

LIPs as proxies for natural Precambrian boundaries

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While the Phanerozoic timescale is based on biostratigraphy (which is increasingly well dated), the Proterozoic time scale is currently divided into broad periods of geodynamic significance but with boundaries quoted at the nearest 100–50 Myr (Ogg et al 2016; www.stratigraphy.org/ICSchart/ChronostratChart2018-08.pdf). In pursuit of natural Precambrian boundaries (van Kranendonk et al 2012) we use well-dated major Large Igneous Provinces (LIPs) as proxies for natural boundaries (Ernst and Youbi 2017).

LIPs, particularly those that are emplaced in a short duration of ca. 1–5 myr, can have a dramatic climatic event including global warming, cooling, anoxia, acid rain, ocean acidification, and mercury poisoning; most of the Phanerozoic mass extinctions are linked to LIPs. Therefore, while large LIPs have a regional-scale magmatic effect, their environmental impact can be severe and global, and would be preserved in the sedimentary record.

Herein we evaluate LIP candidates (such as at 2510, 2056, 1790, 1380, 1205, 1005, 720 Ma) to mark the generalized Proterozoic boundaries. Notably, the 720 Ma Tonian-Cryogenian boundary is now robustly linked to the Franklin LIP (Macdonald and Wordsworth, 2017; Ernst and Youbi, 2017) plus additional coeval LIPs fragments in Siberia, Kalahari and Grunehogna (Ernst et al. 2016; Gumsley et al. 2019). The c. 1400 Ma Calymmian-Ectasian boundary is re-defined to match 1380 Ma LIPs on many crustal blocks, associated with final breakup of the Nuna (Columbia) supercontinent and marked by black shales (Zhang et al. 2018). The 2050 Ma Rhyacian-Orosirian boundary is linked to the 2056 Ma Bushveld LIP (Kaarvaal craton), and the coeval Kevitsa LIP (Karelian craton).

Ernst & Youbi (2017) *PPP*, 478: 30–52. Ernst et al. (2016). *Nat. Geosci.* 9: 464–469. Gumsley et al. (2019) 2019 abstract. Macdonald & Wordsworth (2017), *Geophys. Res. Lett.*, 44: 1938–1946. Ogg, et al. 2016. *A Concise Geologic Time Scale 2016*. Elsevier, 243 pp. Van Kranendonk et al. 2012. In: *The Geologic Time Scale. 2012*: p. 299–392. Zhang et al. (2018) *Geology*, 46: 963–966.