

Authors response on comments from anonymous Referee #2:

The authors would like to thank both anonymous referees for their comments and suggestions. We would like to comment on them point by point as recommended. Additionally, we would like to give a general outlook on the changes, which were implemented in the revised version of the manuscript.

General comment:

However, the motivation and resulting implications of their exhaustive characterizations are not at all clear from the abstract, introduction or discussion. Presumably, they chose to focus on these rocks because they can be reservoir rocks. If this is the central motivation, then the abstract should state this point, and the discussion should describe how their analyses inform the potential productivity of these lower Cretaceous sandstones.... I recommend changing the organization of the paper to focus on conclusions #6-8, and keeping only the highlights from conclusions #1-5 in the main text. If as the abstract states, "core part of the study is the investigation of macroscopic permeability, upscaled from porescale velocity field" then the bulk of the main text should focus on presenting these results, rather than describing the potential depositional environment of each sample, for example. Determining appropriate representative elemental volumes, and how to upscale porosity and permeability measurements in the lab to crustal scales are important questions that should be explored in more depth here.

The comparing the significant contributions of this work to previous studies on sandstone reservoirs would also help this paper have relevance.

Authors' statement:

The main goal of the paper is to provide a comprehensive and multi-methodological petrographical and petrophysical case study on these particular Lower Cretaceous sandstones from the north of Israel as a fundamental base for future works. This goal is now stated explicitly in the abstract and in the introduction.

However, there is no statement in the manuscript that the present study is being about reservoir rocks. Thus, the suggestion of Referee 2 ("Presumably, they chose to focus on these rocks because they can be reservoir rocks") is not appropriate. We do not intend to focus on permeability only and thus to analyse "the potential productivity of these lower Cretaceous sandstones" as the Referee suggested, also because there is no indication whether they would serve as reservoirs rocks in the northern Israel.

Instead, it is stated in the corrected abstract and introduction that "An applied multi-methodological multi-scale approach allows also a better process understanding and an identification of connection between the parameters evaluated at the different scales". The samples were chosen for investigation because of their differences immediately observed at the various scales: at the outcrop, in the hand specimens, and under a binocular microscope.

Nevertheless, since we recognize that this aim and scope of the paper has not been fully presented as intended in the initial version of the manuscript, we are going to slightly change the title of the manuscript, clarifying that this is a fundamental case study ("Multi-methodological Petrographic and Petrophysical Case Study of Lower Cretaceous Sandstones from Hatira Formation, northern Israel"). Moreover, we shortened and re-organized the manuscript, as described below, in order to make it clearer and more informative for the potential reader of Solid Earth.

The main changes incorporated in the manuscript are listed below:

- The Abstract is shortened and reformulated according to the aim and scope of the paper (as stated above)
- The Introduction was changed to clarify the significance of the study (as stated above)
- The Geological setting (Sect.2 now) is shortened
- The Methods section is significantly shorter and reorganized, in accordance with the format of the journal, and following Comment 4 (below).
- The following changes were implemented in the Results Sect.:
 - The text is shortened
 - Verbal description and figures of classical REV are moved to the Appendix
 - In Fig.3 parts f-h are removed,
 - Figs 7-8 are merged, Fig.9 is moved to the Appendix.
 - Description of the classical REV is removed, while the relevant pictures from the Appendix are referenced in the text.
 - A new correlation plot between porosity and clay content is added to the former Fig.11.
- The Discussion is now composed of three subsections:
 - 5.1 Influence of microscopic pore network characteristics on permeability. This addresses a “process understanding” specified as one of the main objectives of our paper.
 - 5.2 Upscaling permeability: accuracy of the extended computational workflow. It discussed the methodological aspects of our study.
 - 5.3 Inferences on the sedimentology and diagenesis of the samples in the context of the Hatira Formation. It suggests the insights that predefine the similarity and differences between the studied layers.
- The Conclusions are now focused more on former points 6-8.

Detailed remarks:

Comment on line 49: “how large is “sufficiently large”

We have re-phrased this sentence in the text to clarify this point (and removed it from the abstract). Specifically, textural bedding within a 2 mm scale dominates the flow anisotropy. Implicitly, a “sufficiently large” modelling domain would be “as large as necessary” bounded by the scale of this feature (i.e. > 2 mm edge length) and – additionally – “not larger than necessary” (i.e. << 10 mm) in order to optimize the computational efforts in a sufficient amount of time. Now, this point is specified in the Discussion.

Comment on entire manuscript:

1. Comment 1: Abstract: Motivate studying the characteristics in abstract. As mentioned above, be clear about the central motivation for this work.

Response: The abstract was modified and shortened based on the main goal of the paper defined in the general remarks above.

2. Comment 2: Section 1: Rearrange the sections to make 1.1 only part of intro, and make 1.2 background as new section 2.

Response: Performed.

3. Comment on Line 107: overly should probably be overlie

Response: Correct, has been changed.

4. Comment on Methods: Remove list with roman numerals, organize into true sections that align with the journals' format.

Response: Text was reorganized and shortened according to the journal format.

5. Comment: Line 272, line 632, and probably several other places: parentheses should be put around (Fig. X)

Response: Implemented throughout the entire manuscript.

6. Comments on line 308: Describe what the Euler characteristic shows

Response: We defined the Euler characteristic in the Methods Sect. and put the following information in the Appendix:

Euler characteristic is a number that describes the structure of a topological space. The most intuitive way to think about the Euler characteristic is in terms of its Betti numbers (β_i).

$$\chi = \beta_0 - \beta_1 + \beta_2$$

For a 3D object, β_0 is the number of components, β_1 is the number of inequivalent loops and β_2 is the number of cavities (enclosed voids). In describing the topology of the pore space of a porous rock, it can be assumed that the solid matrix is connected, so that $\beta_2 = 0$. In this case, the Euler number reduces to the difference between the number of discrete components and inequivalent loops. If all pore space is connected via one pathway or another, and assuming that there are no isolated pore spaces, then $\beta_0 = 1$. In a pore network of sandstone which can be modeled as a bundle of tubes, the number of loops β_1 is large and χ is negative. Therefore, Euler number is related to the connectivity of the pore space. As the number of loops decreases, the Euler number becomes less negative and will eventually become positive, at which point the system will no longer percolate, according to Vogel (2002).

H.-J. Vogel, Topological Characterization of Porous Media, in Morphology of Condensed Matter, K. Mecke and D. Stoyan, Editors. 2002, Springer Berlin Heidelberg. p. 75-92.

7. Comment in Line 314: There is a strange green box around a bullet point.

Response: Removed.

8. Comment: Section 4.1-4.2 should be in the results, not the discussion

Response: Please see the description of the modified discussion above in the response to the General Remarks, and its motivation.

9. Comments on line 678: Line 678: "post_depositional" seems to have an underscore

Response: Correct, has been removed.

10. Comments on line 833: rewrite with verb "mean porosity lower than the median one "

Response: Has been re-phrased.

11. Comments in line 841 ff.: rewrite this paragraph. There are many grammatical errors.

Response: The entire paper has been proof-read and re-phrased where needed, including the addressed paragraph.

12. Comments in line 899: "In contrast the," change position of comma

Response: Has been changed.

13. Comments on discussion section: In the discussion, it would be useful to compare your porosity and permeability measurements to measurements from similar potential reservoir rocks. This comparison will help make this work relevant to the broader community.

Response: The comparison was presented even in the initial version of the manuscript (e.g. lines 736-742, 920-925, 941-943). We added some data in the corrected version of the paper as well.