

Volcanoes under the ice: melting Antarctic ice could fight climate change

Written by Silvia Frisia, Associate Professor, School of Environmental and Life Sciences, University of Newcastle



Furious winds keep the McMurdo Dry Valleys in Antarctica free of snow and ice. Calcites found in the valleys have revealed the secrets of ancient subglacial volcanoes. [Stuart Rankin/Flickr](#), [CC BY-NC](#)

Iron is not commonly famous for its role as a micronutrient for tiny organisms dwelling in the cold waters of polar oceans. But iron feeds plankton, which in turn hold carbon dioxide in their bodies. When they die, the creatures sink to the bottom of the sea, safely storing that carbon.

How exactly the iron gets to the Southern Ocean is hotly debated, but we do know that during the last ice age huge amounts of carbon were stored at the [bottom of the Southern Ocean](#). Understanding how carbon comes to be stored in the depth of the oceans could help abate CO

² in the atmosphere, and Antarctica has a powerful role.

Icebergs and atmospheric dust are believed to have been the major sources of this micronutrient in the past. However, in research published in [Nature Communications](#), my colleagues and I examined calcite crusts from Antarctica, and found that volcanoes under its glaciers were vital in delivering iron to the ocean during the last ice age.

Today, glacial meltwaters from Greenland and the Antarctic peninsula supply iron both in solution and as tiny particles (less than 0.0001mm in diameter), which are readily consumed by plankton. Where glaciers meet bedrock, minute organisms can live in pockets of relatively warm water. They are able to extract “food” from the rock, and in doing so release iron, which then can be carried by underwater rivers to the sea.

Volcanic eruptions under the ice can create underwater subglacial lakes, which, at times, discharge downstream large masses of water that travel to the ice margin and beyond, carrying with them iron in particle and in solution.

The role of melting ice in climate change is as yet poorly understood. It’s particularly pertinent as scientists predict the imminent collapse of part of the [Larsen C ice shelf](#).

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Researchers are also investigating how to [reproduce natural iron fertilisation in the Southern Ocean](#) and induce algal blooms. By interrogating the volcanic archive, we learn more about the effect that iron fertilisation from meltwater has on global temperatures.



A polished wafer of the subglacial calcites. The translucent, crystalline layers formed while in pockets of water, providing nourishment to microbes. The opaque calcite with rock fragments documents a period when waters discharged from a subglacial lake formed by a volcanic eruption, carrying away both iron in solution and particles of iron. Supplied **The Last**

Glacial Maximum

During the [Last Glacial Maximum](#), a period 27,000 to 17,000 years ago when glaciers were at their greatest extent worldwide, the amount of CO₂ in the atmosphere was lowered to 180 parts per million (ppm) relative to pre-industrial levels (280 ppm).

Today we are at [400 ppm](#) and, if current warming trends continue, a [point of no return](#) will be reached. The global temperature system will return to the age of the dinosaurs, when there was little difference in temperature from the equator to the poles.

If we are interested in providing a habitable planet for our descendants, we need to mitigate the quantity of carbon in the atmosphere. Blooms of plankton in the Southern Ocean boosted by iron fertilisation were one important ingredient in lowering CO₂ in the Last Glacial Maximum, and they could help us today.

The Last Glacial Maximum had winds that spread dust from deserts and icebergs carrying small

particles into the Southern Ocean, providing the necessary iron for algal blooms. These extreme conditions don't exist today.

Hidden volcanoes

Neither dust nor icebergs alone, however, explain bursts of productivity recorded in ocean sediments in the Last Glacial Maximum. There was another ingredient, only discovered in rare archives of subglacial processes that could be precisely dated to the Last Glacial Maximum.

Loss of ice in Antarctica's [Dry Valleys](#) uncovered rusty-red crusts of calcite plastered on glacially polished rocks. The calcites have tiny layers that can be precisely dated by radiometric techniques.



A piece of subglacial calcite coating pebbles. This suggests that the current transporting the pebbles was quite fast, like a mountain stream. The pebbles were deposited at the same time as the opaque layer in the calcite formed. Supplied

Each layer preserves in its chemistry and DNA a record of processes that contributed to delivering iron to the Southern Ocean. For example, fluorine-rich spherules indicate that underwater vents created by volcanic activity injected a rich mixture of minerals into the subglacial environment. This was confirmed by DNA data, revealing a thriving community of [thermophiles](#)

– microorganisms that live in very hot water only.

Then, it became plausible to hypothesise that volcanic eruptions occurred subglacially and formed a subglacial lake, whose waters ran into an interconnected system of channels, ultimately reaching the ice margin. Meltwater drained iron from pockets created where ice met bedrock, which then reached the ocean – thus inducing algal blooms.

We dated this drainage activity to a period when dust flux does not match ocean productivity. Thus, our study indicates that volcanoes in Antarctica had a role in delivering iron to the Southern Ocean, and potentially contributed to lowering CO₂ levels in the atmosphere.

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Our research helps explain how volcanoes act on climate change. But it also uncovers more about iron fertilisation as a possible way to mitigate global warming.

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