.org/preprints/se-2021-76/>

Ref#2 line 80: If I understood well this is a buried or better hidden fault. So, how was recognized in the published works, parameterized, length at surface assessed.....This is crucial! I understand erosion and cover but if the fault does not have surface expression anywhere along 15 km and you see offsets at the subsurface, it could likely mean the amount of offsets are not large enough and also very long recurrence avoiding the cumulation and preservation at the surface.

Authors: the parametrization of this fault is already documented in Brozzetti et al. 2017, but we have briefly integrated the results into the text. The authors remark that this fault is well visible within the Mercure basin as a 3 km long and continuous scarp carved on the present topography. They also suppose its continuation towards South along the VCT being buried below the Holocene alluvial deposits and occasionally suggested by geomorphic scarps. Such observations provided are one of the main motivations for GPR surveying. A dedicated sentence is present also within the Tectonic setting and seismicity in the submitted manuscript: "Along the E-side of the Campotenese basin, the VCT is generally buried by Holocene deposits, but its localization can be inferred based on stratigraphic observations and geomorphic features, such as sharp ridge fronts, linear scarps, and slope breaks".

Ref#2 line 81:

Authors: "Fosso della Valle" has been added in figure 1c.

Ref#2 line 83: You just cite these papers few words before....really over referencing (particularly of papers by the authors of this manuscript).

Authors: text rewritten.

Ref#2 lines 83-84: please explain which is the long-term surface expression of the VCT, which are the evidence for current activity. These are data at the basis of your paper.

Authors: we have integrated and provided more details in the text within the chapter two (Tectonic setting and seismicity).

Ref#2 lines 84-85: I suggest to add the 1915 Fucino clear case of surface faulting in the Apennines, testified by: Oddone, E., 1915. Gli elementi fisici del grande terremoto marsicano-fucense del 13 gennaio 1915. Boll. Soc. Sismol. Ital. 19, 71–216. || these citations refer to the same earthquake (Norcia). Insert only one of these. In general, avoid too long list of citations when not needed and relevant.

Authors: text changed following the suggestions.

Ref#2 line 92: ??to rephrase

Authors: text changed and simplified.

Ref#2 lines 95-98: I do not understand. why to say this and here. The process described is something that always happen! The critical point to raise concerning the preservation of surface faulting expression in the stratigraphy is the rate of occurrence of surface faulting, the size of the displacement vs the rate of deposition and/or erosion.

Authors: We agree with the suggestion, so we have removed the sentence from this section.

Ref#2 lines 98-99: I think you may summarize the objectives. Some are just consequential.

Authors: We have reorganized and modified the text. We maintained the difference between i) and ii) to distinguish a GPR methodological workflow vs the specific application providing new insights on the VCT fault.

Ref#2 line 117: just in german language?

Authors: yes, and we have updated the citation.

Ref#2 line 131: maybe you mean historical seismicity and ...because it is very hard with a seismological study to associate past earthquakes to a specific fault.

Authors: we replaced "several seismological" with "recent seismic activity".

Ref#2 lines 133-134: again, the following citations are not all strictly appropriate for the relative affirmation. Here you clearly mention to Quaternary basin and to seismological and paleoseismological investigations but not all the papers you list are relevant for this. Moreover some papers focus on the same area and also redundantly and useless cited all over the text. || Galli et al. 2006 ?? not in the reference list

Authors: we have reduced the citations.

Ref#2 line 137: Here you cannot ignore the compressive regime with an east-west to east-northeast/west-southwest maximum horizontal stress in the Ionian offshore. The Sibari coastal area within the Pollino seismic gap region represents a transition zone where also compatible oblique normal-lateral faults have been recognized in the literature (i.e., the Sybaris fault in Cinti et al. 2015 and the Rossano fault in the surrounding area in Galadini et al., 2001).

Authors: we have added a sentence with a reference to the suggested papers.

Ref#2 line 138: Warning: you investigated a fault splay within the area. This is not the project where probably you were looking at a different scale with different approaches.

Authors: we have changed the text, as requested.

Ref#2 lines 143-144: Say something more about the Rotonda-Campotense fault, is it a master fault and the VCT is a fault splay in its hangingwall. How far are they, the VCT plain joins the master fault at which depth? Your data in case are on a secondary fault and the faulting history (expression, recurrence etccc) needs to be discussed with this geometry in mind.

Not marked in Figure. Needed to be highlighted the Rotonda-Campotense fault and the VCT splay.

please revise the figure showing this pattern.

Authors: we have added a more complete description of the faults as well as improved the figure, as requested.

Ref#2 line 147: Reference needed

Authors: We deleted the sentence to shorten the section, as we evaluated it too specific for the tectonic setting.

Ref#2 lines 157-159: Who made this analysis? what about the 1693? see Tertulliani and Cucci 2014 on the similarity with the modern sequence...

Authors: We have removed the sentence to shorten the section and because the analysis was not in the focus of our work.

Ref#2 lines 160-163: But this was an objective of the work!!! anticipated.

Authors: we agree, we have removed these sentences.

Ref#2 lines 174-175 and 185: move the reference at the end of the sentence or not have sense to be used. || these are both papers on gpr applied to archaeology, cannot be used just one?

Authors: corrected

Ref#2 lines 190-195 for example, this paper is relevant to cite in this context?

Authors: Yes, the two highlighted citations are among the most recent and interesting literature examples of GPR application on faults.

Ref#2 lines 199-201: e.g., this is not a complete list of papers for this reference, then I would cite only the most representative, or the most recent, or the oldest.... || more than one of these papers better refer to the sentence below (line 202) || what about leaving 2010 and reference therein? check other parts in the text where you repeat these papers.

Authors: we have removed the proceedings, the others by Gross and by McClymont are in our opinion all fundamental papers to cite for GPR applications on faults.

Ref#2 line 214: i.e. loose and chaotic material? colluvial wedges not necessarily provides the same conductivity. For example, if buried and old could be cemented....

Authors: we agree with the observation, we have removed consideration in the methodological chapter.

Ref#2 line 215: what do you mean for near-surface faulting?

Authors: we meant the subsurface sector covered for example by GPR survey; it is referred to near-surface geophysics (for example, a definition is provided by Dwain K. Butler, January 2005, What Is Near-Surface Geophysics? Near-Surface Geophysics, 2005, 1-6, <https://library.seg.org/doi/10.1190/1.9781560801719.ch1>). We have modified the text with "near surface interpretation of faulting".

Ref#2 line: explain where did you acquire relative to the VCT traces in Fig.: along the western splay of the fault and covering a fault sector of X km along strike and a max of 200 m across?

Authors: we have rephrased the sentence including more details as requested.

Ref#2 lines 238-239

Authors: corrected

Ref#2 lines 245-247

Authors: we have changed the text, providing a better explanation of this concept.

Ref#2 line 250: Results? you are still in the survey section.

Authors: we referred to a preliminary interpretation which was useful to better plan the last acquisition. However, corrected.

Ref#2 line 257: which grids?

Authors: fixed

Ref#2 line 267: why favourable? elevation and no forested area?

Authors: corrected

Ref#2 line 280: 3a and 3b not cited yet.

Authors: now cited, and we've upgraded the citations.

Ref#2 lines 383-384: so why you claim wavy reflection as a key layer for this research, explain in which sense or rephrase.

Authors: we have edited and simplified the sentence to avoid repetitions.

Ref#2 line 390: move at the end of the sentence. Is it what you observed in the case of Mars, right?

Authors: corrected

Ref#2 lines 393-398: not clear is a suggestion to consider?

Authors: we corrected the entire paragraph as requested

Ref#2 line 422: see comment on figure caption. The estimates of the offsets by the radargrams are critical and main subject of the paper. Please, show how you proceed for measuring (which surfaces were used to project across the fault) and also explain if you observe an increasing of the amount with depth.....although subtle evidence but this would imply multiple events. to discuss!

Authors: at this stage of the base-knowledge for the study site, our main goal was to find and highlight peculiar GPR signatures in the Quaternary deposits to possibly interpret as faulting features. Nevertheless, we agree that an additional quantitative estimation of the fault displacements would be the best result to achieve, but we are aware it is a critical point particularly without a direct field validation. For this reason, we would avoid a very detailed parametrization deriving by possible overinterpretations of the GPR features. Keeping in mind this consideration but following also the #ref2 (and #ref1) comments, we provide a tentative estimation of the interpreted GPR displacement for the representative profile cmt2n. Thus, we also have integrated in the text and figure 8 some details about the procedure we used, as requested. Regarding the last request, it is currently not possible to know whether the associated displacements occurred during a single surface faulting event or during multiple events.

Ref#2 line 443: higher respect to which other resolution? you mean the comparison between 9a and 9c? well, more than a resolution issue is a different scale of observation.

Authors: we have corrected the text, detailing that the scale of observation is metric.

Ref#2 lines 444-446: ? maybe figure 9c to cite || (at a scale of....) Specify what you want to remark. A detailed mapping of the fault lines with focussed GPR acquisition particularly for such buried sector of the fault?

Authors: corrected and integrated, then moved to section 5.1, in which we detail the description of the 3D model using figure 9.

Ref#2 line 452: associated? explain

Authors: we meant faults-splays of the VCT within the Quaternary sediments. However, we have almost completely reorganized and rewritten the chapter 5.1, in order to remove redundancies and shorten the text as requested also by the editor.

Ref#2 line 456: no name to refer?

Authors: we have referred to h1 an h2 labels we introduced for the hills in figure 2a and related caption.

Ref#2 line 457: fault name?

Authors: we have rewritten the text.

Ref#2 lines 475-476: to be rephrased

Authors: we have rephrased the sentence

Ref#2 lines 479-481: try to rephrase

Authors: we have rephrased the sentence

Ref#2 lines 491-492: please mention, associated based on what.

Authors: we have rephrased the sentence

Ref#2 line 502: more than that to the north and about 50 m to the south. For clarity, you may mention the year of the earthquakes....

Authors: text revised and years added.

Ref#2 lines 511-515: very twisted. rephrase

Authors: we have rephrased and refined the paragraph reorganizing it and removing some redundancies.

Ref#2 lines 516-519: you jump too much without clarity on the concept. A problem is that here you are writing a seismic hazard implications chapter using all affirmation that are independent from the results obtained in this paper.

Authors: we have modified the sentence, which clearly introduces in the discussion other recent works supporting this idea but which are in agreement with our GPR results.

Ref#2 line 519: I suggest to mention about geodetic data and refer to the different papers providing interpretation of tectonic strain and earthquake recurrence in the Apennines. Completely missing in your text on seismic gap.

Authors: as we do not basically provide any info on the strain or recurrence data in our work, we have removed the sentence.

Ref#2 lines 519-523: all this should go in different chapters, not here in hazard. In part in 6. conclusion. and the utility of the gpr data as preparatory phase for other type of campaigns should go at the beginning of the paper as a motivation of the application.

Authors: we removed the sentences as suggested, however we referred not only to GPR results but to a series of additional analysis that will be useful as a further step to confirm our results and obtain quantitative information. We report this concept in the introduction as suggested and in the conclusions as well.

Ref#2 lines 549-551: Literature is full of papers that claim this!! It is an implicit concept of the seismic gap definition. change in: Our study confirms the presence of seismic potential and thus the possible occurrence of a large etq in a future. Remind that: with your workflow you do not extract any date for events and no succession of past events....

Authors: We agree with this comment. We have added in the text the need of further studies to define timing and recurrence time (not provided by GPR).

Ref#2 line 551: please no risk but in case hazard...

Authors: We agree, the difference is clear, it was only an error as we meant "high probability of occurrence". We have corrected and shortened sentence.

Ref#2 line 572: to be carefully revised according to the changes suggested in the text.

Authors: the list has been revised according to comments.

Ref#2 line 1025: -highlight all the splay of the Rotonda-Campotenesse fault that includes the VCT splay. -not visible the rectangle for 1c area, try with a different color line - focal mechanisms from Pondrelli et al 2002 and Scognamiglio et al. 2006? || In figure c, as well as in figure b, you have different lines for faults with different symbology. Moreover what VCT stay for. GPR traces are barely visible, change color and enlarge or useless.

Images should be self support by the caption, without reading the text.

Authors: corrected according to the comments: RSB and VCT are now enhanced in fig.1b; the rectangle of the area is now much better visible; we have updated the legend of fig. 1c, to explain the different symbology used, also to highlight the main and minor faults; the GPR lines have been removed from this figure; now the VCT fault name is reported also in its extended version. The caption has been updated.

Ref#2 line 1028: cmt stay for.....

Authors: added in figure caption.

Ref#2 line 1034: to be insert in the text. not cited.

Authors: added.

Ref#2 line 1037: white arrows?

Authors: added.

Ref#2 line 1045: white arrows point to....

Authors: added.

Ref#2 line 1050: please insert this info also within the image

Authors: added in all images displaying the depth on the y axis.

Ref#2 lines 1055-1057: view to the SW? || the arrows is not the best to show bedding. Try something different. || please insert this info also within the image

Authors: image corrected by changing symbols and adding labels as well as two informative inserts. Vertical exaggeration added in figures a and b. Caption corrected accordingly.

Ref#2 line 1061: I like it a lot! Please, add the horizontal/vertical scale meters.

Authors: Thank you! corrected.

Ref#2 line 1065- 1066: do you see a wedge shape from the signal? in case it is nice to mark it with a symbol. But I am wondering if you mean a deposits from earthquake fault free-face degradation in the close HW of the fault, that felt and stucked within a small graben coseismic area (that I see in the section shown area 1, don't you?)

Authors: We agree about another possible interpretation of area 1. Our aim is only to suggest within the dashed circles, avoiding overinterpretations, a few areas with interesting geometry possibly resembling "colluvial wedges" or possibly, as suggested, deposits from earthquake fault free-face HW degradation. Thus, we have added a label "cw?" to suggest the presence of such geometries. Vertical exaggeration label was added as well.

Ref#2 line 1066 show how measured. interpolation of surface across fault...

Authors: we have updated the figure adding the inset to show how we estimated possible GPR displacement of GPR reflections and integrated the text. We hope this solution can work fine to clarify this process.

Ref#2 line 1068: the 0.5 is for fc2 and fc1? no larger offset for fc2? show how measured. interpolation of surface across fault.. it is a net measure? can you estimate an offset for fc1?

Authors: we partly already replied in the above comment, adding the inset and integrating the text and figure caption.

Ref#2 line 1068: no fault line to trace?

Authors: we picked the potential faults which following the geophysical indexes mentioned in the text are more visible, improving our interpretation by updating the figure.

Ref#2 line 1070: mark the cw with a symbol

Authors: "cw?" labels added in figure

Ref#2 line 1071: show how measured. interpolation of surface across fault.. || please insert this info also within the image

Authors: done as answered above.

Ref#2 line 1073: toponyms are not clearly readable. Again, abbreviations legend is missing: CVN. RSB, VCT..... The light blue line?

Authors: the abbreviations of faults surrounding the study area are defined in the text and reported in figure one. The light blue line is now mentioned within the figure caption and updated in all figures.

Ref#2 line 1073: This is a 3D view at the scale of the basin with geology and faults from a different source paper, not this one, please cite. Figure 9a could be imaged without the GPR results from this work, that cover only a portion of the fault and do not provide info for the model at this scale. I would not present this illustration as a result.

Authors: We agree the image is modified using a map after Brozzetti et al. (2017a) but here it is presented including a 3D model of the main fault segments. We think it is necessary to aid the readers better figuring-out with the different scales of observation from the basin to the very detailed GPR scale.

Ref#2 line 1075: nice! I do not understand why do not show the same interpreted view for cmt2_n in figure 8 (as a fig. 8c). Structures identified are the same and also deposits. Here you insert a new section without any apparent reason. please explain. However here I would leave the 3D.

Authors: thank you. We here present the GPR results using another profile (figure 9b) to show more data and the similarity/coherency of interpreted features, to convince the readers about the spatial continuity of the structures detected. Finally, we summarize the interpretation as a detailed 3D model in figure 9c (we agree to leave this image), but we also enriched the figure with a conventional structural map with more quantitative information. We thrust the updated image fitting all the requests.

Ref#2 line 1075: the blue fault around meter 25 on cmt1_bn is alone?

Authors: yes, we interpreted such fault as clear only on this profile, and we evaluated not enough the faulting GPR signature on adjacent profiles to interpolate a longer surface. To consider, however, that the GPR profiles are to the north (n) are 25 meters spaced, whilst 10m on the south (s), thus allowing more detailed insights.

Ref#2 line 1076: Scale of observation? How large and long is the area you show. it is needed. Also, it is to avoid confusion with the model in fig. 9a. Symbology to be explained: d1 to d3? Figures have to be self-readable.

Authors: we agree with the comment. As reported in the comment above, we wanted to highlight the different scales between figures 9a-9c. Figure corrected.

Ref#2 line 1080: please insert this info also within the image

Authors: together with other labels, also the "vertical exaggeration" was added in figure.