

**Response to review comments for the paper titled: "Multiscalar 3D characterisation of the Mid-Norwegian passive margin evolution, Central Norway: A multi-technique approach to unravelling the structural characteristics and tectonic history of offshore basement highs"**

Referee 1) Dr Petroccia Alessandro; Citation: <https://doi.org/10.5194/egusphere-2023-2504-RC1>

Dear Dr Petroccia,

We wish to extend our sincere gratitude for your thorough review and insightful comments on our manuscript entitled "Multiscalar 3D characterisation of the Mid-Norwegian passive margin evolution, Central Norway: A multi-technique approach to unravelling the structural characteristics and tectonic history of offshore basement highs."

We appreciate the time and effort that you have contributed to our manuscript, and the constructive feedback will be invaluable in improving the quality of the work overall. We have thoroughly considered each of your points below and present our responses and revisions.

**General comments (summarised):**

1. Simplify Sentences: The manuscript's sentences are excessively verbose, making it challenging to follow. Adopting a more succinct writing style would enhance clarity and understanding.
2. Abstract Length and Content: The abstract is lengthy and resembles an introduction rather than summarising the study's quantitative results. It is advised to present the main findings concisely rather than providing extensive background information.
3. Abbreviations: The excessive use of abbreviations in both the text and figures leads to confusion. Improved explanation of abbreviations or inclusion of a table listing their meanings is recommended.
4. Figure Organisation: Figures are cited in the text without following a numerical order, leading to inconsistency. It is suggested to either cite them progressively or rearrange the figure order for better coherence.

**General responses and revisions made to manuscript:**

1. We appreciate the suggestions regarding a more succinct and less verbose text. Revisions to the text have involved simplifying the descriptions and characterisations where possible, to aid clarity and understanding. Furthermore, sentences including more than one key point, have been separated where possible.

2. The Abstract has been reduced in length, with a focus on the results and interpretations of the study. To provide some introduction into the study, only a minimal inclusion of both the geological background and motivations of the study has been maintained.
3. We acknowledge the use of abbreviations in both the text and figures does lead to some confusion. We have tried our best to ensure all abbreviations are explained in the body of text and the figure captions. We understand that a table of abbreviations explanations would be helpful, but we feel the abbreviations are sufficiently explained now in the revised manuscript that a table would be redundant.
4. We agree that the figure numbers, as cited in the text, did not always follow sequentially. We have revised the manuscript now to limit this issue, and to ensure that the figures correspond properly in the text.

### **Annotated comments within the text:**

The referee comments within the manuscript are included below with the page number and line number of the original annotated manuscript. Below each referee comment, we provide our response, and our change(s) made within the new revised manuscript.

### **Abstract**

Page 1, line 10: sentence very long and wordy

Response: We agree that the abstract is too long and wordy. We have now amended the abstract to focus on the results, with minimal information regarding the motivation and geological background of the study.

### **Introduction**

Page 2, line 33: In this section, a lot of sentences are very long and wordy. Please make them shorter with a direct message

Response: We agree many of the sentences can be shortened and improved. We have rewritten and shortened the sentences through the introduction.

Page 2, line 35: Please explain the concept better

Response: The basement highs offshore Norway are typically buried under younger sedimentary rocks, and below the Norwegian Sea. This makes them inaccessible. We have amended to the text to highlight the difficulty of accessing them in deep oceanic waters and beneath younger sedimentary cover.

Page 2, line 34: Text removed

Response: The text has been rewritten due to the above comment, but we do not agree with this deletion. This sentence is in contrast against/a modifier of the previous sentence, so it needs a “however”.

Page 2, line 51: why inside the quote?

Response: The single quotation marks signify the word “gap” is being used as a term. This is unnecessary, so we have amended the text to remove the singular quotation marks.

Page 2, line 51: provide a definition of this word with relative references

Response: We have clarified the term with a relevant reference and changed the text to “connected natural fractures and faults hosted within basement volumes (intrabasement structures) in an offshore context (Holdsworth et al., 2019).”

Page 2, line 52: offshore structures

Response: We agree and have updated the text to the suggested.

Page 2, line 53: wordy and hard to follow. please rephrase

Response, we accept the suggestion, and have rewritten the text to a shorter sentence: “Consequently, characterising sub-seismic to regional-scale structures, and their potentially long-lived tectonic evolution, requires more than just low resolution datasets.”

Page 2, line 56: could you provide any examples?

Response, we accept the suggestion and have amended the text to provide some examples.

Page 3, line 63: is this part of the sentence necessary?

Response: We agree and have removed the text.

Page 3, line 70: this is valid for the overall main text, if not necessary of fundamental, try to avoid words like novel, new... etc

Response: We agree and have rewritten this section of the Introduction.

Page 3, line 70: also this one is valid for the overall text, homogenize the use of "-"

Response: We agree, this portion of text has been removed from the introduction.

Page 3, line 75: why the "-" after geological?

Response: We agree, this portion of text has been removed from the introduction.

Page 3, line 76: strange word

Response: We disagree, as the oriented drill holes do indeed offer a relatively unprecedented 3D view of the Smola geology. This has not been previously available. However, this portion of text has been removed from the introduction.

Page 3, line 80: Text removed

Response: We agree, and the text has been removed.

### **Geological framework**

Page 4, line 104: there is an extra space after the bracket

Response: Well noted, and the text has been removed.

Page 5, line 120, Figure 1: the black continue lines are not explained in the legend

Response: We agree, and we have amended the legend of Figure 1A to reflect the symbology of the black lines (major structures).

### **The applied toolbox**

Page 7, line 172: document or material?

Response: we agree and have amended the text to “material”.

Page 7, line 178: what does it mean?

Response: we agree this is too vague, so we have amended the text to “standard geological field methods”.

Page 7, line 180: total,

Response: we agree and have changed the text to the suggested.

Page 7, line 180: collected data?

Response: Data is indeed collected through measurement and observation. We have not amended the text.

Page 7, line 184: you jump from figure 3 up to 8

Response: We have updated the text to also include the mention of the 3D modelling, which provides an intermediate figure. The K-Ar sample figure is however much further through the manuscript, so a ‘jump’ in figure numbers is unavoidable.

### **Results**

Page 8, line 194: how can you trace it? from the DEM?

Response: The onshore lineaments involved a combination of DTM and aeromagnetic data, while the offshore data exclusively used aeromagnetic data. We have amended the text to make this more clear for the reader.

Page 9, line 206, Figure 2: the dashed line is not explained in the legend. I suggest making the colour with higher transparency, so that the different fracture systems would be more visible (the same transparency of the zoom)

Response: We agree with this suggestion, however we have removed the dashed line, which along with the area labels A – F, make this figure item easier to understand. We have adjusted the transparency of the offshore areas to make it easier to distinguish the on and offshore areas. The overall Figure 2A map has also been enlarged to help make the lineaments more visible.

Page 9, line 206, Figure 2: which contour calculation did you use? krikig?

Response: The geophysical imagery was processed using standard gridding (minimum curvature) and levelling methods of the Geosoft Oasis montaj (Geosoft, 2010). A full description of the geophysical data processing and merging methodology is available in (Nasuti et al., 2015). As these details are out of the scope of this manuscript, we have not amended the text, and refer the reader to the supplementary material.

Page 9, line 206, Figure 2: the differences between 2-3 order is hard to distinguish in the figure

Response: We agree, and we have made the trace lines on Figure 2A thicker for the 1<sup>st</sup> and 2<sup>nd</sup> order lineaments, so they can be more differentiated from the 3<sup>rd</sup> order lineaments.

Page 10, line 223: ?

Response: “Abut” means to terminate against something. To avoid any confusion, we have changed the use of “abut” to “terminate” in the text.

Page 11, line 258: homogenize, use always or Figure or Fig.

Response: We agree, and have decided to use “Figure”, and have removed the use of “Fig.” in the text.

Page 11, line 258: Text removed

Response: text rewritten to “a novel 3D perspective on Smøla's geology”.

Page 11, line 260: Text removed

Response: We agree, and the text has been removed.

Page 12, line 282: epidote or episode? please explain. Clc according to what mineral abbreviation guide?? Please use the conventional way for minerals, like Warr, 2023

Response: Thank you for the suggestion, “epi” should be “Ep”, and “clc” should be “Cal”. We are using the mineral abbreviations after Siivola & Schmid (2007). We have amended the text to ensure all mineral abbreviations are standardised.

Page 13, line 290, Figure 4: explain bk

Response: The abbreviation “bk” is already described in the caption for the figure. The use of “bk” is with “Chl (bk)” for black chlorite. No changes have been made to the text.

Page 15, line 331, Figure 5: what is frg?

Response: This is an abbreviation for “fragment”. We have amended the text of the caption and included an explanation of the abbreviation as “Reworked host rock fragments (frg)”.

Page 15, line 332: As a suggestion, the letter of the figure (A...) are very large and heavy to see. Also, if it is not necessary, please make the photos clearer, with less lines. Can you provide a better photo of FIGURE E? It is not so clear as a ECC

Response: We can accommodate this suggestion. We have decreased the size of the letter labels and decreased the number of lines on the sub-figure (E). The photomicrograph is the best that is available for this microstructure. The microstructure is clearly a ECC texture, with the C` planes inclined to a primary slip plane (white line), reworking an older S fabric.

Page 15, line 337: All abbreviations should be explained the first time they appear in the text

Response: We agree, and the caption for the microstructures figure (now Figure 6) has been updated to explain this abbreviation.

Page 16, line 357: reference

Response: We agree and have inserted the following reference: “(e.g. Passchier & Trouw, 2005)”.

Page 16, line 361: decorated seem to not be a scientific geological word

Response: We disagree, this term is in used to describe mineral coatings on the bounding fracture and vein surfaces (e.g. Scheiber & Viola, 2018; Viola et al., 2016). We have not changed the text.

Page 17, line 382: maybe its better to explain abbreviations before in the manuscript. Also a table with all the used abbreviations could be useful

Response: We appreciate this suggestion. The Figure 6 in the reviewed manuscript has now been moved earlier in the manuscript (now Figure 3), with the mineral abbreviations now being explained before the results of the field and drill hole mineral/deformation feature observations.

Page 19, line 439: jumped from figure 7 to 10. Please check the figure order and how you cite them in the text

Response: We agree that this is an issue. This section of the manuscript is actually misplaced (belongs to the 3D modelling section). The amended manuscript does not have this same figure number jump.

### **K-Ar geochronology and X-ray diffraction**

Page 20, line 472: here you can use wt% since you have already explained the abbreviation in line 470

Response: We agree, however this text has now been removed.

Page 24, line 513, Table 4: Mus Capitalize the first letter of the abbreviations

Response: We agree, however this table has now been removed, with a pie chart figure describing the XRD results for the K-Ar samples. The abbreviation for muscovite, has the first letter capitalised as "Mus".

We would like to extend our gratitude once again to Dr. Petroccia for his invaluable contributions to the improvement of our manuscript. Your thoughtful suggestions have been carefully considered, and where possible, we have made corresponding revisions to enhance the clarity and robustness of our work. We are confident that these adjustments will strengthen the overall quality of the manuscript.

Yours sincerely,

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