Reply to referee comment #1 of doi:10.5194/sed-6-1625-2014:
Analogue experiments of salt flow and pillow growth due to basement faulting and differential loading
by M. Warsitzka, J. Kley, and N. Kukowski,

First, we would like to thank Christopher J. Talbot for critically commenting our study and rising some questions addressing topics crucial for the description of our experimental procedure and some which seem to be misleading or causing the impression of over-interpretation in the discussion. Here, we comment on the reviewer's questions and also provide additional information complementing what we wrote in the current version of the manuscript. This additional information then will be included in a future version.

Experimental set-up:

We mentioned that our experiments were adapted to the conditions of the Central European Basin System, where a substantial thickness of pre-kinematic (pre-halokinetic) Lower Triassic sediments always cover the Permian salt. The reviewer's comment however, shows us that we need to describe our intention explicitly and in some detail in the description of the experimental set-up.

We mentioned in the discussion why we artificially separate basement extension and sedimentation. We agree with the reviewer that this approach is essential to the experimental procedure and, therefore, must be explained in the introduction and in the methods section. We also would like to thank the reviewer for his draft of a new, revised introduction.

Answers to specific questions:

1. Fig. 7a displays patterns of horizontal strain after basement extension was stopped. No post-extensional sand had been added at this stage. Therefore, we conclude that all observed strain has to be a consequence of post-extensional deformation of the viscous layer. However, it is a well-known characteristic of analogue experiments that the thickness of sand layers sifted by hand exhibit slight irregularities (which makes them a good representative for nature), which may lead to smaller modifications of the strain patterns.

2. Sediment compaction is difficult to model in analogue experiments. We are not aware of any analogue materials showing a compaction behavior similar to that of natural sediments. We assumed that overburden density exceeds the density of salt at depths of 600 – 1000 m (e.g. Hudec et al., 2009). Therefore, we think that it is reasonable to assume a slightly higher density ($\Delta\rho$ = 100 – 200 kg/m^3 in nature and experiment) for scaled overburden thicknesses of 6 – 15 mm (scales to 600 – 1500 m in nature) as applied in our experiments.

3. Independent of the density of the overburden relative to the viscous material, lateral thickness variations inevitably cause a pressure head that forces lateral movement of

the viscous material. However, the growth of downbuilding salt structures requires the pressure head to exceed the elevation head. This is not achieved, as long as the density of the overburden remains lower than the density of the viscous material. Even with no pre-kinematic layer, the subsidence of a minibasin sinking into a salt layer would cease, if no density inversion would be present. We think that without the occurrence of density inversion, a shallow salt pillow still might be initiated by differential loading, but it will not be able to grow further at some point. Therefore, the overburden has to be (at least slightly) denser than the salt to maintain growth of a downbuilding salt structure. The effect of density inversion on the kinematics in the salt layer is a process worth to be investigated in the future (but is beyond the scope of this study).

4. The reviewer's comment made us aware that the wording of our first conclusion obviously was misleading. We do not suggest that a pre-kinematic layer is required to form a significant structural relief. Instead, we suggest that *despite* a pre-kinematic overburden with considerable thickness and strength, pillow structures are initiated by small-offset basement faults and successive downbuilding. In contrast, some previous works (e.g. Vendeville, 2002) have suggested that pillows only evolve due to lateral stresses e.g. thin-skinned compression or thin-skinned extension. We will explain our conclusion in more detail.

5. Our conclusion that pillows require a phase of tectonic quiescence to be initiated is based on the argument that continuing basement extension would lead to the formation of a crestal graben adjacent to the basement fault and, therefore, to reactive diapirism. However, we agree with the reviewer that this suggestion is not explicitly supported by our model results. However, we still think this point is of importance, although more a hypothesis than a conclusion. Therefore, we plan to add a section presenting this hypothesis in our revised manuscript

6. We talked of a "small-offset" basement fault if the offset was small relative to the thickness of the viscous layer. In our case, "small-offset" means that displacement along the basement fault (6 mm/ ~600 m) is significantly smaller than the thickness of the viscous layer (10 – 20 mm/ 1000 – 2000 m). Previous experimental studies mostly applied much higher displacements (e.g. Dooley et al., 2005; Ge and Vendeville, 1997; Koyi et al., 1993; Nalpas and Brun, 1993). However, in our revised version of the manuscript we will present a definition of the term "small-offset" and how we use it.

   In our experiments we mostly applied displacement rates of 4mm/h. This scales to ~400 m/Myr in nature, which is a reasonable extension rate for continental rifts (Allen & Allen, 2005). 20 mm/h (~2 mm/yr or 2000 m/Myr in nature) displacement rate as applied in Experiment 2 probably represents a very fast extension (although GPS measurements show that such displacement rates are possible; e.g. Friedrich et al., 2003). However, our intention was to test the influence of basement extension rates on the kinematics in the viscous layer. Therefore, we varied the rate of basement extension within about an order of magnitude. The results of this experiment series reveal that the kinematics in the viscous layer are in principle similar to each other, which would be a hint that basement displacement rate is not a parameter crucially affecting strain patterns in the viscous layer.

7. In general, here we agree with the reviewer. Indeed, the observation/ interpretation of tiny basement faults beneath large salt diapirs in the North German Basin was one of the reasons why we performed experiments presented here. Our experimental results show that salt diapirs most likely cannot be initiated by “small-offset” basement faults.

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