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First life may have been forged in icy seas on a freezing Earth


At what temperature did these rocks formed? Maarten de Wit

By Colin Barras

Did life begin in the freezer? Early Earth may not have been as hot and hellish as we thought. In fact, it may have become a snowball around the time life first emerged.

This is according to a fresh analysis of rocks from South Africa that formed about 3.5 billion years ago, during the Archaean period. Previous research suggested that the ocean in which these rocks formed was warm – perhaps around 85°C.

But Maarten de Wit at the Nelson Mandela Metropolitan University in Port Elizabeth, South Africa, now says the ocean temperature was similar to today's – and that there is even evidence that ice was present.

Because South Africa's Barberton Greenstone Belt, where these rocks are now found, formed at a latitude of 20° to 40°, this implies that Earth may have become engulfed in ice at least once during the Archaean, he says.

Rocky balance

The temperature of oceans in which ancient rocks formed is reconstructed by measuring the balance of oxygen isotopes inside the rocks.

Some of these reconstructions have found that temperatures were high when the belt formed. But de Wit says that's because the isotopes they looked at had been subject to extensive hydrothermal activity – as there are remains of ancient hydrothermal vents in the rocks. This means the isotope evidence doesn't tell us about the temperature of the ocean water, he says.

So de Wit and Harald Furnes at the University of Bergen, Norway, looked at rocks formed out of ocean sediments that hadn't been exposed to hydrothermal activity. They found evidence that a mineral called gypsum was able to grow. "Such minerals only grow today in deep-sea environments where there is cold water," says de Wit.

The pair also looked at slightly younger rocks in the belt that formed in shallow oceans or even above sea level. In these rocks, de Wit and Furnes found finely banded siltstones with occasional pebbles embedded within them.

These rocks are similar to "varve" sequences that form in the still waters below an ice-covered ocean, they say – with the larger pebbles resembling dropstones that fell from the bottom of icebergs.

Glacial doubters

But not everyone is convinced by the new evidence

Paul Knauth at Arizona State University in Tempe, who has argued in favour of warm ancient oceans, says experiments show that gypsum can actually grow well in water that is at 80°C.

De Wit counters that gypsum will only grow at such warm temperatures in very shallow oceanic environments where water is evaporating. "The difference is that we can show these gypsum crystals grew in deep ocean water, 2 to 4 kilometres deep," he says.

Don Lowe at Stanford University in California, meanwhile, says his team's extensive studies in the area have found no evidence of glaciation but he doesn't entirely dismiss the idea that ice may have been present.

"We will definitely revisit and re-examine the outcrops yet again in order to evaluate the hypotheses presented in this paper," he says.

De Wit and Furnes's ideas aren't completely out of step with geological thinking. Ruth Blake at Yale University says her oxygen isotope research also suggests water temperatures in the area were relatively cool in the Archaean, and similar to those of modern tropical oceans.

Life's cold birth?

If there was glaciation at this time, it may have implications for the origin of life. This is because some research suggests life might actually have emerged in frozen water.

“Key organic compounds thought to be important in the origin of life are more stable at lower temperatures,” says Jeffrey Bada at the University of California at San Diego. He adds that organic molecules considered key to the origin of life – that might have been present in tiny quantities in the early ocean water – could become more concentrated in ice.

James Attwater and Philipp Holliger at the MRC Laboratory of Molecular Biology in Cambridge, UK, have also explored the possibility that ice was important early in the history of life.

One idea for the origins of life suggests that the very first replicators from which life evolved were RNA molecules, in what is called an RNA world.

“Studies from our laboratory and others have shown how frozen conditions could benefit the emergence of an RNA world,” says Holliger. Ice enhances the synthesis of some important molecules, and it slows the breakdown of fragile molecules once they do form.

Alternatively, life could have still formed in hot conditions, around hydrothermal vents within those cold waters. There’s no obvious way to work out which of the competing ideas is correct.

But the new research does, at least, suggest that some of the world’s most ancient rocks still have secrets to reveal. “The Barberton Mountains are a beautiful but tough terrain and it does not easily reveal its treasured memories of the deep past,” says de Wit. “You have to really drag it out of them.”

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