A diachronous opening of the Iapetus Ocean in the Neoproterozoic

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The late Neoproterozoic is a time interval of dramatic changes affecting the biosphere, the cryosphere and the lithosphere, including the final disaggregation of the supercontinent Rodinia and the formation of Gondwana. The Iapetus Ocean opened during the breakup of Rodinia, i.e. resulting from the separation of the three major continental blocks: Laurentia, Baltica and Amazonia. Protracted continental extension to rifting from 750 to 530 Ma is observed along the involved continental margins and may indicate several ocean openings in addition to the Iapetus Ocean. Breakup timing is still much debated in the literature, as it remains unclear how to best interpret the fragmentary geological record along the rifted margins, and because only few reliable paleomagnetic data are available for this period of time. Three distinct times for the breakup are proposed for Laurentia and Amazonia: at (1) 750-700 Ma, (2) 615-570 Ma and (3) 550-530 Ma. Various terranes are also involved in the opening of the Iapetus Ocean and may have drifted along with or independently of Amazonia.

In this study, we reviewed the geological observations of each of the involved margins and the available paleomagnetic data from 750 to 520 Ma to test these scenarios. Paleomagnetic data from Laurentia and Amazonia-West Africa constrain the breakup age to occur before 575 Ma, discarding the possibility of a late Ediacaran/Early Cambrian opening. Geological observations, better preserved in Laurentia and Baltica, indicate two main phases of (attempted) continental rifting, from 750 to 680 Ma and from 615 to 550 Ma. The second phase is usually interpreted as leading to the breakup of Laurentia, Amazonia and Baltica, as in scenarios (2) and (3). Nevertheless, it cannot easily explain (i) the absence of the Central Iapetus Magmatic Province in West Amazonia, (ii) the dynamics of accreted terranes now observed in South America and (iii) the distinct late Neoproterozoic detrital zircon age population in Phanerozoic sediments along West Amazonia (which are moreover absent in East Laurentia). These observations are better explained by a model wherein Laurentia and Amazonia broke apart during the first rifting phase around 750-680 Ma. In this scenario, the second phase of rifting (615-550 Ma) leads, in the west, to drifting of small terranes southward and toward Amazonia, and in the east, to the final breakup between Laurentia and Baltica.