# Reactive Oxygen Species on the Early Earth and Survival of Bacteria


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An oxygen-rich atmosphere appears to have been a prerequisite for complex, multicellular life to evolve on Earth and possibly elsewhere in the Universe. However it remains unclear how free oxygen first became available on the early Earth. A potentially important, and as yet poorly constrained pathway, is the production of oxygen through the weathering of rocks and release into the near-surface environment. Reactive Oxygen Species (ROS), as precursors to molecular oxygen, are a key step in this process, and may have had a decisive impact on the evolution of life, present and past. ROS are generated from minerals in igneous rocks during hydrolysis of peroxy defects, which consist of pairs of oxygen anions oxidized to the valence state -1 and during (bio) transformations of iron sulphide minerals. ROS are produced and consumed by intracellular and extracellular reactions of Fe, Mn, C, N, and S species. We propose that, despite an overall reducing or neutral oxidation state of the macroenvironment and the absence of free $O_2$ in the atmosphere, organisms 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 its derived ROS. Conversely it appears that microorganisms "learned" to take advantage of the enormous reactive potential and energy gain provided by nascent oxygen. We investigate how oxygen might be released through weathering. We test microorganisms in contact with rock surfaces and iron sulphides. We model bacteria such as *Deionococcus radiodurans* and *Desulfotomaculum, Moorella* and *Bacillus* species for their ability to grow or survive in the presence of ROS. We examine how early Life might have adapted to oxygen.