Indeed, so firmly entrenched are the views on the advent of cyanobacterial evolution around, or slightly earlier than, 2.7 Gyr ago and the progressive rise of atmospheric oxygen at 2.4 Gyr ago that current research is more focused on explaining the 300-Myr time lag[11] than on pushing back the timing for the evolution of oxygenic photosynthesis.

Future studies exploring whether this haematite is really a reflection of oxygenated deep water will most probably focus on the mechanisms by which haematite nucleates directly from sea water, the syndepositional nature of the haematite and whether the haematite is a localized feature. It is also critical to determine the exact depth at which the iron oxidation and mineral precipitation reactions occurred, considering its influence on our understanding of the chemo-stratigraphy of the Archaean oceans.

Although it is possible to envisage localized oxygen oases in shallow water settings if cyanobacteria had already evolved at that time[12], explaining the presence of oxygen in deep water is a completely different matter. In my opinion, the authors make a strong case for sediment accumulation in a deep-water setting. And if the haematite is truly primary and penecontemporaneous with the chert, it most probably formed from a hot fluid, close to the hydrothermal source. However, the alternative possibility that amorphous ferric oxyhydroxides precipitated in the photic zone and sank about 200 m to the sea floor, only to transform later into haematite, is not, in my mind, completely ruled out.

Hoashi and colleagues[4] question current thinking of anoxia throughout the early and middle Archaean by bringing their views on early ocean oxygenation to deeper waters. The scrutiny of the wider scientific community will show whether this idea will stand the test of time. ❒

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PALAEOCLIMATE

Tales of collapse

Deep beneath the ice shelves of Antarctica, sediments have been slowly accumulating on the sea floor, marking the passage of time for millions of years. These sediments should record changes in the overlying ice-sheet conditions, potentially providing an archive of variations in the West Antarctic ice sheet. However, the thick layer of ice that seals the sediments has rendered these archives unreachable.

In 2006, the scientists of the Antarctic Geological Drilling (ANDRILL) project took on the technological challenge of drilling through 85 m of the Ross Ice Shelf to reach the sediments below. Not only did they reach the sea floor, but they recovered over 1,200 m of sediments, spanning up to 13 million years of Earth's history. Now the team, led by Tim Naish of the University of Wellington, New Zealand, have reconstructed the behaviour of the West Antarctic ice sheet during the early to middle Pliocene epoch, 3–5 million years ago. At the time, climate was about 3 °C warmer than at present, and atmospheric carbon dioxide levels probably hovered around 400 ppmv, similar to today's levels (*Nature* **458,** 322–328; 2009).

Their sediment analyses reveal a long history of alternations between grounded ice sheets, floating ice shelves (like those found today) and open waters.

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These cycles occurred with a periodicity of 40,000 years, consistent with the cyclic variations of the tilt of the Earth's axis. From 3.6 to 3.4 million years ago, the microfossil assemblage suggests largely sea-ice free conditions, implying that winter temperatures were generally above freezing. During this period the West Antarctic ice sheet probably disintegrated.

Meanwhile, David Pollard of Pennsylvania State University and Robert DeConto of the University of Massachusetts at Amherst faced technical challenges of their own as they created a numerical model capable of simulating variations in the ice sheets of Antarctica over the same time frame (*Nature* **458,** 329–332; 2009). According to their simulations, multiple collapses of the West Antarctic ice sheet have occurred throughout the Pliocene epoch; one period of prolonged and frequent collapses occurred about 3.4 million years ago, coinciding with the interval described from the ANDRILL core. Indeed, most of the main ice-sheet collapses simulated by the model closely correspond to open-water conditions reported from the sediment records.

By running simulations at a higher resolution to examine the mechanisms of ice-shelf collapse, Pollard and DeConto found that melting along the interface between the ice and the underlying sea water is the dominant regional control on the stability of the Ross Ice Shelf, which serves as an accurate indicator of West Antarctic ice volume. In their model, it takes about 5 °C of warming in nearby ocean waters to trigger a collapse of the West Antarctic ice sheet, starting from modern conditions. With a projected surface air temperature change of up to 3 °C near Antarctica by 2100 — as suggested by the 2007 report of the Intergovernmental Panel on Climate Change — such a time may not be as far off as we would like.

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