

Interactive comment on “Influence of inherited structural domains and their particular strain distributions on the Roer Valley Graben evolution from inversion to extension” by Jef Deckers et al.

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1. As it stands now the manuscript is more or less a local study of the RVG, which is interesting and important as well. Clarifying what we can learn from your study applicable to similar tectonic settings would highly enhance the importance of your manuscript. In the introduction you should give a short (one or two sentences) overview of the ‘state of the art’ in our understanding of inversion tectonics. What are the main controlling factors (mechanical weakening, fault orientation, strain distribution, thermal heating, etc.) for or typical structural features associated with inverted systems. You can then pick up these e.g. factors in your conclusions, which will provide a nice ‘frame’

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for your observation/study.

We have added several sentences to describe the more generic issues of our manuscript. By doing so, we have also better described the issue we are dealing with: the influence of pre-existing graben border fault segmentation on strain-distribution during reactivation.

2. A more or less general or regional overview is missing. Adding an overview map with the location of your study area would be nice. Furthermore, I was wondering about a missing illustration of e.g. a subcrop map of the base Cenozoic and a cross-section including pre-Chalk Group strata, which would help to better understand the situation.

We have added a figure 3 of composite seismic lines across the RVG to illustrate the regional overview. It shows the major stratigraphic units (Carboniferous, middle Mesozoic, Upper Cretaceous, pre-rift and syn-rift) and structural features (Gruitrode Lineament, CB, RVG, Peel Block).

3. As a general comment: All regional and local names used in the text should be shown in at least one figure. Keep in mind that your audience is not familiar with local geographical and geological names.

We agree and have done so.

4. Even if the authors concentrate on the extensional reactivation of the RVG, the RVG initially formed as a graben during Jurassic times and became contractionally overprinted during the Cretaceous. During the Cenozoic the RVG became reactivated again under extension. How are the relations - and thus the reactivation potential - between Jurassic, in parts reactivated normal faults and Cretaceous reverse faults (and footwall shortcuts)? Which faults became extensionally reactivated? Is there any relationship between mechanical weakening due to repeated fault activity or between the geometry and kinematics (fault dip or initial sense of slip) and their reactivation potential during extension?

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We have now provided a better discussion on the fault evolution from the middle Mesozoic up to the Cenozoic in chapter “5.1 Graben border activity and segmentation”.

5. The “Dataset und methodology” chapter needs some improvements. As it stands now, it is still unclear for me whether the authors made (1) a new model presented in that study, (2) made the G3Dv3-model for that study or (3) extracted parts or maps and crosssections from the G3Dv3-model. Either in the abstract “In Flanders, a new geological model was created: : :” or in chapter 3.3 “: : :we constructed a map view: : :” some misleading information is provided. Therefore I strongly suggest reworking the methods chapter to clarify what was done for exactly that study. Which software was used? Did you generate a 3D-model or a “map-based” GIS-model, etc.?

We have modified the chapter Dataset and Methodology accordingly by adding sentences that we extracted maps and cross-section from the G3Dv3-model by ArcGIS and iMOD software.

6. In chapter 4 (results) the authors should think about chapter captions and the associated text. In general, the text gives a very extensive description of individual structural features. In contrast, captions suggest that processes leading to these structures are described. Probably restructuring this chapter a little bit, would improve the manuscript. Therefore, I suggest to separate the ‘results’ chapter into ‘description of model results’ (very concise) and ‘interpretation and indications for fault kinematics’.

We have changed the captions of chapter 4. The former caption “Late Oligocene to recent rifting” was changed into “Structural style of Cenozoic rifting”, while the former caption “Late Cretaceous compression” was changed into “Structural style of Late Cretaceous inversion”.

7. Separate the chapter 5. Discuss your interpretation and afterwards precisely write your conclusion. Do not mix!

We have added a chapter 6. Conclusions

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8. The polyphase evolution of the RVG make some descriptions difficult to follow. Especially in chapter 4 there are plenty descriptions of fault throws and the authors should carefully check their description. E.g. (L359-360) “Due to Cenozoic normal reactivation, only few faults in the study area have net reverse throws as the result of Late Cretaceous compression.” If that is the case, how can we ensure that these faults were reactivated? Is there any indication for past fault throws on single faults? How is throw distributed on single faults (e.g. for the pre-Chalk Group strata, syn-inversion strata and rift-strata)? Do the model have the potential to show throw distribution on single faults and for single horizons (e.g. by use of Allan Maps, etc.)? If yes, that would significantly help to illustrate and understand strain distribution across the RVG.

We use the thickness changes across faults of the Late Cretaceous Chalk Group and Cenozoic syn-rift strata to evaluate their syn-compression and syn-rift throws, respectively. In order to better visualize throw distribution along the FFS, we have added figure 8 that shows the vertical throw of the base of the syn-rift strata along the major faults in the FFS in both northern and southern structural domains.

9. Furthermore, there are some detailed comments to the text:

a. L41: What means “both” here? You mention at least three stratigraphic units. We have changed this sentence into “This is indicated by gravimetric maps of the area (Fig. 1) and in more detail in geological maps of the middle Mesozoic (Jurassic), Upper Cretaceous and Cenozoic stratigraphic distributions and thicknesses in the area (c.f. Duin et al., 2006; Deckers et al., 2019).”

b. L56: Please specify the used data. Is it reflection or refraction seismics? What kind of borehole data was used?

We have changed this sentence into: “The G3Dv3-model of the area was created by the integration and interpretation of all available 2D seismic reflection and borehole data (borehole descriptions and wireline logs).”

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c. L58: What means "basement" in that context? Crystalline or sedimentary "sub-décollement" strata? I suggest to clarify/define that.

We have changed the word "basement" into "strata", since the term basement is not relevant for this study.

d. L70: Here, you mention "Chalk Group". I highly suggest to provide ages and chronostratigraphic names. Please keep in mind that most of your readers are not familiar with the local stratigraphic names of the RVG region.

We have added the chronostratigraphic names Campanian to middle Maastrichtian.

e. L77-78: Although I understand the intension of this from the modeller's point of view. Nevertheless, it seems a little bit confusing that Mesozoic strata is named 'Cenozoic'. Probably, it would be helpful to modify/enhance the stratigraphic overview figure (Fig. 2) and include some 'real' stratigraphic horizons in relation to your 'model stratigraphy'.

We have removed the "Cenozoic" from the "Cenozoic pre-rift strata" and now only refer to them as pre-rift strata. This is also mentioned in the text as follows: "For the purpose of this study, the latest Maastrichtian to early Oligocene strata are here referred to as the pre-rift strata". We have now also included real stratigraphic names for the syn-rift strata (Voort, Bolderberg, Diest, etc. formations).

f. L87: Please use (or define) the names of structures. What is the Roer Valley Rift System? The Roer Valley Graben? Or is the graben a part of that system? You should check the entire manuscript and use unique names.

These structures are defined in the text of chapter 2.1 as follows: "Major fault activity resumed in the late Oligocene, when the Roer Valley Rift System developed as a northwest-trending branch of the Rhine-Graben-System (Ziegler, 1988), throughout the south-eastern part of the Netherlands, eastern Flanders and adjacent parts of Germany (Fig. 1). This system currently extends over a distance of roughly 200 km and has a width of up to 75 km. Those faults with the strongest displacements divide the

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central Roer Valley Rift System into the Campine Block in the west, the pre-existing Roer Valley Graben in the center and Peel Block in the east."

These different structural features (now also including the Roer Valley Rift System) are also shown in figure 1.

g. L91: "main faults or those with the largest displacement" - Especially in inverted systems with a high potential to fault reactivation this definition is problematic. Delete that part or provide a definition for 'main faults'.

We have deleted the word "main".

h. L92: Please check the consistent use of abbreviations. The use of 'CB vs. Peel Block vs. RVG' in one sentence isn't good style.

We have changed the abbreviations in this sentence into actual names, so CB to Campine Block and RVG to Roer Valley Graben

i. L94: What is the Oligocene Voort Formation? That should be shown in your stratigraphic chart.

We have added this stratigraphic unit to the stratigraphic chart of figure 2.

j. L329-330: Contradictory numbers (150m vs. 100m)?

The vertical throw along the GBF decreases from 250 m towards 150 m, or by 100 m.

As said above, I strongly suggest the publication of this work. Even if this is still one local piece, such case studies will significantly improve our understanding of inversion tectonics. Furthermore, the study shows how geological modelling can help to understand even complex structures like the RVG and their kinematics. If systematically interpreted and evaluated this third - or, if analysed for various chronostratigraphical horizons as done in that study, fourth - dimension enable various new insights into 'inversion tectonics'. Some modifications and additional work will significantly improve the manuscript. Congratulations for that very interesting contribution. Kind regards, A.

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Malz

Please also note the supplement to this comment:

<https://se.copernicus.org/preprints/se-2020-23/se-2020-23-AC2-supplement.pdf>

Interactive comment on Solid Earth Discuss., <https://doi.org/10.5194/se-2020-23>, 2020.