Robert Berner Lecture 2019

Did the evolution of microbes and fauna in the seabed impact atmospheric oxygen and climate?

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The burial of reduced species (like organic carbon compounds and pyrite) in seafloor sediments is the ultimate process that controls the build-up of oxygen in the atmosphere. In its very essence, such burial increases the geological storage of electrons, making the subsurface more reduced, and the atmosphere and oceans more oxidized. Robert Berner, to whom this annual lecture is dedicated, played a seminal role in developing this concept, describing and modelling the rise of atmospheric oxygen through geological time, and forwarding how increased oxygen levels could be linked to biological innovation and the evolution of life.

The question about directionallity and co-evolution remains intriguing and hotly debated: to what extent did biological innovation and the evolution of life have any feedback on atmospheric oxygen and the long-term redox state of the Earth system? To this end we need to look at how biology influences the redox transformations in the seafloor. Of particular importance is the impact of microbes and fauna on the interplay between the iron, sulphur and carbon cycle in marine sediments, which determine redox cycling, and eventually, the burial of electrons as organic carbon or pyrite.

In this Berner lecture, I will dicuss how two different biological innovations in the seafloor may have induced substantial regime shifts in the electron flow: (1) the rise of animal life and the evolution burrowing behabiour and bioturbation, and (2) the evolution of long-distance electron transport by centimeter-long filamentous bacteria in microbial mats. We will discuss how these biological innovations have influenced the electron shuttling in marine sediments, and what the potential implications this may have had for the global biogeochemical cycles of carbon, oxygen and sulphur.