



# Review Report

Pierce et al., Satellite Mapping of Fault Rupture from the 1968 and 1979 Dasht-e Bayaz and Khuli-Buniabad Earthquakes, Northeast Iran: Rupture Complexities and Evidence of Rupture Arrest and Re-rupture in Successive Earthquakes, TEKTONIKA, 2024.

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# 1<sup>st</sup> Round of Revisions

## Decision Letter

Dear Ian, and coauthors

We have now received two detailed reviews on your article, "Satellite mapping of fault rupture from the 1968 and 1979 Dasht-e Bayaz and Khuli-Buniabad earthquakes, northeast Iran: evidence of rupture arrest and re-rupture in successive earthquakes." Both reviewers (Mathilde Marchandon, Wendy Bohon), the associated editor (Adam Forte) are consistent in their recommendation that Request Revisions, but that after revision this paper will make a valuable contribution.

Both reviewers focus the majority of their comments on the necessity of better documentation of the methodology and uncertainties for both the rupture mapping and estimation of displacements. They have made very detailed comments and recommendations using the Tektonika review form (attached to this message as 2 .docx files). Both provide helpful and concrete suggestions for what is needed and possible additional figures that might aid readers in evaluating the work. Reviewer 1 additionally highlights what seems a critical additional reference that should be included and the results of this work considered within the context of the new results presented here. Reviewer 2 has also made some comments directly on the manuscript file (attached too). Please consider these comments.

The reviewers regret that your detailed mapping / imagery is not yet fully available. You wrote that it will be posted on a data repository after review, but reviewer 2 feel that they "cannot adequately assess their methods without that data". As executive editor, I ask you to upload your files to a repository and provide a link together with your revised manuscript (at this stage you can keep the link private, providing it only for review and waiting for distributing a public DOI). Please also consider reviewers' suggestions to enrich the data availability section and relevant references in the text.

We look forward to receiving a revised version of your work for a second stage evaluation. We hope you will be able to submit it within two months, by October 9th. This is a non-strict deadline and we will not close the evaluation process at the due date. But we recommend not delaying too much the revision process. If needed, please keep us informed about your timetable.

When uploading your revision provide us with a full rebuttal addressing all reviewer's comments (you may answer directly using the tektonika review form and/or provide a comprehensive rebuttal letter) and also a second manuscript version with all changes clearly outlined.

Adam Forte, associate editor  
Robin Lacassin, executive editor

## Authors Reply to Editorial Comments

Dear Adam, Robin, Wendy, and Mathilde,

Thank you so much for the detailed reviews of our manuscript. We apologize for the very long time it took to revise and resubmit this manuscript. The lead author (Ian) has changed jobs to a non-academic position & moved country since the original submission. We have addressed all of the comments in the reviewer response documents, but want to emphasize two issues we are not able to fully address (these below comments are copied from those documents). We have also added the mapping files to a repository, now linked in the revised draft. Our comments in the review response document are in bold. We incorporated most of the reviewers' feedback, and of those we did not, provided justification for these decisions.

Regarding the figures:

- A) The quality of the figures is a direct result of the quality of the data. It is not ideal and this was a desktop-based study using available satellite imagery. We try to downplay the emphasis on the visualization of these data and focus on the geometric takeaways we can get from this earthquake rupture pattern. We feel that these are still valuable contributions.
- B) There are a number of logistical issues that preclude us from addressing every figure comment. We did address as many as we were able. We do not feel that these significantly impact the paper, though this outcome is less than desired.
- 1) This project has been handed down from person to person for about 7 years. Much of the original georeferencing and linework (particularly of the 1968 AT linework) was conducted as part of a senior thesis. As such there are some minor errors with the georeferencing and digitization.
  - 2) The lead authors are no longer affiliated with Oxford University and no longer have access to the software / data needed. Neither Pierce nor Elliott can access Bing imagery through a GIS environment as their US government GIS licenses do not allow this.
  - 3) The transition from ArcMap to ArcGIS Pro means that many of the original figure files can no longer be modified.

Thank you,  
-Ian Pierce and coauthors

## Comments By Reviewer 1 and Authors' Response

### Section A: Overview of manuscript

#### A1) Overall evaluation, general comments & summary

##### A1.1) Reviewer's comments

###### A1.1.1 ) General evaluation and publication suggestion – Required:

*Please use this space to describe, in your own words, the core subject of the submission and your overall assessment of its suitability for publication.*

In this manuscript, Pierce and al. present a new mapping of the surface ruptures produced by the 1968 Mw 7.1 Dasht-e Bayaz (DeB) and 1979 Mw 7.1 Khuli-Buniabad (KB) earthquakes (that broke the western and eastern part of the DeB fault, respectively) using historical and modern optical images taken at different times. They also use the optical imagery to measure the offsets across the fault at several locations along the DeB and KB ruptures. Their detailed surface rupture mapping reveals that the DeB and KB ruptures are characterized by a number of simple fault segments where surface slip is 4m on average separated by geometrical complexities (such as double bends and step-overs) with low or no slip. From their updated rupture mapping, the authors confirm that ~5 km of the fault at the eastern end of the 1968 rupture was reactivated in the 1979 event, and discuss the role of a large restraining double bend located in the overlapping area in the propagation and arrest of the two events' rupture. They interpret this large fault complexity as an 'earthquake gate' that has let through the rupture in the first event but arrested it in the second.

Up to now, only low-resolution surface rupture mappings were available for most of the DeB and KB ruptures (only the western end of the DeB rupture was mapped in details). This new mapping together with the new fault offset measurements contributes to get a more complete documentation of the surface ruptures of these two large events. Therefore the work done by the authors is valuable and should be worth publication after major revisions. Indeed, the manuscript could be largely improved by 1) improving the quality of the figures (see comments section B6) 2) adding more details in the method about the approach used to map these up to 55 years old surface rupture traces (see comment section B3) 3) adding confidence level assessment on the various rupture traces mapped (see comments section B4) and 4) acknowledging all the previous efforts done to characterize the rupture of the DeB sequence. I am referring to the study of Nowroozi & Mohajer-Ashjai (1980) that is not cited in this paper, although their surface rupture map is reproduced in Figure 5.

*Nowroozi, A. & Mohajer-Ashjai, A., 1980. Faulting of Kurizan and Koli (Iran) earthquakes of November 1979. A field report., Bull. B.R.G.M,IV(2), 97–99.*

Mathilde Marchandon

**A1.1.2 ) What does the submission need to be publishable? (select as needed; comment for all cases)**

- No changes required
- Rewriting
- Reorganising
- ~~More data~~ **Better** figures
- Condensing
- Reinterpretation
- Other

**Comments:**

see section A.2.1

**A1.1.3) Can the submission be improved by reducing/adding any of the following? (select as needed; comment for all cases)**

- Text
- Table
- Figures
- Supplementary material

**Comments:**

[Free form box]

**A1.1.4) Please complete the following section if you recommend that the submission is NOT appropriate for publication (select as needed; comment if a box is selected)**

- Quality is poor
- Research is not reproducible
- Other

**Comments:**

[Free form box]

## **A1.2) Author(s) Responses:**

## **A2) Summary of main merits and main points of improvement**

### **A2.1) Reviewer's comments**

*Please describe below in a few sentences (100 to 300 words) the main merits of the submission and suggestions for improvements.*

#### **The main merits I have found are...**

- updated surface rupture mapping and expanded fault offset measurements for the Dasth-e-Bayaz and Khuli-Boniabad earthquakes that all together contribute to a more complete characterization of these two large events.

#### **The main points of improvement I have found are...**

- The quality of the figures is too poor in my opinion. This is detrimental to the quality of the article. Better figures would really help to emphasize the results and highlight the contribution of this study. See details and suggestions in section B6.
- No assessment of the rupture mapping confidence level is given.
- More details should be given in the method section (see section B3)
- Some citations are missing and some of the works previously published are not always acknowledged.
- The paper needs some slight changes in the organization (one paragraph in the results section belongs to the background section).

### **A2.2) Author's responses:**

**The quality of the figures is a direct result of the quality of the data. It is not ideal and this was a desktop-based study using available satellite imagery. We try to downplay the emphasis on the visualization of these data and**

**focus on the geometric takeaways we can get from this earthquake rupture pattern. These are still valuable contributions.**

**We added a few lines to the methodology describing our rupture mapping methodology & confidence.**

## **Section B: Detailed evaluation of manuscript**

### **B1) Title and abstract**

#### **B1.1) Reviewer's comments**

*These statements are a **guide** to what good Titles and Abstracts include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Title* describes the main topic of the manuscript **accurately** — [YES]

The *Title* describes the main topic of the manuscript **succinctly** — [YES]

The *Title* includes **appropriate key terms** — [YES]

The *Abstract* includes a **clear aim and rationale** — [YES]

**The *Abstract* supports the rationale with sufficient background information** — [NO]

**The *Abstract* includes a well-balanced description of the methods** — [NO]

The *Abstract* describes the **main results sufficiently and adequately** — [YES]

The *Abstract* clearly describes the **importance/impact of the study** — [NO]

The *Abstract* clearly states the **conclusions of the study** — [YES]

The *Abstract* is **clear and well structured** — [YES]

#### **Comments:**

There is no description of the method in the abstract (only “satellite-based mapping”). More details could be added, for example saying the different kinds of image that have been used to make the new rupture mapping. **Satellite based mapping is a standard methodology for tectonic studies. It does not need expansion in the abstract.**

- I think the contribution of this study could be better highlighted in the abstract by briefly explaining why a new mapping of these ruptures was needed or what was missing from previous efforts. **Done**

- L35-36 “We use legacy KH-9 satellite imagery acquired between the earthquakes to determine that ~5 km of fault at the eastern end of the 1968 rupture was reactivated in the 1979 event.”

Please replace the word “determine” with “confirm”, as it was already known that the ruptures of DeB and KB overlap. **Done**

## B1.2) Author’s responses

## B2) Introduction

### B2.1) Reviewer’s comments

*These statements are a **guide** to what good Introductions include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Introduction* provides **sufficient background and context** for the study — [YES]

The *Introduction* describes the **aim/hypothesis/rationale** clearly, providing **sufficient context** — [YES]

The *objective/hypothesis/rationale* **flows logically from the background** information — [YES]

The *Introduction* describes the study’s **objective and approach** (last paragraph) — [YES]

The *Introduction* contains **relevant, suitable citations** — [MOSTLY YES]

The *Introduction* is **organized effectively** — [YES]

### Comments:

- Some citations are lacking (see minor comments in section C1).

### B2.2) Author’s responses

[Free form box]

## B3) Data and methods

### B3.1) Reviewer's comments

*These statements are a **guide** to what good Method sections include and good practices for Dataset accessibility. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Methods* are described **concisely and with enough detail** for reproducibility — [NO]

Necessary information about **data sources/acquisition/processing** is included — [NO]

**Data used are accessible** via either supplementary files or links in the data availability statement — [NO]

The *Dataset and/or Methods* are **organized effectively** — [MOSTLY YES]

#### **Comments:**

##### Data:

There is not enough information about the data acquisition. It is written in the Data Availability section that the KH9 and Bing images are publicly available but no explanation is given about where to find them. Also no detail is given about the data processing. KH9 images are provided not orthorectified and not georeferenced. Details about how the KH9 images have been processed should be given. I would also recommend to give some first order information about the images or refer to the appropriate publication (the "Microsoft 2023" reference is of no help). The exact name of the KH9 images used should be given, so the image can be retrieved by the reader. Also, not much information is given about the aerial images taken after the DeB earthquake.

##### Method:

The surface ruptures mapped in this study are ~ 50 years old. Having looked at the KH9 and Bing images myself, I know that the surface rupture traces are very clear and well preserved in some places but very difficult to detect in some others. The authors should briefly explain in the method section the approach they used to distinguish surface ruptures from other features that could resemble, particularly when the rupture traces are hard to detect. Also, an assessment of the level of confidence for each rupture segment mapped should be given (and a figure illustrating the confidence level should be added in the supplements).

### B3.2) Author's responses

We agree that the ruptures are subtle in some places. Added more details to method section. We disagree and think that confidence assessments aren't useful here, so we are not adding them. Added a statement that our confidence is generally high.

## B4) Results

### B4.1) Reviewer's comments

*These statements are a **guide** to what good Result sections include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Results* findings are **supported by data** — [YES]

The *Results* findings are presented **clearly and succinctly** — [YES]

The text in the *Result* section **cites tables and figures appropriately** — [YES]

The *Results* directly **relate to the study objectives** — [YES]

The *Results* present **data for all the approaches** described in the *Methods* section — [YES]

The *Results* **text belongs to the Results section**, not to *Introduction*, *Methods*, or *Discussion*. — [NO]

The *Results* section is **organised effectively** — [YES] / [NO]

#### **Comments:**

- The paragraph lines 216-228 does not describe results and belongs to the background section.

**While we agree that this is background, it would seem out of place in the background section and fits better when it is referenced to the mapping result of the study.**

- L275-277 *"The westernmost end of the 1979 rupture terminates in the north-striking reverse fault that splays from the NNW reverse section ruptured in both earthquakes (e)."* Field mapping from Nowroozi & Mohajer-Ashjai (1980) indicates that the Khuli-Boniabad earthquake did rupture west of the NS reverse fault bend. No offset has been measured west of the bend by Nowroozi & Mohajer-Ashjai (1980) and the surface rupture in this part is not detectable in optical correlation results (Marchandon et al. 2018), so it is very likely that the rupture did not produce considerable offsets. But still, it seems that the rupture did pass the bend.

**We could not corroborate their mapping and as it was at a very low scale it isn't readily georeferenced. We are leaving our work as is. They also do not describe their mapping**

**methodology at all. We expect they misattributed this area to the 1979 earthquake when it was part of 1968.**

- L359-361: “*This bend thus appears to act as an earthquake gate, passing rupture in the first event and arresting rupture in the second.*” It is not obvious to me that the restraining double bend acted differently for the DeB and KB earthquakes. Both ruptures seem to have passed the bend (see the rupture trace in Nowroozi & Mohajer-Ashjai (1980)) and both ruptures seem to have quickly died out after passing the bend without producing considerable surface offsets.

**As stated above we disagree with their result as it is not supported by any data.**

## **B4.2) Author’s responses**

## **B5) Discussion and conclusions**

### **B5.1) Reviewer’s comments**

*These statements are a **guide** to what good Discussions and Conclusions include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Discussion* is **focused on the objectives** of the study — [YES] / [NO]

The *Discussion* **addresses all major results** of this study, which are shown in *Results* — [YES]

The *Discussion* section makes **comparisons with other studies** that are relevant and informative — [YES]

The *Discussion* section properly identifies all **speculative statements** — [YES] / [NO]

The *Discussion* section presents the **implications of the study** persuasively — [YES]

The *Discussion* section **highlights novel contributions** appropriately — [YES]

The *Discussion* section **addresses the limitations** of the study appropriately — [NO]

The *Discussion* section is **organised effectively** — [YES]

The *Conclusions* are **consistent** with and **summarise** the rest of the manuscript — [YES]

The *Conclusions* are **supported by the data** in *Results* and **follow logically** from the *Discussion* — [MOSTLY YES]

The *Conclusions* are **clear and concise** — [YES]

**Comments:**

The interpretation of the double restraining bend as an earthquake gate that has acted differently in the Dasht-e-Bayaz and the Khulib-Boniabad earthquakes is questionable when considering the rupture trace mapping of Nowroozi & Mohajer-Ashjai (1980).

## B5.2) Author's responses

We disagree with their mapping as it isn't supported by any data or the image correlation results. Leaving as is.

## B6) Figures, tables and citations

### B6.1) Reviewer's comments

*These statements are a **guide** to what good Figures and Tables include and how they are presented. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

*Tables and Figures are **ordered logically** and **numbered sequentially** — [YES]*

*Tables and Figures have **captions that explain** all their major features — [NO]*

*Tables and Figures have **captions that complement** the information in the main text — [YES]*

*Tables and Figures present data that **relate** to the study objective — [YES]*

*Tables and Figures present data that are **consistent** with and support the description of results — [YES]*

*Tables and Figures have **succinct and informative titles** — [YES]*

*Figures are **accessible** (elements are clearly labelled, accessible colour palettes, colour contrasts, font size legible, etc....) — [NO]*

*Please, check our [\[Figure guidelines\]](#)*

*Figures with **maps or cross-sections** contain all **elements to be understood** (north arrow orientation, scale, visible coordinates, sufficient coordinate grid intercepts) — [NO]*

*Figures with **maps** have **sufficient location information** (in the map or caption) — [NO]*

*Cross-sections have clear labels for **scale and coordinates** at ends and within-section kinks — [YES] / [NO]*

All georeferenced elements are provided in common format (.shp, .geotiff, .kml) [in an open-access repository] — [NO]

Citations throughout are relevant, suitable, and comprehensive — [YES]

**Comments:**

**Figure 1:**

- The main plot is very crowded. It could be improved by reducing the size of the white circles showing the seismicity to emphasize only the major earthquakes of the sequence. It would also allow to see the fault traces of the Dasth-e Bayaz and Abiz faults.
- The GPS uncertainty circles are sometimes in bold, sometimes not. Please homogenized.
- Indicate in the legend the time period for which the seismicity is plotted.
- The inset figure showing the map of Iran doesn't appear in the legend.

**Figure 2:** This figure is somewhat a mixture between a method, background and result figures that shows previously published rupture mapping, the new results of this study, and also the data coverage. More importantly, the figure is too small to effectively convey the work done by the authors as we don't clearly see the new surface rupture mapping. If it is possible, this figure would be better in landscape format.

Some of the labels are too small (e.g.the city names, coordinates) and hardly visible.

Another suggestion would be to add a subplot in figure 1 showing the long term fault trace of the area, the previously published rupture mapping of the DeB and KB ruptures and the data coverage. Showing the previous rupture mapping of the DeB and KB ruptures would really help to highlight the contribution of this study, in particular in the eastern part of the DeB rupture and for the KB rupture, as previous mapping for these parts lack of details.

**Figure 3:** Please reduce the thickness of the black rectangle in figure A, add a scale on figure B,C, and D. Also, either add coordinates in figure A or indicate the location of figure A on figure 2. Finally, indicate in the legend that the black rectangle locates figure B, C, D.

**Figure 4:** add coordinates to each subplot.

**Figure 5:** typo in the legend, “the east-west **displacements**”. I recommend to re-create Figure A and B using the data of Marchandon et al. 2018 available here: [https://drive.google.com/drive/folders/1dsY\\_-J5JUjvdlw8nH0CAJsn00HvnCzbr?usp=sharing](https://drive.google.com/drive/folders/1dsY_-J5JUjvdlw8nH0CAJsn00HvnCzbr?usp=sharing), so you can properly get rid of the white labeling. In figure B, the field mapping is from Nowroozi & Mohajer-Ashjai (1980), the citation should appear in the figure legend. Moreover, Nowroozi & Mohajer-Ashjai (1980) is not cited anywhere in this study although it is one of the

two published papers that provide a field investigation of the KB rupture. This work should be acknowledged.

**Figure 6:** add in the legend that the location of each subplot is indicated in figure 2.

**Figure 7:** In the legend "Colors and numbers are the same" Which numbers?

Previous published measurements are missing from this figure. Why don't you show also the offset measurements from Tchalenko and Berberian (1975) for the DeB earthquake and the offset measurements of Nowroozi & Mohajer-Ashjai (1980) for the Khuli-Buniabad rupture?

*Tchalenko, J. S., & Berberian, M. (1975). Dasht-e Bayaz fault, Iran: Earthquake and earlier related structures in bed rock. Geological Society of America Bulletin, 86(5), 703-709.*

## **B6.2) Author's responses**

Figure 1- Added a second panel just highlighting the faults. Corrected issues with circles weights.

Figure 2 – increased the size & rotated the figure to make it more readable.

Figure 3 – Unfortunately we're unable to modify the rectangle thickness. Added note to caption about inset location. Added coordinates & scale for BCD.

Figure 4- done

Figure 5 – we would like to incorporate the data but we are unsure how to open a .NC file in the google drive. Can you provide a jpg/png/tif raster image?

Added refs to Norwoози & Mohajer-Ashjai.

Figure 6 – done.

Figure 7 – caption corrected. DeB measurements from T&B 1975 are already shown as X's (these are duplicates of A&T 1969). The Nowroozi & Mohajer-Ashjai measurements for the 1979 earthquake are not readily georeferenced and would be difficult to include without substantial location uncertainty.

## **Section C: Additional comments**

### **C1) Minor/line-numbered comments**

#### **C1.1) Reviewer's comments**

##### **Introduction:**

- L83-85 "*In all of the above examples, the individual earthquake ruptures commonly terminated at or near fault complexities such as bends, branch points, discontinuities, or changes in frictional behavior*"

Please add citations **added (references above)**.

- L96-99 "We present the results of new mapping based on a declassified 1972 legacy KH-9 satellite image (D3C1203-100074A007, Earth Resources Observation and Science (ERoS) Center, 2018) and modern Bing satellite data of the three  $M > 7$  ruptures within the sequence that together ruptured the Dasht-e Bayaz fault in 1968 and 1979, and the 1997 rupture of the Zirkuh/Abiz fault." This is misleading as the authors do not present a new mapping for the Zirkuh earthquake.

**Removed reference to 1997 mapping from this section.**

#### **Tectonic Background:**

- L121-123 'The Dasht-e Bayaz fault, south of the Doruneh fault, is another of these left-lateral faults, with a slip-rate that is unknown'

There are at least two published papers that estimate slip rate at 2.5 mm/y for the DeB fault:

Fattahi, M., 2015. OSL dating of the Miam Qanat (KARIZ) system in NE Iran, *J. Archaeol. Sci.*, 59, 54–63.

Fattahi, M., Walker, R., Khatib, M.M., Zarrinkoub, M. & Talebian, M., 2015. Determination of slip-rate by optical dating of lake bed sediments from the Dasht-e-Bayaz fault, NE Iran, *Geochronometria*, 42, 148–157.

- L130 "with only small cumulative geological slips"

Please report the estimates with the associated citations.

**This is discussed in Walker et al. 2004 (page 16) but it is not clear the slip magnitude estimate, it is in rather vague terms. Leaving as is.**

- L157-161 "Based on a simple model of the orthogonal fault geometries, the left-lateral rupture of the 1979 Khuli-Buniabad event should have increased normal stresses on the orthogonal Abiz fault, reducing the likelihood of failure of the Abiz fault. However, paradoxically, the Abiz fault ruptured anyways with a  $M_w 7.2$  earthquake in 1997. "

Marchandon et al. (2021) model the Coulomb stress change during this sequence. They indeed show that Coulomb stress calculation assuming simplified fault geometries leads to negative interaction between the DeB and KB earthquakes with the Abiz fault (Figure S1 in Marchandon et al. (2021)). However, when realistic fault geometries are taken into account and, more importantly, when the moderate earthquakes are included in the modeling, a substantial part of the Abiz fault (including the area where the earthquake nucleated) shows positive Coulomb stress change. This shows that the moderate earthquakes that occurred near the Abiz-DeB intersection, played a crucial role in the triggering of the Zirkuh earthquake.

**Added reference to your work.**

- L163- 170: The contribution from previous studies that focus on the characterizat on of the DeB and KB surface ruptures should be more detailed. Beside, some studies are missing.

**Added ref to Nowroozi and Mohajer-Ashjai.**

**Method:**

- L175 "Successive earthquakes" Precise which ones.

Done

**Results:**

- L306 "*The left lateral slip measurements range from ~0.5-4 m (Figure 7), however from the satellite imagery there are nowhere measurable slips < ~1.5 m*" It is unclear what you mean. Do you mean that all the measurements < 1.5m are from Ambraseys and Tchalenko (1969)?

**Clarified**

- L315 "*our measurement threshold (~0.5m)*" It seems from the sentence L306 that your measurable threshold is rather 1.5m isn't it?

**Changed to 1.5m**

- L316 "*of of Marchandon et al. (2018)*". Typo, remove one "of"

Fixed

**Discussion:**

- L370 '(d)' Do you mean section D in figure 2 (and subplot D in figure 6)?
- Fixed**
- L384-386 "*It is unlikely that paleoseismology would distinguish the three events since the resolution of available dating methods is generally insufficient to differentiate prehistoric events over a 30 year timespan*" I guess paleoseismology would distinguish the DeB events from the Abiz event considering that these two faults are nearly orthogonal.

**Not necessarily as there are examples of conjugate faults rupturing in a single event.**

## **C1.2) Author's responses**

[Free form box]

## **C2) Other remarks**

## **C2.1) Reviewer's comments**

[Free form box]

## **C2.2) Author's responses**

[Free form box]

## Comments by Reviewer 2 and Authors' Response

### Section A: Overview of manuscript

#### A1) Overall evaluation, general comments & summary

##### A1.1) Reviewer's comments

###### A1.1.1 ) General evaluation and publication suggestion – Required:

*Please use this space to describe, in your own words, the core subject of the submission and your overall assessment of its suitability for publication.*

This manuscript is looking at a sequence of historic earthquakes along the Dasht-e Bayaz and adjacent faults. Two of these earthquakes occurred 11 years apart on opposite ends of the Dasht-e Bayaz fault and ruptured and then re-ruptured a restraining double bend in the central portion of the fault. The authors use satellite data and declassified satellite imagery from different years, as well as previous work, to map these different earthquake ruptures and outline areas of fault complexity. They find that the discontinuous nature of the surface rupture from these events would make future geologic interpretation of the earthquake sequence difficult, with researchers more likely to interpret the ruptures as one event, rather than two separate earthquakes. This has significant implications for seismic hazard models and paleoseismic interpretation, in particular. Additionally, they found that the double restraining bend acted as a “gate” allowing one rupture to propagate while causing another rupture to terminate.

###### A1.1.2 ) What does the submission need to be publishable? (select as needed; comment for all cases)

- No changes required
- Rewriting
- Reorganising
- More data/figures
- Condensing
- Reinterpretation
- Other

**Comments:**

There are some inconsistencies in the text that need to be addressed, as well as some points that should be clarified or removed. Additional figures would be helpful for assessing the validity of their interpretations and to improve the clarity of the results.

**A1.1.3) Can the submission be improved by reducing/adding any of the following?  
(select as needed; comment for all cases)**

- Text
- Table
- Figures
- Supplementary material

**Comments:**

In my opinion the discussions about the Abiz fault either need to be expanded upon or removed. As it currently stands that discussion adds complexity to the story without providing much clarity or additional insight.

While the authors included a note to reviewers that they would make the mapping available after the initial reviews, it's difficult to assess the validity of their offset data without that evidence.

**A1.1.4) Please complete the following section if you recommend that the submission is NOT appropriate for publication (select as needed; comment if a box is selected)**

- Quality is poor
- Research is not reproducible
- Other

**Comments:**

[Free form box]

**A1.2) Author(s) Responses:**

## A2) Summary of main merits and main points of improvement

### A2.1) Reviewer's comments

*Please describe below in a few sentences (100 to 300 words) the main merits of the submission and suggestions for improvements.*

#### The main merits I have found are...

The manuscript outlines a significant problem with current assessments of prehistoric earthquakes and adds valuable data to the discussion of earthquake sequences, fault segmentation mapping and paleoseismic interpretation.

#### The main points of improvement I have found are...

The manuscript could be strengthened with the addition of figures, clarifying some points of discussion and fixing some inconsistencies within the manuscript.

### A2.2) Author's responses:

[Free form box]

## Section B: Detailed evaluation of manuscript

### B1) Title and abstract

#### B1.1) Reviewer's comments

*These statements are a **guide** to what good Titles and Abstracts include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Title* describes the main topic of the manuscript **accurately** — [YES] / **[NO]**

The *Title* describes the main topic of the manuscript **succinctly** — [YES] / [NO]

The *Title* includes **appropriate key terms** — [YES] / [NO]

The *Abstract* includes a **clear aim and rationale** — **[YES]** / [NO]

The *Abstract* supports the rationale with **sufficient background information** — [YES] / [NO]

The *Abstract* includes a **well-balanced description of the methods** — [YES] / [NO]

The *Abstract* describes the **main results sufficiently and adequately** — [YES] / [NO]

The *Abstract* clearly describes the **importance/impact of the study** — [YES] / [NO]

The *Abstract* clearly states the **conclusions of the study** — [YES] / [NO]

The *Abstract* is **clear and well structured** — [YES] / [NO]

### **Comments:**

The manuscript discusses multiple complexities and discontinuities within the fault system (and the implications of these) and this is not reflected in the title.

## **B1.2) Author's responses**

[Free form box]

## **B2) Introduction**

### **B2.1) Reviewer's comments**

*These statements are a **guide** to what good Introductions include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Introduction* provides **sufficient background and context** for the study — [YES] / [NO]

The *Introduction* describes the **aim/hypothesis/rationale** clearly, providing **sufficient context** — [YES] / [NO]

The *objective/hypothesis/rationale* **flows logically from the background** information — [YES] / [NO]

The *Introduction* describes the study's **objective and approach** (last paragraph) — [YES] / [NO]

The *Introduction* contains **relevant, suitable citations** — [YES] / [NO]

The *Introduction* is **organized effectively** — [YES] / [NO]

**Comments:**

[Free form box]

**B2.2) Author's responses**

[Free form box]

**B3) Data and methods**

**B3.1) Reviewer's comments**

*These statements are a **guide** to what good Method sections include and good practices for Dataset accessibility. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Methods* are described **concisely and with enough detail** for reproducibility —  [YES] / [NO]

Necessary information about **data sources/acquisition/processing** is included — [YES] / [NO]

**Data used are accessible** via either supplementary files or links in the data availability statement — [YES] / [NO]

The *Dataset and/or Methods* are **organized effectively** —  [YES] / [NO]

**Comments:**

It is difficult to assess whether their methods, in particular the way they calculate uncertainty in lateral offsets and the quality of the piercing points used to determine these offsets, is reasonable without having access to the mapping / imagery. They have included a reviewers note that this will be made available after the initial review but as this is as critical piece of the findings I don't feel that I can adequately assess their methods without that data.

Additionally, there are potential inconsistencies in the reporting of uncertainties (Discussed in "Results").

## B3.2) Author's responses

Addressed the uncertainties in another section. We are providing the mapping with this revision. [Free form box]

## B4) Results

### B4.1) Reviewer's comments

These statements are a **guide** to what good Result sections include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.

The *Results* findings are **supported by data** — [YES] / [NO]

The *Results* findings are presented **clearly and succinctly** — [YES] / [NO]

The text in the *Result* section **cites tables and figures appropriately** — [YES] / [NO]

The *Results* directly **relate to the study objectives** — [YES] / [NO]

The *Results* present **data for all the approaches** described in the *Methods* section — [YES] / [NO]

The *Results* **text belongs to the Results section**, not to *Introduction*, *Methods*, or *Discussion*. — [YES] / [NO]

The *Results* section is **organised effectively** — [YES] / [NO]

### Comments:

There are potential issues with uncertainties. Line 314 says the measurement threshold is ~0.5m but line 193 says that the uncertainty of lateral measurements is the pixel size of the imagery, or ~0.6m. Overall a more thorough discussion of the uncertainties would be helpful.

I may be misunderstanding the intent of the statement in line 305 ("from the satellite imagery no where are there slips < ~1.5 m") but it seems that the resolution limit of the data is closer to 1.5 m given that there are no measurable slips < 1.5 found in the satellite data but they were found in the ground-based mapping (albeit over a limited area). Do you expect that lack of lateral offsets in the satellite data reflect a true lack of offsets of that size or is it a resolution issue?

I'm not sure that the Abiz fault and rupture are an important part of this story beyond basic context (specifically line 292-301 and parts of the intro). If the authors feel that this an

important piece there should be more detail, if possible, about the interaction between the two faults systems.

## B4.2) Author's responses

**We added text to clarify in the methods on this topic. The data resolution / measurement *uncertainty* is 0.6. The minimum measurement threshold is ~2.5 pixels (~1.5 m) (this is the amount of displacement required for us to identify it. These are 2 different (but related) criteria. We also added a statement clarifying that this is from satellite data – the field mapping shows smaller measurements.**

**We have downplayed the Abiz rupture.**

## B5) Discussion and conclusions

### B5.1) Reviewer's comments

*These statements are a **guide** to what good Discussions and Conclusions include. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

The *Discussion* is **focused on the objectives** of the study —  [YES] / [NO]

The *Discussion* **addresses all major results** of this study, which are shown in *Results* —  [YES] / [NO]

The *Discussion* section makes **comparisons with other studies** that are relevant and informative — [YES] / [NO]

The *Discussion* section properly identifies all **speculative statements** — [YES] / [NO]

The *Discussion* section presents the **implications of the study** persuasively — [YES] / [NO]

The *Discussion* section **highlights novel contributions** appropriately — [YES] / [NO]

The *Discussion* section **addresses the limitations** of the study appropriately — [YES] / [NO]

The *Discussion* section is **organised effectively** — [YES] / [NO]

The *Conclusions* are **consistent** with and **summarise** the rest of the manuscript — [YES] / [NO]

The *Conclusions* are **supported by the data** in *Results* and **follow logically** from the *Discussion* — [YES] / [NO]

The *Conclusions* are **clear and concise** — [YES] / [NO]

**Comments:**

This is the strongest part of the manuscript. It is well-written and clearly outlines the findings and importance of the study and its value to the scientific community.

**B5.2) Author's responses**

[Free form box]

**B6) Figures, tables and citations**

**B6.1) Reviewer's comments**

*These statements are a **guide** to what good Figures and Tables include and how they are presented. Please select YES or NO to the statements below if you wish and detail in the free form box below your reasons for any box checked with NO, or to comment on any other matter.*

*Tables and Figures are **ordered logically** and **numbered sequentially** — [YES] / [NO]*

*Tables and Figures have **captions that explain** all their major features — [YES] / [NO]*

*Tables and Figures have **captions that complement** the information in the main text — [YES] / [NO]*

*Tables and Figures present data that **relate** to the study objective — [YES] / [NO]*

*Tables and Figures present data that are **consistent** with and support the description of results — [YES] / [NO]*

*Tables and Figures have **succinct and informative titles** — [YES] / [NO]*

*Figures are **accessible** (elements are clearly labelled, accessible colour palettes, colour contrasts, font size legible, etc....) — [YES] / [NO]*

*Please, check our [\[Figure guidelines\]](#)*

*Figures with **maps or cross-sections** contain all **elements to be understood** (north arrow orientation, scale, visible coordinates, sufficient coordinate grid intercepts) — [YES] / [NO]*

*Figures with **maps** have **sufficient location information** (in the map or caption) — [YES] / [NO]*

*Cross-sections* have clear labels for **scale and coordinates** at ends and within-section kinks — [YES] / [NO]

All georeferenced elements are provided in common format (.shp, .geotiff, .kml) [in an open-access repository] — [YES] / [NO]

*Citations* throughout are relevant, suitable, and comprehensive — [YES] / [NO]

**Comments:**

The text cites figures appropriately, but additional figures at an appropriate scale would be helpful for demonstrating the findings. For instance, the Results section often refers to Figure 2, but the scale of this figure is not sufficient to see the features mentioned. It would be useful to have additional figures showing the satellite imagery at a scale where these features could be resolved. For example, a figure for each of the letters mentioned that shows not only the mapping (which is shown in Figure 6) but the mapping overlaid on the satellite imagery, or even the satellite imagery alone. Again, not having the mapping data makes it difficult to follow and assess this study.

Figure 1 – The line weights on some of the GPS velocity arrows and error ellipses are difficult to see. If the different line weights are meaningful, please explain what that means in the caption. If not, please ensure all line weights are equal (and visible).

**Corrected line weights.**

Figure 2. It is somewhat unclear to me (although I could have missed a critical detail, for sure) how the mapping of the Abiz can be attributed to the 1997 rupture. As geomorphic features can persist for long time periods in this environment how can you differentiate the 1997 rupture and the 1979 rupture? I keep getting distracted by this fault system and I'm not sure that it actually adds much to the overall story.

**We downplayed Abiz in the revised text. This distinction is based on insar/late image correlations.**

Figure 3B. Are the blue lines your digitized traces of the previous mapping? They don't seem to align very well with the features in the image.

***This is a result of 2 factors. 1: this digitization, georeferencing, and mapping was done as part of a senior thesis. 2: the overlapping air photos, while georeferenced, are not perfectly orthorectified so from photo to photo they do not line up perfectly. The photo used for the figure is probably not the photo that was used for the mapping.***

Figure 4. Where is this? The locations shown here need to be clearly marked on a map.

**Coordinates added & locations now marked on Fig 2.**

Figure 5B. I know that this is a reproduction but there needs to be a mention of what Pleiades image mapping is, just for clarity.

**Added clarification to caption stating ‘Pleiades Satellite Imagery’.**

## **B6.2) Author’s responses**

*There are a number of logistical issues that preclude us from addressing every figure comment. We do not feel that these significantly impact the paper, though this outcome is less than desired.*

- 1) *This project has been handed down from person to person for about 7 years. Much of the original georeferencing and linework (particularly of the 1968 AT linework) was conducted as part of a senior thesis. As such there are some minor errors with the georeferencing and digitization.*
- 2) *The lead authors are no longer affiliated with Oxford University and no longer have access to the software / data needed. Neither Pierce nor Elliott can access Bing imagery through a GIS environment as their US government GIS licenses do not allow this.*
- 3) *The transition from ArcMap to ArcGIS Pro means that many of the original figure files can no longer be modified.*

## **Section C: Additional comments**

### **C1) Minor/line-numbered comments**

#### **C1.1) Reviewer’s comments**

Line 80-81 – “unruptured faults” is unclear phrasing. Suggest rewriting to clarify that you don’t mean inactive faults.

**Fixed**

Line 84-85 – “Changes in frictional behaviour” doesn’t seem to fit with the other examples.

**It only fits as it is a factor influencing rupture behavior, leaving as is.**

Line 266 – May be a word missing – there is only “s”

**Fixed**

Line 305 – “are nowhere measurable” is strange phrasing. Perhaps change to “there are no measurable” are something similar.

**Fixed**

Line 357 – Where exactly did the 1979 rupture terminate?

**Added reference to Fig 7.**

Line 391-394 – YES! THIS!

#### **C1.2) Author’s responses**

[Free form box]

## **C2) Other remarks**

### **C2.1) Reviewer's comments**

[Free form box]

### **C2.2) Author's responses**

[Free form box]

## 2<sup>nd</sup> Round of Revisions

### Decision Letter

Dear Ian and co-authors,

We have now received two new reviews on your revised manuscript. Both reviewers think you have improved the manuscript a lot, but that it needs a final moderate revision round before we can consider accepting it. You'll find below Adam's recommendation (as the Associate Editor managing the review process) and the comments by the two reviewers. Reviewer 2 (S. Bello) has also commented directly on your manuscript's file. You'll find the relevant file on the online record of your submission.

However, one important point raised via email by one of your co-authors, Austin Elliott, is that the manuscript didn't get USGS approval. Austin is working to obtain it, but your manuscript cannot be accepted until the USGS internal review is completed and any changes required by that review are also addressed. We will therefore suspend our final decision until the USGS decision has been issued (and any changes requested by the USGS is implemented and accepted by us).

Best regards

Robin Lacassin  
Adam Forte

## Comments by Associate Editor

Both reviewers found the revised version close to be ready for publication but they have made relatively minor suggestions for improvements. Of note, Reviewer 1 was one of the original reviewers and noted that several suggestions from the first round of review were not necessarily addressed, but that they still found the revised version acceptable.

Reviewer 2 has some good suggestions for clarifying individual figures that I think would improve the manuscript before acceptance. Reviewer 2 also suggests expanding the applicability of the manuscript by considering implications for other fault types. Personally, I feel that earthquake histories on strike-slip fault systems such as there are likely interesting enough on their own that I'm not sure this is explicitly necessary, but it is not a bad suggestion to consider. I do encourage the authors to touch on some of the broader implications that they include in their discussion also in their conclusion. As it stands, the conclusion is quite brief and really doesn't necessarily give readers much of a sense of the interesting aspects of their results that are transportable beyond regional workers (e.g., the extent to which sequences of ruptures like this would be distinguishable as individual events in the paleoseismic record).

As stated above, I am suggesting to send the paper back to the authors for minor revisions, i.e., address the figure suggestions from Reviewer 2, update the supplementary information as requested by Reviewer 1, and consider a little strengthening / expansion of the discussion (as suggested by Reviewer 2) and/or the conclusion (as suggested by me). I do not anticipate that this would need to go out for review again, but the paper needs a little more polish before acceptance.

## Comments by Reviewer 1

Although some comments have not been taken into account, I find the paper improved compared to the first version. I appreciate the efforts made by the authors to improve the figures and clarify the methodology.

I have only two comments:

- I would suggest to rename the shapefile called 'Fault.shp' in the Zenodo repository with a name that reflects what is in the file (e.g. rupture\_DEB\_Ambraseys\_Tchalenko\_1969.shp) or add a README file.
- It seems the new fault offset measurements presented in Figure 7 are not in the Zenodo repository. It would be great to make them available for the community, as you did for the rupture mapping.

PS: I added the .tif files for the Khuli-Boniabad displacement field in the google drive: [https://drive.google.com/drive/folders/1dsY\\_-J5JUjvdlw8nH0CAJsn00HvnCzbr?usp=drive\\_link](https://drive.google.com/drive/folders/1dsY_-J5JUjvdlw8nH0CAJsn00HvnCzbr?usp=drive_link)

## Comments by Reviewer 2

Dear Authors,

I have reviewed your paper with pleasure and consider it suitable for publication after addressing some errors/typos/minor suggestions, which I have noted in the attached file.

As a general comment, I would recommend providing a bit more space for broader considerations and the implications of your study, particularly in terms of applicability and comparison with other regions of the world. Many of the points you highlight are also relevant to faults with different kinematics, such as normal faults. Including a brief paragraph discussing this could provide a broader perspective to your manuscript.

This is just a suggestion. Congratulations on your work, and best of luck.

Simone Bello

## Authors' Response to Editorial and Reviewers' Comments

Thank you so much for the detailed reviews of our manuscript. We apologize for the very long time it took to revise and resubmit this manuscript. The lead author (Ian) has changed jobs to a non-academic position & moved country since the original submission. We have addressed all of the comments in the reviewer response documents, but want to emphasize two issues we are not able to fully address (these below comments are copied from those documents). We have also added the mapping files to a repository, now linked in the revised draft. Our comments in the review response document are in bold. We incorporated most of the reviewers' feedback, and of those we did not, provided justification for these decisions.

Regarding the figures:

1. The quality of the figures is a direct result of the quality of the data. It is not ideal and this was a desktop-based study using available satellite imagery. We try to downplay the emphasis on the visualization of these data and focus on the geometric takeaways we can get from this earthquake rupture pattern. We feel that these are still valuable contributions.

1. B) There are a number of logistical issues that preclude us from addressing every figure comment. We did address as many as we were able. We do not feel that these significantly impact the paper, though this outcome is less than desired.

- 1) This project has been handed down from person to person for about 7 years. Much of the original georeferencing and linework (particularly of the 1968 AT linework) was conducted as part of a senior thesis. As such there are some minor errors with the georeferencing and digitization.

- 2) The lead authors are no longer affiliated with Oxford University and no longer have access to the software / data needed. Neither Pierce nor Elliott can access Bing imagery through a GIS environment as their US government GIS licenses do not allow this.

- 3) The transition from ArcMap to ArcGIS Pro means that many of the original figure files can no longer be modified.

We have provided a clean & tracked changes versions of the manuscript, as well as review response documents with our treatment of comments in bold.

Thank you again,  
-Ian Pierce & coauthors.

## Acceptance Letter

### Decision Letter

Dear Ian Pierce,

We have reached a decision regarding your submission to tektonika, "Satellite mapping of fault rupture from the 1968 and 1979 Dasht-e Bayaz and Khuli-Buniabad earthquakes, northeast Iran: evidence of rupture arrest and re-rupture in successive earthquakes."

Our decision is to: Accept Submission

You will soon be contacted by our technical team.

Thanks for submitting to Tektonika,

Robin Lacassin, executive editor

Adam Forte, associate editor

## Authors' Response to Editorial Comments

Dear Robin & Adam,

We have accepted nearly all of the requested changes by both reviewers in the second revision and corrected all of the figures as requested. We have also added two lines to the conclusion following on Adam's suggestion. We hope this version will be publishable and thank you again for the patience and assistance in this process.

I left off one comment - Matthilde requested the slip distribution be uploaded - it is in the e-supp/attached to this submission. I have clarified this in the data availability statement.