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Early Earth catastrophic melting events and biosphere-atmosphere-ocean evolution.

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There is increasing evidence from both crust and mantle geochemistry that the Early Earth experienced 3 to 4 large melting events. It is a long-standing observation that the age of the Earth's continental crust (CC) has spikes in abundances, most prominently at 1.2, 1.9 and 2.7 Ga. These peaks suggest that the CC grew in a series of pulses, with minimal growth in between. However, the peaks can also be interpreted in terms of survivorship. Recently, statistical studies of Os and He isotopic data on mantle-derived samples has revealed that the same age peaks are apparently present throughout the convecting mantle as well. Since CC and convecting mantle heterogeneities are not subject to the same destructive processes, the similarity of their age distributions strongly supports a causal link between the two. It suggests that the crust did indeed grow in pulses, and further, implies that the mechanism of growth was protracted periods of extremely high mantle melting rates.

Such massive melting events would have had profound effects on the biosphere-atmosphere-ocean system. And indeed, anomalies in the C and S isotopic record correspond quite well with the crust-mantle peaks. There are two major excursions in the organicC-isotope composition of the atmosphere-ocean system at 2.7 Ga (Fortescue) and 2.0 Ga (Francevillian), and one excursion in carbonate at 2.3-2.0 Ga (Lomagundi-Jatulian). The S-isotope composition of the atmosphere shows a prominent anomaly due to mass-independent fractionation that starts at 2.7 Ga (and ends at 2.45 Ga with the oxidation of the atmosphere). The age distribution of banded iron formations (BIFs, generally considered to record changes in atmospheric oxygen concentration) also corresponds to the melting events, with a peak in BIF formation at 2.7 Ga and their

cessation at 1.9 Ga. The above anomalies correlate well with the periods of enhanced melting represented by the mantle and crust age peaks, providing firm evidence that the melting events induced profound changes in the atmosphere-ocean system.

The response of the atmosphere and oceans to inputs from the mantle will be mediated by and coupled to the biosphere. Increasing numbers of genomic and protein sequences have been used to reconstruct prokaryotic phylogeny as well as assign dates to the divergences of major metabolic systems. Major radiations occurred at or near the 2.7, 1.9 and 1.2 Ga mantle events. Most notable is the rise methanotrophic bacteria between 2.8 and 2.5 Ga, as well as the introduction of aerobic photosynthesis in the same time period. In this presentation we will discuss the correlation of the mantle-crust pulses with the stable isotope and geobiologic record, and propose mechanisms by which episodic mantle inputs controlled the Early Earth evolution of the biosphere-atmosphere-ocean system.