

Synchronous deposition of black shales and their correlation with large igneous provinces during 'the Boring Billion'

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Recent results on ca. 1380 Ma large igneous province (LIP) activity and coeval black shales in the Nuna (Columbia) supercontinent indicate a temporal and causal link between large igneous provinces (LIPs) and black shales and suggest a potential way for using coeval black shales and LIPs as natural markers for boundaries in the Mesoproterozoic geological time scale [1]. Our preliminary review on the LIPs and black shales formed during 'the Boring Billion' in different Precambrian cratons show that in addition to the ca. 1380 Ma LIP activity (that are coeval with black shales as recently proposed [1]), other LIPs during 'the Boring Billion' can preliminarily be divided into several stages including 1790–1750 Ma, 1650–1620 Ma, ca. 1580 Ma, ca. 1500 Ma, ca. 1320 Ma, ca. 1270 Ma, ca. 1100 Ma, ca. 900 Ma and ca. 720 Ma, and that some of them are mostly likely contemporaneous with deposition of black shales. Our results demonstrate that global-scale LIPs and black shales in 'the Boring Billion' can potentially be used as natural markers for subdivisions of the Proterozoic geological time scale. The results also suggest that, while 'the Boring Billion' was characterized by suboxic or mildly oxygenated marine basins, that it was interrupted by ocean anoxic events (recorded by global black shales) at several times that are partly caused by the environmental impact of LIPs. Correlation of black shales and LIPs provide a new way to explain the fluctuating evolution of atmosphere, life and marine basins during 'the Boring Billion' as identified by many recently studies [2-6].

[1] Zhang S.-H. et al. (2018) *Geology* **46**, 963–966. [2] Mukherjee & Large (2016) *Precam Res* **281**, 13–26. [3] Large et al. (2017) *Econ Geol* **112**, 423–450. [4] Zhu et al. (2016) *Nat Commun* **7**, 11500. [5] Zhang K. et al. (2018) *Nat Geosci* **11**, 345–350. [6] Zhang S.-C. et al. (2016) *PNAS* **113**, 1731–1736.