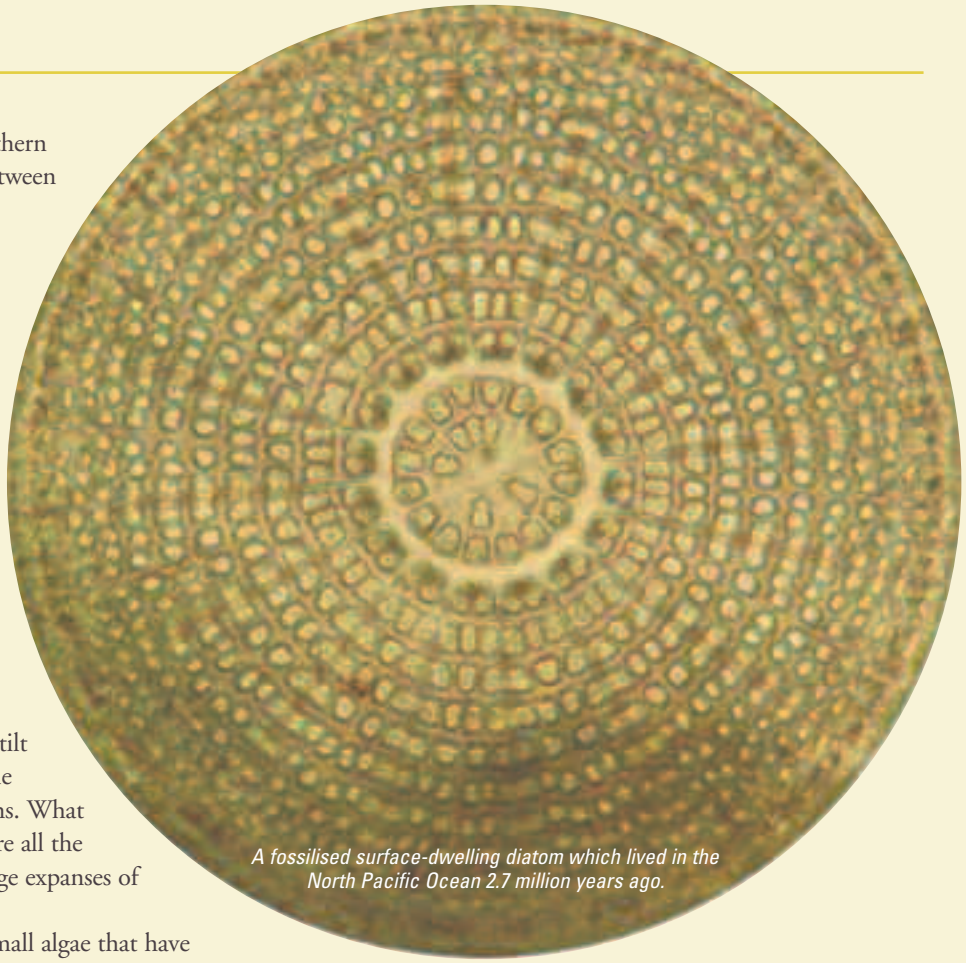
Ice everywhere – but how did it get there?

George Swann, Melanie Leng and Mark Maslin explain where enough water came from to cover much of North America in ice.



A fossilised surface-dwelling diatom which lived in the North Pacific Ocean 2.7 million years ago.

The first recorded glaciation in the northern hemisphere occurred in Greenland between 10 and 6 million years ago. From this point, the global climate gradually cooled. About 2.7 million years ago, the ice ages suddenly intensified which resulted in ice sheets growing to cover much of the northernmost areas in both North America and Eurasia. This climate transition is known as the onset of major Northern Hemisphere Glaciation. Scientists believe this cooling was caused by long-term changes in the positions of the Earth's tectonic plates (such as the closure of the Panama ocean gateway between North and South America), together with decreases in the amount of solar radiation received by the Earth. The latter was caused by natural changes in the tilt of the Earth's axis, and the distance from the Earth to the sun during the summer months. What remains unknown about this period is where all the water and snow came from to build the huge expanses of ice in North America.

We decided to analyse fossil diatoms, small algae that have lived in the surface waters of the Pacific Ocean for millions of years, to see if we could find an answer. The fossils contain two major oxygen isotopes: oxygen 18 and oxygen 16. Changes in the ratio of one to the other are directly related to changes in the ocean's temperature and salinity.

The oxygen isotopes in 2.7 million-year-old diatoms from the north-west Pacific Ocean reveal that the ocean became seasonally warmer and less salty during the autumn and early winter months. These unusual patterns contrast with the numerous other records from around the globe, which indicate that the oceans were significantly colder at this time. But the surprising results explain how more rain came to fall on North America. Fresh meltwater from newly formed ice-sheets, would have ended up in the sea where it floated on top of the salty seawater, like oil sitting on water. This would have divided the ocean into two separate layers, a salty layer under a fresher layer. Because the two layers didn't mix, the top fresher layer would have become even warmer, and would then have stayed relatively warm until the late autumn/early winter months. This warmer water would evaporate more easily, making the air in the region moist. Winds would have then pushed this moisture westwards towards North America, bringing increased rain and snow to feed the region's ice-sheets and make them grow. It seems therefore that the moister air originating from the North Pacific combined with colder winters were the triggers for the huge expansion of ice-sheets across the North American continent.

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