Training with Oxygen: Abiotic sources of reactive oxygen species on the early Earth

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The question of how free oxygen became available on the early Earth is still shrouded in uncertainty. Here we study processes that result in oxygen formation during simple weathering in an initially anoxic subsurface environment. Reactive Oxygen Species (ROS) are precursors to molecular oxygen during this process. Due to their toxicity they may have strongly influenced the evolution of life. A possible way out of this dilemma comes from a study of igneous and high-grade metamorphic rocks, which indicates that a small but significant fraction of the oxygen anions in their minerals exists in the 1- state, forming peroxy links of the type O_3Si-OO-SiO_3 [1,2]. Water hydrolyzes these peroxy links to hydrogen peroxide, H_2O_2. Another way to form ROS on the early Earth is iron sulphides such as pyrite [3].

We propose that, despite an overall reducing or neutral oxidation state of the macroenvironment and the absence of free O_2 in the atmosphere, microorganisms on the early Earth had to cope with ROS in their microenvironments. They were thus under evolutionary pressure to develop enzymatic and other defences against the potentially dangerous, even lethal effects of oxygen and ROS. As a result, microorganisms that attach themselves to mineral grains will be exposed to a constant trickle of ROS from the production of H_2O_2. Many different groups of microorganisms are able to grow or survive in the presence of ROS.

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