More bang for your buck? Ecological thresholds, oxygen, and the Cambrian explosion

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A hypothesized oxygenation event near the Precambrian-Phanerozoic transition is generally considered a main driver in the evolution of large, ecologically diverse animals. And indeed, there is obvious volatility in marine geochemical proxy records during this time. Some redox proxies, such as redox-sensitive trace element abudances in anoxic shales, show evidence for oxygenation at this time period. Others, however, such as Mo isotopes, statistical analyses of iron speciation data and some models of atmospheric O_2 indicate limited or no evidence for oxygenation. The sum of emerging data suggest that the dawn of the Phanerozoic may not have been a state change with respect to oxygenation, and that full oxygenation may have continued through the Paleozoic.

Such limited oxygenation scenarios cast doubt on the links between oxygen and the Cambrian explosion. The ecology of modern Oxygen Minimum Zones—areas with geologically long-lasting chronic low oxygen conditions—can provide an analogue to better understand how small changes in oxygen may have affected early animal communities. Intriguingly, at very low oxygen levels benthic animal communities exhibit non-linear threshold behavior in many ecological factors with respect to increasing oxygen. These responses include organic carbon processing efficiency, total species diversity, food web complexity and relative carnivore abundances. Although oxygen thresholds vary between responses, the most significant effects of oxygen on benthic faunas occur in the ~5 to 20 *u*mol/kg 0_2 range (~0.1 to 0.45 mL/L). These levels are ~2-10% of modern surface ocean oxygen saturation, and broadly correspond to commonly-assumed oxygen levels for the Proterozoic ocean.

Thus, a strong hypothesis can be put forward that a relatively small oxygen increase could move animals past critical ecological thresholds, especially with respect to factors such as carnivory, and trigger the Cambrian radiation. This however is obviously a more subtle and complicated scenario than most current hypotheses that call upon an oxygen increase to modern levels as the key environmental trigger.