Solid-Earth Processes are Key Drivers in the Evolution of Earth's Redox State and Set the Stage for the Great Oxidation Event

H. HARTNETT[1,2] C. TILL[1], A. ANBAR[1,2], D. GLASER[2], M. GUILD[1], K. IACOVINO[1], A. JOHNSON[1], J. LEONG[1], C. OSTRANDER[1], AND THE DYNAMICS OF EARTH SYSTEM OXYGENATION TEAM

[1] School of Earth & Space Exploration, Arizona State Univeristy, Tempe, AZ 85287; h.hartnett@asu.edu
[2] School of Molecular Sciences, Arizona State University, Tempe, AZ 85287

The evolution of life and of Earth's biogeochemical cycles are inextricably linked to the evolution of the solid Earth. Our thesis is that oxygenation of Earth's atmosphere during the Great Oxidation Event (GOE) was a result of changes in the interaction between deep Earth processes – e.g., the deep redox budget, flux of mantle-derived volatiles, and the generation of contiental crust – and biological O_2 production at Earth's surface.

An integrated "theory of Earth evolution" describing the mechanistic links between the Earth's interior and surface, and how they have changed with time is needed to if we are to develop a quantitative understanding of the interactions and consequences of these planetary-scale processes. Such a theory would provide a unifying framework for understanding the GOE, which is one of the singular events in Earth's evolution. Here we present such a framework that considers the evolution (post-core formation) of the solid Earth.

The GOE is fundamentally an evolution in the balance between the supply of O_2 (sources) and the supply of reductants (O_2 sinks). Recent advances make it possible to assess the role of solid Earth processes in the evolution of Earth redox state and thus, sources and sinks for O_2. We present a 1D continuity equation that integrates geophysical and biogeochemical processes with which to quantify fluxes and reactions generating reductants/oxidants across a range of geochemcial systems. We emphasize the role of solid Earth processes including: magamatic processes, rock alteration, weathering, and biology. The formalism addresses diffusive, advective, and reaction terms for individual reductants and highlights the fact that an individual process can affect multiple chemical species. We further explore the feedbacks and uncertainties that must be assessed before the impact of any particular process can be quanitfied. We also identify some key knowledge gaps that must be addressed in order to develop forward-models of Earth's redox evolution through time.