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Reply to Comment by Åke Johansson on Li et al. (2023): A dynamic 2000—540 Ma Earth history: From cratonic amalgamation to the age of supercontinent cycle

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We welcome comments by Johansson (2023) on our recently published work (Li et al., 2023). As we stated in our paper, being the first full-plate reconstruction going back to 2 Ga, there ought to be ample room for improvement in every aspect. Our work was based on decades of studies by geoscientists around every corner of the world. However, due to the enormous time, space, and dimensional coverage/scope of the work, we were unable to do in-depth discussions on the many global orogens or basins that are marked on, and provided important constraints for, our reconstructions, or review all previous reconstruction ideas covering all or parts of the 2000–540 Ma Earth history. As a result, many worthy studies, such as that of Johansson (2009) which proposed the elegant 'SAMBA' connection for the Proterozoic between Baltica, Amazonia and West Africa, were not specifically cited in the paper due to either being inconsistent with other constraints or being deemed non-critical for the discussions. Below we address each of the comments by Johansson (2023) in the order of their appearance, starting from why we did not adopt the 'SAMBA' hypothesis for either the Mesoproterozoic supercontinent Nuna or the transition period to the Neoproterozoic supercontinent Rodinia.

The 'SAMBA' hypothesis of Johansson (2009) was entirely based on broad-brushed crustal province correlation between the three cratons concerned. However, reconstructions entirely based on such intercontinental correlations are often non-unique. In fact, in a systematic palaeomagnetic examination of the 'SAMBA' hypothesis, Pisarevsky et al. (2014) found that the palaeomagnetic poles available then only permit a possible 1790 Ma connection between Baltica and Amazonia (although one pole from an Amazonian terrane still does not fit such a connection), but not for ca. 1420 Ma or 1210–1150 Ma (Tohver et al., 2002; Elming et al., 2009). In our reconstruction (fig. 2 of Li et al., 2023), the position of Amazonia against the rest of Nuna (neighbouring Baltica) was constrained by comparing ca. 1789 Ma and 1419–1416 Ma palaeopoles from Amazonia with that of the generalised common apparent polar wander path (APWP) for the core components of Nuna (fig. 3 of Li et al., 2023), although it might still be possible to pull Amazonia slightly away from Baltica within the error allowance of the palaeomagnetic poles.

Recent work by Gong et al. (2021) used matching palaeopoles of ca. 2.0 Ga, ca. 1.75 Ga (VGP), and ca. 1.38 Ga between West Africa and Amazonia to suggest a West Africa-Amazonia connection during the 2.0–1.38 Ga interval that is rather different from their relative positions

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during Gondwana time, thus arguing against the validity of such a connection for the Proterozoic as in the 'SAMBA' hypothesis. In our model, while still preserving the triple palaeopole matching as in Gong et al. (2021), we introduced a slightly modified West Africa-Amazonia reconstruction from that of Gong et al. (2021) (fig. 2 of Li et al., 2023) to avoid overlaps with other continental blocks. We wish to point out that the idea of opting to use the alternative polarity of the 1.38 Ga palaeopole from West Africa, as suggested by Johansson (2023), would place West Africa ca. 1500 km away from Amazonia on the other hemisphere, still disallowing the 'SAMBA' connection.

The comment on subduction around the Baltica margin is a good one. All plate boundaries in a full-plate reconstruction are interpretative ones, and ongoing plate boundaries need to be connected as a global network. In our Nuna reconstructions (e.g., fig. 11 of Li et al., 2023), we followed the Pangaea example (where the present-day circum-Pacific subduction girdle is what has become of the prior circum-Pangaea subduction girdle) to have a subduction girdle surrounding the supercontinent. Nonetheless, such a subduction girdle ought to have sections of transform faulting between subduction zones (like what we observe along the present-day west coast of North America and across New Zealand). This might indeed be the case for the active margin along the western and southern margin (in present-day coordinate) of Baltica, where a continental arc likely existed along the western margin as recorded by the Mesoproterozoic orogens there, but a transform fault could have existed along the southwestern margin as suggested by Johansson (2023).

In our animations, we gradually rotated West Africa's relative orientation to Amazonia from a pre-1300 Ma one to a Gondwana one between 1300 Ma (start of Nuna break-up) and 900 Ma (the final assembly of Rodinia).

Johansson (2009, 2023) prefers to have a coherent 'SAMBA' connection for the entire Proterozoic, encompassing the Nuna and Rodinia supercontinent cycles. However, apart from the argument earlier that 'SAMBA' was palaeomagnetically impossible for the Nuna time, it would also not be possible during the transition between Nuna and the Neoproterozoic supercontinent Rodinia, because reliable ca. 1.2 Ga palaeomagnetic constraints have Amazonia separated from Baltica by a $>$ 1000 km latitudinal distance (figs. 11d and 12a of Li et al., 2023). Our Rodinia reconstruction (fig. 5 of Li et al., 2023) is not too far off from a 'SAMBA'-like configuration between Baltica, Amzonia and West Africa, but the presence of Grenville-aged orogenic record between Amazonia and Baltica along northern Amazonia (the Putumayo orogen; e.g., Fuck et al., 2008; Li et al., 2008; Ibañez-Mejia, 2020) argues that even if such a configuration did exist during Rodinia time, it would only have formed after the Mesoproterozoic instead of throughout the entire 1.8–0.8 Ga period as in the 'SAMBA' hypothesis (Johansson, 2009). In trying to avoid having such a Grenville-age convergent plate boundary between Amazonia and Baltica, as required by the 'SAMBA' hypothesis, Johansson (2023) was forced to interpret Grenville-age drill-core data from the northern Amazonia margin (present-day coordinate) as being laterally transported from the Andean margin without evidence for such an interpretation.

Finally, all databases and GPlates project files used for our study are available online (https://doi.org/10.1016/j.earscirev.2023.104336), and our published plate motion models show kinematically feasible motions of individual plates during the transition between Nuna break-up and Rodinia assembly with reasonable plate motion speed (fig. 15 of Li et al., 2023). Readers are advised to use the free GPlates software (https://www.gplates.org; Williams et al., 2012) and the GPlates project files that we provided (supplementary material 10 of Li et al., 2023) to examine the motion of specific plates if such plates or continents fall at the edge of the published reconstruction figures.

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Declaration of Competing Interest

There is no conflict of interests regarding this Reply.

Data availability

No data was used for the research described in the article.

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References

Elming, S.-Å., D'Agrella-Filho, M.S., Page, L.M., Tohver, E., Trindade, R.I.F., Pacca, I.I.G., Geraldes, M.C., Teixeira, W., 2009. A palaeomagnetic and40Ar/39Ar study oflate Precambrian sills in the SW part of the Amazonian craton: Amazonia in theRodinia. Geophys. J. Int. 178, 106–122.

Fuck, R.A., Neves, B.B.B., Schobbenhaus, C., 2008. Rodinia descendants in South America. Precambrian Res. 160 (1–2), 108–126.

Gong, Z., Evans, D.A.D., Youbi, N., Lahna, A.A., Söderlund, U., Malek, M.A., Wen, B., Jing, X., Ding, J., Boumehdi, M.A., Ernst, R.E., 2021. Reorienting the West african craton in Paleoproterozoic-Mesoproterozoic supercontinent Nuna. Geology 49 (10), 1171–1176.

Ibañez-Mejia, M., 2020. The Putumayo Orogen of Amazonia: a synthesis. In: Tapias, J. Gómez, Mateus-Zabala, D. (Eds.), The Geology of Colombia, Volume 1 Proterozoic – Paleozoic. Servicio Geológico Colombiano, Bogotá, pp. 101–131. Publicaciones Geológicas Especiales 35.

Johansson, Å., 2009. Baltica, Amazonia and the SAMBA connection–1000 million years of neighbourhood during the Proterozoic? Precambrian Res. 175 (1–4), 221–234.

Johansson, Å., 2023. Comment on Li et al. (2023): A dynamic 2000—540 Ma Earth history: From cratonic amalgamation to the age of supercontinent cycle. Earth Sci. Rev.

Li, Z.X., Bogdanova, S.V., Collins, A.S., Davidson, A., De Waele, B., Ernst, R.E., Fitzsimons, I.C.W., Fuck, R.A., Gladkochub, D.P., Jacobs, J., Karlstrom, K.E., Lu, S., Natapov, L.M., Pease, V., Pisarevsky, S.A., Thrane, K., Vernikovsky, V., 2008. Assembly, configuration, and break-up history of Rodinia: a synthesis. Precambrian Res. 160, 179–210.

Li, Z.-X., Liu, Y., Ernst, R., 2023. A dynamic 2000–540 Ma Earth history: from cratonic amalgamation to the age of supercontinent cycle. Earth Sci. Rev. 238, 104336.

Pisarevsky, S.A., Elming, S.A., Pesonen, L.J., Li, Z.X., 2014. Mesoproterozoic paleogeography: Supercontinent and beyond. Precambrian Res. 244, 207–225.

Tohver, E., Van, D.P.B.A., Van, D.V.R., Rizzotto, G., Scandolara, J.E., 2002. Paleogeography of the Amazon Craton at 1.2 Ga; early Grenvillian collision with the Llano segment of Laurentia. Earth Planet. Sci. Lett. 199 (1–2), 185–200.

Williams, S.E., Müller, R.D., Landgrebe, T.C., Whittaker, J.M., 2012. An open-source software environment for visualizing and refining plate tectonic reconstructions using high-resolution geological and geophysical data sets. GSA Today 22 (4/5), 4–9.