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Peer Review File

Blind magmatism abets nonvolcanic continental rifting

This manuscript has been previously reviewed at another Nature Portfolio journal. This document only contains reviewer comments and rebuttal letters for versions considered at Communications Earth & Environment.

Web links to the author's journal account have been redacted from the decision letters as indicated to maintain confidentiality.

22nd Dec 23

Dear Dr Ajala,

Your manuscript titled "Blind magmatism abets nonvolcanic continental rifting" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment provided you add further discussion to place your interpretations into the context of alternative explanations for your results, as requested by Reviewer #2. If suitable, we will publish the revised manuscript under the open access CC BY license (Creative Commons Attribution v4.0 International License).

We therefore invite you to revise your paper one last time to address the remaining concerns of our reviewers. At the same time we ask that you edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

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We hope to hear from you within three weeks; please let us know if you need more time.

Best regards,

Joe Aslin

Senior Editor,
Communications Earth & Environment
https://www.nature.com/commsenv/
Twitter: @CommsEarth

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

The revision of the manuscript has addressed the main concerns of the reviewers in some detail. The manuscript is now acceptable for publications. The manuscript provides important insights into the deep structure of the
Chris Morley

Reviewer #2 (Remarks to the Author):

Review report on the manuscript entitled "Blind magmatism abets nonvolcanic continental rifting "by Ajala et al.
Ajala and colleagues used high-resolution local seismicity data and thermo-rheological model to understand lithospheric extension in magma-poor or non-volcanic rift zone in the Tanganyika-Rukwa segment of the East African Rift System. Their result shows that while the surface tectonics is driven by tectonic forces, magma/melt may present at depth to facilitate extension. This makes a perfect sense since surface manifestation of deep magmatic activity can be significantly delayed during rifting history. As I already noted in my previous review report, their finding has a huge significance to understand rifting in magma-poor segments in east Africa and/or around the world. After reading their revised MS and rebuttal letter to my previous review report submitted to Communications Earth & Environment, I noticed that many of the issues in the previous version are properly addressed. The following two points should be discussed in detail.
The first is the concept of strain localization in the rift basin faults (line 142-149). The authors are studying the present-day tectonics of a rift zone that has started opening >10 Myrs ago. During the long-term evolution of the rift, it is expected to observe basin-ward migration of deformation from rift bounding faults to rift floor faults even in the absence of magma (e.g., Muluneh et al., 2020 G-cubed) and weak basement shear zones. It is also likely that the southern Tanganyika rift is at this stage where both rift bounding and rift floor faults are equally contributing to strain accommodation mechanism, as observed in the central part of the Ethiopian rift (Corti et al., 2020 Tectonics). This doesn't mean that magma is not localizing deformation in the Tanganyika rift as proposed by the authors, I just want to stress that equally relevant explanations for the observed deformation partitioning can also exist.
Second, in line 135 the authors interpreted the NE oriented shear wave splitting direction as a result

of LPO induced by regional plate motion. This interpretation requires a strong coupling between the crust and underlying mantle. However, this contradicts with what has been suggested in line 201-203, where the authors deduced that a decoupling between the crust and mantle occurs. How do you reconcile that?

Some minor issues:

Line 136 – N30ºW?

Line 146 – "…. the border faults are abandoned". This is a very strong statement and needs to be toned down. Yes, it is true that strain progressively localizes to faults in the rift floor but in general border faults still contribute to strain accommodation, deformation is localized into narrow zones in the rift floor.

Line 325 – lithospheric strength is strongly dependent on the strain rate considered in the thermo-rheological model (here it is 1e-15 s-1). This means a slight increase or decrease in strain rate significantly alters the lithospheric strength. You can simply acknowledge this limitation in the MS.

Ameha Muluneh
GFZ German Research Centre for Geosciences, Potsdam, Germany.

Reference:

Corti, G., Sani, F., Florio, A., Greenfield, T., Keir, D., Erbello, A., Muluneh, A., Ayele, A. (2020). Recent and active tectonics of the Asela-Langano margin, Main Ethiopian Rift (East Africa). Tectonics, https://doi.org.10.1029/2020TC006075.

Muluneh, A., Brune, S., Illsley-Kemp, F., Corti, G., Keir, D., Glerum, A., Kidane, T., Mori, J. (2020). Mechanism for deep crustal seismicity: Insight from modeling of deformation processes at the Main Ethiopian Rift. Geochemistry, Geophysics, Geosystems. https://doi.org/10.1029/2020GC008935.

We thank Editor Dr. Joe Aslin and the two reviewers, Drs. Chris Morley and Ameha Muluneh for their constructive suggestions, which we have used in our final manuscript revision. Below is our response to the reviewer's comments with line numbers referencing the revised manuscript.

Reviewer 1 (Chris Morley)

The revision of the manuscript has addressed the main concerns of the reviewers in some detail. The manuscript is now acceptable for publications. The manuscript provides important insights into the deep structure of the
Chris Morley

We thank Chris Morley for the constructive review comments, which helped to improve the clarity of our paper.

Reviewer 2 (Ameha Muluneh)

Review report on the manuscript entitled "Blind magmatism abets nonvolcanic continental rifting "by Ajala et al.
Ajala and colleagues used high-resolution local seismicity data and thermo-rheological model to understand lithospheric extension in magma-poor or non-volcanic rift zone in the Tanganyika-Rukwa segment of the East African Rift System. Their result shows that while the surface tectonics is driven by tectonic forces, magma/melt may present at depth to facilitate extension. This makes a perfect sense since surface manifestation of deep magmatic activity can be significantly delayed during rifting history. As I already noted in my previous review report, their finding has a huge significance to understand rifting in magma-poor segments in east Africa and/or around the world. After reading their revised MS and rebuttal letter to my previous review report submitted to Communications Earth & Environment, I noticed that many of the issues in the previous version are properly addressed. The following two points should be discussed in detail.

We thank Ameha Muluneh for the constructive comments on both the previous and current versions of our manuscript, which helped to improve the clarity and quality of our paper.

The first is the concept of strain localization in the rift basin faults (line 142-149). The authors are studying the present-day tectonics of a rift zone that has started opening >10 Myrs ago. During the long-term evolution of the rift, it is expected to observe basin-ward migration of deformation from rift bounding faults to rift floor faults even in the absence of magma (e.g., Muluneh et al., 2020 G-cubed) and weak basement shear zones. It is also likely that the southern Tanganyika rift is at this stage where both rift bounding and rift floor faults are equally contributing to strain accommodation mechanism, as observed in the central part of the Ethiopian rift (Corti et al., 2020 Tectonics). This doesn't mean that magma is not localizing deformation in the Tanganyika rift as proposed by the authors, I just want to stress that equally relevant explanations for the observed deformation partitioning can also exist.

We agree with the reviewer and have revised the texts to clarify this point (see lines 132 – 135) and cited Muluneh et al. (2020). We do not imply that the rift is already at the 'strain localization phase', but that the rift might be at the onset of this phase, given the prominent subsidence and increasing fault offset along the rift axis (see seismic imaging and normalized extension plots in Fig. 1b insets). We argue that the lithospheric weakening due to the blind melts may have initiated this transition.

Second, in line 135 the authors interpreted the NE oriented shear wave splitting direction as a result of LPO induced by regional plate motion. This interpretation requires a strong coupling between the crust and underlying mantle. However, this contradicts with what has been suggested in line 201-203, where the authors deduced that a decoupling between the crust and mantle occurs. How do you reconcile that?

The interpretation of the mantle anisotropy results that we present are from Tepp et al. (2018), and for clarity, we have now updated the sentence with this citation. The mantle SKS splitting results from Tepp et al. (2018) (presented in our Fig. 2d) represent two dominant trends. The northwest trend resulting from a deflected mantle flow is the component that is coupled with our lower crustal shear wave splitting results. The other dominant trend in the northwest direction is interpreted to be from regional plate motion by Tepp et al. (2018). The decoupling refers to the amount of deformation/thinning in the crust and lithospheric mantle, where the numerical models indicate that the lithospheric mantle in the region may have been significantly thinned relative to the crust. We think that these two results can both be true and collocated, in that there is already melt emplacement in the lower crust while the crust is not as significantly thinned as the lithospheric mantle is. For better clarity, we have now further refined the sentence to indicate that the decoupling we suggest refers to the amount of thinning rather than the deformation mechanisms (lines 173 – 175).

Some minor issues:
Line 136 – N30ºW?
This refers to the mean trend of the similar dominant orientations of the crust and mantle anisotropy in the northwest direction.

Line 146 – "…. the border faults are abandoned". This is a very strong statement and needs to be toned down. Yes, it is true that strain progressively localizes to faults in the rift floor but in general border faults still contribute to strain accommodation, deformation is localized into narrow zones in the rift floor.

We agree and have modified our sentence in line 132 to reflect this point.

Line 325 – lithospheric strength is strongly dependent on the strain rate considered in the thermo-rheological model (here it is 1e-15 s-1). This means a slight increase or decrease in strain rate significantly alters the lithospheric strength. You can simply acknowledge this limitation in the MS.

We have acknowledged this point in the manuscript. See lines 304 – 306.

Ameha Muluneh

GFZ German Research Centre for Geosciences, Potsdam, Germany.

Reference:
Corti, G., Sani, F., Florio, A., Greenfield, T., Keir, D., Erbello, A., Muluneh, A., Ayele, A. (2020). Recent and active tectonics of the Asela-Langano margin, Main Ethiopian Rift (East Africa). Tectonics, https://doi.org.10.1029/2020TC006075.
Muluneh, A., Brune, S., Illsley-Kemp, F., Corti, G., Keir, D., Glerum, A., Kidane, T., Mori, J. (2020). Mechanism for deep crustal seismicity: Insight from modeling of deformation processes at the Main Ethiopian Rift. Geochemistry, Geophysics, Geosystems. https://doi.org/10.1029/2020GC008935.