FIRE AND ICE: VOLCANOES AT ANTARCTICA

HOT TAKES

1 At West Antarctica, 91 newly discovered volcanoes lie buried kilometres beneath a thick ice sheet.

2 The ice sheet has co-existed with volcanism for millions of years.

3 Future volcanism is inevitable but fears it would destabilise the ice sheet and accelerate sea-level rise are unfounded.

Many people are concerned the (slight) global warming observed over the past 100 years is unnatural and caused by human activity. Some also believe this will accelerate melting of ice sheets and glaciers and cause rapid catastrophic sea level rise. However this conclusion is dependent on complex computer models containing many untested assumptions. A great many of the assumptions the models need to get right before they are of any use are only very poorly understood.

Some environmentalists believe volcanoes associated with the West Antarctic Ice Sheet (WAIS) could magnify the 'climate change' risk to the ice sheet. However close examination of the relationship between the volcanoes and the ice shows this is unfounded.

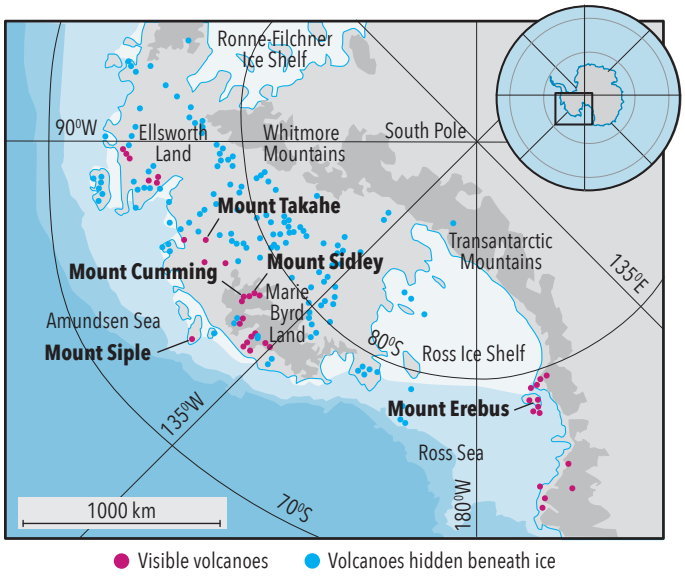
It is widely believed the WAIS is the most vulnerable to future melting. Fears about its 'instability' are well documented. Calculations show that, should this section of the Antarctic ice sheet suddenly 'collapse', sea levels could rise as much as five to six metres.[1]

However, an ice sheet of this size (2.2 million cubic kilometres) cannot simply collapse as it is simply too large. Pollard and De Conto (2009) show the transition between glacial, intermediate, and collapsed states takes one to several thousand years.[2] Nevertheless, in light of the dire consequences of this scenario, the likelihood of it being triggered by unusual volcanic activity on any short timescale relevant to human experience needs to be considered.

Ice Sheet Volcanoes

West Antarctica has at least 138 volcanoes comprising one of the world's largest active continental volcanic fields. The most famous is Mount Erebus, the world's most southerly active volcano. It has a persistent lava lake. Most volcanoes are directly associated with the WAIS (see Figure 1). In fact, 91 of them are only newly discovered because they lie hidden beneath kilometres of ice.

Figure 1: Volcanoes of West Antarctica[3]



Not even the large inland volcanoes protruding through the WAIS were known to exist before 1940 when first seen from the air. Mount Takahe is so remote it was not visited until 1957. Mount Sidley, the highest volcano in Antarctica, was not climbed until 1990, and Mount Siple, another giant shield volcano, has never been climbed.

Impact of Volcanism on the Ice Sheet

The effects of volcanism are generally not considered in computer models of ice sheet collapse. This would make such models even more speculative. Instead, a better approach is to apply a scientific understanding of the volcanology of the volcanoes and the glaciology of the ice sheet, and then use direct observations of the history and geological setting of both to enable a much more rounded and nuanced understanding of the situation.

Can Ice-Sheet Volcanism Impact Global Sea Levels?

The interaction of volcanism with an ice sheet can be complex and non-intuitive. It is not just about melting. In fact, a volcanic eruption beneath an ice sheet could actually hinder ice loss, depending on the circumstances of the eruption. Adding to the challenge is that predicting the timing, power, and location of individual volcanic eruptions is impossible.

Sea-level impacts from volcanic eruptions, of the kind expected under the WAIS, are highly unlikely to directly result from the tiny volumes of meltwater they'd produce, relative to the volume of the WAIS. Extra heat and meltwater could temporarily cause local lubrication of ice sheet flow, but this can also happen where there is no volcanism.

Volcanism has co-existed with the WAIS for millions of years. Eruptions have occurred there very recently and it is certain further eruptions will take place in the future. However, eruption rates are extremely modest. For example, Mount Takahe took 310,000 years and countless small lava eruptions to grow to a volume of 780 cubic kilometres (see Figure 2). Mount Cumming (Figure 3) is another large shield volcano almost completely buried in ice. Other volcanoes are much smaller. For example Figure 4 shows the Brown Bluff volcano at the northern tip of the Antarctic Peninsula.

Unrelated to volcanism, the ice sheet has undergone massive volume changes over the last several million years in response to global 'ice age' glaciation cycles. At times, parts of the WAIS may have disappeared almost entirely, but each time the ice returned. Ten thousand years ago, the ice sheet on the Marie Byrd Land coast was more than 700 metres thicker than today[4]. All the big WAIS volcanoes have witnessed these cycles.

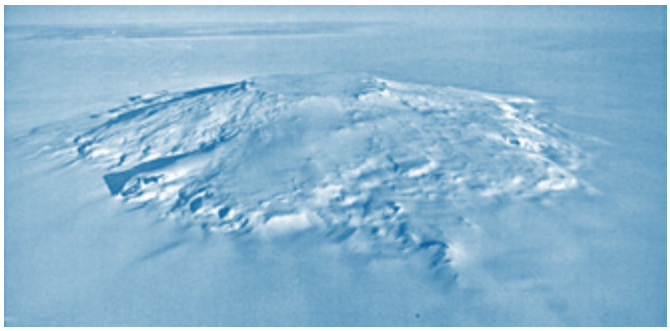
The ice sheet has repeatedly re-grown and buried dozens of volcanoes in this active volcanic field with no discernable impacts on its viability.

Conclusion

Volcanological and geological evidence indicates ice sheet volcanism has occurred for millions of years but has always been extremely modest. It is highly unlikely the intensity of volcanism will increase in the future; future volcanism is unlikely to change overall ice-sheet melting rates; and, because the ice sheet is already in long-term balance with volcanic effects, future volcanism is extremely unlikely to destabilise the ice sheet and accelerate global sea-level rise.

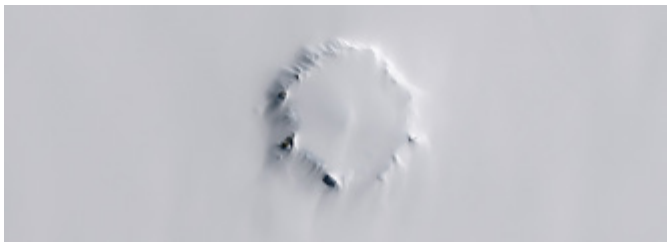
Volcanism-linked destabilisation of the WAIS on any short timescale relevant to human experience would require the sustained eruption of all the more than 100 volcanoes associated with the ice sheet at once. The probability of such an event happening would be once in many millions of years because it is not the eruptive style of the types of volcanoes that coexist with the ice sheet, and it would still take millennia to unfold.

Figure 2: Mount Takahe[5]



Takahe is a large ice-bound shield volcano. It commenced around 310,000 years ago and protrudes more than 2,000 metres through 1,500 metres of ice. The summit caldera is 8 kilometres wide. It last erupted only 5,550 years ago.

Figure 3: Mount Cumming[6]



This large shield volcano is almost completely buried under the ice.

Figure 4: Brown Bluff is a small volcano on the Antarctic Peninsula[7]

This small volcano erupted a million years ago beneath the former Antarctic Peninsula Ice Sheet. The ice has long since retreated, exposing the volcano.

SEE ALSO

FACT SHEET #5: Sacred Bubbles In Ice Cores
FACT SHEET #8: No Evidence Of Warming At Mawson, Antarctica

Information in this fact sheet has been drawn from *Climate Change: The Facts 2020* (IPA 2020), Chapter 4, by Dr Arthur Day. Fact Sheet series general editor: Dr Arthur Day

1. Church et al. 2013, *Sea Level Rise* https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_Chapter13_FINAL.pdf.
2. Pollard, D & De Conto, RM 2009, 'Modelling West Antarctic ice sheet growth and collapse through the past five million years', *Nature*, vol. 458, pp. 329–333.
3. Source: Modified from Figure 2 in Van Wyk de Vries et al. 2017, https://sp.lyellcollection.org/content/461/1/231
4. Stone, et al. 2003, 'Holocene deglaciation of Marie Byrd Land, West Antarctica', *Science*, vol. 299, pp. 99–102.
5. Source: US Navy photo. Public domain, https://upload.wikimedia.org/wikipedia/commons/6/6e/MountTakahe.jpg
6. Cropped from NASA Earth Observatory image by Jesse Allen. https://upload.wikimedia.org/wikipedia/commons/thumb/b/b5/Sidley_oli_2014324_lrg.jpg/800px-Sidley_oli_2014324_lrg.jpg
7. Source: Robert Wyatt, Alamy Stock https://www.alamy.com/brown-bluff-antarctic-peninsulapanorama-image237775919.html

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