

Coevolution of early animals and environment

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Large scale coevolution of organisms and environment is conventionally viewed from the bottom up – with microbially driven biogeochemical cycles providing the ecological opportunity, and larger, more physiologically constrained organisms rapidly evolving in response. Nowhere has this approach been more popularly applied than in oxygen-limitation hypotheses aimed at the seemingly delayed appearance of large and/or predatory animals. In this presentation I consider the nature of biological/environmental coevolution through the Proterozoic-Phanerozoic transition.

There is no question that planetary environments and biogeochemical cycling changed dramatically through the the Ediacaran and early Cambrian, an interval also marked by the first significant appearance of macroscopic organisms in the fossil record. More significantly, fundamental shifts in the the composition and evolutionary dynamics of contemporaneous microfossils attests to the genuine absence of eumetazoans prior to the Ediacaran. If oxygen availability was a first-order constraint on animal evolution, then the critical threshold was crossed in the early Ediacaran. Evidence for earlier oxygen limitation comes from geochemical proxies for deep-water anoxia, though it is notable that these same signatures extend into early Palaeozoic strata – while evidence of significant surface water oxygenation extends well back into the Neoproterozoic.

Such geochemical expression is difficult to reconcile with oxygen limitation hypotheses – particularly in light of the modest oxygen demand of most animals, and the conspicuous monophyly of the Metazoa. As such, the delayed appearance of eumetazoans is more convincingly ascribed to the extraordinary complexity of gene regulatory networks underlying organ-grade multicellularity; i.e., internal rather than external constraints. Once these developmental schemes were established, however, they opened up a new universe of ecological, evolutionary and biogeochemical phenomena, ranging from bioturbation and faecal pellets to the coevolutionary forcing of biomineralization, large body size, eukaryotic dominated phytoplankton and fundamental shifts in oceanic structure. Unlike the exclusively bottom-up microbial world of the pre-Ediacaran, the Phanerozoic biosphere must also be viewed from the top down – with animals playing a key role in the construction and definition of environments.

Influence of secondary organic aerosols (SOA) on “Bromine Explosion” in smog-chamber experiments

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It is assumed that SOA slow down the catalytic bromine release via “Bromine Explosion” (auto catalytic release of reactive bromine from salt surfaces). Based on this theory a new experimental setup was developed, in which a substrate NaCl/NaBr=300:1 mixture was placed on a teflon pan located in an aerosol smog-chamber [1]. Direct observation of BrO is possible using an active Differential Optical Absorption Spectroscopy (DOAS) instrument [2] in combination with a multi-reflection cell. SOA was formed during the ozone-initiated oxidation of α -pinene, catechol and guaicol, respectively [3].

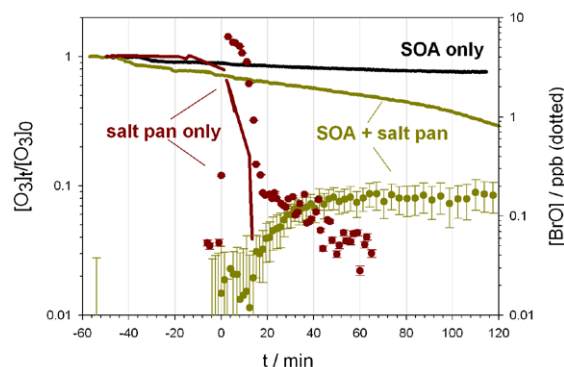


Figure 1: Time profile of O_3 (lines) and BrO(dotted) during experiments with different initial composition: with salt pan as halogen source (red), with SOA only (black) and with both (green). At $t=0$ the solar simulator was switched on.

The experiments showed that the presence of SOA modifies the kinetics of halogen cycles in the gas phase: With salt pan only a complete ozone depletion was observed within first 10 minutes due to “Bromine Explosion” with up to 6ppb BrO. With salt pan and SOA the BrO formation showed a delay and its maximum mixing ratio of 150 ppt was one order of magnitude lower than without SOA.

[1] Siekmann (2008), PhD-thesis, University of Bayreuth [2] Platt and Stutz (2008) Volume. ISBN 978-3-540-21193- Springer-Verlag Berlin Heidelberg [3] Ofner *et al.* (2011) *Atmos. Chem. Phys.*, **11**, 1-15.