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Solid Earth
Discussions

Interactive comment on "From widespread Mississippian to localized Pennsylvanian extension in central Spitsbergen, Svalbard" *by* Jean-Baptiste P. Koehl and Jhon M. Munoz-Barrera

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In their SED paper Koehl and Munoz-Barrera present a study on the structural evolution of central Spitsbergen, Svalbard. In particular, they present new geological field evidence in addition to the analysis of satellite data from the Billefjorden Trough, in Odellfjellet (Austfjorden). The main finding of the work appears to be that the Mississippian sediments of the Billefjorden Group were deposited during active Mississippian extension. Moreover, this deformation is claimed to have been controlled by pre-existing geological structures, a theme addressed in a number of recent SE and SED contributions (Perron et al., 2018; Phillips et al., 2018). SE therefore seems like

an appropriate choice for this work. In addition, I consider this type of field-based study, documenting processes such as reactivation, useful to 'ground truth' and provide analogues for studies interpreting similar processes, which typically use seismic reflection data.

Overall, I think that the work detailed is worthwhile, generally well written and presented. The figures are mostly of good quality and relevant to the manuscript text. My main comments on the manuscript are outlined below, followed by more specific minor suggestions. If the comments outlined can be sufficiently addressed then I would like to recommend publication in SE.

1) Wider implications of the study and comparison to other regions

The authors present an exceptionally detailed examination of geological field observations, complemented by satellite data from a relatively small, isolated region. Although the approach and topic of the manuscript seem reasonable, I found that the relevance of the study, beyond that of the local geology, was not sufficiently outlined either in the introductory sections or later in the discussion. This is not to say that the work does not have such implications but that they are not currently described adequately. As such, I think this is probably a moderately easy, yet worthwhile, aspect to resolve as the study clearly has broader implications that would increase the appeal and usefulness to a wider group.

2) Analysis of satellite imagery

The figures showing the satellite data evidently bring a lot to the study in terms of extrapolating the field-based observations to infer more regional processes, and will no doubt be useful for addressing the point outlined above. However, minimal specifics regarding the satellite data (e.g., resolution or age) are provided in the methods section. For example, does all the data presented have the same specifications? In addition, no details are provided regarding the type of analysis or criteria used to interpret features on this data. Related to the latter point, I felt that better use of the satellite data

could have been made by explicitly tying individual features identified in the field-based studies to specific features on the satellite data. If this type of ground truth investigation was undertaken it should be outlined more explicitly in the manuscript. Currently, I think that the lack of the information described in this point partially undermines the findings that are derived from this analysis. As such, I suggest expanding upon these aspects in the relevant sections, but particularly in the methods section.

3) Description of the deformation - fault rock types

The paper adequately describes the orientation and distribution of deformation sufficiently, both in the outcrop observations and also on the satellite data. However, the nature and categorisation of fault rocks could be better described. This is especially important in reactivation studies as the nature of fault rocks is an important line of evidence to evaluate such aspects. As such, I suggest attempting to better categorise the fault rocks, potentially using a scheme such as those outlined in Killick (2003) or Woodcock and Mort (2008).

4) Referencing

The reference list seems up to date and extensive. However, it currently contains three 'submitted' papers, in addition to an 'unpublished' internal report. I appreciate that much of this aspect is beyond the control of the authors. However, I was wondering if it is possible to cite some published work alongside these, perhaps even conference abstracts? For example, the EGU abstract Koehl et al. (2016) appears to address some of the themes in the present study. In addition, if the internal report can be made available online this would be beneficial. Hopefully during the time taken to review and revise the present paper some of the submitted papers will be accepted to alleviate this issue.

In addition to the more substantial points outlined above the following aspects should also be addressed when revising the manuscript:

Abstract – Currently the abstract is quite long and the scientific aims are not easily discernible. Perhaps the abstract can be restricted to the more salient points to assist with this.

Line 13 – 'central Spitsbergen'. For readers not familiar with the geography of Svalbard it might be helpful to say where this is e.g., offshore Northern Norway.

Lines 27-29 – What are the terms in quotes taken from and are they necessary?

Lines 35-39 – The last sentence of the abstract is currently very long. I suggest breaking this into smaller sentences to make it more poignant and easier to follow. This may assist with addressing the point above on the abstract length generally.

Line 36 – 'mildly reactivated'. In my opinion this phrase is ambiguous as it is not clear what would entail 'mild' reactivation compared to an event that could be considered more extensive reactivation. I therefore suggest rewording this in addition to the variants of it that appear throughout the manuscript such as 'partially reactivated' (line 666) and other occurrences (lines 292, 298, 317 and 658). With respect to 'partially reactivated' this is particularly ambiguous as it is unclear whether this is referring to selective structures being reactivated or whether the magnitude of reactivated fault movement is minimal. Please clarify appropriately.

Lines 48-51 – I suggest referring to the location map (Figure 1).

Geological setting – This section is particularly very well written, with the information mostly confined to only the most relevant points, whilst also being generally well organised. However, the authors may want to consider numbering the sections to make this part of the manuscript easier to follow.

Line 145 – This sentence is currently a bit awkward to read. I suggest rewording.

Line 160 – 'Fourth and fifth'. This approach to denoting the points in this paragraph is difficult to follow. I suggest changing it.

Line 166 – Are the phrases in quotes directly from the reference in this sentence? This is currently not clear in the manuscript.

Line 176 – 'thick Pennsylvanian sedimentary strata'. If possible state the thickness of these sediments.

Line 207 – Suggest removing the word 'these' to make the sentence flow better.

Lines 208-209 – It is not clear whether the observations are from this study or those referenced in the sentence. This should be clarified. If both this present study and the previous work make the same observation this should be made clearer.

Line 242 – Consider replacing 'there' with 'here'.

Line 245 – 'the hereby described grey sandstone'. This phrase is quite awkward to read. I suggest rewording.

Line 250 – Suggest removing the word 'rather' to make the sentence flow better.

Lines 267-268 – 'we propose that the hereby-described red-bed sedimentary succession is part of the Hultberget Formation'. The readability of this sentence could be improved. I suggest something like: 'we propose that the red-bed sedimentary succession described herein is part of the Hultberget Formation'.

Line 275 – 'non-cohesive fault-rock'. In line with the second major point outlined above I suggest better characterising this the fault rock.

Line 285 – 'high angle'. If possible, I suggest stating how steep the 'high angle' fault is.

Line 287 – 'cataclasite'. Here, terminology related to fault rocks is used. I suggest doing this elsewhere in the manuscript.

Line 292 – 'during Cenozoic transpression'. When reading the manuscript I did not feel that the evidence leading to this interpretation was adequately provided. Specifically, what is the time constraint leading to this interpretation?

Line 315 – 'is made of'. Consider replacing with 'comprises' to help the sentence flow better.

Lines 349-350 – 'are believed to have been eroded or never deposited'. It is not clear if this is a finding of this study or previous work. I suggest clarifying.

Lines 359-360 – 'which we interpreted as steep brittle faults'. This is an example of the ambiguity outlined in 3rd main point above. In particular, was any attempt made to directly tie the interpretation of the satellite data to actual field observations such as this? If so I suggest stating it more clearly here and elsewhere in the manuscript.

Line 367 – 'dolerite dykes'. Has an age of these dykes been obtained? If so it would be helpful to state it here.

Lines 437-432 – In these opening sentences of the section numerous lines of evidence 'in favour of Mississippian syn-sedimentary extensional brittle faulting' are presented as one very long sentence. It is therefore quite difficult to follow due to the large amount of information contained, and I suggest either numbering the lines of evidence or separating this into multiple sentences.

Line 520 – 'c.' not 'ca.' when not referring to ages or times.

Line 521 – As previous.

Lines 625-665 – The conclusions section contains many long sentences, with each concluding point comprising one such statement. I suggest shortening the sentences to make the conclusions easier to read and more poignant.

Line 631 – Add 's' after 'suggest'.

Line 634 – 'of the Hultberget Formation, thus suggesting'. I suggest breaking this long sentence into two smaller ones by concluding the first after 'Formation' and replacing 'thus' with 'This'. If this is accepted, then 'suggesting' needs to change to 'suggests' in the second statement.

Line 656 – This sentence is incomplete and ends at the word ‘which’.

Line 663 – ‘gently dipping’. Is it possible to state which way they are dipping?

Line 838 – ‘Geochemistry’ is spelt incorrectly.

Figure 1A – Scale is missing.

Figure 1B – The white areas on the map are not on the key.

Figure 2 – The green and brown colours on the stratigraphic column do not appear on the key.

Figure 3 – Although the caption states ‘The photographs are approximately one kilometer wide’ I think more accurate measurement of the scale of the images is required as they are clearly not all the same dimensions.

Figure 4 – The dip markers on the figure are quite problematic to see and on the key a white line in a black box is shown (fault core boundary). However, this does not appear on the figure.

Figure 5 – the field photographs require scale and orientation.

Figure 6 – This figure contains two types of yellow line. Are these showing different features? If so this is not clear in the figure. Also the statement in the caption that ‘The outcrop is approximately 10–15 m wide’ is a bit ambiguous as it is not entirely clear which parts of the field photo are considered ‘outcrop’.

Figure 7A – The lines marked on here are extremely thin and unlikely to be easily visible at publication scale.

Figure 7A-C – Scales needed.

Figure 8 – Scales and orientation need to be provided for all subfigures.

Figure 9 – Same as previous comment.

Figure 10 caption – ‘c.’ not ‘ca.’ when not referring to ages or times.

Figure 11 – The text on the figure is very small and unlikely to be easily visible at publication scale.

References

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