

Interactive comment on “Faulting patterns determining groundwater flow paths in the Lower Yarmouk Gorge” by Nimrod Inbar et al.

Reviewer #3

Dear Reviewer 3,

We thank you a lot for these critical remarks, by which the quality of the paper was much improved! We hope to sufficiently reply to your comments in the following.

C1: The main issue I have is the lack of a proper, comprehensive discussion. Currently, the discussion is mixed in with the results of the study. By separating them into two individual sub-chapters, both will benefit. The Results section needs to be expanded and presented in a more precise and focused way. The discussion must go into more critical issues that are currently lacking such as: - Tectonic implications - Hydrological implications.

A1: This comment, which refers to the structure of the manuscript was seriously considered. We have tried to transform Chapter 5 (Results) into results and discussion chapters as suggested. Those attempts, has further strengthen our initial consideration that the discussions parts of the chapter are in most cases supporting the rational presentation of results. However, the point raised is absolutely clear and therefore we have transformed the "Conclusion" chapter (chapter 6) into "Summary and conclusion". We hope that this new chapter answers most of the points raised in regards to the order and clarity of the presentation. With that said and done another point has to be clarified, it is not the scope of the current research to provide all answers regarding implications. The current manuscript suggests a new structural framework for future hydrological research together with questions that will hopefully lead to additional tectonic study and subsequently a much more advanced understanding of the geotectonic in that complex area.

C2: In a paper titled “Faulting patterns determining groundwater flow paths in the Lower Yarmouk Gorge” – you do not discuss groundwater flow patterns - A discussion of the mechanism that formed these faults - do they fit in with what we know about the stress field in the area?

A2: The aim of the presented research is to provide additional information to the structural framework of the area, which doubtless implies the geohydrological systems, as suggested by Tzoufka et al., 2018. It is correct, groundwater flow pattern is neither investigated nor discussed here.

The structure is described following interpretation of geological and geophysical data/findings and not following a study of kinematics, which may resolve once the questions of faulting mechanism.

That point is substantially important and we hence changed the title of the manuscript accordingly.

C3: It is not enough to say that since they are along the DSF, it fits. Also, statements such as: “The present study shows that although there is no evidence for large vertical displacements, strikeslip faults must cross the LYG forming fault-blocks. Therefore, these faults must be taken into consideration when discussing groundwater hydrology” (lines 118-120) need to be formulated in a more rigorous way. Why “must” strike slip faults cross the LYG?

A3: Thank you for that remark, we changed it to "might be related" and "suggested to consider".

C4: In addition, the discussion should address issues brought up in the Introduction. On lines 56-64

you mention the hypothetical fault trace of Magri et al. (2016), yet you do not refer back to this to show if your results support this trace or not. This is also true for the results of Goretzke et al (2016), which you mention in the introduction – do your results support or disprove their theories?

A4: This remark contributed to the new chapter "summary and conclusion", thank you! We agree with the work of Magri et al. (2015); Goretzki et al. (2016) and Tzoufka et al. (2018) that simulate groundwater flow and heat transfer across a fault crossing the lithological sequence. However, due to the limited available data, we receive only a coarse picture of the subsurface. Based on these available data in the study area, we are not able to trace a fault along the path of the gorge. However, unpublished data by GSI indicate a SW-NE running fault, coming from the Lower Jordan Valley and reaching Hammat Gader indicate, faulting may also occurred along the gorge, which would directly support the cited hydrological modeling studies

C5: The GII provides a comprehensive database of historical-recent seismicity. In such a study, I would also expect you to use seismicity to prove the presence of strike-slip faults or thrusts and help rule out previous suggestions. I think this would strengthen your arguments.

A5: We have scanned that database for all its content (about 100 years). We have not found any event with epicenter located in the study area. We can only conclude that the system has not been active for the last 100 years. As we believe that such statement does not contribute to the presentation it was omitted from the final text.

C6: Technical issues: - While the paper is well written, there are still a few grammatical mistakes. Please check the English again.

A6: We followed the advice and corrected grammatical mistakes.

C7: Every location, borehole, seismic line, etc. mentioned in the text needs to appear on a comprehensive location map, which is referred to in the text (e.g. Meizar 1,2 & 3 (Fig. 1)). This should be the very first figure of the manuscript (and not the third). This holds for every place name mentioned in the introduction and throughout the paper (GH, LYG, Golan syncline, Mt. Hermon, Sheikh Ali fault, Ajloun Dome, Hammat Gader and Mukheibeh springs, Meizar 1,2 & 3)

A7: Following that remark we have changed figure 1 to include also figure 3 and 4a. The new figure 1 has all required information. Thank you very much this step dramatically improved the MS.

C8: Line 19-20: Please do not cite in the Abstract

A8: Agree. Citation was removed from the abstract

C9: Line 31: The more correct term is “Dead Sea fault (DSF)” in keeping with the “San Andreas fault”

A9: The term DST is well known and accepted in the literature. Google scholar gives about 359,000 results for that term, starting with Garfunkel, Zvi. "Internal structure of the Dead Sea leaky transform (rift) in relation to plate kinematics." *Tectonophysics*80.1-4 (1981): 81-108. We prefer to keep this term.

C10: Line 97-98: The DST was already defined above. There is no need to define it again.

A10: Agree. Changed

C11: Lines 99-100: You present the eastern fault entering the Sea of Galilee as the main branch of the DSF. Why do you rule out the western branch (Hurwitz et al., 2002)?

A11: we accept this suggestion and added faults on the western side of the lake to complete the picture. Still, it is important to note that the N-S fault on the western side is not a strike-slip fault but an oblique-slip fault (Inbar, 2012)

C12: Line 134: “dots were connected” – please use a more scientific term. Perhaps “interpolation was carried out between data points”

A12: Thank you, we change it to more scientific terminology.

C13: Lines 140-146: From this paragraph it seems that you use the interpretation of Meiler (2011) for seismic cross section DS-3545. So when you say “reinterpretation” on line 149, what do you mean? It is not clear if you just took Meiler’s interpretation or if you did something of your own. Please clarify.

A13: It is repeatedly mentioned that we used Meiler's PSDM processes line and added our interpretation. The new interpretation adds new faults, which were previously neglected by Shulman (1989 and 2004) as well as by Meiler (2011). Those newly interpreted faults were probably not important for the regional study however they are highly significant when studying the LYG. We have also amended horizon identification, however exceeding the scope of the current MS this topic is not discussed.

C14: Line 151-152: I do not understand the logic of the argument. Please rephrase so that it is clearer. Why is a thrust fault the more logical solution?

A14: Rephrased. "Another possible solution for the 2D seismic data is a thrust fault. This solution seem to fit better with the newly presented structural frame."

C15: Line 156: Seismic data is not measured. It is collected.

A15: Thank you, it's corrected.

C16: Line 159: Repetition

A16: Thanks. Deleted

C17: Line 184-187: Please refer to Figure 4

A17: Thanks, done.

C18: Lines 191-193: Repetition

A18: Yes, the entire paragraph is rephrased.

C19: Figures: Figure 1 should be a comprehensive location map that includes all places, boreholes, seismic lines, features, etc. mentioned in the text.

A19: Yes, it has been changed accordingly.

C20: Figure 2: please show non-interpreted seismic line together with the interpretation. Also on 2b – the vertical scale cannot be depth since this is a time section.

A20: yes, that’s correct – we changed it.

C21: Figure 3: this is in fact your location map and should come first. I cannot see the difference between Figure 4a and the bottom of Figure 3. Why do you need both if they are the same except for the location of profile A-A’?

A21: We changed it entirely.