Toxic oceans may have delayed spread of complex life

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A new model suggests that inhospitable hydrodgen-sulphide rich waters could have delayed the spread of complex life forms in ancient oceans.

The research, published online this week in the journal *Nature Communications*, considers the composition of the oceans 550-700 million years ago and shows that oxygen-poor toxic conditions, which may have delayed the establishment of complex life, were controlled by the biological availability of nitrogen.

In contrast to modern oceans, data from ancient rocks indicates that the deep oceans of the early Earth contained little oxygen, and flipped between an iron-rich state and a toxic hydrogen-sulphide-rich state. The latter toxic sulphidic state is caused by bacteria that survive in low oxygen and low nitrate conditions. The study shows how bacteria using nitrate in their metabolism would have displaced the less energetically efficient bacteria that produce sulphide – meaning that the presence of nitrate in the oceans prevented build-up of the toxic sulphidic state.

The model, developed by researchers at the University of Exeter in collaboration with Plymouth Marine Laboratory, University of Leeds, UCL (University College London) and the University of Southern Denmark, reveals the sensitivity of the early oceans to the global nitrogen cycle. It shows how the availability of nitrate, and feedbacks within the global nitrogen cycle, would have controlled the shifting of the oceans between the two oxygen-free states – potentially restricting the spread of early complex life.

Dr Richard Boyle from the University of Exeter said: "Data from the modern ocean suggests that even in an oxygen-poor ocean, this apparent global-scale interchange between sulphidic and non-sulphidic conditions is difficult to achieve. We've shown here how feedbacks arising from the fact that life uses nitrate as both a nutrient, and in respiration, controlled the interchange between two ocean states. For as long as sulphidic conditions remained frequent, Earth's oceans were inhospitable towards complex life."

Today, an abundance of nitrate, in the context of an oxygenated ocean, prevents a reversion to the inhospitable environment that inhibited early life. Determining how the Earth's oceans have established long-term stability helps us to understand how modern oceans interact with life and also sheds light on the sensitivity of oceans to changes in composition.

Provided by University of Exeter

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