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Press Release

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Iron toxicity for cyanobacteria delayed oxygen accumulation in early Earth's atmosphere

Tübingen geomicrobiologists say first O_2-producing bacteria poisoned by abundant Fe in ancient oceans

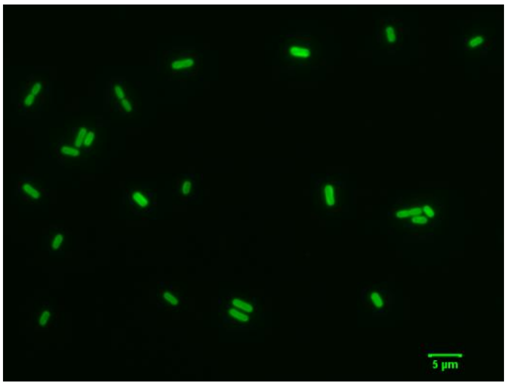
Tübingen, 5 January 2015

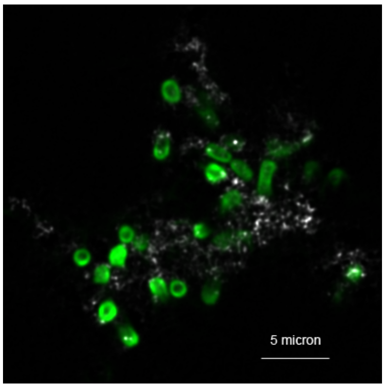
Three billion years ago, the Earth's atmosphere contained less than 0.0001 percent oxygen. Today's atmosphere has around 20 percent oxygen – and that is due to the work of tiny microorganisms in the Earth's primeval oceans. Cyanobacteria, which still exist in a similar form today, probably started using energy from sunlight to photosynthesize some of the carbon dioxide in the atmosphere into organic compounds. Oxygen gas was a byproduct of this process. After about two billion years, it enabled the evolution of the many higher organisms that respire on oxygen, including us.

Tübingen geomicrobiologists Dr. Elizabeth Swanner and Professor Andreas Kappler say that after evolution of the first cyanobacteria, one would expect a rapid and massive oxygen production, i.e. cyanobacteria could have produced much more oxygen much sooner. Working with colleagues from the Department of Geosciences at the University of Tübingen and geoscientists from the University of Alberta (Edmonton, Canada) they looked for factors which prevented early bacteria from multiplying faster. They found that soluble iron in the earliest oceans quickly combined with oxygen to form rust – forming reactive oxygen molecules, which damage biological tissue and make the cyananobacteria grow more slowly and produce less oxygen. Their findings are published in the latest *Nature Geoscience*.

Today's seawater contains little iron. But more than three billion years ago, the oceans contained abundant reduced iron. This is partially because oxygen, which causes the iron to precipitate, had not yet entered the ocean to great depths, and also because the seafloor at that time contained abundant iron released by bursts of hydrothermal activity. "In these periods, we often find no indicators of oxygen release," says Elizabeth Swanner, the study's lead author. The researchers carried out lab experiments seeking a link between high concentrations of iron and low cyanobacteria growth. It appears that the iron – which the bacteria needed to live – hindered photosynthesis when it was present in high concentrations, thereby cutting off the bacteria's energy supply. "Too much iron in the presence of oxygen was harmful. You could say the early cyanobacteria poisoned themselves," Andreas Kappler says.

These new findings will help scientists to better understand the global cycles of carbon and oxygen in the periods of higher soluble iron concentration, also shedding light on the processes in which iron stopped being food and became poison for cyanobacteria and other photosynthesizing organisms. In addition, the connection between iron levels and oxygen production found here will help researchers to reconstruct the long-term processes behind the evolution of animals – which need high levels of oxygen.





Cyanobacteria: Such tiny organisms produced today's proportion of about 20 per-cent oxygen in the atmos-phere of the earth. Images: Kappler, Swanner/University of Tübingen

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Swanner, E.D., Mloszewska, A.M., Cirpka, O.A., Schoenberg, R., Konhauser, K.O., Kappler, A. (2015). Modulation of oxygen production in Archaean oceans by episodes of Fe(II) toxicity. *Nature Geoscience*, in press.

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