# The Planet as Province

ARIEL D. ANBAR[1]

[1]School of Earth and Space Exploration & School of Molecular Sciences, Arizona State University, Tempe, AZ 85287 anbar@asu.edu

Large Igneous Provinces (LIPs) are commonly approached from the perspective of solid Earth sciences. From this perspective, LIPs are geographically localized phenomena associated with hotspot volcanism and other tectonic processes, and are especially interesting because of widespread impact on the environment, including as drivers of mass extinctions. However, approached from a geobiological perspective, LIPs are a particular case of the general process of Earth interior-surface interaction that has shaped the surface environment and its hospitability for life throughout Earth's history. Beginning with the magma ocean, Earth's thermochemical evolution as it gradually cooled drove chemical differentiation, mantle convection, crust formation, plate tectonics, and other key physico-chemical processes that shaped the course of biological evolution in ways we are still discovering. Beyond mass extinctions, key phenomena such as the emergence of life, the rise of an aerobic biosphere, biological radiations, and even human evolution were shaped by the trajectory of Earth's internal differentiation and dynamics, and their expression in surface tectonics and volcanism. From this 4.5 billion year perspective, the entire planet is the "province", and LIPs represent interior-surface interaction of the Earth system at a relatively mature, organized, and evolved state.

This presentation will review the evolution of the planet-as-province, focusing in particular on the role of interior-surface interactions in controling the rise of an aerobic biosphere. The recent discovery of a secular increase in the oxidation state of the mantle itself[1,2] – presumably driven by progressive mantle mixing and/or degassing as the planet cooled – implies a secular increase in the oxidation state of volcanic gases that shifted the balance between net biological $O_2$ production and abiotic, geological $O_2$ consumption. Quantitative modeling of this shift, incorporating data-driven understanding of mantle redox evolution, indicates that a key tipping point was crossed at approximately 2.4 Ga, plausibly accounting for the timing of the "Great Oxidation Event".[3]

1. Aulbach and Stagno, Geology 44: 751-754 (2016)
2. Nicklas et al., GCA 250: 49-75 (2019)
3. Kadoya et al., in prep.