New study shows freshwater input route from melting ice led to rapid cooling

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Scientists have long known that a reduction in Atlantic Ocean currents bringing warm water to the Northern Hemisphere from the tropics created abrupt cooling known as the Younger Dryas cold period nearly 13,000 years ago, but the cause of this phenomenon has not been proved.

Now a team of scientists from the United States and Canada think they have the answer – input of fresh water from the Laurentide Ice Sheet retreating from the Lake Superior basin, creating a river through the lower Great Lakes to the Gulf of St. Lawrence and the North Atlantic.

The findings are important because it could happen again, a result of both the Greenland Ice Sheet melting and a significant rise in fresh water from the Arctic through increased rain and snow. The study also highlights how sensitive the Atlantic current is to changes in the input of fresh water.

Results of the study have been published online in *Geology*, a publication of the Geological Society of America.

"It has been well-documented that the Atlantic meridional overturning circulation, or AMOC, slowed because of fresh water, but there has been little agreement as to how," noted Anders Carlson, an Oregon State University geologist and co-author on the study. "Some scientists have argued for years that it has been this freshwater path, but others say the region was still iced in when the cooling period begun.

"Some people have even speculated that a comet caused the cooling period. We found convincing evidence, however, that it was fresh water – a river the size of the Mississippi that flowed into the North Atlantic."

The key to the research team's discovery came from the sampling of boulders in the region where the Laurentide Ice Sheet once dominated the Northern Hemisphere, covering some 5 million square miles and reaching a thickness of 8,000 to 10,000 feet at some points. The last glaciation was at a maximum about 23,000 years ago and dominated the landscape until it began retreating as the planet warmed.

The glacial retreat took more than 10,000 years, Carlson noted, but the "tipping point" that caused the reduction of the Atlantic current may have happened in a single summer.

"As the ice sheet retreated, there were enormous freshwater lakes that drained down the Mississippi and into the Gulf of Mexico," Carlson said. "But at some point, the Lake Superior region became ice-free and it was like removing a dam. That water shifted from a southern drainage to an eastern drainage, and into the North Atlantic."

The result was a significant cooling of the North Atlantic that led to lower temperatures on land – as much as 10 degrees Celsius (or about 18 degrees Fahrenheit) in a little more than a century.

Carlson and his colleagues went into the field to see if they could find out when the Lake Superior basin became ice-free, thus opening up the freshwater pathway to the North Atlantic. They sampled boulders throughout the region to see how long they had been exposed to cosmic rays. As those cosmic rays hit the quartz in the rock, it splits the elements and creates beryllium-10.

"Essentially what we did was to measure the sunburn on the rocks," Carlson said. "The cosmic bombardment by neutrons leaves a clear picture of just when those boulders were first exposed to the sun. The evidence shows that Lake Superior was deglaciated 13,000 years ago, much earlier than was previously thought."

The boulder evidence was made possible through the use of a mass spectrometer roughly the size of a basketball court at Purdue University. The technique, referred to as accelerator mass spectrometry, utilizes an older-generation nuclear physics particle accelerator to measure individual atoms – in this case, beryllium-10 – produced in these boulders by cosmic rays.

"This new approach allows us to narrow the time range of when areas become ice-free from millennial time scales down to a few centuries," said Marc Caffee, a Purdue physicist and co-author on the study. "Going forward, it will allow us to be much more precise in measuring the retreat of ice margins and their relationship to climate change. A key to understanding future climate change is a detailed understanding of past climate changes."

Although the results of this study may have resolved a long-standing controversy, the researchers say, many aspects of past climate change are still poorly understood. The cosmic bombardment of surface materials provides a clock that researchers can use to understand cause-and-effect relationships in past climate changes.

It would take a significant increase in freshwater input into the North Atlantic to overturn the currents again, Carlson pointed out – the melting of the Greenland Ice Sheet over some 1,300 years along with a huge increase in fresh water from the Arctic.

"Models show that as the planet warms the Arctic will receive more snow in the winter and more rain in the summer," Carlson said. "The increase in precipitation is already happening."

Provided by Oregon State University