COMMENTS TO THE PAPER SE-2021-73
(Late Quaternary faulting in southern Matese (central Italy): implications for earthquake potential in the southern Apennines; by Boncio et al.)

GENERAL COMMENTS

The paper deals with active tectonics along a sector of the Southern Matese mountain front that has been believed to exert low tectonic activity in the late Quaternary.

The theme is of high scientific interest, as very recent activity of this fault strand has not been proved to date. In addition, the authors propose a correlation between the Gioia Sannitica fault activity and some poorly known historical earthquakes (e.g., the 346 and the 1293 events).

English style is fine, I just highlighted very few corrections at the end of this file (see section "Technical correction") but I'm not an English mother tongue, so I may have missed something.

I think the paper may be of high interest, but it needs to be re-thought in the light of general and specific comments. In particular, I encourage the authors to clearly distinguish results and discussion section, which are not easily identifiable in this current version, and to focus the discussion on the comparison between APMF and GF, and not only on the seismogenic potential of GF. So, despite the high interest of the argument, I think the paper needs relevant modifications before acceptance. I highlighted several points that are listed below, and my decision is to reconsider it after major revision.

One of the main criticisms is that authors show evidence of recent tectonic activity along the GF but they also mentioned that this portion of the mountain front is mature by referring to Valente et al. (2019). A mature mountain front would imply either an inactive mountain front or very low fault slip-rate overwhelmed by erosional processes. I never found I clear discussion of these contrasting data, which is just shallowing approached in Sections 6.2 and 7.

Furthermore, proving the tectonic activity of a mature mountain front is a very interesting issue, but a comparison with similar case studies in different tectonic and climate context is missing. I encourage you to address this issue, which would increase interest of the international scientific community towards this paper. This should be discussed in a separate section before the Conclusion.

Evidences of recent tectonic activity of GF include some meter-high scarp detected by Lidar data at the base of the mountain front. By the way, this scarp occurs close to the alluvial fans' topographic apexes, where the alluvial fans are strongly dissected (up to several meters) by channels feeding youngest fans (channels are very clear by Lidar in Fig. 2b). So, you should consider the hypothesis that this scarp may be due to erosion and not to fault activity. Furthermore, post-LGM throw rates are not convincing to the south of GF (see specific comments).

To enforce your hypothesis that this scarp is due to fault activity, you should provide other geomorphic markers of recent tectonic activity of the GF, such as knickpoints. Given that the scarp cross over adjoining drainage basins, I expect that river long profile should have a knickpoint in the surroundings of the scarp. You have Lidar data so river long profile should highlight the presence of some meters high knickpoints. If not, the scarp may be the result of differential erosion, as it seems to be.

Regarding along strike variations in throw rates, you mentioned that the APMF has no evidence of recent tectonic activity. Anyway, I think that throw rates you estimated near Sant'Angelo d'Alife are supported by strong field evidence (Fig. 10), whereas throw rates along GF are not very clear and may lead to possible alternative interpretation (see comments in the entire file about throw rates). In my opinion, your data highlight a more recent activity of the APMF than the GF, which would imply that APMF is more active than GF, according to already published data. I think this is a crucial point, and your discussion should be addressed towards comparison of the two study areas, and not only in addressing the seismogenic potential of GF.
The seismogenic potential of GF should be re-thought according to the previous comment.

Stratigraphical and structural setting in the Mt. Erbano embayment is very tricky. Firstly, the presence of the varicolored clays (intended as a lithological unit, not like a Formation) within the Meso-Cenozoic succession of the Camposauro and northern Matese ridges has been proved (Vitale and Ciarcia, 2018). So, are you sure that Vitale and Ciarcia (2018) setting cannot be exported to your area? If so, you do not need a back-thrust, but the varicolored clays may stratigraphically overlain the Miocene deposits. Secondly, the dashed projection of the GF towards south-east is not convincing as you do not show evidence of recent fault activity in this area. In fact, profile 12, which is the only profile in this sector of GF, show an 85 m high scarp carved in the carbonate bedrock. This would imply that the scarp is due to a lithological contrast between the bedrock and the debris deposits. The apparent offset of unit sd1 may due to erosion. In fact, profile 12 is very close to a deep incision, which may have lead erosion that caused the outcrop of the buried bedrock, with debris on top of the bedrock being simply a remnant of the Quaternary cover.

A point that deserves further discussion is the apparent increasing throw rate from the Middle Pleistocee (<0.1 mm/yr in the last 450 kyr) to the Upper Pleistocene and the Holocene (>0.2-0.4 mm/yr in the last 15 kyr). Several factors can underestimate long-term fault slip rates. One of them refers likely to geological processes such as compaction of accumulated sediments and/or erosion of marker beds. You should also discuss this point.

The age of the paleosol on top of tephra layer in Fig. 9 rise some questions. It would imply that there has been no sedimentation from 508 ka to 6 ka, and that the mountain front has been not active in this very long time interval. Consequently, units 4 to 7 accumulated since the Middle Holocene. This contrast with the age you assigned to Quaternary units as no Holocene deposits have been mapped in this sector of the pediment. Also, the story these data would imply is:
1) tectonic quiescence from 500 ka to 6 ka; 2) accumulation of units 4, 4b and 5; 3) faulting of these units; 4) erosion and accumulation of units 6; 5) faulting of this unit (you mentioned it at line 349, but I disagree with your hypothesis as the colluvial wedge seems accumulated in a topographic low due to erosion. I don't see any thickening of the colluvial wedge towards F5. Again, its geometry may be due to erosion); 6) accumulation of unit 7; 7) formation of the modern soil. Maybe, it is a bit too much to occur in just 6 ka! Is it possible that this very young age is due to contamination from the overlying deposits?

SPECIFIC COMMENTS

MAIN TEXT

TITLE: Central Italy and Southern Apennines sounds in contrast. The Matese ridge is part of the Southern Apennines and study area is geographically constrained to the Southern Italy.

Line 17: structural data in Supplementary File "Tab.S3_Data points with structural data" refer to the entire Southern Matese Fault System, and not only to the Gioia Sannitica fault. You should either add location of structural data in the main map or add a field in the excel tab to specify to what sector of the Southern Matese Fault System the data are referred.

Line 19: are you sure "mature geomorphology" is the correct term? It may be used to indicate a tectonically inactive area, so its use may lead to misunderstanding.

Lines 22: I guess you reported here the average values listed in Tab. 4. If so, average value along GF is 6.2 and not 6.1.

Line 25: the 1349 event is not poorly known such as the 346, the 847 and the 1293 events.

SECTION 1 - INTRODUCTION: the authors should introduce papers that discuss very recent activity of the Southern Matese Fault System (e.g., Ascione et al., 2018; Valente et al., 2019). It seems that you addressed the Introduction towards your findings, which is to prove the very recent activity of the Gioia Sannitica Fault, without referring to papers that contrast with your working idea. Furthermore, in Boncio et al. (2016), you already mapped the APMF (Ailano-Piedimonte Matese Fault) as an active structure and the PMGF (Piedimonte Matese – Gioia Sannitica Fault) as a possible active structure, so you should also introduce this point.

Line 34: add some reference to support this sentence.

Lines 63-65: add references about the morphotectonic setting of the Matese massif.

Line 68, lines 72-74 and lines 81-82: refer to scheme showing tectonic evolution from Valente et al. (2019)

Line 86: Ailano is not mentioned in Fig. 1, maybe you referred to Alife

Lines 90-93: references listed in this section do not talk about the presence of this tephra layers within the Middle Pleistocene deposits, but refer to the volcanic activity of these volcanic areas. You should refer to papers that suggest the presence of the Roccamonfina and the Campi Flegrei products within the Middle Pleistocene deposits.

SECTION 2.2 – QUATERNARY TECTONICS: you should mention the paper by Ascione et al. (2018) that show evidences of recent activity of faults bounding the southern slope of the Matese massif.

Line 95: Pay attention, you wrote that you mapped these Quaternary faults, and this sentence sounds like you are introducing your results whereas you are still in Geological Setting.

Lines 97-98: connection between the San Pietro Infine fault and the SMF is not discussed in this paper, so you should add adequate references. I think your paper Boncio et al., 2016 is one of the papers, or even the first one, where this connection is hypothesized.

Lines 99-104: you should also add references to papers that highlight recent tectonic activity of the SMF (e.g., Boncio et al., 2016; Ascione et al., 2018; Valente et al., 2019).

Lines 108-110: add reference to justify along strike variation in fault activity along the SMF. I guess it should be the paper by Valente et al. (2019). If so, the sentence at lines 116-118 is a repetition of this sentence.

Line 131: add reference to Galadini and Galli, 2004_Annals of Geophysics.

Line 135: you mentioned that the 2013 event had a magnitude of 4.9 whereas you indicated a magnitude of 5.2 in Fig. 1. Rovida et al. (2020) indicate magnitude 5.16 for the 2013 Matese event. Please, make the main text and the figure consistent. Furthermore, detail of the 2013 event are also reported in Valente et al. (2018), so you should also refer to this paper.

Lines 138-141: why did you refer to the 2016 event? As you correctly stated, it occurs NE of the Matese area. It testifies that earthquakes in this sector of the Apennine chain occur along NW-SE striking normal faults, but this event is not due to activity of the faults bounding the Matese massif. Or, do you think this event is due to activity of the Northern Matese Fault System? Do you have data for supporting this hypothesis? If yes, please add further details to support it. If not, you should not mention the 2016 event in this section.

Line 146: what does CTR means? I know, but you should specify it for international readers not used to Italian acronyms.

SECTION 3.2 – SAMPLE DATING: you mentioned that you performed tephrostratigraphic analysis, but I did not find any tephrostratigraphic analysis both in the main text and in the supplementary data.

Lines 182-183: see comments to Supplementary Data.

Lines 222-227: is the correlation between tuff interlayered in the U2 deposits and the WTT supported by tephrostratigraphic analysis you mentioned in the Methods section? Or, is it just a working hypothesis?

Line 247: refer to Plate 1 to locate Criscia.

Lines 298-302: estimated post-LGM throw rates are not convincing. In fact, profile 13 shows a 6.5 m offset in Sd1 unit, which you constrained to the late Lower – Middle Pleistocene, whereas profiles 14 and 15 show offset U1 unit, dated at the early Middle Pleistocene. Throw rates should be referred to these chronological intervals, which may lead to values like those one obtained by profiles 3, 9, 11 and 12.

Line 355: if the scarp is due to erosion, as you mentioned, then it is not a fault scarp and you cannot derive throw rates.

SECTION 6.1 – OVERALL ARCHITECTURE AND KINEMATICS: you should also refer to scheme showing tectonic evolution of the SMF proposed by Valente et al. (2019), and not only to papers by the authors.

SECTION 6.2 – THROW RATES: regarding mature geomorphology of mountain front, you did not introduce any data supporting this hypothesis, so you should just refer to Valente et al. (2019). You should also consider the possibility that the scarp you used to derive throw rate is only due to erosion (see general comments).

Line 405: compare your values with values from Cinque et al. (2000) and Ferranti et al. (2014).

SECTION 6.3 – SEISMOGENIC POTENTIAL: this section should be revised according to my comments on how you estimated throw rates.

Table 1 and 2: you should add coordinates of sampling site and show their location in some map, at least in Fig. 4 and Plate 1. Regarding samples in the surroundings of Sant'Angelo d'Alife, you may add their location in Fig. 2.

FIGURES

Figure 1: correct "Northern Maters Fault System". Why did you place the 346 epicentre in the core of the Matese massif? Galli and Naso (2009) and Galli et al. (2017) placed it in the surroundings of Ailano. You also mentioned, in the main text, that the SMF may be the source area of the 346 earthquake, so it looks a bit in contrast the location of this event in the core of the massif. What data do you have to place it to the south of the Matese Lake?
Furthermore, are there marine deposits within the Quaternary basin? Are you sure? If so, cite papers mentioning these marine deposits within the main text. Also, the upper age limit of this deposits is missing.
Add coordinates and north arrow.

Figure 2: fault traces should be thicker.

Figure 3: you show that units U3 and sd2 contain the NYT and the CI tephra layers. Anyway, you never presented data showing the presence of this tephras both in the main text (see lines 228 to 234) and in the boreholes section of Plate 1. What data do you have? Please, introduce them in the main text.

Figure 4: revise accordingly to comments at geological map and cross-sections in Plate 1.

Figure 6: the outcrop of Triassic bedrock close to the fault trace and the lateral variation in scarp height, which is maxima where the bedrock outcrops, suggest that the scarp is due to differential erosion and not to fault activity.

Figure 7: specify, in the caption, if fault colours are referred to fault colours in Plate 1. If not, add a small legend to specify what different fault colours indicate.

Figures 8 and 9: to facilitate readability of these figures, authors should complete details of faulted deposits with reference to units mapped in the geological map (Fig. 4 and Plate 1). Unit U1 is present in this sector of the study area, which should refer to units 1 to 3 in both figures, whereas C14 data indicates that units 4 to 7 are Holocene in age, but there are no Holocene deposits in this sector of the pediment. Furthermore, it seems to me that unit 6 in Figure 8 can be prolonged towards the NE and may cover the fault trace, but maybe this different interpretation is due to colours in the picture.

Figure 10: age of unit 4 should be "BCE" and not "CE".

Figure 11: I missed in the main text Middle Pleistocene to 15.3 ka throw rates for the Raviscanina and Piedimonte Matese areas. I just found throw rate >0.35 mm/yr during the late Holocene (see line 379 of the main text).

SUPPLEMENTARY DATA

TAB. S3_Data points with structural data

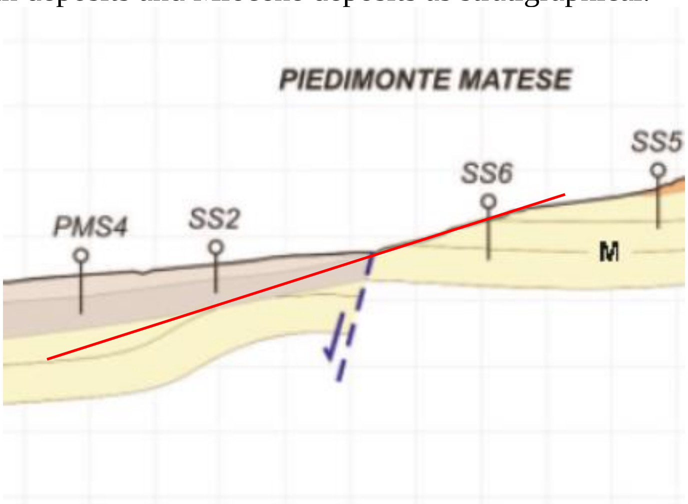
- See comment to line 17.

PLATE S1
MAIN MAP

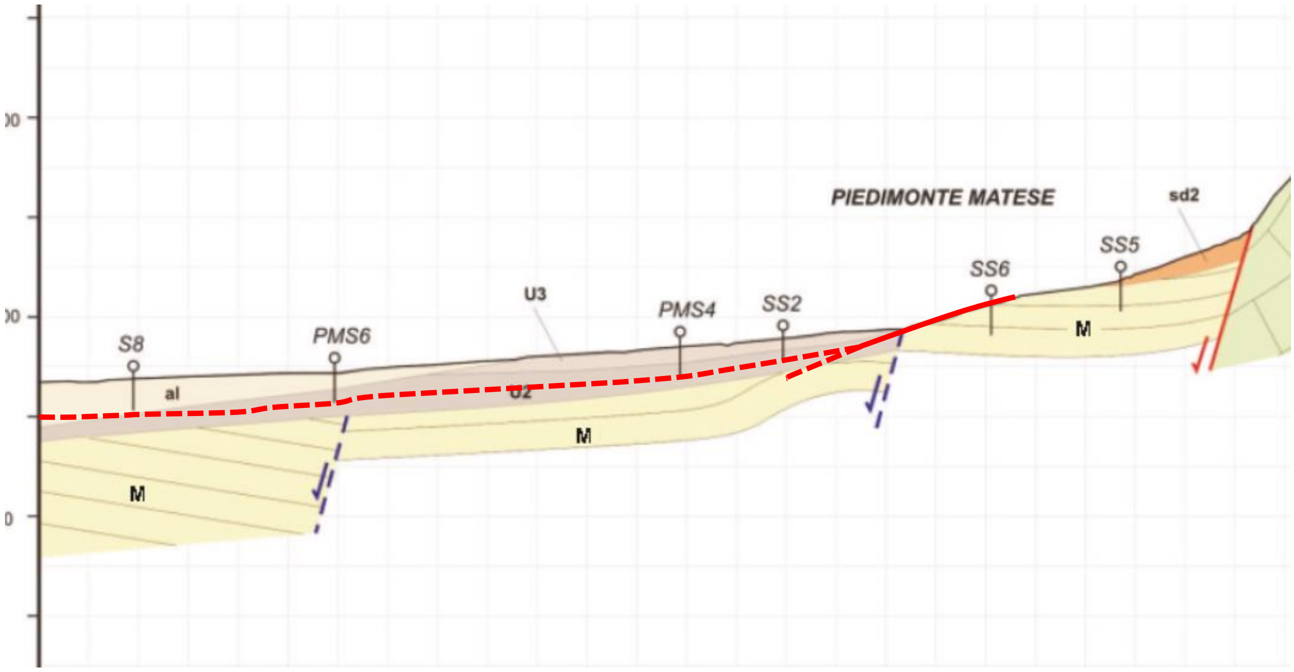
- The Gioia Sannitica fault passes, laterally, to a generic Quaternary fault to the north of Calvisi. How it is possible?
- The tectonic setting near Curti, Petrella and Caselle is very tricky (see comments in the "General comments" section)
- The Quaternary faults to the west of GF are not supported by your data (see next comments), so I suggest removing them and modifying the cross-sections accordingly

CROSS-SECTION
Enlarge text on the X and Y axes. Add "Elevation (m a.s.l.)" to the left of the Y axe and "distance (m)" below the X axes.
CROSS SECTION A-A'

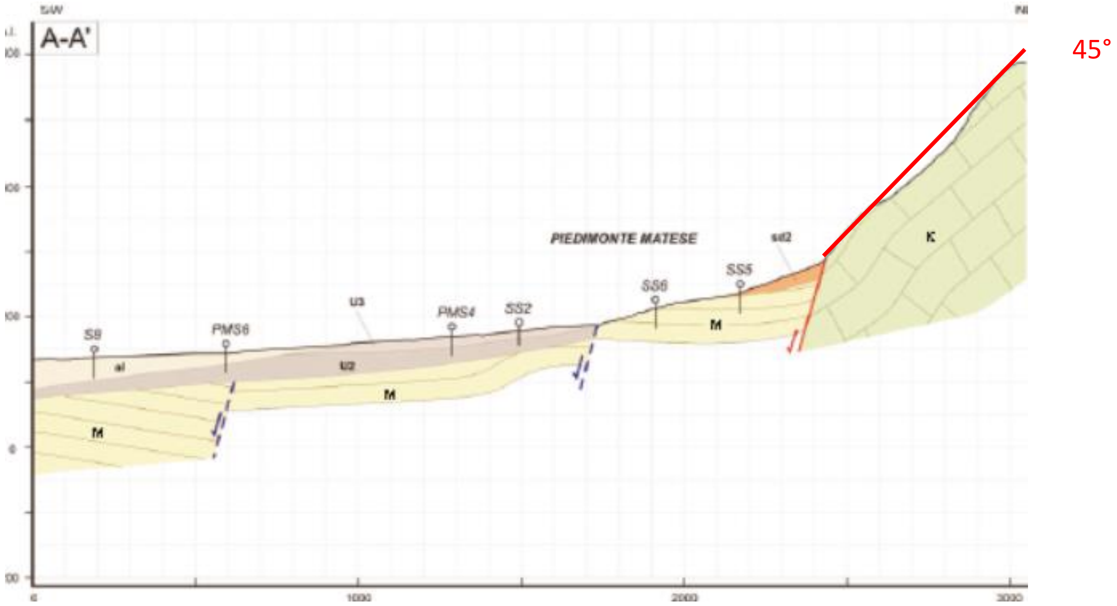
- I have some doubts about blue faults you reported in this cross-section. Borehole data do not show any offset, as borehole SS6 drill the Miocene unit whereas boreholes SS2 and PMS4 drill alluvial units. If you project the topographic surface near borehole SS6 south-westwards, you do not need a fault (see red lines in the figure below). So, it is easier to interpret the contact between alluvial fan deposits and Miocene deposits as stratigraphical.



- Furthermore, borehole data do not allow to infer the presence of another fault, near borehole PMS6, because there are no offsets in the Quaternary units. In this area, borehole data do not allow to infer both the thickness of the alluvial fan deposits and the depth of the bedrock, so the lower part of the cross-section is not supported by data. I suggest ending the cross-sections at the base of boreholes (a possible solution is provided below).



- I also found some incongruences about Miocene deposits dip in the hangingwall of red fault (e.g, the Gioia Sannitica fault). In fact, Miocene deposits dip towards SW in cross-section A-A' and D-D', towards NE in cross-section B-B', C-C' and F-F', and are horizontal in cross-section E-E'. Few bedding data on Miocene deposits reported in the main map do not allow to support such variations, so the authors should re-draw this part of the cross-sections.
- Lastly, the Cretaceous units dip 40° towards the SW. This is the only bedding data reported in the main map and it does not support folding of this units as reported in cross-section A-A'. Furthermore, I evaluated the dip of the Mt. Olnito slope which resulted to be of 45°. This would suggest that this slope is a dip-slope. So, if the very recent activity of the Gioia Sannitica fault is estimated by the steeper lower sector of the Mt. Olnito slope, I think this interpretation is not correct.



CROSS SECTION B-B'

- What are the evidences to infer the location of a Quaternary fault to the NE of the Gioia Sannitica fault?
- Your data do not allow to infer depth of the Quaternary bedrock, so you should stop your cross-section at the base of the boreholes (the same for all the cross-sections)

- Again, your data do not support the presence of an inferred Quaternary fault to the SW of San Potito Sannitico

CROSS SECTION C-C'

- Stratigraphy of the borehole S"S93" is not reported in the borehole stratigraphy figure
- There are no evidences to infer the presence of the dashed blue fault.
- What data do you have to infer the tectonic contact between Mesozoic carbonates and Miocene units along blue fault?

CROSS SECTION D-D'

- Again, there are no evidences to infer the presence of the dashed blue faults.
- How can you hypothesize the presence of the Varicoloured Clays? Looking at your map, they seem to be limited to the Petrella area. See also comments in the "General comment" section.

CROSS SECTION E-E'

- The map shows, in the surroundings of Auduni, the presence of U2 deposits whereas U1 deposits are reported in the cross-section.
- This cross-section is not very clear as there are no bedding data in its surroundings that allow the infer the complex geological setting, with folded Miocene and Mesozoic units.
- The Gioia Sannitica fault is inferred in the main map whereas it is certain in this cross-section.
- Why you did not project borehole GSA4 in cross-section E-E'?

CROSS SECTION F-F'

- There are no evidences to infer the presence of Quaternary faults to the SW of the Gioia Sannitica fault.

BOREHOLE DATA

- You distinguished, in the main map, SD1 and SD2. I agree, but most of the boreholes drill another SD unit, that is not listed in the legend. Looking at both the map and the cross-sections, I guess it should be the Miocene unit. Borehole data must be consistent with geological map and cross-sections to avoid any misunderstanding.
- The unit CC drilled in boreholes S14 and GSA5 is not listed in the legend. What is it? Furthermore, authors could project borehole S14 on cross-section A-A'.
- Borehole GSA7 drill SD1 deposits whereas it drills SD2 deposits in cross-section D-D'.
- Boreholes S9, S12 and PMS2 are placed in an area where U2 deposits are present whereas they drill U1 deposits.
- I cannot find boreholes PMS6 and SS1 in the main map. Where are they located?
- Boreholes SS5 and SS6 drill SD unit in the borehole stratigraphy figure whereas they drill Miocene unit in cross-section A-A'. So, is the SD unit composed of debris slope deposits or the SD unit correspond with the Miocene unit?
- Stratigraphy of borehole GSA1 indicates that it drills, in the upper part, U3 deposits whereas it is in an area where U1 deposits are present. Furthermore, you indicated that the WTT tephra is present within the U2 deposits, whereas, in borehole GSA1, the WTT occurs within U3 deposits.
- Regarding the WTT, how can you establish that this tephra layer is the WTT? Did you sample it in all boreholes and performed tephrostratigraphic analysis? Or the classification of this tephra layer as the WTT is just your assumption?
- Again, what is the SD units in boreholes GSA3, GSA4, GSA5, GSA6, GSA7, SPS1, SPS2, SPS3, SPS4, SPS5, SPS6 and SPS7?
- Stratigraphy of borehole GSA6 indicates that it drills, in the upper part, SD2 deposits whereas it is in an area where Miocene deposits are present.
- Boreholes 158202, 163920 and S"S93" and reported in the main map but are not detailed in the borehole stratigraphy figure.

TECHNICAL CORRECTIONS

Line 84: type NE-SW instead of SW-NE
Line 168: delete “which was”.
Line 173: the letter “o” of Alo, Feo, Sio, should be written in capitals.
Line 241: it should be Mt. Acero.