Radioactive chlorine from nuclear bomb tests still present in Antarctica

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New research finds some glaciers in Antarctica are still releasing radioactive chlorine-36 created during 1950s nuclear weapons tests. Credit: NASA/Joe MacGregor

Antarctica's ice sheets are still releasing radioactive chlorine from marine nuclear weapons tests in the 1950s, a new study finds. This suggests regions in Antarctica store and vent the radioactive element differently than previously thought. The results also improve scientists' ability to use chlorine to learn more about Earth's atmosphere.

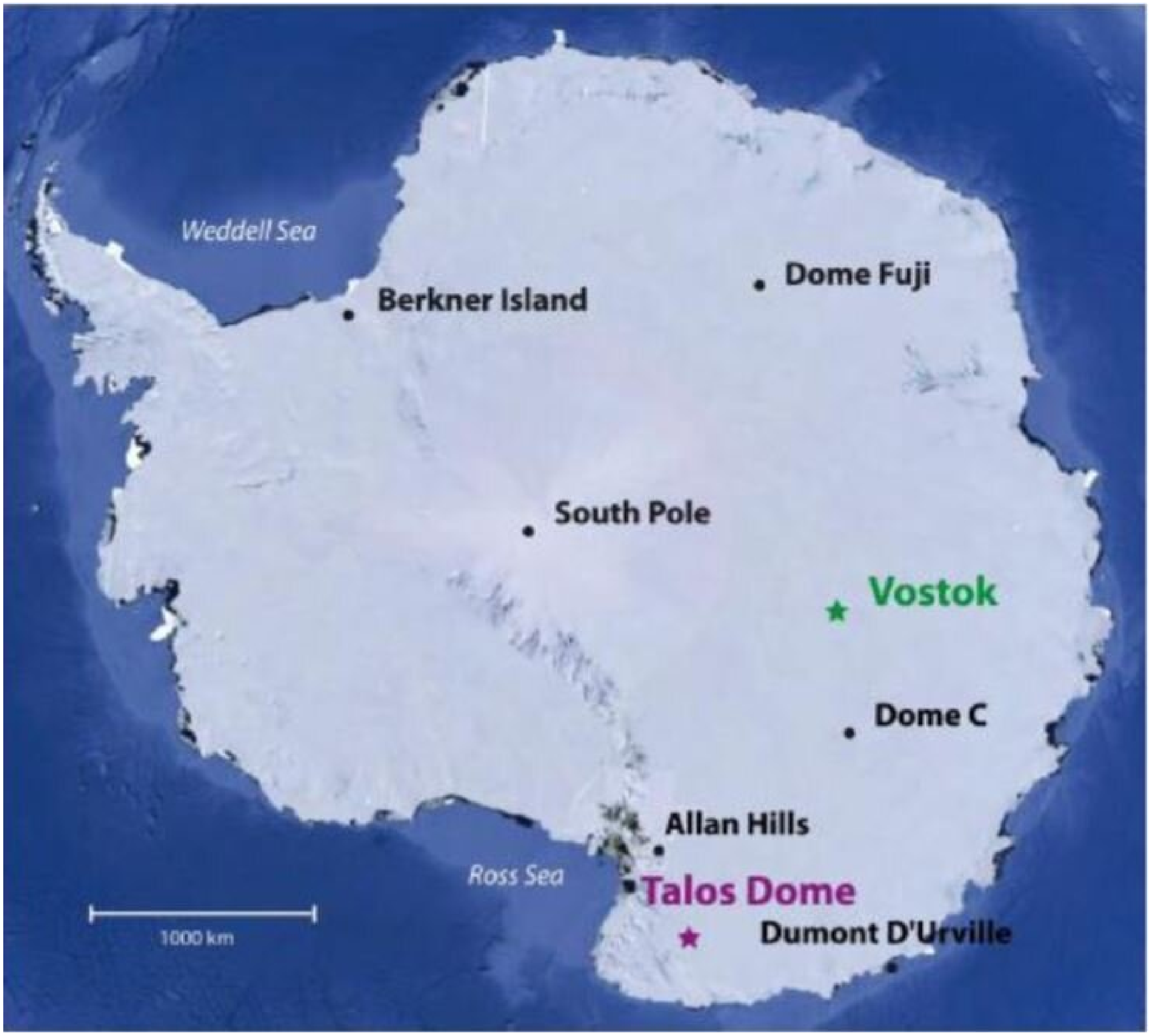
Scientists commonly use the radioactive isotopes chlorine-36 and beryllium-10 to determine the ages of ice in ice cores, which are barrels of ice obtained by drilling into ice sheets. Chlorine-36 is a naturally occurring radioactive isotope, meaning it has a different atomic mass than regular chlorine. Some chlorine-36 forms naturally when argon gas reacts with cosmic rays in Earth's atmosphere, but it can also be produced during nuclear explosions when neutrons react with chlorine in seawater.

Nuclear weapons tests in the United States carried out in the Pacific Ocean during the 1950s and the 1960s caused reactions that generated high concentrations of isotopes like chlorine-36. The radioactive isotope reached the stratosphere, where it traveled around the globe. Some of the gas made it to Antarctica, where it was deposited on Antarctica's ice and has remained ever since.

Other isotopes produced by marine nuclear bomb testing have mostly returned to pre-bomb levels in recent years. Scientists expected chlorine-36 from the nuclear bomb tests to have also rebounded. But new research in AGU's *Journal of Geophysical Research: Atmospheres* finds the Vostok region of Antarctica is continuing to release radioactive chlorine into the atmosphere. Since naturally produced chlorine-36 is stored permanently in layers of Antarctica's snow, the results indicate the site surprisingly still has manmade chlorine produced by bomb tests in the 1950s and in the 1960s.

"There is no more nuclear chlorine-36 in the global atmosphere. That is… why we should observe natural chlorine-36 levels everywhere," said Mélanie Baroni, a geoscientist at the European Centre for Research and Teaching in Geosciences and the Environment in Aix-en-Provence, France, and co-author of the new study.

Studying the chlorine's behavior in Antarctica can improve ice dating technology, helping scientists better understand how Earth's climate evolved over time, according to the study's authors.



Vostok and Talos Dome are both shown on this map of Antarctica. Vostok is still releasing anthropogenic chlorine-36 into the atmosphere. Credit: AGU

In the new study, Baroni and her colleagues examined chlorine emissions in different parts of Antarctica to better understand how chlorine behaves over time in areas where annual snowfall is high versus areas where snowfall is low. The researchers took ice samples from a snow pit at Vostok, a Russian research station in East Antarctica that receives little snow accumulation, and compared them to ice samples from Talos Dome, a large ice dome roughly 1400 kilometers (870 miles) away that receives a lot of snow accumulation every year.

The researchers tested samples from both sites for concentrations of chlorine-36 and determined how much chlorine was present in Vostok's ice from 1949 to 2007 and how much was in Talos Dome's ice from 1910 to 1980.

The results showed chlorine-36 in Talos Dome ice has gradually decreased over time, holding only four times the level of natural chlorine-36 level, in 1980. However, the Vostok ice showed very high levels of chlorine-36, with the top of the snow pit reaching levels of 10 times the expected natural concentration in 2008.

The consistently higher levels suggest the Vostok snowpack is still releasing radioactive chlorine from the 1950s and 1960s marine nuclear bomb tests. The amount of radioactivity is too small to have an effect on the environment, but the results are surprising because a different radioactive isotope produced by nuclear tests had already returned to prebomb levels in Vostok, according to the study's authors. They had hypothesized chlorine-36 would behave similarly.

They also compared the Vostok ice samples with samples from the same site taken in 1998. Measuring the depth of each sample, they found chlorine-36 had moved closer to the surface of the snowpack, which was surprising, according to Baroni. The chlorine was not only spreading to the atmosphere from the firn surface of the snowpack, but moving up from the snowpack's depths, meaning the chlorine is more mobile scientists previously thought.

Scientists are currently planning to drill for a 1.5 million-year-old ice core in the Antarctic and understanding how Vostok releases manmade chlorine-36 could improve how scientists use the isotope to glean data from the ancient ice core, Baroni said.

Determining how manmade nuclear chlorine-36 moves in low snow accumulation zones over the last century could serve as a microcosmic example for how natural chlorine-36 has built up in snowpacks over the last 1 million years, according to the study authors. The results give more information to future scientists using the isotope to date ancient ice and uncover Earth's past climate, according to the study.

More information: S. Pivot et al. A comparison of 36 Cl nuclear bomb inputs deposited in snow from Vostok and Talos Dome, Antarctica, using the 36 Cl/Cl - ratio, *Journal of Geophysical Research: Atmospheres* (2019). DOI: 10.1029/2018JD030200

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