Referee 1 - Fernando Ornelas Marques

Assessment: the topic of the ms. is relevant for geosciences, and therefore suitable for EGUsphere, but not in its present form. The ms. needs major revision before matching the high standards of the journal. Based on their experimental results, the authors conclude that the scenario proposed by Marques et al. (2014) for the inversion of the Araripe Basin is not viable. This is wrong because they did not test the arguments used by Marques et al. (2014), which are much lower angle between shortening direction and graben strike (<45º), and fault lubrication by injected soft clays. Therefore, all the authors may conclude is that 45º are not enough to explain the amount of inversion in the Araripe Basin. This is the main problem that the authors have to solve. The authors should read more carefully what previous authors have said about the mechanics of inversion of normal faults (e.g. Sibson 1985; Brun and Nalpas, 1996; Marques and Nogueira, 2008), in particular what Marques et al. (2014) proposed for the Araripe Basin.

- **Answer:** Thank you for your review, it is very important to have a revision from an author that worked in the area of interest. First of all, we agree that we have to discuss more papers on the inversion of the Araripe. We have improved that in the revised version and added more references to these papers.
- Regarding the reactivation of rift faults, we must unfortunately disagree with the reviewer. The main rift fault system is oriented NE-SW to ENE-WSW. If we look at the map from Marques et al. (2014), the indicated reverse faults are mainly oriented NW-SE, therefore these faults are not related to the pre-existing rift system (NE-SW).
- In our figure 1, we added the main NE-SW normal faults that controlled the Araripe rift phase. This figure was drawn using existing geological and aeromagnetic maps (Scherer et al., 2014; Camacho and Souza, 2017), and seismic interpretations (Rosa et al., 2022). The grabens shown on the figure are well-known from the literature.
- Moreover, the argument that fluid-assisted deformation could assist inversion of faults may on itself be valid, but we argue that these NW-SE faults do not represent the main rift system and there is no evidence, in seismic studies (Ponte and Ponte-filho, 1996, Rosa et al., 2022), for large-scale fault inversion due to horizontal compression. Therefore, this argument, like the argument of more

oblique convergence to explain the inversion of the Araripe Basin rift structures, is superfluous.

- Instead, it may be that Marques et al. (2014) over-extrapolated the structures they found in the field. A recent study by (Rosa et al., 2023) suggested the existence of two phases of extension with different extension during rifting in the Araripe Basin. Such a reorientation of extension may have caused some minor reactivation of the normal faults described by Marques et al. (2014).
- However, there are in fact some signs of inversion on seismic sections from the Araripe Basin, as well as from other basins in the region (Rio do Peixe Basin, Vasconcelos et al., 2021). It is just by far not as intense as the Marques et al. (2014) scenario. As such, we still need to explain where the deformation was expressed in the Araripe Basin since it did not cause the inversion of the original rift structures, and here our analogue models come into play.
- Our models show that for various scenarios, the bulk of inversion can be accommodated by new reverse faults. This fits very nicely with the findings from the recent work by Vasconcelos et al (2021) on the nearby Rio do Peixe Basin, where such reverse faults were found outside of the main basin.
- We now added this information to introduction, and discussion parts of the text, presenting a somewhat revised argument* that still leads to the same interpretation as in the previous version: we predict that the bulk of inversion in the Araripe Basin is accommodated by new reverse faults.

* Revised argument in the new manuscript:

- there are two end-member models for the Araripe Basin uplift: regional uplift (Peulvast and Bétard, 2015) and full inversion of the old rift structure (Marques et al. 2014)
- We know that inversion happened (minor inversion seen on seismic lines, indications from other basins) so that the Peulvast and Bétard (2015) model is not complete.
- But all available data indicates that it did not cause the large-scale inversion of the rift basin structures that Marques et al. (2014) proposed.

- Thus, we ran a series of analogue models to explore how inversion of the basin could have taken place.
- We find that new reverse faults can be a good explanation as to how inversion in the Araripe Basin may have occurred, which is in line with observations from nearby inverted basins.

Main comments

Models with orthogonal and oblique inversion cannot be directly compared because the amount of extension (rift phase) and shortening (inversion phase) are not the same (smaller in the oblique inversion). This is because the run time is the same for most experiments, and even worse when the inversion time was reduced from 120 to 85 minutes. It is easy to see the problem using vectors and simple trigonometry. Angle of 45º for the inversion phase – Brun and Nalpas (1996) showed experimentally that the angle between graben strike and shortening direction must be < 45º for inversion of precursor normal faults to take place. They also show in their Fig. 4 that at 45º new thrusts form, and that inversion of normal faults is minimal, similarly to the experiments presented by Richetti et al.. Therefore, what these authors are showing is that 45º is too much, and so they cannot argue that reactivation of precursor normal faults is not enough to explain the Araripe inversion. Make your definition of angle alfa equal to Brun and Nalpas' definition for consistency. For the non-expert reader it becomes confusing, because your alfa is the complementary angle of Brun and Nalpas' definition.

- **Answer:** We agree that there may be some issues if one would attempt a quantitative comparison. However, we are not doing so, as we are more interested in the general behaviour of the system by means of a qualitative comparison. The differences in main structures are quite clear when comparing our various models. As such, we believe that not having the exact same amount of shortening in a couple of our models is a big issue.
- Please note that different analogue modellers use different definitions of angle alpha in their papers (either the angle between the normal to the rift axis and the displacement direction, or the angle between the rift axis and the displacement directions). We believe that our definition (the latter) is more intuitive as it means

that orthogonal divergence or convergence is defined as alpha = 0˚ (no obliquity) and prefer to keep it as is.

Richetti et al. say in lines 497-499, and I quote: "*However, although we observed some fault reactivation in our oblique inversion models, this reactivation did never lead to full inversion of the graben normal faults (Figs. 9 and 10), which* ***contradicts*** *the Marques et al. (2014) scenario*". **No, it does not contradict**. We proposed a much lower angle between shortening direction and graben strike (you can check in Fig. 6B). Besides, we also considered fault weakening as a mechanism that can promote inversion (read text upfront in the Abstract, and look at Fig. 11 for a field example) as experimentally shown by Marques and Nogueira (2008), which you should cite when discussing mechanisms of normal fault inversion and the Araripe Basin.

- **Answer:** We deleted part of the sentence the reviewer does not agree with, but no indications of large-scale inversion is observed in other (field and geophysical) studies of the Araripe Basin and other basins in the region. Therefore, the discussion whether higher degrees of oblique convergence, or fault weakening is in fact irrelevant. As described above, we have rewritten part of the manuscript to better reflect this argument.

Richetti et al. further say in lines 514-515, and I quote: "*We thus find that neither of the two end-member scenarios seems to fully explain the inversion observed in the Araripe Basin area.*". This is simply wrong, for two reasons: (1) you did not test Peulvast and Bétard's hypothesis; (2) you did not test what Marques et al. (2014) proposed for the Araripe inversion, which is low inversion angle and fault lubrication.

- **Answer:** We disagree, as pointed out in the new manuscript, both end-members do not work: we see that there is some localized inversion going on in the area, but we do not see the large-scale inversion of rift faults as proposed by Marques et al. (2014). However, field data from other basins nearby does show the kind of reverse faults away from the basin that we would expect based on our modelling results.

Fault lubrication – Marques et al. (2014) proposed that inversion was facilitated by injection of soft materials (mostly clay, but most probably also fluid overpressure; e.g.

Cobbold and Castro, 1999; Mourgues and Cobbold, 2003) into the precursor normal faults. This effect was shown experimentally by Marques and Nogueira (2008), who concluded that normal fault inversion, even by orthogonal compression, is possible if, and only if, the fault friction is greatly decreased. Given that Richetti et al. did not test the effects of fault lubrication, they should be more cautious when discussing what Marques et al. (2014) said about the inversion of the Araripe Basin, and they should cite Marques and Nogueira (2008) to support what Marques et al. (2014) proposed.

- **Answer:** We simply don't see the large-scale fault reactivation in any other studies that show the Araripe basin seismic lines, so the argument regarding the effects of fault weakening is irrelevant (see previous comments on this topic).

Abstract

Line 14

- **Comment:** infill currently found
- **Answer:** Thanks for the suggestion, it is modified.

Line 14

- **Comment:** "is proposed" gives the impression to the reader that the idea is yours, which is not the case. Therefore, it should be replaced by "has been proposed by previous authors"
- **Answer:** Thanks for the suggestion, it is modified.

Line 17

- **Comment:** This is not correct, you only tested one scenario, the tectonic inversion scenario

Line 23

- **Comment:** Échelon
- **Answer:** Thanks for the suggestion, it is modified.

Line 25

- **Comment:** What angle between shortening direction and master border fault strike?

Line 30

- **Comment:** This is not true. Marques et al. (2014) include all your experimental results, mainly new reverse faults and inverted normal faults. Additionally, Marques et al. (2014) also explain normal fault inversion by weak fault rock that lubeicates the fault during inversion.
- **Answer:** The rift faults should be reactivated and highly inverted in our experiments to include all Marques et al. (2014) results. See previous comments on why fault lubrification/weakening (nor highly oblique convergence) does not solve the issues of the missing large-scale inversion of original rift faults.

Line 31

- **Comment:** I do not see why this an alternative to the explanation given By Marques et al. (2014)
- **Answer:** It is different since we propose no major reactivation of rift boundary faults. Instead, we propose the formation of new reverse faults away from the original basin.

1 Introduction

Line 48

- **Comment:** Sinistral
- **Answer:** Thanks for the suggestion, it is modified.

Line 52

- **Comment:** and ca. 500 m above the surrounding basement
- **Answer:** Thanks for the suggestion, it is modified.

Line 54

- **Comment:** You have to cite Gurgel et al. (2013), Nogueira et al. (2015) and Ramos et al. (2022)
- **Answer:** Thanks for the suggestion, we added the references.

Line 55

- **Comment:** maximum compressive stress
- **Answer:** Thanks for the suggestion, it is modified.

Line 60

"According to Marques et al. (2014), this compression caused the complete inversion of the initial high angle normal faults of the Araripe Basin (Fig. 1e) through an oblique compression and injection of soft material into these faults."

- **Comment:** and the creation of new low angle reverse faults in
- **Answer:** Marques et al (2014) figure of their inversion model does not represent new low angle reverse faults in the basement outside the rift grabens. That's very different from our results, these new reverse faults are very important in our models.

Line 61

- **Comment:** into
- **Answer:** Thanks for the suggestion, it is modified.

Line 66

- **Comment:** Brun and Nalpas (1996) must be cited here
- **Answer:** Thanks for the suggestion, added the reference.

Line 67

- **Comment:** Marques and Nogueira (2008) should be included here for inversion, because the precursor normal faults have been more easily inverted due to weakening of the fault rock, which decreases friction
- **Answer:** Thanks for the suggestion, added the reference, but as stated earlier, it seems that fault weakening did not play an important role as rift faults did not experience major inversion.

Line 71

- **Comment:** and differential erosion (basin sediments more resistant to erosion than basement granitic and metamorphic rocks)
- **Answer:** Thanks for the suggestion, it is modified.

Line 75

- **Comment:** tectonic inversion
- **Answer:** Thanks for the suggestion, it is modified.

Line 75

- **Comment:** These authors do not consider tectonic inversion a viable mechanism. They say it up front in the Abstract
- **Answer:** Thanks for the suggestion, it is modified.

Line 76

- **Comment:** could have taken
- **Answer:** Thanks for the suggestion, it is modified.

Line 77 (figure 1)

- **Comment:** These normal faults do not agree with inversion as proposed by Marques et al. (2014). Check Fig. 6b of Marques et al. (2014)
- **Answer:** This is because we compiled the rift faults from other works (these are cited in the figure caption), since inversion structures in Marques et al. (2014) are mainly oriented NW-SE and the faults are no plotted over a map, while the DEM image cuts out the main east portion of the basin where most rift faults are found. In conclusion, Marques et al. (2014)'s figure 6b proposes new inversion faults (which, as pointed out earlier, are not identified on seismic lines) and no rift inverted rift-related faults.

2 Methods

2.1 Model set up

Line 90

- **Comment:** end walls, because it is confusing to have 4 sidewalls
- **Answer:** Thanks for the suggestion, it is modified.

Line 91

- **Comment:** Thick
- **Answer:** Thanks for the suggestion, it is modified.

Line 92

- **Comment:** Intercalated
- **Answer:** Thanks for the suggestion, it is modified.

2.2 Materials

Line 133

- **Comment:** quartz
- **Answer:** Thanks for the suggestion, it is modified.

2.3 Model parameters

Line 149

- **Comment:** All this is a major problem, because you cannot compare final results of orthogonal and oblique rifting and inversion
- **Answer:** The comparison is indeed not 100%, as the timing is not exactly the same, but still we can do a highly useful comparison as the general structural template is established early on. Longer duration does not significantly change the major features.

Line 157 (table 2)

- **Comment:** Why not?!
- **Answer:** We do not show these sections because we only made them for one model in series B, and we do not focus on these models as there is no sedimentation in these models (therefore they are less realistic). We now added in the table that these cross-sections are presented in the supplementary material.

2.4 Scaling

Line 163

- **Comment:** Nature
- **Answer:** Thanks for the suggestion, it is modified.

3 Results

Line 229

- **Comment:** This figure does not exist in the PDF I received
- **Answer:** The sections are included in the supplementary material and we corrected the text.

3.1 Series A – Reference models

Line 233

- **Comment:** delete the hyphen
- **Answer:** Thanks for the suggestion, it is modified.

3.1.1 Orthogonal rift without syn-rift sedimentation - Model A1

Line 237

- **Comment:** With
- **Answer:** Thanks for the suggestion, it is modified.

Line 242

- **Comment:** Shows
- **Answer:** Thanks for the suggestion, it is modified.

Line 242

- **Comment:** associated with
- **Answer:** Thanks for the suggestion, it is modified.

Line 246

- **Comment:** of the rifting
- **Answer:** Thanks for the suggestion, it is modified.

Line 247

- **Comment:** two master faults bounding the
- **Answer:** Thanks for the suggestion, it is modified.

Line 248

- **Comment:** subsidence
- **Answer:** Thanks for the suggestion, it is modified.

3.1.2 Orthogonal rifting with syn-rift sedimentation – Model A2

Line 253

- **Comment:** At what stage?
- **Answer:** Thanks for the suggestion, we added details to the text.

Line 258

- **Comment:** Models
- **Answer:** Thanks for the suggestion, it is modified.

Line 260 (figure 3)

- **Comment:** You must give the used vertical exaggeration in d and h
- **Answer:** Thanks for the suggestion, we added to the figure caption.

Line 260 (figure 3)

- **Comment:** There is something wrong when comparing d and h with i and j, because the width of the final graben in h is significantly smaller than in d, which is the opposite of i and j
- **Answer:** We do not really follow what the issue is here. The graben is correctly depicted between h and j. Perhaps the issue is that the topographic profiles overlap due to the constant sedimentary infill?

Line 260 (figure 3)

- **Comment:** Vertical axes are missing. The reader needs dimensions
- **Answer:** There must be some confusion, as the vertical displacement measurements are there in the figure.

Line 261

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

3.2 Series B – inversion without sedimentation

Line 271

- **Comment:** models
- **Answer:** Thanks for the suggestion, it is modified.

Line 272

- **Comment:** models
- **Answer:** Thanks for the suggestion, it is modified.

3.2.1 Orthogonal rifting - orthogonal (B1) and oblique inversion (B2)

Line 275

- **Comment:** oblique (B2)
- **Answer:** Thanks for the suggestion, it is modified.

Line 276

- **Comment:** This is a repetition of A1. Delete
- **Answer:** I described model B1 rifting phase in this sentence I can't delete it.

Line 281

- **Comment:** What is initially? How many minutes?
- **Answer:** Thanks for the suggestion, it is modified.

Line 284

- **Comment:** Give time (minutes) to all these stages that you describe
- **Answer:** Thanks for the suggestion, it is modified.

Line 285

- **Comment:** adjacent to
- **Answer:** Thanks for the suggestion, it is modified.

Line 285

- **Comment:** Of
- **Answer:** Thanks for the suggestion, it is modified.

Line 287

"After the first hour of oblique inversion in Model B2, strain was localized along the graben border faults (Fig. 4l) showing direct reactivation of the original graben faults only, in clear contrast to the orthogonal inversion of Model B1 (Fig. 4d). At the end of

Phase 2, however, a single oblique reverse fault had appeared at the model surface grid, north of the graben, while all previous rift related faults were inactive (Fig. 4m). The final topography shows a significantly higher maximum elevation than the pre-rift surface of ~15 mm in orthogonal inversion Model B1 (Fig. 4f, h), while the oblique inversion Model B2 (Fig. 4n, p) had an ~7 mm higher elevation than the pre-rift surface."

- **Comment:** You should quantify all this description by making measurements on the topographic profiles and produce graphs with evolution over time
- **Answer:** The evolution over time of the topography is already provided. We already added some quantification and are not sure what other quantification is requested here.

- **Comment:** You should also draw on the profiles the inversion faults within the graben
- **Answer:** They are provided within the cross-sections, wherever available. For models without cross-sections, it is not possible to place these faults with confidence. However, the new reverse faults can be indicated over the topography profile, and we already indicated them.

Line 294 (figure 4)

- **Comment:** Insert dashed lines in d, e, l and m that represent the master border faults at the end of the rifting phase, so that we can better visualize the effects of shortening
- **Answer:** We opted not to insert more dashed lines in these pictures since it would make it to crowded and we can see the faults clearly as they are.

- **Comment:** Minimum
- **Answer:** Thanks for the suggestion, it is modified.

- **Comment:** Zero should be the initial horizontal topographic surface
- **Answer:** Thanks for the suggestions, we will provide this change at the figures

- **Comment:** Why are g and o so different?
- **Answer:** They are not that different in fact, the only difference is the graben shape and not the general subsidence pattern. We believe is it due to sand collapse during the rifting process. Some variation is to be expected in analogue models, this is not an issue here.

- **Comment:** Where are the inverted faults?
- **Answer:** The inverted faults can be seen in the DIC minimum normal strain figures. It would be too uncertain to draw them at the topographic profiles without having access to cross-sections. We also believe the image would become too crowded when adding faults to them, and we already pointed out the new reverse faults.

Line 295

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

3.2.2 Oblique rifting - orthogonal (B3) and oblique inversion (B4)

Line 302

- **Comment:** oblique (B4)
- **Answer:** Thanks for the suggestion, it is modified.

Line 304

- **Comment:** échelon to be corrected everywhere in the text
- **Answer:** Thanks for the suggestion, it is modified.

Line 305

- **Comment:** show
- **Answer:** Thanks for the suggestion, it is modified.

Line 308

- **Comment:** formation of a
- **Answer:** Thanks for the suggestion, it is modified.

Line 312

- **Comment:** was
- **Answer:** Thanks for the suggestion, it is modified.

Line 313

- **Comment:** Quantification of all this description as for models B1 and B2
- **Answer:** Thanks for the suggestion, we were more specific with the timing of the models through the description.

Line 315

- **Comment:** Model
- **Answer:** Thanks for the suggestion, it is modified.

Line 317

- **Comment:** Shows
- **Answer:** Thanks for the suggestion, it is modified.

Line 322

"The topography profiles indicate uplift of the rift structures (17 mm elevation of the bottom of the graben) and the new reverse faults on both sides of it (Fig 5p), and while

the northern reverse fault became inactive, distributed uplift affected the northern part of the model (Fig. 5p).”

- **Comment:** It cannot be northern in both cases
- **Answer:** Both are northern because we were describing the distributed uplift related to the reverse fault inactivity (even though the fault is inactive, there is still some general uplift going on).

Line 322

- **Comment:** Topographic
- **Answer:** Thanks for the suggestion, it is modified.

Line 324 (figure 5)

- **Comment:** Where are the inverted normal faults?
- **Answer:** The reactivation of normal faults can be seen on the DIC minimum normal strain analysis figures related to the experiments (Figure 5l)

Line 325

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

Line 330

- **Comment:** This makes it impossible to compare final stages. Why did you do this?
- **Answer:** See previous comments on this topic. This is not a major problem to our models and to the kind of assessment we are doing in this manuscript.

3.3.1 Orthogonal rifting with sedimentation - orthogonal (C1) and oblique inversion (C2)

Line 338

- **Comment:** oblique (C2)
- **Answer:** Thanks for the suggestion, it is modified.

Line 345

"Cross-section thickness measurements from each of the 15 minutes syn-rift sedimentation intervals (I1-I8), indicate a progressive increase of subsidence in the first two sedimentation intervals (Fig. 7a$_I$; I1 to I3)."

- **Comment:** How did you measure?
- **Answer:** It was measured at the cross-sections sedimentation intervals represented by the quartz and feldspar sand intercalation, indicated in figure 7. We will check the text and the figure to be more specific.

- **Comment:** Indicate where the reader can see this (insets in Fig. 7)
- **Answer:** Thanks for the suggestion, it is modified.

Line 349

- **Comment:** Inherited
- **Answer:** Thanks for the suggestion, it is modified.

Line 351

- **Comment:** also rose
- **Answer:** Thanks for the suggestion, it is modified.

Line 356

- **Comment:** SE quadrants
- **Answer:** Thanks for the suggestion, it is modified.

Line 357

- **Comment:** Shows
- **Answer:** Thanks for the suggestion, it is modified.

Line 358

- **Comment:** visible on
- **Answer:** Thanks for the suggestion, it is modified.

Line 361 (figure 6)

- **Comment:** Minimum Correct everywhere
- **Answer:** Thanks for the suggestion, it is corrected.

Line 363

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

Line 369 (figure 7)

- **Comment:** Replace with: Model C1 - orthogonal rift and inversion. Idem for b, c and d
- **Answer:** Thanks for the suggestion, it is modified.

- **Comment:** Move inset upwards so that we can see the full reverse fault in the N
- **Answer:** Thanks for the suggestion, it is modified.

Line 370

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

3.3.2 Oblique rifting with sedimentation – orthogonal (C3) and oblique (C4) inversion

Line 385

- **Comment**: results similar to models
- **Answer:** Thanks for the suggestion, it is modified.

Line 386

- **Comment:** rifting,
- **Answer:** Thanks for the suggestion, it is modified.

Line 390

- **Comment:** Represent, filling
- **Answer:** Thanks for the suggestion, it is modified.

Line 391

- **Comment:** be more specific
- **Answer:** Thanks for the suggestion, it is modified.

Line 406

- **Comment**: hidden by the inset
- **Answer:** Thanks for the observation, it is corrected.

- **Comment:** Not necessarily. It can root at the inherited normal fault immediately to the South

- **Answer:** I wrote what was observed at the cross-section and there was no connection with the normal fault. Added more description to the text to improve its understanding, than you for the observation

Line 408

- **Comment:** Figure caption
- **Answer:** Thanks for the suggestion, it is modified.

4 Discussion

4.1 Summary and comparison to previous models

Line 417

- **Comment:** imposed kinematics
- **Answer:** Thanks for the suggestion, it is modified.

4.1.1. Rifting phase

Line 427

"Furthermore, oblique extension caused a decrease in graben width compared to the orthogonal rifting models, as also described in previous studies (Zwaan and Schreurs, 2016; Zwaan et al., 2018a) (Figs. 3 and 4)."

- **Comment:** The issue is not that it is oblique, it is that run time is the same for orthogonal and oblique rifting
- **Answer:** We are not sure what is the issue here. We have the same amount of displacement along the direction of deformation used in the rifting phase of each model.

Line 429

"This reduction in width is caused by the strike-slip component accommodating deformation in oblique rifting settings."

- **Comment:** It seems to me that it is due to different amounts of extension. To be comparable, the orthogonal extension should be identical in both models, which means that the oblique extension should run for longer time.
- **Answer:** See previous comments, our analysis is consistent.

Line 431

- **Comment**: In science, demonstrations are restricted to Mathematics. Replace with showed
- **Answer:** Thanks for the suggestion, it is modified.

Line 434

"A narrower graben forming during oblique rift evolution led to smaller loads of sedimentation, consequently there was less weight to cause graben floor subsidence."

- **Comment:** But not because it is oblique. Again the problem of identical time for differently otiented vectors
- **Answer:** Again, it is not a problem. Same answer as to the same questioning above (lines 427, 429).

4.1.2. Inversion phase

Line 460

"Without sedimentation, the rift structures were reactivated during inversion, and the new reverse faults developed independently of inversion direction (Fig. 9)."

- **Comment:** This is not true. Compare panels h and p in Fig. 4, and h and p in Fig. 5. If you draw the inverted normal faults you will see significant diferences
- **Answer:** In figure 9 (schematic for models in figures 4 and 5) we show those topographic profiles at the 3D cubes for each model and we see new reverse faults

developing in every model. As for the inverted normal faults, we see the reactivation in the DIC and its very clear how the topography inside the graben is inverted.

- **Comment**: These are sketches, not true profiles as in Figs. 4 and 5
- **Answer:** Yes, they are the 3D sketches of the true topographic profiles in figures 4 and 5.

Line 464

- **Comment:** You must show this on the topographic profiles by drawing the inverted faults
- **Answer:** Reactivation is showed in the DIC figures of minimum normal strain and since we don't have cross-sections, we don't want to draw these faults in section. that's why we added dashed lines in the schematic drawings.

Line 475

- **Comment:** This is one reason why Marques et al. (2014) considered a much smaller angle (in Brun and Nalpas, 1996, notation) for the inversion of the Araripe Basin. Fault lubrication can also promote inversion of normal faults, as experimentally shown by Marques and Nogueira (2008), and observed in the field by Marques et al. (2014)
- **Answer:** See earlier replies: the argument of having more oblique convergence or fault lubrication/weakening is not relevant, as there are no large-scale inverted rift faults in the area.

Line 476

- **Comment:** If you believe that these authors are corrected, why did you use 45º?
- **Answer:** We were interested in the general effect of obliquity to explore the potential evolution of the basin, and what is pointed out here is that similar behaviour has been observed by other modellers. This is a good thing in our eyes.

Line 479

- **Comment:** In Fig. 4p I can clearly see inverted normal faults in the graben. Why don't you show them here?
- **Answer:** We are showing them, because these schematic drawings of the models are exactly the topographic profiles you see in the results figures. The top lines in the front and in the back of the cube are the topographic lines for each model. But we added some detail to the figure.

- **Comment:** The same here. Check Fig. 5p.
- **Answer:** The problem we see here is that we did not add the dashed lines representing the probable reactivated normal faults we see in the DIC. We are adding this to the figure so it's the same as models B1, B2 and B3.

4.2 Comparing model results with the Araripe Basin

Line 487

- **Comment:** currently peaks
- **Answer:** Thanks for the suggestion, it is modified.

Line 488

- **Comment:** 2007), i.e. ca. 500 m above the surrounding basement.
- **Answer:** Thanks for the suggestion, it is modified.

Line 489

- **Comment:** and differential erosion
- **Answer:** Thanks for the suggestion, it is modified.

Line 499

"However, although we observed some fault reactivation in our oblique inversion models, this reactivation did never lead to full inversion of the graben normal faults (Figs. 9 and 10), which contradicts the Marques et al. (2014) scenario."

- **Comment:** No, it does not. We proposed a much lower angle between sigma 1 and graben strike. Besides, we also considered fault weakening as a facilitator mechanism, as experimentally shown by Marques and Nogueira (2008)
- **Answer:** Deleted part of the sentence the reviewer does not agree with, but as pointed out before, no indications of large-scale inversion of rift faults is observed in other studies of the basin.

Line 499

"In fact, no large-scale fault reactivation has been observed in the Araripe Basin (Ponte and Ponte-filho, 1996)."

- **Comment:** Maybe Ponte and Ponte-Filho (1996) overlooked large-scale fault reactivation, but we did not, and we show pictures of them in our paper Marques et al. (2014)
- **Answer:** To be frank, inversion on the scale proposed by Marques et al. (2014) would be somewhat hard to miss on seismic data. Instead, it may be more likely that the faults found by Marques et al. (2014) are not that significant as the authors propose. See also previous replies on this topic

Line 500

"A further argument against the Marques et al. (2014) scenario would be that the post-rift sediments outside the original graben domain would not have been uplifted in contrast to what we see in nature (Fig. 1)."

- **Comment:** This is a wrong and unfair statement. For the study in 2014, we did not have the time to study the rocks outside the main graben. In the Rio do Peixe Basin we had plenty of time and so we found reverse faults outside the main basin. You can check Vasconcelos et al. (2020), for instance in Fig. 9a and e.
- **Answer:** The reviewer is right and are thankful for the reference to this paper. Vasconcelos et al (2021) found reverse faults in the basement outside the Rio do

Peixe Basin, which fits perfectly with our models. We are adding this in the discussion. On the other hand, in the inversion model by Marques et al. (2014), shown in their figure 18, all deformation is concentrated in the form of inverted normal faults (which, as pointed out earlier, does not fit with data from the Araripe Basin).

- We think we were not clear with this sentence, so we deleted it and wrote a new paragraph. What we meant here was that part of the Araripe high standing topography (post-rift units) is not only on top of the previous rift grabens of the basin, but in the western part of the Araripe mesa the post rift units are covering the pre-Cambrian basement. Therefore, we should expect to see a structural difference along this topographic feature if this were to be a result of pure inversion of the original rift faults (it would mean that the post-rift sediments away from the original graben would not have been uplifted).
- About Rio do Peixe Basin, there are no post-rift units currently there (maybe they are simply eroded), which is probably why there is no high standing topography there too. Vasconcelos et al (2021) state that the inversion intensity in the Rio do Peixe faults is mild to moderate compared to the Araripe Basin (even so, the authors found reverse faults away from the basin, which makes their presence in the more inverted Araripe Basin all the more likely). However, the main difference between these two basins seems to be the current presence of the post-rift units, and without these units Araripe probably would look the same as the Rio do Peixe Basin topography wise.

Line 503

"This uplift of post rift sediments outside of the original graben domain can be explained by the Peulvast and Bétard (2015) scenario…"

- **Comment:** Not only. It can also be explained by thrusting outside the main basin, as proposed by Vasconcelos et al. (2021) for the Rio do Peixe Basin
- **Answer:** Indeed, this is the whole point: we expect reverse faults outside of the basin, as seen in our models. We thank the reviewer for pointing us to the Vasconcelos et al. (2021) paper that supports our interpreration (see answers to the previous comment[s]). We rewrote the text a bit here.

Line 508

- **Comment:** Many other references are missing here. See list given in the report
- **Answer:** Added the references listed about the South American plate compression.

Line 510

- **Comment:** Critical references are missing here, including for the Araripe Basin inversion. See list given in the report
- **Answer:** Added the references related to the basin inversion proposed by the reviewer.

Line 514

- **Comment:** This is simply wrong, for two reasons: (1) you did not test Peulvast and Bétard's hypothesis; (2) you did not test what Marques et al. (2014) proposed for the Araripe inversion, which is low inversion angle and fault lubrication.
- **Answer:** We deleted this sentence and rewrote it focusing on a modified argument (see previous replies).

Line 518

- **Comment:** This statement is wrong, because you only tested 45º
- **Answer**: Rewrote the sentence to better explain my point here, I was only talking about my own models and not generalizing.

Line 519

- **Comment:** This is a wrong statement, because, to my knowledge, reverse faults have not been observed outside the main Araripe Basin
- **Answer:** As the author specified in another comment, Marques et al. (2014) did not have the opportunity to explore the geology away from the basin. This does

not mean that such structures do not exist. In fact, as the reviewer pointed out, such faults have been found in the nearby Rio do Peixe Basin and our modelling results suggest that they may very well exist in the Araripe Basin area as well.

5 Conclusions

Line 538

- **Comment:** This is a conclusion already reached by several authors before you, so it is not a conclusion of your work
- **Answer:** It is an important outcome of this study and should be mentioned here.

Line 542

- **Comment:** I do not understand this. I cannot see what you mean in terms of mechanics
- **Answer:** What we mean is that when comparing an empty graben with a filled one (like in nature) we don’t see much fault reactivation after compression.

Line 546

- **Comment:** Again, this is simply wrong. Read what Marques et al. (2014) said about the inversion of the Araripe Basin
- **Answer:** See previous comments explaining why previous models do not fully explain the situation in the Araripe Basin.

Referee 2 - Ioan Munteanu

Comment: Basin inversion pccurs aslo as extensional not just as compresional. Please mention that you refere to compresional inversion of extensional basins.

Answer: Thank you for your comment, we mentioned in the text that we refer to compressional inversion.

Line 11

- **Comment:** Basin inversion occurs either in extensional or compressional settings, like negative or positive inversion.
- **Answer:** This comment is not very clear to us

Line 42

- **Comment:** This aborted rifts are actually part of the early intra-continental stage. And like North sea is actually part of the Atlantic system.
- **Answer:** Thank you for your comment, this is more or less what we have written in the text

Line 47

- **Comment:** I can't see this E-W direction in your fig. 1
- **Answer:** Thanks for the suggestion, it is modified.

Line 56

- **Comment:** A rift can't push so much that you invert a a basin. The formation of oceanic crust will bring exhumation especially on the rift shoulder. Other must be the case
- **Answer:** It is not only because of that, it's the combination of the mid Atlantic ridge push and Andes mountains initial subduction to the west

Line 77 – figure 1

- **Comment:** Can you have an seismic like or a geological cross-section to illustrate the inversion?
- **Answer:** We can't reproduce the seismic lines in this manuscript due to copyright restrictions, but we cited a recent work in the discussion that show two interpreted seismic lines for the Araripe Basin.

- **Comment:** The offset of this fault is similar with the one in the extensional stage, where is the inversion?
- **Answer:** This is a representation of the inversion model proposed by Marques et al. (2014), where, according to the authors, previous rift faults went under large-scale inversion. The offset is clearly different from the rift stage though, and the proposed reactivation of rift faults is indicated by arrows.

Line 236

- **Comment:** and how much extension?
- Answer: this is after 30 minutes, so that is 10 mm of divergence, given a divergence velocity of 20 mm/h. We have added some quantification of divergence and convergence wherever we felt it would be good to do so.

Line 243

- **Comment:** Is better to represent this in extension rate etc.
- **Answer:** We agree that it may be better to specify the amount of divergence for a given time step and have added these details (see also previous comment)

Line 247

- **Comment:** Which means in % of extension
- **Answer:** What is specified is the width of the graben. The total divergence at that time step is 40 mm (see also previous comments)

Line 280

- **Comment:** As I stated earlier, will be easy to quantify also in % relative to you crust
- **Answer:** The original sand layer (upper crust) is 6 cm thick, so the subsidence is similar to 33% of the thickness of the upper crust. Note however, that the lower crust is also rising up below the graben (see Fig. 3), so that the total thickness of the sand layer is ca. 33% of the original at this point. We have added some quantification here and elsewhere where we thought it helpful.

Line 304

- **Comment:** you want to say relay ramps. En enchelon we use more for strike-slip, which is not the case.
- **Answer:** En echelon is also routinely used for oblique extension settings, we prefer to keep it as is.

Line 502

- **Comment:** This natural case scenario has to be supported by an geological cross-section, the sketch in the Figure 1 is not enough
- **Answer:** We don’t have field data, this is not a field study, and we can’t reproduce seismic sections. We are proposing a model based on the experiments and it fits with the general data on the area. We believe this is ok.

Line 513

- **Comment:** reactivation or inversion?
- **Answer:** Thanks for the suggestion, it is modified with inversion.

Line 514

- **Comment:** Inversion
- **Answer:** Thanks for the suggestion, it is modified.