Reorganization of Earth's biogeochemical cycles briefly oxygenated the oceans 520 Myr ago

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The sudden radiation of bilaterian animals at the beginning of the Phanerozoic is frequently linked to oxygenation of Earth's oceans. Animals require molecular O_2 for respiration and other life functions, and the actions of animals (feeding strategies, larger body size and locomotion), in various ways, can influence O_2 availability in the environment. In theory, these feedbacks could have driven the co-evolution of early animals and marine oxygenation via self-propelling and self-stabilizing processes [1-3]. However, data specifically linking the evolution of early animal ecosystems to Earth's biogeochemical cycles is lacking.

We report parallel positive isotope excursions of $\delta^{238}U$, $\delta^{13}C$ and $\delta^{34}S$ from carbonate successions in Siberia across the Cambrian Stage 2-3 boundary documenting a global marine oxygenation event 521-520 Myrs ago and increased organic carbon and pyrite sulfur burial in ocean sediments. These geochemical trends are collectively explained by a sudden increase in the delivery of organic matter to sediments driven by a greater proportion of primary productivity escaping remineralization in the water column.

The oxygenation event coincides with the onset of the first major diversification of arthropods in the fossil record. We propose that as larger animals invaded the pelagic zone (e.g. meso-zooplankton), ballast was added to sinking organic matter by excreting moults and faecal pellets, which led to an increase in the average sinking velocity of organic matter [2].

Our geochemical data and model suggest that more reducing conditions returned 1.3±0.8 Myr after the onset of this oxygenation event, necessitating a strong counterbalancing force such as the O_2-limiting effect caused by the activity of bioturbating animals [3] at low atmospheric pO_2 <4.8±2.9 atm%. Therefore, the appearance of larger swimming animals with guts fortuitously delivered both food and O_2 to the benthos, while still decreasing atmospheric pO_2. These results suggest an intimate coevolution of early animal ecosystems and oxygenation of Earth's surface environment.

[1] Lenton et al., *Nature Geo*. 2014 [2] Logan et al. (1995) *Nature* [3] Boyle et al. *Nature Geo*. (2014).