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Interactive comment on "Mechanisms of destructing translational domains in passive margin salt basins: Insights from analogue modelling" *by* Zhiyuan Ge et al.

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Dear Dr. Tim Dooley

We thank you for reading our manuscript and for the very positive comments. We have addressed all the issues in this file. The following is a point to point reply for the overall remarks. The fully revised text and figures are in the supplement file attached in the reply to reviewer 1.

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General comments:

1. These experiments follow on from several papers published since 2017 on the impact of base-salt relief on deformation on these types of margins and are thus quiet timely. These other studies used physical models, numerical models and seismic-based studies. I think the authors should refer to these in the introduction and state the differences, and similarities, between those studies and their own, rather than just adding this in as a footnote at the end of the manuscript.

AUTHORS: We have expanded the introduction of previous work on how base-salt relief influences translational domain deformation and compare the similarities and differences.

2. My main problem with the manuscript is the presentation of results. There are 3 experiments with essentially 2 basins in each experiment, and the authors present them in pairs. There is no need to do this. There are 6 distinct experiments as there was no connectivity between the "basins". Split these up so that you can present the parameters you tested in a logical fashion. See the comments on the manuscript for more details but you can work it like so: 1. Evaluating sediment thickness controls on the size of the translation zone 2. Evaluating sediment deposition rates on translation zones – but use strength 3. Evaluating discontinuous loads on translation zones

AUTHORS: The other reviewer also mentioned this problem. We have rearranged the models to group them as the reviewer suggested: one is on sediment thickness and deposition rate and the other is on sediment loading. Please find the detailed changes in the attached file.

3. I also feel that some areas of the text need expanding on, and others are perhaps too wordy. See the comments on the PDFs.

AUTHORS: We have addressed all the points the reviewer has raised in the PDF.

The following is a point to point reply to the remarks commented in the PDF. Minor corrections in accordance with reviewer's such as choices of words or phrases are not reported unless we choose another word or phrase. Suggestions to images are all implemented and can be found in the new images. Note the page and line number (P?L?) is based on the commented (submitted) version of PDF rather than revised one.

1. P2L8: Well the whole point of Dooley et al. (2017) was to point out that base-salt rugosity impacts the extension-translation-contraction model. But in broader terms that still generally defines these salt-cored margins.

AUTHORS: Exactly, that is why we referenced it here. Also, the model of fig.1 in of Dooley et al 2017 is exactly showing the conceptual model with kinematic partition of extension, translation and contraction.

2. P2L10: Well yes but 3 papers by myself and coworkers focused on modified strain histories in translational domains due to the effects of base-salt relief. Also new studies by Pichel et al. using numerical models and seismic-based studies in the Santos Basin.

AUTHORS: We have discussed the influence of base-salt relief on modifying translational domain with related references as follows:

'Recent studies have shown that base-salt relief can initiate extensional and contractional structures as well as ramp syncline basins in the mid-slope therefore modify the translational domain (e.g. Dooley et al., 2017; Dooley et al., 2018; Ferrer et al., 2017; Pichel et al., 2018). However, in basins where pre-salt relief is limited or very gentle (e.g. Fig. 1b and c), such as the Lower Congo Basin, other mechanisms may be responsible for overprinting the translational domain.'

3. P2L28: 'When used as a term describing the basin-wide structural partitioning, the

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translational domain usually indicates an area located between the upslope extensional and downslope contractional structures (e.g. Fig. 1a).' Yes, that's what people mean.

AUTHORS: According to this definition, translational domain indicates an area between extension and contraction. As we mentioned in the text, extension and contraction can intervene due to upslope migration of contraction, and thus the translational domain may disappear during the basin evolution, even with a large undeformed block in the mid-slope (e.g. Fig. 7a in the revised text). Therefore, we feel this definition alone is too vague and does not really depict the conceptual model well.

4. P3L26: There are other studies using DIC...

AUTHORS: We have added more recent references as well as put 'e.g.' to indicate there is more similar work with DIC method.

5. P3L29: Need some references here – main work by Ruud Weijermars on scaling properties of PDMS for rock salt in experiments.

AUTHORS: We have added relevant references in the text.

6. P5L8: 'Each of the experiments takes about ten days from preparation to slicing. The silicone is filled in the silicone basin at least 3 days to settle' Not really required.

AUTHORS: We have shortened the sentence to 'The silicone is filled in the silicone basin.'

7. P5L14: 'During the experiment, the granular material is added by sieving within about twenty minutes onto the model surface every 12 hours to simulate syn-kinematic sedimentation (Appendix Table A2). After the experiment, the model surface is covered with sand before being gelled, sliced and photographed.' Rewrite this. Take out

unnecessary stuff. Use appendix for some of these details.

AUTHORS: We have revised the sentences to ‘During the experiment, the granular material is added by sieving every 12 hours to simulate syn-kinematic sedimentation (Appendix Table A2). After the experiment, the model is sliced and photographed for cross section view.’

8. P5L20: So it’s a mixture of gliding and spreading with wedges. Needs some discussion.

AUTHORS: The other reviewer also raised a similar point. In our experiments. The pre-kinematic layer is sieved evenly, so only the syn-kinematic wedge is sieved with thickness variation. However, the wedge shape of sedimentation in Fig. 3 is just a guideline. During the experiments, areas with deformation, such as extensional structures, receive more sedimentation due to their topographic reliefs. Therefore the differential sieving is not only a driven force but also a sedimentation response to gravity gliding. Moreover, it is also evident from Model D (no differential loading) that the basin has kinematic partitions and structural evolution as the ones with wedge shape syn-kinematic sedimentation. We have also added relevant details into the text to clarify the issue. Please also refer to answer point 7 in review 1’s reply to overall comments.

9. P5L24: Rewrite this for clarity and use figures.

AUTHORS: We have reorganized the description of model designs.

10. P5L28: ‘Minibasin spacing and dimensions are constrained by generalization of natural observations (Cramez and Jackson,2000; Hudec and Jackson, 2004; Marton et al., 2000).’ Expand on this.

AUTHORS: We have given more details of rational of minibasin creation as well as technical details of creating them in the main text. Please also refer to answer âŚğ in reply to review 1.

11. P6L13: first paragraph of Experimental monitoring. Can be shortened

AUTHORS: We have shortened the paragraph a bit.

12. P6L23: This makes it sound like Vx is subsidence and Vz is uplift. Rephrase.

AUTHORS: We have revised the text as ‘horizontal displacement (Vx) showing downslope movement and vertical displacements (Vz) reflecting salt outflow and inflow.’.

13. P7L1: first paragraph of Experimental results Is all this necessary?

AUTHORS: We feel such paragraph may help readers who are not familiar with modelling get an idea of the presentation of results.

14. P7L11: The use of "Experiment 1" is awkward as there are 2 experiments in here.

AUTHORS: We now have reorganized the order of models in order to avoid such situations.

15. P7L17: Thicker/stronger roof favors flow within the salt layer – Poiseuille flow. Salt-flow-driven uplift is seen at the downdip edge of the basin which you don’t even mention.

AUTHORS: We now have briefly mentioned the uplift due to silicon flow in Model B. However, as the manuscript focuses on the translational domain evolution and the subsidence and uplift displacement have similar patterns across different models, we feel a very detailed description of subsidence and uplift is beyond the scope of this study. Moreover, we feel we are not in a position to comment on the silicone flow type, either Poiseuille or Couette flow, as we did not monitor the silicone flow directly.

16. P7L20: ‘In Basin 1b, major deformation starts in the mid stage when a thrust belt Tb1 occurs c. 10 cm away from the silicone basin tip in the downslope’ Rephrase.

P7L25: ‘At the same time in Basin 1a, the thrust belt shifts towards the basin tip of the downslope as well as the upslope and both thrust belts keep active into the late stage (εxx in Fig. 5a).’ Rewrite this

P8L1 ‘In Basin 2a, differential loading of the pre-kinematic layer and early syn-kinematic sieving results in a basin-wide imprint of minibasins downbuilding, as shown by the subsidence pattern during the early stage where strings of thicker pre-kinematic layer subside stronger than intervened regions forming minibasins’ Rewrite for clarity

P8L8 ‘During the transition, the minibasin area (apart from Minibasin 1) becomes a shadow zone of deformation and transfer strain passively while the diapirs start to accommodate deformation (Fig. 7c).’ Not clear

AUTHORS: We have reworded the relevant text as follows.

‘Major deformation starts in the mid stage when extensional domain occurs in the upslope with c. 10 cm width (Fig. 4e). In the meantime, a thrust belt Tb1 occurs c. 10 cm away from the basin edge in the downslope (Fig. 5b).’

‘In the mid stage (after 48 hours), the thrust belt shifts towards both upslope and downslope with all thrust belts being active in the late stage (εxx in Fig. 5a)’

‘In Model E, differential loading of the pre-kinematic layer and early syn-kinematic sieving (with 8 minibains) results in a basin-wide imprint of minibasins downbuilding. The differential loading process is most prominent on the subsidence pattern during the early stage where thicker minibasin areas subside stronger than intervened regions forming minibasins (Vz in Fig. 8a)’

‘During the transition, the minibasin area (apart from Minibasin 1) is lack of internal deformation while the diapirs in between start to accommodate deformation (Fig. 9c).’

17. P8L5: Annotate this on the figure. It’s not clear to people unfamiliar with this type of data.

AUTHORS: We have annotated early stage minibasin development in Fig. 9c.

18. P9L20: ‘i) migration of extensional and contractional domains into a previous undeformed translational domain; ii) differential loading by sedimentation into minibasins that triggers salt-related structures, such as diapirs, from the beginning of basin evolution, therefore, prevents the formation of a tectonically stable translational domain.’ But it does form. Local weaknesses can allow jostling and squeezing etc. but the translational domain exists. It’s just not a nondeformed zone. And extension can propagate into it as well.

AUTHORS: As we mentioned in point 3, if the translational domain, whether it is deformed or not, only indicates an area between the extension and contraction, then translation is a time-dependent concept. As shown in Model A and C (Figs 5a and 7a), the contraction can migrate to the location that just next to the extension. As defined above, the translational domain does not exist anymore. Moreover, such definition provides no diagnostic structural evidence that can help us recognize translational domain in nature. Therefore, we had defined the translational domain with character as undeformed to make it practical to discuss why such undeformed domain does not occur in nature.

19. P9L25: ‘sedimentation rate’ In reality you’re are not scaling a sedimentation rate as the layers are basically added instantaneously. Use roof strength as a proxy for that.

AUTHORS: We agree that syn-kinematic layers are added instantaneously so they are not exactly sedimentation rate. However, they are not only cover strength as well. We have used the phrase ‘sedimentation pattern’ instead.

20. P10L5: ‘According to our study, a 1 mm 5 thick pre-kinematic layer and 2-3 mm sediment from syn-kinematic sedimentation (few hundreds of meters if scaled to nature) seems strong enough to form a stable translational domain from beginning to end, such as in Basin 1a (Fig. 5a).’ So does 1B - very large unstrained domain in Figure 5.

AUTHORS: We have added a short discussion on Model B (Basin 1B) on its thicker cover.

‘With a thicker cover, such as Model B (5 mm pre-kinematic layer), the translational domain gets even larger (c. 55 cm wide) due to stronger cover (Fig. 5b).’

21. P10L22: Well it could occur if margin tilt is modified during late-stage evolution of the margin – like in Kwanza basin.

AUTHORS: We have added the relevant discussion of Kwanza Basin on its sub-salt uplift of upslope area and downslope migration of extension.

22. P10L33: You’re adding load in a linear fashion, perpendicular to the slope so that has an impact.

AUTHORS: We have indicated that the minibasins are idealized as strings in shape.

23. P11L15: ‘A translational domain therefore is not necessary to be present during the whole evolution of the passive margin salt basins.’ Yes, perhaps, but it still forms the translational domain, i.e. not in a zone of continuous shortening nor in a region of

regional extension. This would also depend on the orientation of diapirs in how they take up strain.

AUTHORS: We explained the reason in points 3 and 18 that the definition of translational domain between extension and contraction is not very practical. We agree that the orientation of diapirs influences the strain distribution. We have added the importance of diapir orientation into the text.

24. P11L25: 'Moreover, progradational sedimentary wedges can also prevent the translational domain from forming. As the sedimentary wedges progressively move basinward, early formed contractional structures are superimposed by late extensional structures, completely destroying the translational domain (Brun and Fort, 2011; McClay et al., 1998; Vendeville, 2005). Although the sedimentary wedge is also one type of differential loading, the absence of tilting makes the system very different 30 from the ones presented in this study. Future research, therefore, is needed to fully understand the influences of sub-salt structures and progradational wedges on the development and destruction of translational domains.' Not very clear here.

AUTHORS: We have revised the paragraph to make it clear.

25. P12L1: on Conclusions Models should be described discussed as: 1. Evaluating sediment thickness controls on the size of the translation zone 2. Evaluating sediment deposition rates on translation zones 3. Evaluating discontinuous loads on translation zones

AUTHORS: We have clarified the influences of cover thickness on translational domain evolution. However, we think it is difficult, if not impossible, to evaluate the sediment thickness and deposition rate completely separately because a high sedimentation rate leads to a thick cover layer.

26. P12L16: Refer to other reasons for deformation within this domain. Published work.

AUTHORS: We have indicated other reasons for translational domain deformation in the discussion.

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