EGUsphere, referee comment RC1
https://doi.org/10.5194/egusphere-2022-1251-RC1, 2022

Comment on egusphere-2022-1251

Fernando Ornelas Marques (Referee)

Referee comment on "Analogue modelling of basin inversion: implications for the Araripe Basin (Brazil)" by Pâmela C. Richetti et al., EGUsphere,
https://doi.org/10.5194/egusphere-2022-1251-RC1, 2022

Report on "Analogue modelling of basin inversion: the role of oblique kinematics and implications for the Araripe Basin (Brazil)" by Richetti et al.

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.

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.

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.

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.

- 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.
- Many critical references are missing in the ms. (see list below).

Many comments, main and minor, can be found in the attached annotated PDF.

The text is in many cases sloppy. Although not being my job, I carried out the revision of the ms. that should have been done by author and co-authors. I did not revise everything, therefore there is still need for a more thorough revision of the text and English. For instance, verb tenses are mostly inconsistent throughout the text. Position of commas (mostly absence) are also a problem.

References that should be cited by the authors:

Assumpção, M., 1992. The regional stress field in South America, J. Geophys. Res. 97, 11889-11903.

Assumpção, M., Dias, F.L., Zevallos, I., Naliboff, J.B., 2016. Intraplate stress field in South America from earthquake focal mechanisms. Journal of South American Earth Sciences 71, 278-295.

Cobbold, P.R., Castro, L., 1999. Fluid pressure and effective stress in sandbox models. Tectonophysics 301, 1–19.

Coblentz, D.D., Richardson, R.M., 1996. Analysis of the South America intraplate stress field. J. Geophys. Res. 101, 8643-8657.

Cooper, M.A., et al., 1989. Inversion tectonics: a discussion. In: Cooper, M.A., Williams, G.D. (Eds.), Inversion Tectonics. Geological Society Special Publication 44, 335– 347.

Garcia, X., Julià, J., Nemocón, A.M., Neukirch, M., 2019. Lithospheric thinning under the Araripe Basin (NE Brazil) from a long-period magnetotelluric survey: Constraints for tectonic inversion. Gondwana Res. 68, 174–184.

Marques, F.O., Nikolaeva, K., Assumpção, M., Gerya, T.V., Bezerra, F.H.R., Nascimento, A.F. do, Ferreira, J.M., 2013. Testing the influence of far-field topographic forcing on subduction initiation at a passive margin. Tectonophysics 608, 517-524.

Marques, F.O., Nogueira, C., 2008. Normal fault inversion by orthogonal compression: Sandbox experiments with weak faults. Journal of Structural Geology 30, 761-766.

Mourgues, R., Cobbold, P.R., 2003. Some tectonic consequences of fluid overpressures and seepage forces as demonstrated by sandbox modelling. Tectonophysics 376, 75–97.

Nemocón, A.M., Julià, J., Garcia, X., 2021. Lithospheric structure of the western Borborema Province from receiver functions and surface-wave dispersion: Implications for basin inversion. Tectonophysics 816, 229024.

Ramos et al., 2022. Relations between inherited basement fabric and fault nucleation in a continental setting: the Rio do Peixe Basin, NE Brazil. Marine and Petroleum Geology, 139, 105635.

Sassi,W., Colletta, B., Balé, P., Paquereau, T., 1993. Modelling of structural complexity in sedimentary basins: the role of pre-existing faults in thrust tectonics. Tectonophysics 226, 97–112.

Sibson, R.H., 1985. A note on fault reactivation. Journal of Structural Geology 7, 751–754.

Lisbon, 02.12.2022

Fernando Ornelas Marques

Please also note the supplement to this comment:
https://egusphere.copernicus.org/preprints/2022/egusphere-2022-1251/egusphere-2022-1251-RC1-supplement.pdf