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Interactive comment on "Structure and kinematics of an extensional growth fold, Hadahid Fault System, Suez Rift, Egypt" *by* Christopher A.-L. Jackson et al.

Christopher A.-L. Jackson et al.

c.jackson@imperial.ac.uk

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Dear Editor,

Thank you for the invitation to resubmit our manuscript se-2019-147.

Please find attached a revised version of the manuscript that acknowledges and incorporates the insightful and constructive comments made by reviewers Tavani and Conneally. Please see below our response to the reviewers' comments, suggestions, and corrections. We explicitly indicate where we have declined to undertake a suggested correction. Please note that all minor typographical and grammatical errors

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have been addressed and are not explicitly listed below. Line numbers (e.g. L123-124) refers to the Track Changes version of the document.

Stefano Tavani

1. Add Fossen and Rotevatn (2016) and Camanni et al. (2019) to L52 – Thanks for bringing these two papers to our attention. They both contain material very relevant to our study and are cited accordingly (L60 and L61). 2. There is an inconsistency in the labelling of key structures in Fig. 2 and 3 – The text has been modified so that the correct faults are called-out in relationship to Figs 2-4 (L112-113). 3. There is a grammatical issue on L270 – We have removed "we" to make this sentence grammatically correct (L311). 4. The observation that reverse faults lie in the immediate hangingwall of the master fault is in agreement with our documentation in Basque-Cantabrian basin and with the results of analogue/numerical models – Having spoken to Reviewer Tavani it appears that in the case of the Basque-Cantabrian basin, these reverse faults are related to post-rift inversion and not syn-rift extensional growth folding. We have therefore elected not to cite Tavani et al. (2018) at this point in the manuscript. We do, however, cite this paper (and Tavani et al., 2013; 2015) at another appropriate point in the manuscript (e.g. L49). 5. Modify Fig. 2 to make the differences between stratigraphic units clearer – We have modified Fig. 2 to make the differences between stratigraphic units clearer. 6. Show the location of Figs 3, 6, 8 and 10 in Fig. 2A, as well as the cross-section in Fig. 2B – We have modified Fig. 2A to schematically show the location of the cross-section shown in Fig. 2B. However, we have elected not to modify Fig. 2A to show the locations of the maps shown in Figs 3, 6, 8 and 10, primarily because this would make the figure to cluttered and difficult-to-read. We have instead modified Fig. 4B to show the locations of the maps shown in Figs 3, 6, 8 and 10 (see also responses to comment 9 and 10 by Reviewer Conneally). 7. Are the 90° stratal cut-offs against the HFS correct in Fig. 2B? – This was incorrect and has been modified in the revised manuscript; i.e. based on field observations, hangingwall strata now display an open syncline geometry and dip away from the fault. 8. Figs 2 and 3 could

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be merged – We have elected not to merge Figs 2 and 3 given they show very different pieces of important information. Fig. 2 shows the regional setting of the study area, and thus lacks a detailed breakdown of the structural and stratigraphic framework. In contrast, Fig. 3 shows the detailed structural framework of the study area, including the individual fault and fault-fold segments discussed in the text. 9. Is Fig. 4 necessary? – We argue Fig. 4 is indeed necessary, given it shows along-strike variations in the cross-sectional structural style of the Hadahid Fault System and flanking strata. The cross-sections compliment those shown in other figures (e.g. Fig. 6B and C; Fig. 8b). 10. Add the stratigraphic column in Fig. 5 to Fig. 3 – Given the size of both figures, it would be very difficult to move Fig. 5 alongside Fig. 3. We have therefore elected to modify the stratigraphic key in Fig. 3 so that it more clearly shows the age of the key units (i.e. Precambrian, Mesozoic, Cenozoic), as well as their tectono-stratigraphic significance (i.e. pre-, syn-, or post-rift). 11. Fig. 20 would benefit from more clearly showing the temporal (i.e. 4D) evolution of extensional growth folds and their related faults – Given that reviewer Conneally was complimentary about this figure, and based on concerns we have about making this already complex figure more detailed via the addition of numerous temporal stages, we have elected not to modify it.

John Conneally

1. Please define the term “partly breached monoclines” – We have removed this term from the manuscript, given a monocline is either breached or unbreached, partly or otherwise. 2. Change the word “depicted” to the phrase “seen to be” – We have replaced “depicted” with “define”. 3. Add Ferrill et al. (2007; 2012) and Ferrill and Morris (2008) - Thanks for bringing these two papers to our attention. They both contain material very relevant to our study and are cited accordingly (e.g. L48). 4. Please define the term “fault-fold (segments)” – See response to comment 1; i.e. we have removed “partly breached monoclines” from the text and, therefore, no longer use the term “fault-fold segments). 5. Given your statement “provides strong evidence for a northward decrease in displacement”, please provide some details of the size of this decrease and

give some details on the split between discrete and continuous displacement along the fault – We have modified the text to state, “Ignoring the fact that the position of the master fault is locally uncertain, the overall north-westward transition from breached to unbreached monoclines clearly defines a north-westward decrease in the ratio between discontinuous (i.e. fault offset-related) and continuous (i.e. fold-related), at-surface deformation (Figs 3 and 4A-I). One hypothesis links this along-strike change in structural style to the north-westwards propagation of the Hadahid Fault System from its branch-line with the Gebah and Sinai Massif faults. In this model, extensional growth folds formed and were breached earlier in the SE than they were in the NW. The cessation of extension and the death of the Hadahid Fault System meant that unbreached extensional growth folds are preserved in the NW. We may refer to this along-strike in structural style as being a so-called ‘propagation effect’. An alternative hypothesis is that the Hadahid Fault System nucleated broadly synchronously along its length and then propagated upwards, more quickly in the SE, which ultimately leading to north-westwards propagation of the fault system’s surface trace. We may refer to this along-strike in structural style as being a so-called ‘geometric effect’. Differentiating between these two hypotheses is impossible given: (i) our structural level of inspection is restricted to the Earth’s surface, thus we cannot demonstrate that fault-related displacement (i.e. discontinuous deformation) increases north-westwards at deeper structural levels (e.g. at the depth of top crystalline basement or top pre-rift; Fig. 5); and (ii) discontinuous exposures of very poorly dated syn-rift deposits in the hangingwall of the Hadahid Fault System means we cannot establish the relative timing of faulting and folding along the structure; i.e. do the very earliest syn-rift growth strata become younger towards and thus document the north-westward initiation of folding and subsequent faulting, and hence north-westwards propagation of the fault system?”. (L192-220). 6. The strike of the Hadahid Fault Segment is substantially different to the other segments on the fault and it also appears to have a much higher total throws than the segments either side of it. Even allowing for a reasonable displacement gradient. (i.e. the total throw on the Nubian sandstone seems to be significantly higher in the sections in Figs. 4

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and 14), how is the displacement being conserved? Is the displacement distributed across several structures or folds on the other segments? – We have removed the regional cross-section in Fig. 4h given the subsurface geometry is poorly constrained in this location. Figs 14d and 16d show that throw across top Nubian is 200-600 m, decreasing southwards, along an along-strike distance of c. 2 km, to c. 200 m on the Hadahid Monocline Segment. Even allowing for a throw of c. 600 m on the central part of the Hadahid Fault Segment (i.e. Fig. 16b), this along-strike throw decrease yields a throw gradient of c. 0.2, a value that we deem entirely plausible, and which does not require the addition of secondary faults and folds. However, lack of exposure of deep structure means we cannot unequivocally prove this. 7. Did the Hadahid Fault System propagate north-westwards or is this a geometric effect? Is there any indication of any variation in throw on any of the other major fault systems in the area? – This comment relates to comment 5; i.e. how do we know the Hadahid Fault System, as defined at the deeper structural levels, propagate northwards? 8. Highlight the edges of the monoclines on the structures in Fig. 1 to make the geometries a little bit clearer – We are unsure what the reviewer means here, given the monocline geometries are, in our view, clear in all four figure parts. 9. I find Fig. 2 a little confusing; i.e. the outline of the main map is not shown in the inset and the outline of the study area is shown in the inset but not on the main map. Put the outline of Fig. 3 in the main map and the outline of the main map in the inset. Highlight the location of the section in Fig. 2b on the main map and indicate what portion of this section crosses the main map. Make the colour scheme consistent between the two parts of the figure – We have modified the outline of the location (red rectangle) of Fig. 2a in the inset map to make it more fairly reflect the shape and size of Fig. 2a. We now indicate the location of the map in Fig. 3 on Fig. 2a, and have added a double-headed red arrow to show the approximate location of the section in Fig. 2b. Fig. 2b now shows the approximate area covered by the map in Fig. 2a. We have made the colour scheme consistent between Fig. 2a and b. 10. Make Fig. 3 and b the same shape and show the location of the maps in Figs 6, 8, 10, 12, 14, and 18 – We have modified Fig. 3 to make both maps the same size, and have added the location of the maps in Figs 6, 8, 10, 12, 14, and 18 to Fig. 3b. 11. There is a hidden layer issue with Fig. 20 – This has been fixed by removing the hidden layer (which became visible during the PDF build).

We would again like to extend our thanks to the reviewers for their constructive and insightful reviews, and to you for the additional feedback; we believe this input has resulted in a greatly improved manuscript. We hope that you now find this paper suitable for publication in the Solid Earth. If you have any further questions or comments, please do not hesitate to contact me on c.jackson@imperial.ac.uk.

Yours sincerely, Christopher A.-L. Jackson Paul S. Whipp Robert L. Gawthorpe Matthew M. Lewis

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