EGUsphere, referee comment RC3
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Comment on egusphere-2022-708

Anonymous Referee #3

Referee comment on "Formation and geophysical character of transitional crust at the passive continental margin around Walvis Ridge, Namibia" by Gesa Franz et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-708-RC3, 2022

I was asked to review this manuscript on the basis of my knowledge of the continent ocean transition and associated magmatism. My background is not that of MT or gravity. Accordingly, I am unable to assess the methods used in this manuscript. Nor am I familiar with or able to assess the accuracy or precision of the results of this manuscript. The focus of this review of the manuscript is how the results are interpreted in the context of existing constraints. I would classify the review as requiring moderate revision (though that isn't an option with the editorial system).

Preamble: The manuscript is well-written with figures that are of high quality. The broad topic is important to the community at large as it addresses a typically poorly studied domain in the study of tectonic processes. These factors combine to make it appropriate for the journal to which the manuscript was submitted. Note that this review is the last of the peer reviews posted – however it was completed independently of the other reviews (I did not consult them prior to writing the formal review presented here). This review is divided into sections – first the larger issues, the second the more detailed issues.

Larger Issues

Point 1: I may not understand the methods that are used. However a question that might arise for a reader when considering the model was how error was handled. The model that forms the basis of the manuscript examines the electrical resistivity and density at each model cell. But the propagated error calculation that indicates what variability may be caused by uncertainties in the input data to the properties of each model cell is not presented. For a reader that may not be familiar with this type of model, this may be something that is handled within the model generation but for a general readership it might help to describe how such errors are handled so that the reader can have confidence in the conclusions that are being made. For example, in figure 3 the XY plot with individuals symbols would might benefit from x and y error bars in order to assess the distinctness of the clusters. This would therefore permit the reader to assess how different the clusters may be from one another and how robust this differentiation might be.

Point 2: What is the purpose of this manuscript? The manuscript makes it clear that this contribution is utilizing existing datasets and points to an earlier paper. The MT data and density data are previously collected and the joint inversion of these data are also presented in the previous paper. From what I was able to understand, this manuscript's contribution is the clustering analysis and discussion of the results of this clustering. Coming to this conclusion (which may not be accurate) required examining the 2021 paper from the authors; the current manuscript does not make it clear to the reader what new insights this clustering approach has created over and above the previous 2021 paper. In short why was this work necessary and what novelty does this manuscript bring in terms of conclusions or method.

Point 3: A major issue in this manuscript is the discussion as it relates to the mantle. The manuscript asserts that the difference in resistivity of the mantle relates primarily to differences in depletion associated with a mantle plume. Specifically, the increased magma generation associated with the plume reduced the iron and hydrogen content of the residual mantle, thus increasing the resistivity. This hypothesis relies on the assumption that i) magma generation south of the Walvis Ridge is from melting of an upper mantle without the significant influence of a plume. This concept is alluded to earlier in the manuscript on line 79 where it is suggested that the continental flood basalts in this region are 'mainly of upper mantle composition instead of a deep plume' and also later on line 447/8 (see comments in the line by line). ii) Magma generation at the Walvis Ridge area is the result of plume melt. These assumptions may be problematic:

- The origin of continental flood basalts in this region is not universally considered to be in the shallow upper mantle (i.e., lithospheric mantle) as suggested in the manuscript. While some authors argue for this source as correctly pointed out by the citation used, others present counter arguments. Please read and incorporate the following citations:

Thompson, R.N., Gibson, S.A., Dickin, A.P., and Smith, P.M., 2001, Early Cretaceous basalt and picrite dykes of the southern Etendeka region, NW Namibia: windows into the role of the Tristan mantle plume in Paraná–Etendeka magmatism: Journal of Petrology, v. 42, p. 2049–2081.

Ewart, A., Marsh, J.S., Milner, S.C., Duncan, A.R., Kamber, B.S., and Armstrong, R.A., 2004, Petrology and geochemistry of Early Cretaceous bimodal continental flood volcanism of the NW Etendeka, Namibia. Part 1: Introduction, mafic lavas and re-evaluation of mantle source components: Journal of Petrology, v. 45, p. 59–105.

Gibson, S.A., Thompson, R.N., and Day, J.A., 2006, Timescales and mechanisms of plume–lithosphere interactions: 40Ar/39Ar geochronology and geochemistry of alkaline igneous rocks from the Paraná–Etendeka large igneous province: Earth and Planetary Science Letters, v. 251, p. 1–17.

- Plume sources are considered to have more water and iron than the depleted upper mantle – please research works by Dixon and also Herzberg. While melting of a plume source may lead to depletion, it would require all the material to have been melted. There are further questions on this model as noted below.
- The depth over which the model is sensitive is ~300km, and at least 100km is being interpreted in the manuscript - as presented per the manuscript text and figures. This extends below the thinned lithospheric mantle along this continental margin and is within the convecting upper mantle. This would suggest that melt depleted mantle material has remained within the convecting upper mantle over an extended interval. The manuscript does not present a mantle flow field argument supporting that this is possible. Moreover, the upper 300km of mantle in the region has seen material from the African LLSVP intrude into it (see recent paper by O'Connor Nature Communications in 2020). Melting of such material may not occur until about 120km depth if the mantle potential temperature is 1530C. This would result in a complex mantle with residual and enriched materials. How might hybrid compositions of pyroxenites impact the interpretations of the model?

On the basis of these points, the hypothesis posed in the manuscript is interesting but requires further support and clarification.

Point 4: An additional area of concern relates to the conductivity measurements in the upper crust north of the Walvis ridge. This region is known to have significant salt deposits. There is no discussion of the impact of even small salt horizons in this region. There is an allusion to this with respect to highly conductive layers, for example associated with mineralization of lavas. However, it wasn't apparent that any discussion has occurred in relation to these already mapped salt horizons. The authors must address this directly in their models as workers in this region will be familiar with these deposits and it would raise questions that would detract from this important work.

Directed comments:

Line 35 : mantle

Line 62: check ages of rifting
Line 71: basement
Line 79: technically this is volcanic. There are no constraints as to whether plutonic rocks were generated initially. The timing of magmatisim and rifting is of considerable controversy – please examine the following papers and incorporate their insights.

Baksi, A.K., 2018, Paraná flood basalt volcanism primarily limited to~ 1 Myr beginning at 135 Ma: new 40Ar/39Ar ages for rocks from Rio Grande do Sul, and critical evaluation of published radiometric data: Journal of Volcanology and Geothermal Research, v. 355, p. 66–77.

Gomes, A.S., and Vasconcelos, P.M., 2021, Geochronology of the Paraná-Etendeka large igneous province: Earth-Science Reviews, v. 220, article number 103716.

Renne, P.R., Ernesto, M., Pacca, I.G., Coe, R.S., Glen, J.M., Prévot, M., and Perrin, M., 1992, The age of Paraná flood volcanism, rifting of Gondwanaland, and the Jurassic-Cretaceous boundary: Science, v. 258, p. 975–979.

As you will see from the papers, the correlation between magmatism and rifting is not quite as portrayed.

Line 81: This statement is open to misinterpretation and does not reflect the totality of how these rocks were generated. These rocks are generated by a plume but the melt mechanism is debated. See comments in major points above

Figure 1 - spelling of Kaoko belt is different in the figure.

Line 138: this line is unhelpful as it presumes a vector of continuing increasing melt. There is no evidence that underplates form before flows. Indeed, volcanism is contemporaneous with rifting and break up. Underplates may form in response to fractional crystalization at the crust mantle boundary by progressive accumulation of these phases. Delete this line.

Line 141: a typical feature associated with these flows cannot be SDRs as these are seismic features to which the flows themselves belong. Rephrase.

Line 146: volcanic not magmatic.

Line 148/9: what evidence exists for chemical heterogeneity. No citation is provided and I'm not aware of one in this locale.

Line 151: rapidly

Line 155: there is evidence of volcanic activity to the north, just much less. The transition isn't as abrupt as noted here. For example, the Namibe basin just north the FFZ has thick

SDRs in the south and not much salt. Please examine the existing literature describing the marginal basins to the north of the FFZ.

Line 159: citation required for this assertion.

Line 162: pronounced

Line 163: see paper by Morgan et al 2020 on plume flow in PNAS
Line 395: data do not disclose, rephrase
Line 399: comma required

Line 406: delete further

Line 445: Speculation. There is no evidence of particularly wet melts along this margin. Delete.

Line 447/8: it is entirely unclear to the reader how this follows. From my reading of this section, the paper suggests that the speculation of a wetter and drier mantle is associated with more or less plume activity. This is used to suggest the plume is dominant to the north along the WR and that the southern area is 'rift driven breakup'. This is totally unclear as it does not explain the source of magmatisim. Much more discussion is needed and actual evidence from the magmatic system.