

List of all relevant changes made in the manuscript

- The results section is rewritten to include only description of features
- The discussion section is re-arranged to give the model of opening of the Laccadive towards the end of the MS
- The introduction is re-written to more clearly describe the region picture and figure 1 is modified.
- All the corrections to figures suggested by the reviewers are incorporated.
- Three more seismic section is included in the supplementary material to show the continuity of the interpreted volcanic Ridge along the centre of the Laccadive Basin.

Reviewer-1 Comments and Reply

Reply to major comments:

9) Lines 79-83: It is mentioned that “*Further, a curvilinear trend of volcanic intrusive features is identified in the Centre of the Laccadive Basin parallel to the identified extensional trend. This trend is also observed in the gravity anomaly map as a broken chain of highs*”. This inference does not appear to be convincing. First of all, you have only two seismic sections in which intrusives are mapped, therefore, with these two profiles, we can neither interpret the continuity of the features nor its arcuate trend. In addition, I am unable to identify any clear and convincing curvilinear trend from any of the maps presented in Figure 3”. Your other interpretations on the ENE-WSW and NW-SE extension on the Laccadive Plateau are convincing as it is clearly observed from the seismic sections. Bringing the inference of Laccadive Basin trend actually dilute the quality of the paper. Therefore, this inference appears to be too weak to be accepted. Hence, I suggest removing this inference on the Laccadive Basin and these sentences. Abstract and conclusions also may be modified accordingly.

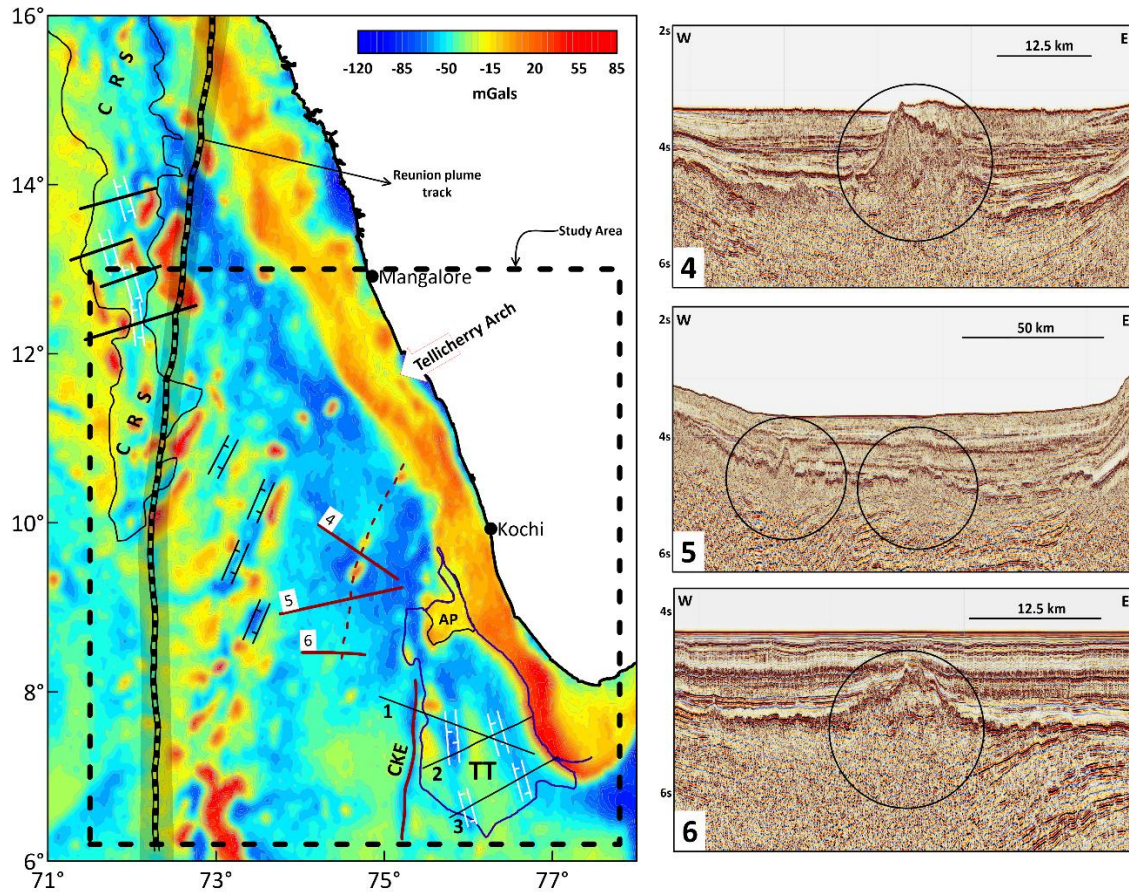
10) Line 88: “.... Either side of the identified volcanic ridge”. Please read this in view of my comment 9.

Reply to comments 9 and 10.

We thank the reviewer for the comments. Comments 9 and 10 made by the reviewer critically analyses the trend and continuity of the volcanic intrusive feature identified towards the center of the Laccadive Basin. Two main arguments are put forward by the reviewer: 1) Only two seismic sections are showing intrusives which are not enough to interpret the continuity of the feature or the curvilinear trend. 2)The trend is not clearly visible in the gravity anomaly maps presented in figure 3. The arguments are very much valid and reasonable.

However, we inferred the presence of volcanic intrusive feature along the center of the basin by joint interpretation of the sediment deposition pattern, free-air gravity anomaly and seismic data. We noted that the sediment deposition pattern from Early Eocene to Early Miocene (Figure 4B) shows a divide along the center of the Basin and the intrusive pattern identified in the seismic sections falls along the same line. This led to the conclusion of the extent of the feature and its trend. Still we agree with the comment of the reviewer that this is not very convincing as the feature is only seen in the free-air anomaly map and not crustal Bouguer anomaly maps and its derivatives.

We have gone through some additional seismic lines in the region (sections given below) which very clearly show the intrusive features along the center of the Basin. The sediments are seen onlapping to the volcanic feature. This matches very well with the sediment deposition pattern from which we inferred the continuity of the feature. We infer from the new data that towards the center of the basin away from the shelf where the seismic data is located, the intrusive reached the sea bottom with subsequent sedimentation. This along with deeper water depth in the region mask the anomaly created by the intrusive in the crustal Bouguer anomaly map. This is argued as a reason for not observing the trend of the volcanic intrusive feature along the center of the basin in figure 3. We included these seismic sections in the supplementary material (Fig S3).



11) Lines 124-128: *“The trend of the intrusives and bathymetric highs in the study area follows the identified extensional trends....., we noticed a series of volcanic mounds with a trend almost parallel to the CKE..... The observed trend correlates well with the crustal Bouguer anomaly map as well as the trap depth map”*. The inference on trend of the intrusives in the Laccadive Basin derived only using two seismic section appears to be weak. Further, the bathymetric highs (consisting of seamounts, plateaus, knolls, hills, and guyots), most of which are interpreted to be associated with volcanism, are distributed randomly in different parts of the Laccadive Basin (please see Bijesh et al., 2018), but do not show any characteristic and systematic trend. Other than one trend representing CKE, any other such trends are not clearly visible from the crustal Bouguer anomaly map as well as the trap depth map provided in Figure 3. Therefore, this inference on the Laccadive Basin appears to be weak.

Reply to comment 11:

Three main arguments are put forwarded by the reviewer in this comment.

- 1) The inference on the trend of the intrusives in the Laccadive Basin derived only using two seismic section appears to be weak
- 2) Further, the bathymetric highs (consisting of seamounts, plateaus, knolls, hills, and guyots), most of which are interpreted to be associated with volcanism, are distributed randomly in different parts of the Laccadive Basin (please see Bijesh et al., 2018), but do not show any characteristic and systematic trend.
- 3) Other than one trend representing CKE, any other such trends are not clearly visible from the crustal Bouguer anomaly map as well as the trap depth map provided in Figure 3

The first point is discussed in the reply to comment 9 and 10 above.

Regarding the distribution of bathymetric highs, we believe that our idea was not clearly conveyed. We observed from the high-resolution bathymetry map that was published by Bijesh et al., 2018 that, most of the bathymetric highs south of Mangalore seems to be elongated in NE-SW direction. As mentioned in the comment, we also associate the high related to volcanism which we consider to be emplaced through weak zones or faults as discussed in section 5.2. Therefore, the orientation of the faults influenced the emplacement of the volcanic highs, as a result, the highs appear to be elongated roughly parallel to the trend of the Laccadive Basin. This strengthens the argument regarding the opening of Laccadive Basin.

Regarding the expression of bathymetric highs in the anomaly maps, we agree with the reviewer that the trends of the highs and lows (figure 3) are not prominent or continuous as that of CKE in the crustal Bouguer anomaly map and trap-depth map, however, the band-pass filtered crustal Bouguer anomaly and its first vertical derivative clearly show these features. Band-pass filtering is done to remove the deeper effects and enhance the crustal features. The trends are prominently seen in these two maps which indicate that these are shallow crustal level features (could be volcanic intrusives with few reaching the surface). The preferable elongation of these features indicates the direction of faults/weak zones through which the magma was able to migrate.

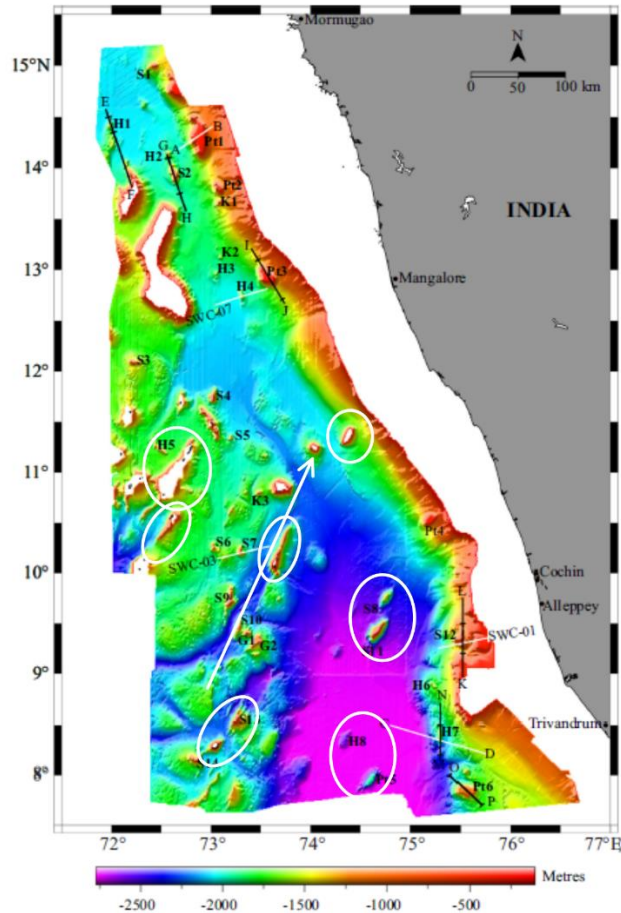


Figure: This is high resolution bathymetry map presented by Bijesh et al., 2018 where the elongation of the features towards the south of Mangalore is clearly seen

Reply to minor comments:

1) In the whole text: “Reunion” may be corrected as “Réunion” in throughout the manuscript.

Reply: We thank the reviewer for pointing this out. The text is corrected accordingly

3) Line 9: “pre-rift” may be modified as “pre-drift” since the age information cannot be derived from magnetic anomalies observed from rift stage crust, but possible only when these magnetic anomalies are formed by seafloor spreading (i.e., drifting”). Therefore, magnetic anomalies can provide only “pre-drift” juxtaposition.

Reply: We agree with the reviewer and the correction is made accordingly.

4) Lines 9-10: The detailed mapping of seafloor spreading magnetic anomalies in the conjugate Arabian and eastern Somali basins (spreading between India-Laxmi Ridge block and Seychelles) was published by Chaubey et al. (2002, Geological Society, London, Special Publication 195, pp. 71-85). The same may be quoted here. Although you mentioned geochronology here, the references are missing, please add the same.

Reply: We thank the reviewer for pointing out this and the references were added accordingly. More references of geochronology studies have been added as per the suggestion of the reviewer.

5) Figure Caption 1: “MR: Murray Ridge” may be deleted since you have not used this abbreviation in the figure, it is written in expanded form in the figure.

Reply: The correction is made as per the suggestion of the reviewer.

6) Lines 21-23: You mentioned “..... *whereas, more recent studies (Torsvik et al. (2013); Bhattacharya Yatheesh (2015) incorporate....*”. This sentence is misleading since Bhattacharya and Chaubey (2015) has not included Mauritius in their model. So, this sentence may be modified as “.....whereas, more recent studies incorporate continental fragments like Laccadive Ridge (Bhattacharya and Yatheesh, 2015) or Mauritia, consisting of Mauritius, Southern Mascarene Plateau, Laccadive Plateau and Chagos Bank (Torsvik et al. (2013) between India and Madagascar in the India-Madagascar pre-drift scenario”.

Reply: We agree with the reviewer for pointing out this and the sentence is modified according to the suggestion.

7) Line 37: “complicity” may be corrected as “complexity”.

Reply: We thank the reviewer for pointing out this and the typo is corrected.

8) Line 39: The sentence “..... Laccadive Basin area will shed light on the margin’s evolution” May be modified as ““..... Laccadive Basin area will provide important constraints on the margin’s evolution”.

Reply: The sentence is modified according to the suggestion of the reviewer.

12) Line 152: “..... titled intrusive” or “tilted intrusive”? Please check.

Reply: We thank the reviewer for pointing out this and the typo is corrected.

13) Lines 17, 198, 225, and 227: The author’s name “Bhattacharya, G.” may be corrected as Bhattacharya, G.C.”

Reply: We thank the reviewer for pointing out this and this is corrected in the Manuscript.

14) Line 181: “GEBCO, C.G.”. Please check, what is “C.G.”?

Reply: We thank the reviewer for pointing out this and the typo is corrected.

Reviewer-2 Comments and Reply

Results section:

Comment: Result item describes events instead of structures....i suggest that the authors separate description from interpretation when presenting results.

Reply: We agree with the reviewer and accordingly, the results section was rewritten as per the suggestion.

Discussion part:

Comment: The discussion part is not well organised...some information should be shifted to item 2 in order to help explaining the tectonics of the area.....giving tools to understand the results and interpretations further

Comment: 5.3 and 5.4 could be shifted to results or could be the start of the discussion item....leaving the plate tectonic picture to the end of the paper along with figure 5

Reply: The sections 5.3 and 5.4 are shifted after 5.1 and the section 5.2 describing the tectonic picture of the area is shifted towards the end of discussion as suggested by the reviewer. We thank the reviewer for the suggestion and we noticed that this change has improved the readability of the paper.

Section 2 comments:

Comments:

Contextualize the area and these separation events Expand chapter 2 and do some rewriting of the Introduction

The item ‘Tectonics of the study area’ describes the main features but actually not the tectonics

Reply: We thank the reviewer for the comment. The section is renamed as “Description of tectonic elements”. A late Paleozoic fit of Gondwanaland showing the relative position of India and Madagascar is included in figure 1 to give a broader geodynamic view. Some rewriting of the introduction is done describing the major events that shaped the margin.

Figures:

Comment: The maps and figures in 3 & 4 are not extensively described and discussed

Reply: We have now included some more description regarding figure in the revised MS.

Comment: In figure 3D and 3E, the eastern LB and western LB are wrong

Reply: We thank the reviewer for pointing out this. The names were interchanged and now it is corrected in the fig 3.

Comment: In figure 4 please add absolute age interval – numbers in Ma for A and B

Reply: The figure is updated to add the absolute age interval in Ma for A, B and C.

Comment: Figure 5 is important since it summaries tectonic evolution in time slices.... Enlarge the maps and add legend ...also add time interval

Reply: We thank the reviewer for pointing out this. The figure is modified as per the suggestion of the reviewer.

Figure 1 comments:

In figure 1 insert of Central Gondwana reconstructed, with the coastline of main continental blocks plus minor blocks in a Jurassic fit.

Add tectonic domains simplified (cratons and mobile belts) and suture/Shear zones since inheritance is described vaguely in the MS

In figure 1 – some features are lacking explanation – a legend would help

Reference to colours do not match map colours such as “Black solid lines are shear zones”... this is also true for figure 2

Add names Kochi and Mangalore to figure 1

I wonder if its possible to add an estimated COB or COT

Add the location of wells to one of the maps since they are cited throughout the text.

Reply: We thank the reviewer for the comments on figure 1. We have inserted a picture of Central Gondwana in figure 1. Further the names Kochi and Mangalore are now added to the MS and the locations some wells are also plotted in figure 1 and necessary corrections to figure 1 are made as per the suggestion.

Scientific Question

Comment: What would be a post-rift event? This would relate to which rift? Madagascar-India or Seychelles-India?

Reply: We thank the reviewer for the comment. By post-rift, we meant the post-India Madagascar breakup event. Even though the margin was affected by two breakup events (the India-Madagascar and India-Seychelles), the later affected the northern part of the margin, north of Vengurla Arch. The region under consideration is towards the southern part and is related to India-Madagascar separation.

We now change post-rift to post-India-Madagascar separation throughout the MS.

Comment: Is there any evidence of a horizontal component for these graben-horst faults? Did the authors consider a transtensional component that would also accommodate the anti-clockwise rotation of India?

Reply: We thank the reviewer for the question. As such we did not notice any transtensional component in the present dataset. However, minor transtensional movement associated with rotation is not totally ruled out.

Comment: Can you add a map with the nature of the crust from this margin? Transitional, oceanic and continental stretched?

Reply: We thank the reviewer for the suggestion. However, as the present study does not involve any crustal modelling, we are not in a position to prepare such a map.

Line by line comments

Comment: Title – please add the age of the extension – “Cretaceous-Paleocene extension”

Reply: We thank the reviewer for the comment. The title is modified as per the suggestion of the reviewer.

Comment: Line 30 – add age of this hot spot

Reply: This is added in the revised MS

Comment: Line 31 – 20 m.y.r (instead of Ma)

Reply: This is added in the revised MS

Comment: Lines 31-33 – the 65 Ma, you mean the sediments above the volcanic trap?

Reply: The sentence is reframed for clarity.

Comment: Line 36 – what do you mean by post-Madagascar activity? Magmatic?

Reply: The sentence is reframed for clarity.

Comment: Line 37 – complicity?

Reply: We meant **complexity**, the typo is corrected in the MS.

Comment: Line 38 – What do you mean by the “state of the lithosphere”.

Reply: We mean the Inheritance in the lithosphere. We have now corrected this in the MS.

Comment: Line 75 – “the prominent ENE-WSW extension observed”, substitute by the NNW-SSE set of grabens observed, interpreted as a ENE-WSW extension...” and so goes through the results section.

Reply: We thank the reviewer for the comment. The results section is rewritten to describe the structures without any interpretation.

Comment: Lines 81 to 83 – call figure here.

Reply: The figure is reference in the revised MS.

Comment: Lines 87-88 – indicate the volcanic ridge on figure 4B, many features named on text are not well shown in the maps.

Reply: The figures are corrected accordingly.

Comment: Item 5.1 – Start please interpreting the data you present, before describing the bigger picture. My suggestion.

Reply: This part of the discussion is shifted towards the end and more description is added for clarity as per the suggestion of the reviewer.

Comment: Item 5.2 – I think there is some speculation in this part of the manuscript, unneeded. (A) “there are a large number of suture zones”. Actually, there are not many, and the authors did not present a map of the terranes and sutures that are well known in the literature and might be related to the features of the margin, crustal scale reactivated structures.

Reply: The prominent shear zones or suture zones are shown in fig1 and fig5 (which shows major suture zones on both Indian and Madagascar side.). These features are not named in the text for brevity as we are not describing the features in detail. But as per the suggestion of the reviewer, the reference is now included in the text (Bhattacharya and Yatheesh 2015 and references therein).

Comment: Line 108 – Long (how long in km?)

Reply: We thank the reviewer for the question. The transform fault in question is from the reconstruction study by Shuhail et al 2018. We wanted here to emphasize the connection between the spreading in the Mascarene Basin and the area near ATTC, by highlighting that this has been suggested by earlier workers.

Comment: Line 111 – We believe? Please argument here.

Reply: We thank the reviewer for pointing out this. We have now elaborated the point with more arguments.