

## ***Interactive comment on “The Ulakhan fault surface rupture and the seismicity of the Okhotsk-North America plate boundary” by David Hindle et al.***

### **Anonymous Referee #2**

Received and published: 22 October 2018

GENERAL COMMENTS: The paper by Hindle et al. combines detailed geomorphological field observations and remote sensing data with luminescence dating to quantify the Holocene fault slip rate for one segment of the Okhotsk-North America plate boundary. In addition, the authors use elastic dislocation modeling to explain vertical fault offsets near the ends of the investigated fault segment and place constraints on the paleoseismicity and seismic hazard of the region. In general, the paper is timely, topical and of broad interest. It is also clearly structured and to a large extent well and concisely written. The methods are adequate and most of the conclusions reached are well supported by the new data. There is no doubt that the paper deserves publication after a few issues have been addressed, which I summarize below (for details see my specific comments below).

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1. Additional information should be provided on the luminescence data and ages.
2. Rather than reporting an approximate slip rate of  $\sim 5\text{-}6$  mm/yr, the authors should make an attempt to estimate the uncertainties of (i) the tectonic offset and (ii) the age of the offset geomorphic feature. These uncertainties should be propagated when calculating the slip rate and an uncertainty for the slip rate should be reported as well.
3. Many of the figures are too small and some important information can therefore not be seen, or is difficult to see, or is lacking. Although I realize that Solid Earth is an online journal, I believe that everything in a figure should be readable, once the pdf file is printed.

SPECIFIC COMMENTS: 1. Reporting luminescence data and sampling locations: a) Add geographic coordinates of the sampling sites to Tables A1 and A2, in order to document the exact position of all samples. Could you mention the number of pits in the text as well, please (5 locations are shown in Fig. 4, however, in the 2 tables there are only 4 locations, right?). It would be nice if would pictures of 1-2 sampling locations would be included. b) The cosmic-ray dose rate and the total dose rate should be reported in the two Tables. c) Which luminescence protocol was used (e.g. the SAR approach?). Please clarify this important issue in section 2.3 and add the respective reference(s). d) The statement on page 6 lines 24-25 somewhat overinterprets the quality of the age data, because the "usable" ages range from about 8.9 to 14.3 ka, which is a relatively large range. To allow the reader to better assess the overall quality of the OSL ages, I strongly suggest to include radial plots showing dose rate distributions for at least a few samples. e) One IRSL age of  $12.3 \pm 1.1$  ka is consistent with the OSL ages. It is not clear, why this samples is considered to be partially bleached and excluded from the ages shown in Fig. 7. Please explain. f) As it is unknown, how the "humidity" (a better term would be "water content") of the samples has changed through time, an estimated uncertainty should be reported for the "water content" in Table A1 and A2 and propagated through the age calculations.

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2. Derivation of fault slip rate: a) The authors state that two small areas of raised topography with straight edges are offset by about 60-65 m (page 5 line 33 ff and page 6). These features are interpreted as channel banks of an earlier drainage system and are shown in Fig. 4 (which includes 3 satellite images; and 2 satellite images with relevant features included). I have no reason to doubt the interpretation of the authors, but I request that the size of the five subfigures of Fig. 4 is increased by a factor of  $\sim 2$ , in order to better convey the information contained in Figure 4 to the interested readers. In addition, a more realistic uncertainty should be assigned to the offset value (e.g.  $\pm 4$  m or  $\pm 5$  m would appear reasonable to me).

b) The tectonic offset of e.g.  $62 \pm 4$  m should be combined with an age estimate based on the luminescence ages to determine the fault slip rate and an associated uncertainty. I suggest to use an age of  $11.6 \pm 2.7$  ka (the error of  $\pm 2.7$  ka would include the age range defined by the 15 luminescence ages (i.e. 8.9 to 14.3 ka; Fig. 7). The slip rate would then be  $5.3 \pm 1.3$  mm/yr (i.e.  $62 \pm 4$  m /  $11.6 \pm 2.7$  m/ka). The slip rate AND its uncertainty should be included in the abstract.

3. Figures: Many of the figures are too small and some important information can therefore not be seen, or is difficult to see, or is lacking. Please improve the size where necessary. In particular, I have the following requests:

Please add scale bars (in km) to Figs. 2, 3, 4, 5 (satellite image), 6, and 8!

Fig. 1: I suggest to add arrows to show that the sense of shear along the OKH-NAM plate boundary is left-lateral. Please indicate region covered by Fig. 2 in this figure.

Fig. 2: Please show extent of Figs. 3 and 8 as black rectangles. Increase letters in legend. Mention the rock-types of the "younger Neogene" and "older Neogene". Increase thickness of red line, indicating the fault trace.

Fig. 3: (a) add arrows to show that fault is left-lateral. Show extent of Fig. 4 as black rectangle, please. To show sample locations in (b) as red dots is not helpful (samples

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are shown in Fig. 4 anyway).

Fig. 4: The black words explaining the Euler vectors cannot be read. Please increase size of all images as explained above.

Fig. 5: Indicate view directions of field photographs in caption or pictures, please.

Fig. 6, 8: In general, vertical offsets across fault scarps are derived by extrapolating the far-field slopes to the scarp using straight lines and measuring their vertical separation. These pairs of straight lines should be included in the topographic profiles shown in Fig. 6 and 8 as well. The profiles should be enlarged by at least a factor of 2.

Fig. 7: What is meant by "a) samples" and "b) samples" in the legend? It would be better to add sample IDs to this figure.

MINOR COMMENTS tied to line numbers Page 1 line 7: It is unclear what is meant by "other theoretical studies". Please explain or remove from abstract. Page 1 line 9: "raising serious questions about". Improve this unspecific phrase in the abstract. Page 3 line 4: Please indicate resolution of Tandem x data in meter (i.e. ~12m). Page 3 line 18: I guess what is meant is that Jurassic rocks were deposited in the basin... Please rephrase sentence to clarify. Page 3 line 24-26: Please split this long sentence in two. Page 3 line 27-29: these basins and scarps can be barely seen in Fig. 4. Page 4 line 23: I suggest to add the information that the fault has a left-lateral sense of movement. Page 5 line 10: "sedimentary age"; improve English, please. Page 5 line 21: "strongly fault parallel orientation". Please be more specific and add the reference to a figure where this can be seen. Page 5 line 26: How to do define/recognize a "dry" zone? please explain. Page 7 line 5: "reflecting times since channel abandonment and burial of sediment". Isn't there a flaw in this sentence? Once, a channel is abandoned, sedimentation will stop. How then, can the samples have been buried? Please, give a bit more information on the sampling sites to bolster your interpretation. Page 7 line 17: I suggest to avoid the term "peneplain" here. Page 8: Title of section 4.1: There are no "seismic data" presented. Please use more appropriate wording. Page

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9 line 17. I can't find Ust Srednekan in Fig. 2. Page 9 line 20: I suggest to write "<0.5 mm/yr" rather than "< 0.1-0.5 mm/yr". Page 9 lines 31-32: It seems to me that the information given here has already been given on lines 15-16 of the same page. Please avoid repetition or explain the issue more clearly. The term "initial age" seems misleading; it is only the age of the offset marker but not the age of the fault segment (or do I misunderstand something here). Title of section 4.3: I don't see that the term "scarp slope" is discussed in this section. Please clarify the issue. Page 10 line 32-33. This sentence requires a reference. Page 11 line 11: This statement is somewhat misleading, because the fault scarp occurs only near the end of the fault. I also would not consider it "substantial", because the height is  $\leq 5\text{m}$ .

TECHNICAL CORRECTIONS: Appendix A2 Lines 6-7: The units should be micrometer ( $\mu\text{m}$ ) not metre. Line 14: What is meant by "stable preheat temperature"? Line 23: Typo, it should be "bleached". The unit "mm yr-1" is often missing a blank/space between mm and yr-1.

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