Deadly Kiss of the LIPs: Causes and consequences of Large Igneous Province emplacement – A case study from the Early Toarcian

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Past Large Igneous Province (LIP) emplacement is commonly thought to have been caused by mantle plume upwelling, and is proposed as a likely driver of past global change events because of volcanic carbon emissions. One of Earth's largest past environmental perturbations, the Early Jurassic Toarcian oceanic anoxic event (T-OAE; ~183 Ma), has been linked to emplacement of the Karoo-Ferrar LIP. However, the role of mantle plumes in controlling the onset and timing of LIP magmatism is poorly understood.

Here, utilizing global plate reconstruction models, and Lower Toarcian sedimentary mercury (Hg) concentrations from the Mochras borehole (Wales, UK) we demonstrate (1) that the Early Toarcian OAE occurred coevally with Karoo-Ferrar LIP emplacement, and (2) suggest that the timing and duration of LIP-emplacement was governed by a reduction in local Pangean plate motion associated with a reversal in plate movement direction. With this, we present a new model that mechanistically links Earth's interior and surficial processes, and we show that this mechanism may be consistent with the timing of several of the largest LIP volcanic events throughout Earth history and thus, by inference, the timing of many of Earth's past global climate change and mass extinction events.

Furthermore, the Toarcian oceanic anoxic event is characterized by one of the largest carbon cycle perturbations of the Mesozoic Era, with associated climatic and environmental change, most notably the widespread development of anoxia in epicontinental marine basins. On land, an enhanced hydrological cycle led to the development of major lakes, or significantly elevated lake levels, in continental basins, such as in the Sichuan, Tarim and Junggar basins (China). Stratified lacustrine water columns and the development of anoxic–euxinic lake bottom- water conditions initiated a negative feedback mechanism in Earth's climate system through increased lacustrine (lake) carbon burial. The sheer size of these lakes and associated carbon burial fluxes allowed for lacustrine carbon drawdown to have a demonstrable impact on Earth's carbon cycling at that time. Here, we show new geochemical data from the Sichuan Basin and show that lake levels rose at the onset of the T-OAE. Importantly however, lake levels were likely not stable, but rather fluctuated on astronomical timescales, possibly in response to periodic changes in the hydrological cycle and the transport of moisture into continental interiors.