Precambrian LIPs and environmental perturbation

C.W. DIAMOND[1], R.E. ERNST[2,3], S.H. ZHANG[4], T.W. LYONS[1]

[1]Department of Earth and Planetary Sciences, University of California, Riverside, CA, USA [cdiam001@ucr.edu]
[2] Department of Earth Sciences, Carleton University, Ottawa, Ontario, Canada
[3] Faculty of Geology and Geography, Tomsk State University, Tomsk, Russia
[4] Institute of Geomechanics, Chinese Academy of Geological Sciences, MNR Key Laboratory of Paleomagnetism and Tectonic Reconstruction, Beijing, China

Large-scale igneous activity has occurred stochastically throughout Earth history. Over the past 500 Ma, these events are frequently correlated with rising global temperatures, expanding oceanic anoxia, widespread deposition of organic-rich black shale, and metazoan extinctions. These effects are the result of a complex interplay between a number of related feedbacks. While the initial drivers of these environmental perturbations are factors intrinsic to Large Igneous Province (LIP) emplacement itself, the inevitable outcome for the Earth system is dependent on the boundary conditions present at at the onset of activity. Specifically, in a bacterially dominated Proterozoic world with lower atmospheric oxygen and widespread suboxia/anoxia present in the oceans, the emplacement and subsequent weathering of continental LIPs could have generated conditions favorable for enhanced productivity and hence oxygenation of the ocean/atmosphere system, rather than deoxygenation.

Here, we will review the records of several oceanic redox proxies, summarizing their systematics and utility, and compare them with the record of continental LIPs. The mid-Proterozoic (1.8-0.8 Ga) is widely known as a time of prolonged environmental stability. However, multiple independent geochemical records suggest intervals of transient oxygenation. One such interval, at ~1.4 Ga, coincides roughly with a period of widespread LIP activity that has been linked recently to the deposition of black shales on several paleocontinents. We will go on to explore the feedbacks that acted to stabilize the mid-Proterozoic Earth system and consider how LIP activity could have influenced the balance between nutrient, carbon, and oxygen cycling. In the Phanerozoic, perturbations to these systems often led to deoxygenation of marine habitat and metazoan extinction. In the mid-Proterozoic, however, the converse may have been true—LIP activity could have spurred oxygenation that favored advances in eukaryotic evolution.