

Response to review of Daniela Pantosti

Dear Daniela Pantosti,

All the co-authors thank you very much for your detailed review of our submitted paper about Sharkhai fault, the propositions of correction and the comments that allowed us to clarify, correct and improve our first submission.

All the correction you proposed in the PDF have been included in the new version. Thank you for this detailed review.

Here under, you will find our answers to each of your general comment and to two specific comments in the PDF. There is no opposition and we agree with them.

Answers to general comments.

1. Comment D. Pantosti: English language needs some improvements.

Answer: all the suggestions have been included. A complete review on the English language has been done as well.

2. Comment D. Pantosti: At the beginning of 2021 a paper from Suzuki et al was published on SRL and shows the presence of a fault located very close to the capital city named Ulaanbaatar fault. On the basis of tectonic geomorphology and trenching the authors show that this is an active fault threatening this part of Mongolia. The Ulaanbaatar fault is not discussed in your paper nor reported in your maps. However, I strongly recommend to integrate the Suzuki et al data and discuss convergences or divergences between the results and interpretation to provide a more complete view of the hazard for the capital city and surroundings.

Answer: We include in the corrected version of our paper the recent work of Suzuki et al. 2020. This “Ulaanbaatar fault” is discussed in the “introduction and context” part with other known faults. We also added it to the new Figure 2 (results of the merging of initial figure 2 and 3 as proposed by D. Pantosti)

3. Comment D. Pantosti: Since a few years the scientific community has adopted the use of Common Era – CE/BCE to replace AD and BC. Please change accordingly.

Answer: All the dates have been changed to the common Era- CE/BCE.

4. Comment D. Pantosti : I cannot reproduce the interevent interval 2080+/-470 from the ages of MRE and PE. Maybe I have lost something. MRE can have occurred anytime between 775CE and today, or better the year in the Mongolian history from which an earthquake along this fault would have been reported in the historical documentation. In Europe this can be 1600-1700 CE. What about Mongolia? Can 1800 be the oldest age for an earthquake to be recorded in historical documentation in Ulaanbaatar? It is true that the town was established there in 1778? Can we assume that any earthquake after that date should appear in some historical documentation? If this is correct the MRE can have occurred anytime between 775 CE and 1778 CE. Thus, this is the range to be used for interevent calculation along with 1605-835BCE for the PE. On this basis the interevent can be as long as 3383 and as short as 1610 years. Your interval appears much smaller: 1610-2550 yr All the calculation derived from the interevent estimate should be refreshed.

Answer: The comment is right. We checked the oldest age for an earthquake to be recorded in historical documentation. We can consider 1778 CE as the oldest age for an earthquake in the region of Ulaanbaatar. The calculations of interval time are corrected, the minimum is 1610 yr. and the maximum

is 3383 yr., thus yields an average interval time of 2496 ± 887 years. The induced values of slip rate estimates are also corrected (paragraphe 4.2 Magnitude, co-seismic displacement and slip rates).

5. Comment D. Pantosti: The morphologic evidence of the fault sections should be better explained, what are the geomorphic elements that support the reconstruction of the fault trace? These should be discussed and also highlighted in figures (as for example in fig 11).

Answer: Drainage offsets are the main geomorphological features observed along the Sharkhai fault, in addition to small scarps of about 50 cm height along the northern section (trench site Figure 14). Between them, we can follow more or less the fault traces in the HR images and on the field a “lineament” at surface, related to the eroded fault trace, locally associated to smoothed scarp or a change in the slope (see new figure 4). Outside HR images or field observations, the fault is very difficult to follow or even detect. (see complements in text).

6. Comment D. Pantosti: Figures are too small and resolution increased.

Answer: The figures in PDF have a reduced resolution. All the figures will be provided with the highest resolution for the final version.

7. Comment D. Pantosti: Figures 2 and 3 should converge in one single figure with geology draping the topography

Answer: We merged initial figures 2 and 3 (the topography and the geological context of The Ulaanbaatar region and the active faults) in the new Figure 2. All the other figure numbers have been corrected

8. Comment D. Pantosti: Figure 4 should show the fault without covering it with a black line. I would recommend to remove the line and use arrows to point to the fault. As it is now it is impossible to recognize the fault geomorphic expression. A better version of the fault trace is presented in figure 13. I would suggest that these two figures are merged to make a single one composed of two panels: 1) a good DEM highlighting the geomorphic elements used to recognize the fault trace (using arrows and symbols not covering the fault) and 2) the fault trace with all possible details always on the DEM. Consider that this figure should be at the beginning (eg fig 4) because it is critical to the description of the fault sections.

Answer: The figure 4 is modified as requested, the new one (called now figure 3) is composed of two panels: one with a good DEM without fault trace and the second with the details.

9. Comment D. Pantosti: Figures 5-10+12 are nice reconstructions of offset streams to measure offset. I think that part of these should go as supplementary material to leave space to field photos showing the fault, its geomorphic evidence and setting. I would also recommend to extend the summary table 1 including site name and coordinates, measured offset and type/age of sediments recording the offset. Moreover, the estimate of uncertainties appear well too small. You should consider first the resolution of the images, then max and min measure of offset with their own uncertainty (that should be calculated by correlating stream axis with different trends especially when streams are not perpendicular to the fault and have a windy geometry). Therefore, all these uncertainties sum up in the cumulative offset evaluation.

Answer: Some figures are displaced in supplementary material. The table 1 has been extended with the information requested except for the type/age of sediments recording the offset that has not been studied in this work. The uncertainties are re-estimated considering the resolution of the images (see details in text and legend of figures).

10. Comment D. Pantosti: Figure 14 contains some details on the complexity of the fault trace I was asking to show in the chapters describing the fault. However, the scale is still not adequate for these fine complexities (ex.: I cannot see the changes in strike), some field remote sensing evidence should be shown as in fig 11.

Answer: These details in the mapping have been removed from figure 14 as they are very local complexity of fault traces (at metric scale) and they do not bring fundamental information for our results and the mapping of the fault.

11. Comment D. Pantosti: Figure 15 g. Add units names in the log

Answer: The unit names have been added.

Answers to specific comments included in the PDF version of the reviewed paper.

12. Comment D. Pantosti line 12: Part of it was already reported in Suzuki et al as Saharai fault? Is correct? see fig 1

Answer: The Sharkhai fault reported by Suzuki et al. (fig 1 of their paper) at very small scale is based directly on our work and preliminary results (Al-Ashkar et al., 2013 and Schlupp et al., 2013) on Avdar and Sharkhai faults. Our work is not cited in the legend of their figure 1 but well cited in their text.

13. Comment D. Pantosti line 256: this age is meaningless, any age younger than the age of the industrial time cannot be considered. Just for your information the living roots are removed in the lab by acids during the preparation of the sample. Just do not consider this measure as reliable and use sample

Answer: It seems it was a confusion. The age was BP and not AD, therefore it was not associated with industrial time but to 45 ± 80 CE. We clarified in the text the part related to the roots which was not the idea understood.

Thank you again for the review.

With kind regards
Co-authors

Response to review of Laurent Bollinger

Dear Laurent Bollinger,

All the co-authors thank you very much for your detailed review of our submitted paper about Sharkhai fault, the propositions of correction and the comments that allowed us to improve our first submission.

Here under, you will find our answers to each of your general comment. There is no opposition and we agree with them.

1 Part 1 Introduction and context :

I find the introduction not well structured. Indeed, in my opinion, the succession of paragraphs from line 50 to the end of the introduction go too much back and forth (e.g. from paragraph line 50 : Ulanbaatar exposure to earthquakes, then active faults, then geology, the Ulanbaatar exposure and risk, then the targetted faults

I suggest either :

-to separate the general introduction from the local seismotectonic setting.

-or to change the order of the paragraphs of the present introduction so that the succession go less back and forth

Answer: The introduction has been reconstructed to be more linear and clearer.

Table 1 :

You estimated 7 cumulative offsets of geomorphic features along the fault, and found that two fall around 57 meters and three around 35 meters. I think that a discussion regarding whether the geomorphic features offset by these quantities could be related (or not) with a specific climatic events would enrich your work.

Answer: The rates of deformation are first estimates associated with too large uncertainties to be correlated with climatic events. We nevertheless added a complement in the text for the two “groups” of cumulative offsets.

Line 289-290 and Figure 15g

The geological units logged in the trench are well described in the text. However, a point remains unclear to me : several faults are mapped as possibly affecting the base of Unit U11 (red dashed line on figure 15g). In the meantime the text mentions that « Between 0 and 3m and between 5 and 7.5m all ruptures terminate at the top of U30 and are truncated by the upper erosion surface« (see line 289-291). This is either not coherent, or the text do not sufficiently expose the observations and their uncertainties.

Answer: The phrases are corrected, Between 0 and 3m the ruptures truncated actually the unit U11, So they are considered MRE.

minor blemishes and technical corrections

Introduction :

Line 32 : why opposing strike slip and uplift ? structure and motion ? replace by « numerous strike slip structures and minor thrust or normal faults ... «

Answer: We agree and include your proposition.

Paragraph around line 55 : Figure 2 should be referred in that paragraph, before introducing the local fault names.

Answer: We agree and include your proposition

Figure 2 : Gunj fault is missing on this figure. The kinematics associated to Avdar and Sharkai fault are missing

Answer: We agree and include your proposition

Paragraph 85 : about 1.5 million in the capital of 3.2 million : unclear, rephrase Line 86 : insert 'airport' in « replacing the actual 'airport' too short and now too close to the city »

Answer: We agree and include your proposition

Line 91 : suppress « , which shows clear evidence for a major seismic activity » or replace it with something less strong. It is still the introduction and you already mention your results are clear and strong. The reader will make his own opinion.

Answer: We agree and include your proposition

Line 97 : with 2 earthquakes, it is difficult to speak about a « recurrence time ». An « interevent time between the penultimate and latest earthquake » is more appropriate.

Answer: We agree and include your proposition

Line 102 : you mention the « very well-expressed geology » but I missed a description of the lithological nature of the bedrock along strike. Could be helpful to understand the along strike variations of morphology of the two compartments of the fault.

Answer: The lithological nature of the bedrock along strike has not been analyzed in this work dedicated to the activity of the fault and not to geological context. We did not add such a work despite the fact that we agree with the reviewer that it could be a complementary work for the description of the area.

Line 124 : replace « the « large extensional step-over, by « a » large....

Answer: We agree and include your proposition

Line 148 « limiting possible records of displacement » : rephrase

Answer: We agree and include your proposition

Table 1 : Specify the GPS location (in geographic) of P1 to P7 , as well as the location of the trench

Answer: We agree and include your proposition

Table 2 (and the text) We miss an information about where the samples were sent (which laboratory ?), what was their lab number (this table could also present their Delta 13C, and recall that the radiocarbon age were determined on bulk sediments)etc .

Answer: We agree and include your proposition

Line 220 : Could you be more specific about the nature of the massive Carboniferous bedrock ?

Answer: We agree and include your proposition

Indeed, in your introduction, you mention that the lithologies exposed in the region's carboniferous rocks comprise sandstone, mudstone, conglomerates ... but I found no mention to what was found in the field along strike Sharkai fault and in the trench.

Answer: Same answer as for the similar question at line 102: The lithological nature of the bedrock along strike has not been analyzed in this work dedicated to the activity of the fault and not to geological context. We did not

add such a work despite the fact that we agree with the reviewer that it could be a complementary work for the description of the area.

Line 257 : suppress « both »

Answer: We agree and include your proposition

Line 279-280 : suppress the parenthesis after 15 b-e , replace 14g by 15g

Answer: We agree and include your proposition

Data and ressources

I suggest adding information on the radiocarbon dating (which lab ?) within that section.

I suggest listing the date of acquisition of the images that were used in the study (at least the date of acquisition of the images illustrating Figures 5-7-8-9-10-11-12.

Answer: We agree and include your proposition

%References :

I noticed that some recent references (post 2018) on faults in UB vicinity and central Mongolia are missing probably because your study took place years before the most recent works published was undertaken.

Updating the bibliography with recent references will make your paper more exhaustive and up-to-date.

Answer: We agree and include your proposition

Line 512 : Replace Reimer, P : by Reimer, P et al., ...

Answer: We agree and include your proposition

Thank you again for the review.

With kind regards

Co-authors