Atmosphere-ocean oxygen and productivity dynamics during the Cambrian explosion

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Large, motile animals proliferated during the Cambrian explosion, 540–515 million years ago, and this period has been associated with both rising and declining O_2 levels on Earth [1–3]. To explore this conundrum, we reconstructed the global extent of seafloor oxygenation at ~sub-million year resolution based on U isotope compositions in 187 marine limestone samples from China, Siberia and Morocco, and coupled this record to simulations of atmospheric O_2 levels using a mass balance model constrained by carbon, sulfur and strontium isotopes in the same rocks.

The studied samples were investigated petrographically and geochemically to disentangle isotope fractionation processes occurring locally during diagenesis from secular changes in open seawater. We find that Sr/Ca, Mg/Ca and $\delta^{18}O$ help discriminate carbonate samples with a larger $\delta^{238}U$ offset from contemporaneous seawater, and decipher the signal that can be ascribed to global changes in the oceanic U pool. Our data demonstrate two significant expansions of seafloor anoxia in the aftermath of an interval with declining atmospheric pO_2 levels. The combination of atmospheric and oceanic O_2 records offers a self-consistent and highly dynamic picture of atmosphere-ocean oxygenation in which the evolving animal ecosystems might have both responded and contributed to global environmental change.

Animals diversified possibly by a predator-prey arms race peaking in two pulses interrupted by these dramatic fluctuations in seafloor anoxia. When O_2 levels again rose, it occurred in concert with predicted high rates of photosynthetic production, both of which may have fueled more energy to predators and their armored prey in the evolving marine ecosystem.

Refs. [1] Sperling EA *et al. PNAS* (2013); [2] Boyle RA et al. *Nat. Geo* (2014); [3] Chen X *et al. Nat Com.* (2015).