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A Plate Tectonic Model for the Neoproterozoic with Evolving Plate Boundaries

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The Neoproterozoic was dominated by the formation of the supercontinent Rodinia, its break-up and the subsequent amalgamation of Gondwana, during which, the planet experienced large climatic variations and the emergence of complex life. Here we present a topological plate model of the Neoproterozoic based on a synthesis of available geological and palaeomagnetic data. Subduction zones, which are well preserved in the geological record, are used as a proxy for convergent margins; evidence for mid-ocean ridges and transform motion is less clearly preserved, though passive margins are used as a proxy for spreading centres, and evidence for strike-slip motions are used to model transform boundaries. We find that the model presented here only predicts ∼70% of the total length of subduction active today, though it models similar lengths of both transform and divergent boundaries, suggesting that we have produced a conservative model and are probably underestimating the amount of subduction. Where evidence for convergent, divergent or transform motion is not preserved, we interpret the locations of plate boundaries based on the relative motions of cratonic crust as suggested through either palaeomagnetic data or the geological record. Using GPlates, we tie these boundaries together to generate a plate model that depicts the motion of tectonic plates through the Neoproterozoic. We omit India and South China from Rodinia completely, due to long-lived subduction preserved on margins of India and conflicting palaeomagnetic data for the Cryogenian, but tie them together due to similar Tonian aged accretionary patterns along their respective (present-day) north-western and northern margins, such that these two cratons act as a “lonely wanderer” for much of the Neoproterozoic, and form their own tectonic plate. We also introduce a Tonian-Cryogenian aged rotation of the Congo-São Francisco Craton relative to Rodinia to better fit palaeomagnetic data and account for thick passive margin sediments along its southern margin during the Tonian. The model depicts a sequential breakup of Rodinia, with Australia-Antarctica rifting first (∼800 Ma), Congo-São Francisco (and the Sahara Metacraton) second (∼750 Ma) and Kalahari third (700 Ma). Amazonia and West Africa rift later with the opening of the Iapetus Ocean from ∼600 Ma. We expect that this global model will assist in the development of future regional models for the Neoproterozoic, and that the production of this full-plate topological reconstruction will facilitate the investigation of controls on other earth systems, such as the possible role of volcanism on initiation of the Cryogenian, or the nature of mantle convection in the Neoproterozoic.