Hazy shades of life on early Earth

18 March 2012

A 'see-sawing' atmosphere over 2.5 billion years ago preceded the oxygenation of our planet and the development of complex life on Earth, a new study has shown.

Research, led by experts at Newcastle University, UK, and published today in the journal *Nature Geoscience*, reveals that the Earth's early atmosphere periodically flipped from a hydrocarbon-free state into a hydrocarbon-rich state similar to that of Saturn's moon, Titan.

This switch between "organic haze" and a "haze-free" environment was the result of intense microbial activity and would have had a profound effect on the climate of the Earth system.

Similar to the way scientists believe our climate behaves today, the team say their findings provide us with an insight into the Earth's surface environment prior to oxygenation of the planet.

Study lead Dr Aubrey Zerkle, based in the School of Civil Engineering and Geosciences at Newcastle University, explains: "Models have previously suggested that the Earth's early atmosphere could have been warmed by a layer of organic haze.

"Our geochemical analyses of marine sediments from this time period provide the first evidence for such an atmosphere.

"However, instead of evidence for a continuously 'hazy' period we found the signal flipped on and off, in response to microbial activity.

"This provides us with insight into Earth's surface environment prior to oxygenation of the planet and confirms the importance of methane gas in regulating the early atmosphere."

Dr Zerkle, working along with Dr James Farquhar at the University of Maryland, USA, and Dr Simon Poulton at Newcastle University, UK, analysed the geochemistry of marine sediments deposited between 2.65 and 2.5 billion years ago in what is now South Africa.

They found evidence of local production of oxygen by microbes in the oceans, but carbon and sulphur isotopes indicate that little of that oxygen entered the atmosphere.

Instead, the authors suggest that the atmosphere transitioned repeatedly between two states: one with a thin, hydrocarbon haze and the other haze-free. These geochemical records were supported by models of the ancient atmosphere performed by colleagues at the NASA Astrobiology Institute, led by Dr Mark Claire (currently at the University of East Anglia, UK) and Dr Shawn Domagal-Goldman, which demonstrated how the transitions could be caused by changes in the rate of methane production by microbes.

The conditions which enabled the bi-stable organic haze to form permanently ended when the atmosphere became oxygenated some 100 million years after the sediments were laid down.

"What is most surprising about this study is that our data seems to indicate the atmospheric events were discrete in nature, flip-flopping between one stable state into another," explains co-author Dr Farquhar.

"This type of response is not all that different from the way scientists think climate operates today, and reminds us how delicate the balance between states can be."

Professor Mark Thiemens, Dean of Physical Sciences at the University of California San Diego, adds: "Another important facet of the work is that it provides insight into the formation of atmospheric aerosols, particularly organic ones.

"Besides the obvious importance for the evolution of the atmosphere, the role of aerosol formation is one of the most poorly understood components in the present day climate models. This provides a new look into this process that is quite new and valuable."

More information: A bistable organic-rich atmosphere on the Neoarchaean Earth. Aubrey Zerkle, Mark Claire, Shawn Domagal-Goldman, James Farquhar and Simon Poulton. *Nature Geoscience*. DOI:10.1038/NGEO1425

Provided by Newcastle University