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Discussions

Interactive comment on "Deformation of intrasalt competent layers in different modes of salt tectonics" *by* Mark G. Rowan et al.

Michael Warsitzka (Referee)

warsitzka@ig.cas.cz

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In the submitted manuscript, Rowan et al. summarize, compare and discuss important findings about intra-salt deformation and the deformation of competent interlayers in layered evaporites. Based on results from published analog experiments, numerical models and seismic data, they explain deformation styles of competent layers during extension, contraction, differential loading and passive diapirism. Then, the influence of various physical parameters, such as layer thickness and strength of the competent layers, on the deformation style is discussed, some specific natural case studies are described and, finally, consequences of the occurrence of deformed stringers for drilling wells and interpreting well and seismic data are emphasized.

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Discussion paper

The manuscript is well structured and excellently written. The given examples and illustrative sketches provide fundamental guidelines for analyzing and interpreting internal structures in deformed evaporitic succession. In the frame of challenging future tasks like storing waste and resources in salt structures, the particular strength of this research is its timeliness. After going through some minor corrections and suggestions, which are listed below, I recommend final publication.

Comments and Suggestions:

Chapter 3.2 Contraction:

Page 7 line 20: Fig. 7e must be: Fig. 7d

Page 7 line 21: Fig. 7d must be: Fig. 7e

Chapter 3.4 Passive diapirs: In my opinion, the conceptual model of stringer deformation in passive diapirs does not cover all aspects of diapir evolution. For many diapirs, the model of purely dissected and extended stringers dragged into the diapir might be valid. However, there are examples of diapirs, in which the internal deformation is rather similar to those of salt pillows driven by differential loading. For instance, the internal structure of the Gorleben diapir (Bornemann et al., 2003) is characterized by a folded anhydrite layer at least in its Northwestern half. This indicates contraction due to salt influx into the roughly 3km high diapir. This diapir was probably initiated by extension, but likely underwent a long phase of passive growth. Another example is shown in Fig. 8.26 in Jackson & Hudec (2017). The relatively thin anhydrite layer is dissected, but also folded and doubled, which also indicates contraction. Richter-Bernburg (1980) (Fig. 23) displays the top of the Haenigsen diapir (roughly 4 km tall) with complex internal folding. Even if no competent layers are involved in the folding, the diapir interior is dominated by contractional structures. Furthermore, Rowan et al. admitted in the discussion on page 17 that “This is not typical of passive diapirs” for diapirs in the Santos Basin characterized by complexly folded strata.

I think, even if a passive diapir has no precursor deformation, such as extension or contraction, it undergoes an early phase in which salt flux leads to contraction and, therefore, folding of interlayers in the root zone of the diapir. According to the concept in chapter 3.4 these contractional structures should be destroyed due to increasing strain during passive growth. However, numerical models by Chemia & Koyi (2008) (e.g. Fig. 3) show that even at large strains, folds in the deeper parts of the diapir remain and are left behind, while only less dissected stringers are dragged upwards. Furthermore, I think pure passively growing diapirs are rare in nature, since there is always a mechanism needed to initiate the subsidence of adjacent minibasins, e.g. thin-skinned extension, buckle folding, prograding sedimentary wedges, etc.. Therefore, I do not fully agree with the too general statement given by Rowan et al. on page 17: “passive diapirs driven by differential loading have disrupted, rotated strong layers”. Furthermore, I suggest to avoid the term “tall diapir” or otherwise: could you provide a height to width ratio defining when a diapir is tall? I suggest to rather provide two alternative concepts: (1) passive diapirs dominated by dissected stringers and (2) passive diapirs dominated by contractional folding.

Chapter 4.2.2 Mechanical stratigraphy of multilayers Page 14, line 4: Fig. 17 is mentioned before Fig. 16, so change the order of both figures.

Chapter 4.4.3 Drilling hazards What about hazards due to peaks in shear stresses occurring at boundaries between competent layers and salt layers? This was modelled and illustrated for instance by Weijermars et al., 2014 and would be worth discussing here in a short paragraph. These stress peaks might be very different depending on whether the competent layer is dissected and floats with the salt or still connected and salt flow is stronger above and below the competent layer.

Reference list: For some references doi are provided, but for most of them not. Please make it consistent.

Figure captions: Caption of Figure 11a: Citation must be “Raith, 2017”

Figures: Figure 18: Please provide a scaled colorbar for Figure 18b.

References

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