The Boring Billion, a slingshot for Complex Life on Earth

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The period 1800 to 800 Ma, referred to as the “Boring Billion” or the “dullest period in Earth’s history” is believed to mark a delay in evolution of complex life, primarily due to low levels of oxygen in the atmosphere and ocean. The so-called stasis manifests as remarkably stable and flat C, Cr isotope and trace element trends due to prolonged nutrient, climatic, atmospheric and tectonic stability. However, several critical biological evolutionary events such as the appearance of eukaryotes, their cell organelles, the origin of multicellularity, the origin of sexual reproduction, the first major diversification of eukaryotes (crown group) occurred during this period. Without these key biological innovations, any subsequent evolution of complex life would be impossible. Here we show, by frequent sampling of the Proterozoic rock record combined with a very sensitive geochemical technique (LA-ICP-MS analyses of marine sedimentary pyrite in black shales), that first-order bio-essential trace element (TE) concentrations (Ni, Co, Cu, Se, Mo, Zn, Cd) in the ocean varied in a broad cyclic pattern with a frequency of about 300 Ma. This is in contrast with previous studies that have proposed low and unvarying TE concentrations throughout the Boring Billion that hindered biologic evolution. Without denying the importance of oxygen in an organism’s life cycle, this study highlights the importance of bio-essential trace elements, epecially their scarcity, as previous emphasis has always been only on their abundance. We suggest that periods of low nutrient TE caused evolutionary pressure, and were essential triggers promoting biological innovations. Periods of high nutrient TE concentration, on the other hand, promoted diversification of new species. Rather than a period of biological stasis as currently accepted, we propose the “Boring Billion” is a period of sequential stepwise evolution and diversification of complex eukaryotes. Fluctuating nutrient concentrations caused alternating stress/stress-free conditions triggering evolutionary pathways that made the later rise of micro-metazoans and their macroscopic counterparts possible.