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Dear Editor,

I hereby submit the revised manuscript entitled "**Multiple phase rifting and subsequent inversion in the West Netherlands Basin: implications for geothermal reservoir characterization**" by Annelotte Weert (AW), Kei Ogata (KO), Francesco Vinci (FV), Coen Leo (CL), Jerome Amory (JA), Giovanni Bertotti (GB) and Stefano Tavani (ST) to be kindly considered for publication in Solid Earths special issue '(D)Rifting into the future: the relevance of rifts and divergent margins in the 21st century'.

We thank you for your response and the useful suggestions posted on the discussion page. Following the editors request, we have included an extra NE-SW trending seismic line in the southern half of the studied zone. In the revised manuscript, this is Figure 5, dipline 4225. Also, in the revised manuscript, we have displayed diplines 2610, 3410, 4225, and strikeline 3415 in Figure 7h (former Figure 6h).

Apart from this, we have included all the remarks of both reviewers in the revised version of the manuscript.

The single contributions by co-authors are listed hereafter: AW, corresponding author, conceptualisation, data acquisition and processing, figures and manuscript drafting/editing; KO, figures and manuscript drafting/editing; FV, data acquisition, manuscript drafting/editing; CL, data acquisition, manuscript drafting/editing; JA, manuscript drafting/editing; GB, manuscript drafting/editing; ST, conceptualisation, data processing, figures and manuscript drafting/editing

We hope this revised manuscript will be accepted for publication in Solid Earths special issue '(D)Rifting into the future'.

In case of acceptance for publication, herewith we also confirm our will to support printing costs for colour figures.

With best regards,

Annelotte Weert

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Letter RC1

Dear reviewer,

We thank you for the kind words and insightful suggestions. Please, find below our response to your questions and comments, which are included in the revised version of the manuscript.

Your key suggestion is to clarify how the work improves understanding of the basin's facies architecture. We acknowledge that providing a comprehensive description of the various facies would increase our understanding of the basin, but this is beyond the scope of the current structural study. However, as part of the first author's PhD project, a follow-up study is planned to evaluate the facies distribution throughout the Nieuwerkerk Formation using the same seismic dataset as in this study. This coming research intends to provide a more thorough and extensive investigation of the facies architecture than prior studies.

Following your recommendations regarding Figure 8 (former Figure 7); we totally agree. Our aim was to present a simplified and generic model, "a lesson from" and not "a section of" the West Netherlands Basin. We have adapted the description of the figure along and hope that is now clear that Figure 8 is a toy-model for geothermal exploration and not a simplified section of the West Netherlands Basin.

The suggested figure showing the rates of inversion is a very good idea. We've improved Figure 7h (former Figure 6h) by adding boundaries showing the rate of inversion in the area. Additionally, the geothermal wells are marked in Figure 1b. Most of the data regarding geothermal well performance is confidential and therefore difficult to include into the discussion of this study, wherefore we were not able to include in the revised manuscript.

Please find below our response to the listed questions and comments:

Question	Response
From the abstract it is not directly clear to me what you are doing: giving a detailed interpretation of the syn and post rift episodes" do you mean more detailed than before, and can you specify already here what new details you discovered?	The key new knowledge is about the two Jurassic rift phases, their extension direction, and their influence on each other and the basin sedimentation. We agree with the reviewer that this was not directly clear and have updated the abstract along by adding this sentence: *'Despite multiple studies on the tectonic setting, timing and tectono-stratigraphic architecture of the rift system and its overall control on geothermal systems are still to be fully deciphered. In this framework, a detailed interpretation of the syn- and post-rift intervals in the West Netherlands Basin will be given within the framework of geothermal exploration.'*
line 24-26: ***"This study provides a better understanding of the multi-phase rifting history in the West Netherlands Basin, providing important constraints on the reservoir-seal integrity and with that, the amount of heat that can be safely produced from a geothermal reservoir rock".*** **A few questions on this sentence:**	We agree with the criticism and have removed this sentence from the abstract.

(1) why is the seal integrity important in a geothermal reservoir? (2) I don't understand what you mean: you provide a better understanding..., by providing important constraints on the reservoir-seal integrity and the amount of heat that can be produced. that is quite a big step, can you be a bit more concrete?	
<u>Figure 2:</u> inside mega sequence 5 is a big unconformity, why is this not megasequence boundary? (inside the Northsea Group is a similar unconfromity right, and this is included in your megasequences, or are these different?) How do you define a mega sequence? In this figure it also seems to me as if the entire Nieuwerkerk Formation is Early Cretaceous.	We agree with the reviewer that such an unconformity is existing within megasequence 5. However, we define megasequences mostly according to the tectonic phases. We have added a clarification to the Discussion section: *'It is noted that intra-formational unconformities are present. However, in the framework of a sub-seismic structural reconstruction, only the main stratigraphical units are taken into account.'* We agree about the position of the Nieuwerkerk Formation within the geological timescale, as pointed out by the reviewer. This is updated in Figure 2, thanks for noticing this.
From the intro and geological framework section it is not clear to me what the problem is that you are trying to solve. can you explain that more clearly, please? being the advocate of the devil: exploitation is going quite alright, is it not?	We agree with the reviewer and have rewritten part of the introduction: *'Understanding how the tectonic evolution of a rift basin influences the key parameters used for planning geothermal wells is therefore critical. Such parameters include aquifer thickness and heterogeneity. A thicker and more homogeneous reservoir is preferred, as it allows for better fluid flow, a higher heat extraction and an increased heat recovery (Crooijmans et al., 2016; Willems et al., 2017b), therefore making a geothermal system more profitable. As noted by Willems et al. (2020), current geothermal projects in the WNB demonstrate that the aquifer geology is still not fully understood. Increased knowledge of the regional architecture of the sedimentary rocks hosting aquifers, sub-seismic structural geology, and aquifer properties such as stratigraphic architecture, thickness and heterogeneity, would help to de-risk the geothermal well planning in the area (Willems et al., 2020).'* *'The quality of the recently reprocessed and released L3NAM2012AR seismic 3D cube allows a detailed reconstruction of the main subsurface structures. Contrasting to previous studies that mainly focussed on the NW-part of the onshore*

	WNB (e.g. DeVault and Jeremiah, 2002; Willems et al., 2017c; Vondrak et al., 2018), now the SE-part of the onshore WNB could be integrated into the study area as well. Accordingly, this study gives a detailed overview of the sub-seismic structural geology and increases the knowledge of the regional aquifer architecture, with a focus on the Nieuwerkerk Formation.'
You state that higher N/G is expected in the core of the half grabens, but is that always the case? In these locations there is more accommodation for deposition, but also less erosion, and so more preservation of fines and hence lower N/G could also happen... The ratio of accommodation space increase and sediment supply is key, but we don't quite know that and there is no hard data on this. How should I see this and how is this recognised in data (wells/seismic?)	This in an interesting question that would need further investigation to give an appropriate response. We have toned down this statement: *'Here, the chances of finding hot and thick fluvial sand packages with a higher nett to gross ratio, are increased.'*
<u>Line 430:</u> *"we can identify areas suitable for further investigation within the L3NAM2012AR seismic 3D cube"* : what do you mean with suitable? Are not all areas already being investigated? can you specify what you expect in these areas?	We will rephrase as follows: *'…, we can identify areas of interest for geothermal exploitation'*.
you state that there is difference in degree of inversion between areas, is this reflected in the performance of the 14 active doublets? or in future seismic risk or is there any other potential practical impact? explaining this would enhance practical use and impact of your work. (I asked this before, so ignore if you already address this above)	Unfortunately, the number of doublets and their spatial distribution is not sufficient to carry out any robust correlation between well performance and structural position. The main practical use of our structural template is that in areas of strong inversion the synclinal traps could be breached. We have stressed this point in the revised manuscript by adding the following text in the discussion section: *'Synclinal traps in half-grabens associated with strongly inverted faults are more likely to be breached by faults developed during inversion tectonics. The effects of secondary fracturing due to inversion tectonics can be beneficial in terms of permeability. Instead, the consequences of breaching a geothermal reservoir due to inversion tectonics is less clear. In hydrocarbon reservoirs, indeed, breaching of the anticlinal traps has a clear negative effect (i.e. leakage of the hydrocarbons), while the consequences of breaching synclinal traps in geothermal systems are not yet fully understood. In order to de-risk geothermal exploitation, we therefore advise to choose half-grabens associated with either non-inverted or moderately inverted normal faults.'*

<u>Line 426:</u> could fracturing not also enhance performance of the reservoir?	That is correct for hydrocarbon reservoirs. However, this effect of breaching and secondary faulting due to inversion tectonics in primary porosity geothermal systems is still not well understood. We've added this text in the discussion section to cover this topic: *'The effects of secondary fracturing due to inversion tectonics can be beneficial in terms of permeability. Instead, the consequences of breaching a geothermal reservoir due to inversion tectonics is less clear. In hydrocarbon reservoirs, indeed, breaching of the anticlinal traps has a clear negative effect (i.e. leakage of the hydrocarbons), while the consequences of breaching synclinal traps in geothermal systems are not yet fully understood.'*
Final sentence of the discussion: you suggest that a new deep attribute analysis could disclose information on facies architecture. Can you be more specific? It would be great if there is a suitable attribute, but if no-one did this yet, I think that the big question is on how to image these things and then this statement deserves a bit more speculation/discussion.	We agree with the reviewer. As we are currently working on this topic for a follow-up study, we cannot give a detailed answer yet. Therefore, we have removed the sentence.
<u>Figure 7:</u> how do you explain the high N/G oil/gas reservoirs at the structural highs with this model? Other models that people presented before include one where a single high N/G sand layer (the Delft Sst) is deposited on top of the lower N/G Alblasserdam Mbr, probably also covering the highs.(Out of curiosity: why did you not differentiate between the Delft and Alblasserdam Mbrs?) how do other models describe regional sandstone distribution?	We totally agree with the reviewer. Our aim was to present a simplified and generic model, 'a lesson from' and not 'a section of' the West Netherlands Basin. We have updated the figure description along: *'Simplified figure, showing the geothermal play of a fluvial-deltaic reservoir in an inverted rift basin.'*
you describe the main faults in the basin: I was curious if you have any ideas on sub-seismic structures around these major faults?	We haven't looked into the sub-seismic structures in enough detail yet to provide a full solution. Yet, we are planning a follow-up study, dedicated to the fault architecture.

Comment/corrections	Response
<u>start of intro:</u> perhaps slightly rephrase into a structure like this: ***tectonic evolution is important and explain why. Then introduce the problem you are trying to solve: something is lacking, and then: in this framework this study did that… this is a more logical order.* (hopefully this is clear)**	We thank the reviewer for the suggestion. We have rephrased the latter accordingly: *'Aiming to contribute to the energy transition, this study provides an integrated picture of the geothermal system hosted in the West Netherlands Basin and shows how the reconstruction of the basin's geological history can contribute to the correct exploitation of its*

	geothermal resources. In the West Netherlands Basin, the main geothermal targets are found in the Cretaceous and Jurassic strata that were deposited during rifting and post-rifting stages and were deformed during the subsequent basin inversion. Despite multiple studies on the tectonic setting, timing and tectono-stratigraphic architecture of the rift system and its overall control on geothermal systems are still to be fully deciphered. In this framework, a detailed interpretation of the syn- and post-rift intervals in the West Netherlands Basin will be given within the framework of geothermal exploration.'
line21: ***'…the rifting produced the geothermal target".*** **I'm not sure if this is the correct way to phrase this. The target is formed by sedimentary processes, the rifting compartmentalised it, affected properties maybe, but didn't create it, right?**	We agree with the reviewer. Rifting merely created the accommodation space in which the target is deposited and caused the compartmentalization of the area's principal producing geothermal target, the Nieuwerkerk Formation. We have changed the text: *'These two Jurassic rifting phases not only created sedimentary accommodation, but also caused compartmentalisation of the depocenters of the Late Jurassic Nieuwerkerk Formation, which is the main regional producing geothermal target.'*
Line 20: can you already state whether it's when in the Cretaceous, I was curious straightaway.	The Late Cretaceous, we have added it to the text.
Line 21: 'yet' suggests a contradiction, but which one is not clear to me.	That's right, there shouldn't be a contradiction. We have changed it to *'accordingly'*.
Line 22: *"subsequent inversion… a potential risk."* is this a new problem statement. Or one of your new insights, or a hypothesis? And is breaching the right word? And perhaps explain why this is a potential risk.	This statement needs better description, wherefore we have put a better and more detailed explanation in the discussion section and have removed it from the introduction section. See the comment about secondary fracturing for the rewritten text.
Line 24: second time that you state that the study gives more insight in tectonic evolution of the basin.	Ok, we'll remove this.
Maybe also good to explain briefly why you focus on the Jurassic-Cretaceous for readers that are not familiar with this basin. Final sentence is also quite repetitive.	Ok, good point. We've added this: *'In the West Netherlands Basin, the main geothermal targets are found in the Cretaceous and Jurassic strata that were deposited during rifting and post-rifting stages and were deformed during the subsequent basin inversion.'*
Line 53-55: you state that inversion and the rifting history could have controlled the architecture of the rift phase. What do you mean with that rift phase, structural architecture/structural setting? Or sedimentary	We thank the reviewer for the comment. The sentence, indeed, is not clear and we have removed it.

architecture of the Jurassic tectono-sedimentary sequence?	
<u>Line57:</u> could you add a statement before the listing of your focus on what is missing in current knowledge more clearly. You had something on it in the abstract, but it makes sense to make that extra clear here.	Yes, good point. We've added information about this in the abstract and introduction, see reactions at previous comments.
<u>Line123:</u> why is it relevant to mention that you used a guided approach, and even more specifically name the Petrel terminology? Do you doubt accuracy, otherwise maybe loose it to make it more generic.	It is a matter of reproducibility of the results. Therefore, we have decided to not change the text.

Letter RC2

Dear reviewer,

We thank you for reviewing our manuscript and giving interesting suggestions. Please, find below our response to your questions and comments, which we are included in the revised version of the manuscript.

Following your three main points:

- We agree that the introduction and conclusion needed some work in terms of the relevance of this work in comparison to previous studies. In the West Netherlands Basin, geothermal exploitation is going swimmingly with currently 14 producing geothermal doublets. However, as noted in Willems et al. (2020), the most recent article on the Jurassic reservoir rocks within the area, these geothermal projects also demonstrate that much of the aquifer geology remains unknown. According to Willems et al. (2020), there is still a lack of understanding about (1) regional sedimentary aquifer architecture, (2) sub-seismic structural geology, and (3) aquifer rock properties. This research provides a detailed overview of the relevant geological history of the West Netherlands Basin, which is required for geothermal development. As a result, we provide a better understanding of regional structural and sedimentary aquifer architecture. We've included this information in the revised version of the manuscript.
- We have included some information about geothermal energy in the introduction, but with a focus on the type of geothermal system used in the West Netherlands Basin.
- This is an intriguing suggestion for the well dataset and the possibility of producing a nett-to-gross map or porosity-depth charts. Today's knowledge enables the Dutch geological survey (TNO) to create maps with a regional overview of porosity, permeability, net-to-gross, etc., all publicly available on ThermoGIS. Please find the maps at the bottom of this document for more information. The well dataset has a shortcoming in that the hydrocarbon wells only target structural highs. As a result, the Nieuwerkerk Formation is lacking in data. Geothermal projects drilling and logging the Nieuwerkerk Formation in the northeastern section of the research area are helping to solve this problem. However, there is still a data gap in the eastern part of the study area, where no geothermal wells have been installed.

See below our response to the list of comments that you gave us. The grammar and language corrections are taken into account in the revised manuscript.

Comments	Response
15: just geothermal doublets? Maybe consider expanding to include other geothermal developments as well to widen the scope of the paper.	We agree and we have replaced *'geothermal doublets'* with *'geothermal wells'*.
44-45: it would be interesting to hear how many projects targeted each of these three reservoirs.	Two projects focuss on the Cretaceous sands, ten on the Jurassic sands, and two on the Triassic sands. We have included this information in the introduction: *'Up to 2023, 14 geothermal projects were realised in the area (Geothermie Nederland, 2023), targeting aquifers hosted by the post-rift Cretaceous Rijnland Group (two projects), syn-rift Jurassic Nieuwerkerk Formation (ten projects)*

	and pre-rift Triassic Buntsandstein (two projects).'
<u>46-49:</u> Is there any data available about the success rate of geothermal exploration in the WNB? If so, it would be good to include it here to give context to these statements.	Unfortunately, this kind of data is mostly confidential and can therefore not be included into the revised version of the manuscript.
<u>48-49:</u> As this is a key statement and related to your outcomes, it might be worth explaining how thickness and heterogeneity is important here i.e. a thicker and more homogenous reservoir is better than a thin and heterogenous reservoir.	Thanks for this suggestion. We've added the following: *'Understanding how the tectonic evolution of a rift basin influences the key parameters used for planning geothermal wells is therefore critical. Such parameters include aquifer thickness and heterogeneity. A thicker and more homogeneous reservoir is preferred, as it allows for better fluid flow, a higher heat extraction and an increased heat recovery (Crooijmans et al., 2016; Willems et al., 2017b), therefore making a geothermal system more profitable.'*
<u>Introduction:</u> this provides a good overview of the geothermal scene in the WNB, however its unclear what your study is doing differently. I think a few lines in the final paragraph which differentiate your work from previous studies would be great.	We agree and have rewritten the following: *'As noted by Willems et al. (2020), current geothermal projects in the WNB demonstrate that the aquifer geology is still not fully understood. Increased knowledge of the regional architecture of the sedimentary rocks hosting aquifers, sub-seismic structural geology, and aquifer properties such as stratigraphic architecture, thickness and heterogeneity, would help to de-risk the geothermal well planning in the area (Willems et al., 2020).'* *'The quality of the recently reprocessed and released L3NAM2012AR seismic 3D cube allows a detailed reconstruction of the main subsurface structures. Contrasting to previous studies that mainly focussed on the NW-part of the onshore WNB (e.g. DeVault and Jeremiah, 2002; Willems et al., 2017c; Vondrak et al., 2018), now the SE-part of the onshore WNB could be integrated into the study area as well. Accordingly, this study gives a detailed overview of the sub-seismic structural geology and increases the knowledge of the regional aquifer architecture, with a focus on the Nieuwerkerk Formation.'*
<u>Figure 1 caption: a)</u> The white lines on a light blue background are not the easiest to see. I would suggest either changing the colour of the inversion markers or adding a boundary line around the zones. <u>b)</u> It is unclear why the wells are coloured the way they are. I assume this is	a) Good point, we have given the inversion markers a more clear colour. b) Yes, this is correct. We forgot to include some information about the well colours in the

the deepest formation encountered in each well? Please add a line in the caption explaining this to help the reader.	caption. Thanks for noticing this! We've added to the description: *'…, showing all used wells with their colours referring to the deepest encountered formation, …'*
93: What does the Zechstein Group consist of in the study area? It's not shown in Figure 2 so mention the lithology here to help your reader. Probably worth checking each unit there to make sure you are consistently describing them (e.g. age, stratigraphic name, broad lithological overview).	We have added to the text: *'The very few deep wells that have been drilled into the Zechstein Group have encountered carbonates and shales, but no evaporites.'*
113-115: This is a very large well database but no mention is made here as to what these wells were used for. Expand on this here to help the reader. I assume just formation tops, as the cube was depth converted. Were there any mismatches between formation tops and the depth converted cube?	Yes, we only used the well tops that were provided by the Dutch Geological Survey on nlog.nl. As some of the used wells date from the start of hydrocarbon exploration in the basin in the 50's, and the lithostratigraphic nomenclature changed over time, not all well tops are matching. We've included more information about this in the revised manuscript: *'The well database, together with the available formation tops helped the seismic interpretation. Yet, some of the used wells date from the start of hydrocarbon exploration in the basin in the 50's, and with the lithostratigraphic nomenclature changing over time, not all available formation tops are matching, wherefore the unmatching well tops were neglected.'*
153-154: Always good to include the uninterpreted lines so your reader can understand what features and reflectors you are interpreting, nice one!	Thank you!
152-153: It would be good to describe these active geothermal projects in a bit more detail (e.g. are these closed-loop, open-loop, etc.), given the scope of this paper. Their location relative to inverted structures will allow the reader to see your results in action.	We agree; the geothermal projects are open-loop systems. We've added information about this to the introduction: *'A typical geothermal project in the Netherlands comprises a low-enthalpy geothermal system for direct heat that contains two or more wells; hot water is produced by production wells and re-injected by injection wells after the heat has been extracted (Limberger et al., 2018). In the WNB, only open loop geothermal systems (i.e. a geothermal doublet that uses the aquifer as heat exchanger) reaching production temperatures ranging from 70°C to 90°C are used (Willems et al., 2017b).'*

	We have improved Figure 7h (former Figure 6h) by adding boundaries showing the rates of inversion in the area. Additionally, the geothermal wells in Figure 1b are now marked.
<u>159:</u> I would call this the 'youngest' megasequence (or just megasequence 1) as, strictly speaking, the 'first' megasequence will be the oldest in terms of geological evolution.	Good point, we've changed this.
<u>175:</u> Like the comment above, use of 'first' here could be confusing for the reader. Additionally, to avoid confusion '3' should be spelled out (i.e. three) as it is referring to the three megasequences and not megasequence 3.	Ok, we've changed the text accordingly.
<u>217-218:</u> I would caveat the use of horizon flattening to describe thickness changes, particularly in more deeply buried units. Horizon flattening is a useful 'quick-and-dirty' technique to get broad ideas of unit variation across a section, but doesn't account for things like differential compaction due to thickness variations in shallower units, which can be particularly important in high porosity rocks like the Nieuwerkerk Formation.	We agree and we have changed the text as follows: *'The thickness changes are even more clearly visible on the flattened section (despite all the limitations and biases of the flattening procedure), where the package shows at least four distinct asymmetric fault-bounded half-grabens.'*
<u>Strikeline 3415:</u> I'm unsure if having this strike line is particularly helpful for showcasing the WNB. Structural interpretation on a line parallel to the structural trend will give a false sense of the structures and is best done on lines parallel to the direction of principle movement. It might be worth including one more dip-line, perhaps to the south of the dataset, to give the reader an indication of change along the length of the basin.	We agree with the comment, but for the sake of precision, it is important to show at least one line oriented parallel to the main trend of structures. Also, strike lines allow to image transverse faults. Therefore we keep strikeline 3415 in the revised manuscript and we have included extra dipline 4225 that is located more towards the SE of the study area.
<u>Figure 5:</u> If we are imaging a normal fault (fault i) this obliquely, we would expect the apparent dip to much shallower than the very high angles interpreted here. Additionally, should the absence of megasequence 6 on the Lansingerland High be explained in-text (no mention is made currently)? It is different to the other three sections seen so far.	The steep attitude of fault *i* suggests the occurrence of oblique segments along the trace of this fault. We've added the following to the text: *'The steep attitude of fault i suggests the occurrence of oblique segments along the trace of this fault.'* The absence of megasequence 6 on the Lansingerland High in Figure 6 (former Figure 5) is not correct. There should be a thin layer present. We've changed this in the figure, thanks for pointing this out.
<u>267-268:</u> As you mention changes in seismic facies, does this relate to changing sedimentology and possibly reservoir quality?	Most likely, yes. The reservoir's infill is derived from a fluvial-deltaic environment. As a result, the reservoir rock (megasequence 5) lacks a homogeneous infill. We didn't want to

Can these be used as indicators for geothermal explorers working in this basin?	emphasize this too much on this in this work, because we're preparing a follow-up study on the subject.
<u>332-334:</u> While you're correct the North Sea Dome likely doesn't have much impact on the WNB, it is important to realise that this far from the epicentre of this event, the effects likely to be relatively subtle, and possibly overprinted by later structural evolution. Maybe worth mentioning this as a caveat.	Yes, thank you. We've added the following to the text: *'Yet, it should be noted that later structural evolution could have overprinted subtle effects related to the North Sea Rift Dome. Still, the absence of N-ward thinning makes us discard the hypothesis of doming causing large impact on the depositional pattern of megasequence 6.'*
<u>337-338:</u> As this is the first mention of igneous activity, it's worth expanding on this a bit more here: does this impact the geothermal prospectivity of the basin? There are no igneous structures interpreted on the sections or shown in the strat column, where do they occur?	We know there are igneous rocks present, because some wells accidentally encountered them. Except for the cited paper, no work was done on these volcanic rocks. Currently, renewed interest in these rocks started some research on these rocks, but this is still ongoing work. Although we agree with the reviewer, because of the current ongoing research, and the lack of proper data on the age of the rocks, we'll leave the mention in the text as it is. Because of the lack of dated igneous rocks in the area, we were not able to properly include these rocks in the stratigraphic column of Figure 2.
<u>338-340:</u> Why are we considering these faults are sealed? Is it the lithology towards the top of megasequence 5? Worth clarifying this here to help your reader. Also, do we have evidence of this? Are there any fault-seal studies that be referenced, or are they hydrocarbon accumulations trapped in tilted fault blocks to demonstrate seal effectiveness?	This is our fault. The term sealed refers to packages that are post-kinematics, but it can be misleading when dealing with reservoirs. We have reorganized the text as follows: *'We observe that the upper portion of megasequence 5 postdates all the normal faults (excluding those showing evidence of reverse reactivation).'*
<u>383:</u> Attributing deformation to the Laramide seems a bit unrealistic here, given several other events occurring much closer to the WNB at this time, including the incipient Alpine Orogeny, the opening of the North Atlantic, and the development of the North Atlantic Igneous Province to think of a few.	The Laramide phase is a tectonic phase, recognized in the Dutch geology. This phase is not related to the formation of the Laramide Orogeny. Because the Laramide tectonic phase coincides with several geological events, as you name a few, it is difficult to relate it to one specific event. We've added some more information about the Laramide tectonic phase in the revised manuscript: *'The erosional unconformity at the base of megasequence 2 likely corresponds to the timing of the Laramide uplift that peaked during the Middle Paleocene (Deckers, 2015), which may be related to a significant drop in global sea-level (Haq et al., 1987), along with a contribution from*

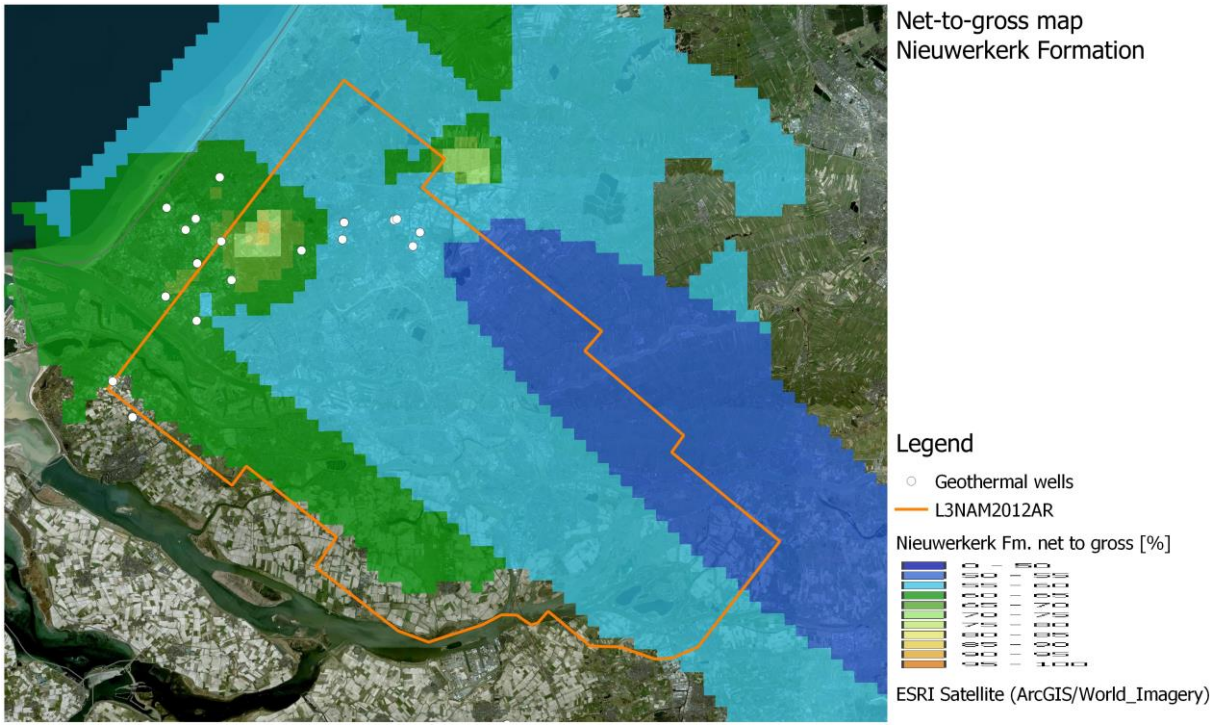
	dynamic topography associated with mantle flow (Kley, 2018; Voigt et al., 2021). The Laramide tectonic phase is believed to have caused basin uplift in the area of the WNB (Deckers and van der Voet, 2018; Kley, 2018).'
389-399: I wonder is it worth talking about the Triassic at all here, as it is not mapped and is not the focus of the study? I leave this to the authors' discretion.	As the Triassic is one of the exploited reservoirs, it made sense to mention it briefly. The results of this study might gain some new insights and help geothermal exploration of the Triassic sands. Therefore, we've kept this part in the revised manuscript.
407: As you state these values are depth and not elevation, they do not need the negative symbol in front of them.	You're right, we've changed this.
408-409: I think it might be useful to have a short introductory section earlier in the manuscript, probably between the intro and geological framework sections, which briefly explains the different types of geothermal energy, and highlight which ones are active or planned in the Netherlands.	Good point, we've added the following information to the introduction: *'A typical geothermal project in the Netherlands comprises a low-enthalpy geothermal system for direct heat that contains two or more wells; hot water is produced by production wells and re-injected by injection wells after the heat has been extracted (Limberger et al., 2018). In the WNB, only open loop geothermal systems (i.e. a geothermal doublet that uses the aquifer as heat exchanger) reaching production temperatures ranging from 70°C to 90°C are used (Willems et al., 2017b).'*
422-423: As there is such a large well database to support this manuscript, would it not be possible to produce a net-to-gross map for each reservoir unit, to validate these claims?	This is an interesting question that we intend to investigate further in the future. Unfortunately, this is beyond the scope of this research paper as it would require an additional dedicated data and methods section, along with new figures. The Dutch geological survey, on the other hand, provide a net-to-gross map of the Nieuwerkerk Formation, which can be accessed on ThermoGIS. This net-to-gross map is attached at the bottom of this document. The problem here is that these maps are based on data from hydrocarbon wells, which only target structural highs. The Nieuwerkerk Formation lacks data as a result of this. In the northeastern section of the research area, this problem is partially resolved by geothermal projects drilling and logging the Nieuwerkerk Formation. However, there is a lack of data in the rest of the study area, where no geothermal wells have been drilled.
426-427: Is there any published data or interpretations to support this? If not, perhaps include a general reference which states the degree of fracturing in inverted structures.	There is no published data that we're aware of. Therefore, we've included a general reference: *(Tari et al., 2020)*.

Breached hydrocarbon accumulations might also support this supposition.	Tari, G., Arbouille, D., Schléder, Z., and Tóth, T.: Inversion tectonics: a brief petroleum industry perspective, Solid Earth, 11, 1865-1889, https://doi.org/10.5194/se-11-1865-2020, 2020.
436-439: As with the comment above, perhaps a porosity vs depth plot could be made from available well data? Comparing the inverted and non-inverted reservoirs will likely show that the inverted areas will have poorer porosity due to deeper burial and greater mechanical compaction prior to inversion when compared to non-inverted areas. This could help support your findings in this study.	This is an interesting question. Yet, like our response to the question above, this is beyond the scope of this research paper as it would require an additional dedicated data and methods section, along with new figures. However, please find below a porosity and permeability map similar to the nett-to-gross map that is also made available by TNO on ThermoGIS.
441-446: I would highlight what new findings you have here, to make your work stand out from existing literature. Similar to what has been suggested for the introduction above.	That is an excellent point. We've added the text below. For an explanation of what is new in this research, see the beginning of this response letter. *'A renewed seismic interpretation of the recently released L3NAM2012AR seismic 3D dataset, allowed a detailed study of the sub-seismic structural geology of the WNB, which helps better understand the regional sedimentary aquifer architecture.'*

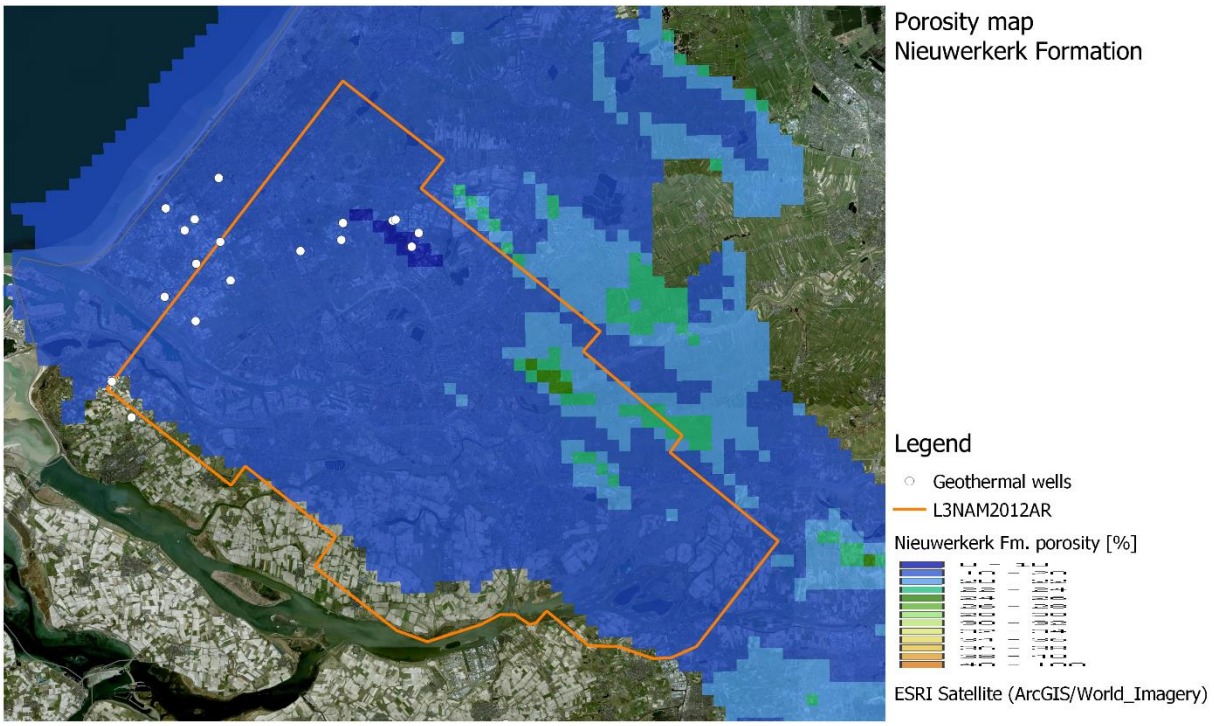
Tari, G., Arbouille, D., Schléder, Z., and Tóth, T.: Inversion tectonics: a brief petroleum industry perspective, Solid Earth, 11, 1865-1889, https://doi.org/10.5194/se-11-1865-2020, 2020.

TNO Geologische Dienst Nederland: ThermoGIS v2.2, https://www.thermogis.nl/mapviewer, last access: 17 August 2023.

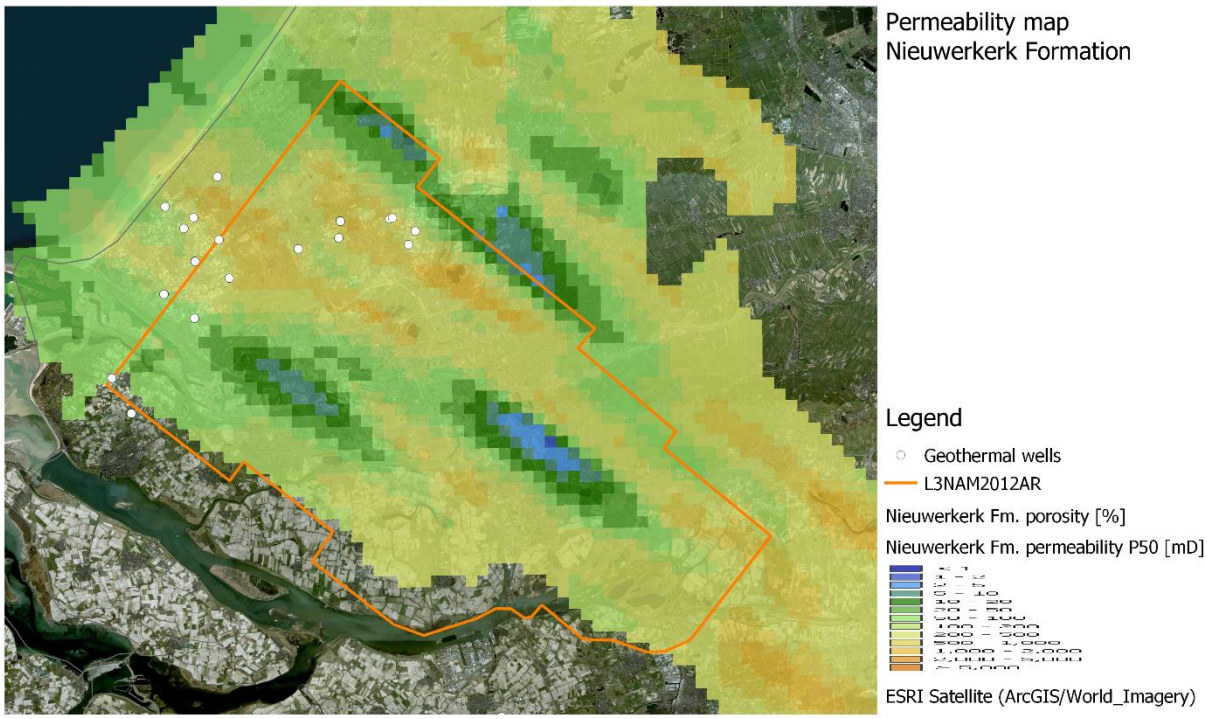
Willems, C. J. L., Vondrak, A., Mijnlieff, H. F., Donselaar, M. E., and van Kempen, B. M. M.: Geology of the Upper Jurassic to Lower Cretaceous geothermal aquifers in the West Netherlands Basin – an overview, *Netherlands Journal of Geosciences*, 99, e1, https://doi.org/10.1017/njg.2020.1, 2020.



Net-to-gross map, made available by TNO on www.thermogis.nl. The map is displayed with the seismic 3D dataset that is used in this study and all geothermal wells that are drilled in the area.



Porosity map, made available by TNO on www.thermogis.nl. The map is displayed with the seismic 3D dataset that is used in this study and all geothermal wells that are drilled in the area.



Permeability map, made available by TNO on www.thermogis.nl. The map is displayed with the seismic 3D dataset that is used in this study and all geothermal wells that are drilled in the area.

The SE part contains some interpretation issues, so we have taken a section in the southern part that doesn't contain this problem.

We've taken the most representative section of the southern part. In this we can

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