

The ice in Antarctica has melted before, says study

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Collecting rocks on Månesigden mountain, in Heimefrontfjella. The polished surface of the rocks show that they have been covered by an ice layer. The researchers analysed the rocks for cosmogenic isotopes that can tell them how long it has been since the rocks were covered by ice. Carl (Calle) Lundberg is taking notes while PhD student Jenny Newall collects samples. Credit: Ola Fredin, NTNU

Sixty percent of the world's fresh water is bound up in Antarctic ice sheets. Thirty million cubic kilometers of ice is perhaps a difficult number to grasp. But if absolutely all Antarctica's ice melted, the seas would rise by 58 meters on average.

"The [ice sheet](#) in East Antarctica stores enormous amounts of water. This means that this is the biggest possible source of future sea level rise—up to 53 meters if all of the East Antarctic ice melts—and is seen as the largest source of uncertainties in the future sea level adaptation planning," says Irina Rogozhina, an associate professor at the Department of Geography at NTNU.

Most melting/[ice loss](#) in Antarctica happens through ocean-driven melting of ice shelves and ice calving. This, in turn, leads to an acceleration of ice streams on land and a greater discharge of ice into the ocean, where it gets lost to melting/calving, she said.

This was also likely the cause of larger ice loss during warmer periods of the past. [In Greenland, these two processes contribute to about 65% of all ice loss.](#)

But not all the ice needs to melt before it can have major consequences.

Researchers from NTNU were among a group of scientists who examined the ice in Queen Maud Land in East Antarctica. The results show that this ice sheet sector has varied a lot over time. This information is important as researchers try to learn more about the planet's climate and how it is changing.

Rogozhina's group studied the ice sheet in East Antarctica and a meltdown that took place a few thousand years ago. The results have been published in the journal *Communications Earth & Environment*.

The ice in the east lies on land

The ice sheet in Antarctica is not evenly distributed or uniform. In the west, large parts of the ice sheet lie under sea level, down to a depth of 2,500 meters. This makes it very vulnerable to ocean warming. In contrast, much of the ice sheet in the east sits directly on land, above sea level, meaning it is less sensitive to the ocean's influence.

This ice sheet sector in East Antarctica was thinner in the past than it is now, and not particularly long ago either. In fact, it was thinner following the end of the last ice age, when massive ice sheets previously covered North America, northern Europe and southern South America. When these ice sheets melted, they raised the sea level by more than 100 meters.

"From the evidence we presented in our study, we concluded that the East Antarctic ice sheet in Queen Maud Land also melted rapidly along its margins between 9,000 to 5,000 years ago, in a period we call the mid-Holocene. At this time, many parts of the world experienced warmer-than-present summers," Rogozhina said.

"Although this kind of response by the East Antarctic ice sheet to the warmth during the Holocene is not completely unexpected, it is still difficult and worrisome to believe that the sluggish East Antarctic ice sheet can change so rapidly," she said.

It's difficult to find a simple, easy explanation for this behavior, or to determine the exact timing when the melting took place, not least because the conditions in this part of the world are rather inhospitable at times.

But the researchers found a way to unravel this mystery.

Cosmic radiation changes rocks

The research group examined rocks from various nunataks in Queen Maud Land for exposure to [cosmic radiation](#).

"Nunataks are mountains that stick up through the ice. We have visited nunataks and taken samples," says Ola Fredin, a professor at the Department of Geosciences and Petroleum.

The researchers examine different isotopes, or variants, of elements such as chlorine, aluminum, beryllium and neon in rocks from the nunataks. With the help of cosmogenic isotopes, they can figure out how high the ice was over geological time in Queen Maud Land. Fredin compares this to using a dipstick to measure the level of engine oil in your car.

In this way, the researchers can say something about how long the rocks have been exposed to cosmic radiation. They can then also say something about how long it has been since the rocks have been under a protective layer of ice and thus have not absorbed any cosmic radiation.

For this, they use data from different areas and run a variety of computer simulations.

Rising seas and warmer water broke up the ice

The researchers also believe that they are on track to find a reason why the ice sheet sector in East Antarctica thinned so much immediately after the end of the last ice age.

"We believe that the ice sheet became less stable due to higher, regional sea levels and warmer water rising from the ocean depths in the polar regions, penetrating under the ice margins and melting them from below.

This leads to the break-up of large icebergs and accelerates the movement of ice from the land to the ocean, which in turn thins the inland section of the ice sheet. The process is similar to when a house on a hill slope loses its supporting foundation and starts sliding downhill," Rogozhina said.

In short, the less stable, rapidly flowing parts of the ice sheet in East Antarctica, which are called ice shelves and float on the ocean, were broken up more easily, which in turn led to the ice sheet becoming much thinner within a relatively short time, geologically speaking, or a few hundreds to thousands of years.

Thick ice is the most common along the coast

Cosmic radiation can also help researchers figure out how common it is for ice to cover an area. The researchers have also investigated this.

The results show that it is most common for the ice in Queen Maud Land to be thick along the coast. But not further into the continent, where mountain peaks protrude through the ice and the land can be several thousand meters high.

"We found that the land masses along the coast of Queen Maud Land have been covered by ice between 75 and 97 percent of the time during the last one million years," Fredin said.

He was part of another study, which has also had its results published in *Communications Earth & Environment*. This group examined rocks from several different areas in Queen Maud Land, and found great variations.

"In contrast to areas along the coast, which have been ice-covered most of the time, we find that mountain summits further into the continent have been ice-covered as little as 20% of the time," Fredin said.

The ice sheet thickness and movement speed therefore vary a great deal over longer periods, and the [mountain range](#) further into the continent seems to be an important division between the dynamic coast and the ice sheet further towards the South Pole, which varies much less in thickness.

More information: Yusuke Suganuma et al, Regional sea-level highstand triggered Holocene ice sheet thinning across coastal Dronning Maud Land, East Antarctica, *Communications Earth & Environment* (2022). [DOI: 10.1038/s43247-022-00599-z](https://doi.org/10.1038/s43247-022-00599-z)

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