Peer Review Report

Roberts et al., Hot, Wide, Continental Back-arcs Explain Earth's Enigmatic mid-Proterozoic Magmatic and Metamorphic Record, TEKTONIKA, 2023.

This document contains:

1/ Pages 2-7: 1st round decision letter followed by the comments from 2 reviewers.

2/ Pages 8-14: Authors' responses to the 1st round of revision.

3/ Page 15: Final decision letter.

1/ First round of peer review

Decision letter

Nick M W Roberts, Kent C Condie, Richard M Palin, Christopher J Spencer:

We have reached a decision regarding your submission to τεκτonικa, "Hot, wide continental back-arcs explain Earth’s enigmatic mid-Proterozoic magmatic and metamorphic record".

Our decision is: Revisions Required

Dear authors,

Your work was reviewed by two experts and found to be very high quality with interesting implications for the Proterozoic evolution of the Earth. I think that your work is an excellent contribution to Tektonika. The reviewers have some minor suggestions for improving the manuscript which deal with either small errors (Figure labels) or places in the text where elaboration is needed. Once these points have been addressed we can move forward. You should be able to access the reviewer comments. If you have any issues with this or any other questions or comments, please contact me or the Journal Editor.

Kind regards,

Kathryn Cutts

Reviewer 1

Roberts, Condie, Palin and Spencer present an explanation for the unusual abundance of anhydrous magmas such as A-types granites and anorthosites in the late Palaeoproterozoic and Mesoproterozoic. This geological interval ranges ~1 billion years – the boring billion – and has been a matter of vigorous debate in recent literature. The peculiar geological features observed in the referred interval are interpreted based on global whole-rock geochemical information, mantle potential temperature constraints and geodynamic models. The main implication of the manuscript is that plate tectonics operated throughout the boring billion, but wider back-arc regions facilitated adiabatic melting and the generation of hotter magmas. This interpretation contrasts greatly with studies that suggest a long single-lid episode in the same interval. This contribution is timely as it offers a perspective on the issue that certainly will not be of agreement to all geoscientists out there, but it is thought-provoking and will move the debate forward. The manuscript is well-written, nicely illustrated and concise. I believe a couple of points deserve to be clearer, but otherwise, the manuscript is an excellent contribution to Tektonika, and only minor revisions are required.

It has to be more explicit that the model presented cannot simply be a function of the mantle potential temperature. Otherwise, if that were the case, geochemical features presented during the boring billion would be intensified in the Archaean as the mantle was even hotter than in the Mesoproterozoic. There is a brief mention in the manuscript in section 7 that rheological controls are important and those inhibited the onset of subduction in the Archaean. However, I think this has to be more directly stated, such as: "It cannot be expected that hotter mantle in the Archaean would have a magnified/amplified outcome because XYZ" or something much better. Additionally, a sentence exemplifying the particular Archaean geochemical/isotope signatures that differ from those found in the boring billion would be helpful to understand the issue as a whole. Are these easily observed in the secular trends in felsic igneous geochemistry in Figure 2?

A more direct explanation of why there was a modern-style plate tectonics episode in the Palaeoproterozoic at c. 2 Ga (pre-dating the Mesoproterozoic model) would be helpful. If the model uniquely depends on mantle potential temperatures, one wonders why there are low thermobaric ratios at c. 2 Ga. Although it is briefly mentioned (lines 299-300) that some heterogeneity in mantle temperature occurred, this has to be more directly explained, as well as the possible links with Columbia amalgamation. For example, consider the recent publication by Roberts et al. 2022 (EPSL), to which all the present authors contributed. Roberts et al. (2022) state that 'exceptionally long tenure and incomplete breakup of Earth's first continent' caused the Mesoproterozoic peculiar record. That interpretation is more compelling in my view as it offers a better explanation of why there is an episode of modern-style plate tectonics during the Palaeoproterozoic and then why it disappears during the boring billion. I think there are compelling arguments in Roberts et al. (2022) that should not be disregarded in the present manuscript.

Lines 269-273: The best reason to negate the continental crust insulation is presented here: "Since mantle heating due to the thermal blanketing effect of a supercontinent is dependent on the architecture of the surrounding subduction zones (Lenardic et al., 2011), we argue that the application of this model to the mid-Proterozoic should remain speculative until a detailed study of mantle heating in relation to specific paleogeographic reconstructions is conducted." (Lines 269-273). This sentence makes sense to me, although respectfully, it is another way to say that we don't know. This differs from what is presented in the abstract, where the reader has the impression that a strong argument will be put forward that negates the supercontinent insulation factor. For example, in the sentences “Our model negates the need for extra mantle heating from supercontinental insulation or plate slowdown” lines 26-27 or “…resulting solely from secular cooling of the mantle.” As a suggestion, I think the abstract and conclusions could be tuned down.

Lines 274-278: “While we do not discount the prospect of some degree of subcontinental mantle warming due to the formation of Columbia, we hypothesise that this mantle heating would have occurred in tandem with the expansive formation of hot continental back-arcs, and that these along can adequately explain the mid-Proterozoic’s enigmatic geological record.” Or perhaps there is a cause and effect here? Mantle insulation by supercontinent formation leads to the formation of hot continental back-arcs, matching the proposed model in figure 3 (marked in the paper as a 2nd Figure 2).

Line 76: xx ?
Lines 85-87: Maybe for MALI, but not for ASI.
Line 92: Figure SX – I didn’t have access to this figure or any supplementary material.
Figure 1. (b) Y axis misses unit - °C/Ga; (c) Y axis misses unit - °C; (d) Y axis misses unit - °C/GPa.
The second Figure 2 is actually Figure 3. Accordingly, please change the text when referring to these figures.

Best regards,
Hugo Moreira, February 2023

Reviewer 2

The authors present a new tectonic model for explaining characteristic yet poorly-understood features of the mid-Proterozoic geological record – elevated recorded T/P ratios in metamorphic complexes, and the abundance of ferroan ("A-type") magmatic rocks (including anorthosites, and rapakivi granites). The paper presents an excellent, thought-provoking synthesis and discussion of a comprehensive geochemical dataset (62,000 samples reported in supplementary data), first to characterise geochemically this period (c. 1.9 to 0.8 Ga), and then to base a new tectonic model involving the development of wide, hot, backarcs resulting from rapid rollback and larger volumes of decompression melting, both enabled by hotter-than-present-day mantle temperatures. It is argued that insulation either by the Columbia supercontinent or from slow plate motion, as previously proposed, are not necessary to have achieved the high crustal temperatures.

From my perspective, an interesting implication for proposing more extensive and rapid trench retreat (rollback), and advance, to achieve these extended, hot backarcs is for the timescales of Proterozoic metamorphism. If, as proposed, arc systems were more dynamic (i.e., experiencing more rapid, more widespread, and larger back-arc extensional events) in the Proterozoic than in the modern Earth, then I would infer that durations of metamorphic cycles would be shorter (assuming that heat transfer could keep pace). But, how does this then square with the longer timescales of metamorphism commonly interpreted for Proterozoic orogens, which are typically on the order of several 10s, or 100s, of Myr? Are, then, these mid-Proterozoic timescales commonly overestimated, for instance by blurring multiple sequential unresolved metamorphic pulses? Or could these hot, wide mid-Proterozoic backarcs persist as long-lived features, maintained by high mantle temperatures, once they have rapidly been created?

The paper is extremely well-written, logically organised, and well-illustrated. I can offer no major suggestions for revision, other than some minor comments and corrections listed below, which I hope can be of help.

Best wishes,
Jon Pownall
University of Helsinki

Main points

Line	Comment
69	Perhaps you could mention a few more examples of ferroan magmatic rocks in addition to rapakivi, and perhaps a brief definition?
77	Why do you filter the data for those specific SiO2 values?
78	There are a few issues with figure numbering: there are currently two figure 2s (and so all references to the 2nd figure 2, which should be figure 3, need updating). Also, line 78 and 83 should refer to Figure 2, not 1.
83	Update to 1.9 – 1.8 Ga (as noted in my comment for Figure 2).
87	I'm not suggesting anything be changed here, but just a thought: If the data were not binned to 100 Myr intervals, but to something smaller (e.g., 10 Myr), would a more exact correlation between different geochemical plots be revealed for the onset of the 'mid-Proterozoic' time as shown in Figure 2?

107 Perhaps further explanation and/or reference needed here for point 1) (unless all 3 points are referring to Collins et al. (2020)).

127 Another thought: If rollback were to have operated more rapidly and extensively in the mid-Proterozoic, what implications would this have on the duration of metamorphic cycles? I would have thought that they would be also more rapid and short-lived, but this would inconsistent with metamorphic record (or, at least the most common interpretations of the metamorphic record).

128 If point (2) is correct, I suppose this would mean that the volcanic arc is also further from the trench? Would this affect the composition of arc magmas and related volcanic rocks?

139 After 'greater', might it be worth adding something like 'than the modern Earth' or 'than the reference model'?

140 Could be a good idea to indicate % value of melt extraction threshold being considered?

146 Yes – I like how this point is stated!

148 Could it be worth mentioning rollback here, to tie in with its discussion in the introduction?

155 Perhaps this is a bit picky, but are these strictly observations? More calculations or inferences?

157 Again, implication for even more rapid rollback than modern arcs, and therefore impact on metamorphic timescales in Proterozoic.

172 The pie chart in figure 3f shows 50:50 Fe:Mg proportions, so this is not really consistent with being "dominated by magnesian magmatism".

186 Nice point!

307 Maybe this paragraph is stating things with a bit too much certainty? A caveat of "likely" needed somewhere?

317 'inboard' perhaps too vague a description here?

Figure 1 A few small things to update on the figure: units are missing for some y-axis labels; space needed between potential and temperature in y-axis label of figure a.

Figure 2 I would suggest extending the mid-Proterozoic shaded region to start 100 Myr earlier, at 1.9 Ga, so that the entire range stated on line 83 is covered (note also that on line 83, it might be clearer to switch the starting range to "1.9 – 1.8 Ga"). For instance, the Sr/Y plots 'drops' would fit much better to this slightly extended timespan. Also, my personal preference would be to arrange all plots in a single column, so that they could all be directly compared, but perhaps there would not be enough space on the typeset page.

Figure 3 (update caption to 'Figure 3', not 2). I have a couple of things to suggest for Fig 3: I'm not sure how you calculated the pie charts: are they just esimates? For parts a and b, I would note in the caption what the 15.01 Myrs and 13.29 Myrs refers to. AMCG abbreviation is different to 'AMC' used in main text, and is not explained in the caption. I like this figure in its current form, so this is not a criticism, but might it be better to change part e slightly so that right edge of the upper plate is shown in the same location in parts e and f, so that the effect of rollback, backarc extension (and widening), and trench retreat is made more obvious? This is a bit difficult to explain, but you could move the contents of part e further to the right within its frame, so that both parts e and f are effectively 'anchored' at the same place at their rightmost extents?

I have checked the supplementary files and they seem good to me.

Minor points

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61	LOWESS --> LOWEST
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160	update refs to figure 3, not 2.
172	update refs to figure 3, not 2.
173	maybe better to write “widened and thinned”?
214	Ramo --> Rämö
277	along --> alone

Authors' response

Reviewer 1

Roberts, Condie, Palin and Spencer present an explanation for the unusual abundance of anhydrous magmas such as A-types granites and anorthosites in the late Palaeoproterozoic and Mesoproterozoic. This geological interval ranges ~1 billion years – the boring billion – and has been a matter of vigorous debate in recent literature. The peculiar geological features observed in the referred interval are interpreted based on global whole-rock geochemical information, mantle potential temperature constraints and geodynamic models. The main implication of the manuscript is that plate tectonics operated throughout the boring billion, but wider back-arc regions facilitated adiabatic melting and the generation of hotter magmas. This interpretation contrasts greatly with studies that suggest a long single-lid episode in the same interval. This contribution is timely as it offers a perspective on the issue that certainly will not be of agreement to all geoscientists out there, but it is thought-provoking and will move the debate forward. The manuscript is well-written, nicely illustrated and concise. I believe a couple of points deserve to be clearer, but otherwise, the manuscript is an excellent contribution to Tektonika, and only minor revisions are required.

We thank the reviewer for their positive comments.

It has to be more explicit that the model presented cannot simply be a function of the mantle potential temperature. Otherwise, if that were the case, geochemical features presented during the boring billion would be intensified in the Archaean as the mantle was even hotter than in the Mesoproterozoic. There is a brief mention in the manuscript in section 7 that rheological controls are important and those inhibited the onset of subduction in the Archaean. However, I think this has to be more directly stated, such as: "It cannot be expected that hotter mantle in the Archaean would have a magnified/amplified outcome because XYZ" or something much better. Additionally, a sentence exemplifying the particular Archaean geochemical/isotope signatures that differ from those found in the boring billion would be helpful to understand the issue as a whole. Are these easily observed in the secular trends in felsic igneous geochemistry in Figure 2?

That is a good point, and something we had discussed ourselves, but evidently did not make clear enough in the ms.

We have added a new paragraph: Although we argue the mid-Proterozoic magmatic and metamorphic record is a natural consequence of secular mantle cooling, the trends in geochemistry are not simply linear, in fact, the preceding late Archean to early Palaeoproterozoic displays many similarities to the Phanerozoic. The cause of this requires more investigation, but the abundance of high Sr/Y and high La/Yb signatures prior to the mid-Proterozoic imply that magma formation was occurring under higher pressure (thicker crust) conditions on average. This, and the abundance of magnesian rather than ferroan compositions, implies that hot and dry magma generation in back-arcs was not as dominant before the mid-Proterozoic as it was during this period. The loci of magmatism has evidently changed through time, despite the fact that back-arc type settings may have existed since at least the Mesoarchean. Although much work has focused on the origin of Archean TTGs, we suggest that further geodynamic numerical modelling could be aimed at a more holistic view of magmatism created during lithospheric convergence at a range of mantle potential temperatures.

A more direct explanation of why there was a modern-style plate tectonics episode in the Palaeoproterozoic at c. 2 Ga (pre-dating the Mesoproterozoic model) would be helpful. If the model uniquely depends on mantle potential temperatures, one wonders why there are low thermobaric ratios at c. 2 Ga. Although it is briefly mentioned (lines 299-300) that some heterogeneity in mantle temperature occurred, this has to be more directly explained, as well as the possible links with Columbia

amalgamation. For example, consider the recent publication by Roberts et al. 2022 (EPSL), to which all the present authors contributed. Roberts et al. (2022) state that 'exceptionally long tenure and incomplete breakup of Earth's first continent' caused the Mesoproterozoic peculiar record. That interpretation is more compelling in my view as it offers a better explanation of why there is an episode of modern-style plate tectonics during the Palaeoproterozoic and then why it disappears during the boring billion. I think there are compelling arguments in Roberts et al. (2022) that should not be disregarded in the present manuscript.
We do not state "there was a modern-style plate tectonics episode in the Paleoproterozoic". This is the reviewer's own view creeping into their reading/understanding of our paper. What the reviewer is referring to, is the presence of lower T/P metamorphism. This does not directly provide evidence for modern-day style plate tectonics, but merely a process that can generate such geothermal gradients. However, we agree that we do not explain the "heterogeneity in mantle temperature", and thus we slightly altered this sentence.

Regarding the final point "I think there are compelling arguments in Roberts et al. (2022) that should not be disregarded in the present manuscript.". This manuscript is meant to build on that previous paper, and not conflict with the conclusions of Roberts et al 2022 in any way. If that has come across, then our conclusions in the present paper have clearly not been expressed accurately. Therefore, we have added the following: Roberts et al. (2022) argued that the mid-Proterozoic was host to a transitional phase of geodynamics, influenced by both secular mantle cooling and the long tenure and impartial break-up of the Columbia supercontinent. Our present model builds on this argument - hot, wide, continental back-arcs located along margins of the Columbia supercontinent provide a mechanism to generate the observed geological record of this period.

Lines 269-273: The best reason to negate the continental crust insulation is presented here: "Since mantle heating due to the thermal blanketing effect of a supercontinent is dependent on the architecture of the surrounding subduction zones (Lenardic et al., 2011), we argue that the application of this model to the mid-Proterozoic should remain speculative until a detailed study of mantle heating in relation to specific paleogeographic reconstructions is conducted." (Lines 269-273). This sentence makes sense to me, although respectfully, it is another way to say that we don't know. This differs from what is presented in the abstract, where the reader has the impression that a strong argument will be put forward that negates the supercontinent insulation factor. For example, in the sentences "Our model negates the need for extra mantle heating from supercontinental insulation or plate slowdown" lines 26-27 or "…resulting solely from secular cooling of the mantle." As a suggestion, I think the abstract and conclusions could be tuned down.
The first sentence "Our model negates the need for…". This sentence in no way implies an argument against supercontinental insulation, it merely directly states that an alternative model exists. Thus, we keep this sentence as is.
The second sentence "…resulting solely from secular cooling…", has been altered to "which could have resulted solely from secular cooling of the mantle.".

Lines 274-278: "While we do not discount the prospect of some degree of subcontinental mantle warming due to the formation of Columbia, we hypothesise that this mantle heating would have occurred in tandem with the expansive formation of hot continental back-arcs, and that these along can adequately explain the mid-Proterozoic's enigmatic geological record." Or perhaps there is a cause and effect here? Mantle insulation by supercontinent formation leads to the formation of hot continental back-arcs, matching the proposed model in figure 3 (marked in the paper as a 2nd Figure 2).
That is an interesting point, and something that will be considered in a separate publication dealing with a different but overlapping topic.

We have reworded to ”While we do not discount the prospect of some degree of subcontinental mantle warming due to the formation of Columbia, we hypothesise that the expansive formation of hot continental back-arcs alone can adequately explain the mid-Proterozoic's enigmatic geological record. However, since sub-continental mantle warming would also potentially increase the ambient temperature of back-arc regions, we note that these processes, if present, would have occurred in tandem.”

Line 76: xx ?
Fixed.

Lines 85-87: Maybe for MALI, but not for ASI.
Reworded to: ASI (Aluminium Saturation Index) has no distinct change, and MALI (Modified Alkali Lime Index) has a subtle increase suggesting an increase in alkalinity of granites during this period.

Line 92: Figure SX – I didn't have access to this figure or any supplementary material.
The supplementary files are viewable on Github, and the link was provided in the ms text. The second reviewer was able to access these.

Figure 1. (b) Y axis misses unit - °C/Ga; (c) Y axis misses unit - °C; (d) Y axis misses unit - °C/GPa.
The second Figure 2 is actually Figure 3. Accordingly, please change the text when referring to these figures.
Figures all fixed now. We apologise for these silly mistakes.
Best regards,
Hugo Moreira, February 2023

Reviewer 2

The authors present a new tectonic model for explaining characteristic yet poorly-understood features of the mid-Proterozoic geological record – elevated recorded T/P ratios in metamorphic complexes, and the abundance of ferroan (“A-type”) magmatic rocks (including anorthosites, and rapakivi granites). The paper presents an excellent, thought-provoking synthesis and discussion of a comprehensive geochemical dataset (62,000 samples reported in supplementary data), first to characterise geochemically this period (c. 1.9 to 0.8 Ga), and then to base a new tectonic model involving the development of wide, hot, backarcs resulting from rapid rollback and larger volumes of decompression melting, both enabled by hotter-than-present-day mantle temperatures. It is argued that insulation either by the Columbia supercontinent or from slow plate motion, as previously proposed, are not necessary to have achieved the high crustal temperatures.
We thank the reviewer for their positive comments.

From my perspective, an interesting implication for proposing more extensive and rapid trench retreat (rollback), and advance, to achieve these extended, hot backarcs is for the timescales of Proterozoic metamorphism. If, as proposed, arc systems were more dynamic (i.e., experiencing more rapid, more widespread, and larger back-arc extensional events) in the Proterozoic than in the modern Earth, then I would infer that durations of metamorphic cycles would be shorter (assuming that heat transfer could keep pace). But, how does this then square with the longer timescales of metamorphism commonly interpreted for Proterozoic orogens, which are typically on the order of several 10s, or 100s, of Myr? Are, then, these mid-Proterozoic timescales commonly overestimated, for instance by blurring multiple sequential unresolved metamorphic pulses? Or could these hot, wide mid-Proterozoic backarcs persist as long-lived features, maintained by high mantle temperatures, once they have rapidly been created?

This is a really interesting discussion point, and slightly off topic here since we do not consider timescales of metamorphism in the paper. (Although we note that during revision another paper has come out that does exactly this – Zou et al., 2023 EPSL).
The geodynamic models of peel-back tectonics, which are not too different from those we propose here (they are just a more extreme consequence of hotter mantle) have PT paths modelled in Chowdhury et al., 2022 Gondwana Research. In those models, slow cooling and exhumation are completely in line with the higher mantle temperature geodynamics. So, all we can say is that yes, perhaps some more specific modelling/looking at nature could be done to consider whether rapid rollback should allow for rapid exhumation, which is not generally known from Proterozoic orogens.

The paper is extremely well-written, logically organised, and well-illustrated. I can offer no major suggestions for revision, other than some minor comments and corrections listed below, which I hope can be of help.
Thank you!

Best wishes,
Jon Pownall
University of Helsinki

Main points

Line	Comment
69	Perhaps you could mention a few more examples of ferroan magmatic rocks in addition to rapakivi, and perhaps a brief definition?

Extra ref added.

Line	Comment
77	Why do you filter the data for those specific SiO_2 values?

To avoid mafic rocks, and to avoid high silica rocks where geochemical signatures tend to merge due to fractionation.

Line	Comment
78	There are a few issues with figure numbering: there are currently two figure 2s (and so all references to the 2nd figure 2, which should be figure 3, need updating). Also, line 78 and 83 should refer to Figure 2, not 1.

Figures are fixed. We apologise.

Line	Comment
83	Update to 1.9 – 1.8 Ga (as noted in my comment for Figure 2).

Fixed.

Line	Comment
87	I'm not suggesting anything be changed here, but just a thought: If the data were not binned to 100 Myr intervals, but to something smaller (e.g., 10 Myr), would a more exact correlation between different geochemical plots be revealed for the onset of the 'mid-Proterozoic' time as shown in Figure 2?

Interesting idea, but the data density are not high enough to reduce to a small bin size.

107 Perhaps further explanation and/or reference needed here for point 1) (unless all 3 points are referring to Collins et al. (2020)).
Refs added.

127 Another thought: If rollback were to have operated more rapidly and extensively in the mid-Proterozoic, what implications would this have on the duration of metamorphic cycles? I would have thought that they would be also more rapid and short-lived, but this would inconsistent with metamorphic record (or, at least the most common interpretations of the metamorphic record).
See comment above.

128 If point (2) is correct, I suppose this would mean that the volcanic arc is also further from the trench? Would this affect the composition of arc magmas and related volcanic rocks?
I believe the answer is yes, the arc probably would be further from the trench. So in theory, yes, since the depth to the slab and melt zone influences arc chemistry. However, modern day geochemical records will be an average of a large range of arc-styles, from thick to thin, from compressive to extensional. The Proterozoic arcs would be the same. There is definitely more detailed work one could do if there were good records of individual Proterozoic arcs, but we don't feel something could be teased out of a global database specifically.

139 After 'greater', might it be worth adding something like 'than the modern Earth' or 'than the reference model'?
Added.

140 Could be a good idea to indicate % value of melt extraction threshold being considered?
Added.

146 Yes – I like how this point is stated!

148 Could it be worth mentioning rollback here, to tie in with its discussion in the introduction?
We feel this isn't necessary.

155 Perhaps this is a bit picky, but are these strictly observations? More calculations or inferences?
We attempted to change this, then decided observation was valid.

157 Again, implication for even more rapid rollback than modern arcs, and therefore impact on metamorphic timescales in Proterozoic.
Perhaps this does explain some features of the metamorphic record – but this is outside of the scope of this current paper, since – 1) the models we interrogate do not include a wide range of PT markers allowing us to better understand potential PTt paths, and 2) we are more focused on general aspects of the magmatic and metamorphic record. Something for the future though…

172 The pie chart in figure 3f shows 50:50 Fe:Mg proportions, so this is not really consistent with being "dominated by magnesian magmatism".
The estimates are 70% magnesian for Phanerozoic, and 45% magnesian in the Proterozoic.

186 Nice point!

307 Maybe this paragraph is stating things with a bit too much certainty? A caveat of "likely" needed somewhere?

Reworded to: In the Neoproterozoic, continued secular mantle cooling would allow geodynamics to further evolve such that deep subduction of continental lithosphere was possible at convergent margins (Condie, 2021; Brown et al., 2022). Back-arc mantle temperatures would also have cooled down due to secular mantle cooling, and by the Phanerozoic, the geodynamics of subduction zone margins were likely similar to present day.

317 'inboard' perhaps too vague a description here?
Reworded to: … and a greater volume and spatial extent of ferroan magmatism, including AMC suites, inboard of the volcanic arc.

Figure 1 A few small things to update on the figure: units are missing for some y-axis labels; space needed between potential and temperature in y-axis label of figure a.
Labelling and spacing fixed.

Figure 2 I would suggest extending the mid-Proterozoic shaded region to start 100 Myr earlier, at 1.9 Ga, so that the entire range stated on line 83 is covered (note also that on line 83, it might be clearer to switch the starting range to "1.9 – 1.8 Ga"). For instance, the Sr/Y plots 'drops' would fit much better to this slightly extended timespan. Also, my personal preference would be to arrange all plots in a single column, so that they could all be directly compared, but perhaps there would not be enough space on the typeset page.
We have changed the shading in all figures to 1.85-0.85 Ga to reflect the time interval stated in the text. We tried to change the figure orientation, but nothing really fitted with one column successfully.

Figure 3 (update caption to 'Figure 3', not 2). I have a couple of things to suggest for Fig 3: I'm not sure how you calculated the pie charts: are they just esimates? For parts a and b, I would note in the caption what the 15.01 Myrs and 13.29 Myrs refers to. AMCG abbreviation is different to 'AMC' used in main text, and is not explained in the caption. I like this figure in its current form, so this is not a criticism, but might it be better to change part e slightly so that right edge of the upper plate is shown in the same location in parts e and f, so that the effect of rollback, backarc extension (and widening), and trench retreat is made more obvious? This is a bit difficult to explain, but you could move the contents of part e further to the right within its frame, so that both parts e and f are effectively 'anchored' at the same place at their rightmost extents?
Caption fixed. Pie charts are just estimates from Figure 1's Ferroan/Magnesian ratio, and this is now stated. Myrs now referred to. AMC fixed and explained.
To move the sections of the figures shown as described, we would have to zoom out a bit, so we have chosen not to do this.

I have checked the supplementary files and they seem good to me.
Great.

Minor points

Line Comment

46 Use of past tense more appropriate here? E.g., questioned, demonstrated, argued, did not…
Fixed.

61 LOWESS --> LOWEST

LOWESS is a statistical treatment. Detail now added.

61 Reference needed also to Brown and Johnson (2018), as mentioned in supplementary data?
Added.

76 'xx sources': needs updating?
Added.

77 space needed between < and 72.
Added.

92 Update Figure 'SX' to S1,2?
Added.

126 (and other places) '+' needed before 80–120 ? (perhaps not important).
Other's just use Delta, so we stick with that. However, we added T after the Delta symbol.

132 2a -->3a
Fixed.

136 at a region --> in a region (perhaps this is better wording?)
Fixed.

140 Also, maybe better to replace 'above' with 'exceeding'?
Fixed.

160 update refs to figure 3, not 2.
Fixed.

172 update refs to figure 3, not 2.
Fixed.

173 maybe better to write "widened and thinned"?
We prefer the original.

214 Ramo --> Rämö
Fixed.

277 along --> alone
Fixed.

3/ Final decision letter

Decision letter

Nick M W Roberts, Kent C Condie, Richard M Palin, Christopher J Spencer:

We have reached a decision regarding your submission to τεκτonικa, "Hot, wide continental back-arcs explain Earth’s enigmatic mid-Proterozoic magmatic and metamorphic record".

Our decision is: Accept Submission