Arctic current flowed under deep freeze of last ice age, study says

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Arctic sea ice formation feeds global ocean circulation. New evidence suggests that this dynamic process persisted through the last ice age. Credit: National Snow & Ice Data Center

During the last ice age, when thick ice covered the Arctic, many scientists assumed that the deep currents below that feed the North Atlantic Ocean and help drive global ocean currents slowed or even stopped. But in a new study in *Nature*, researchers show that the deep

Arctic Ocean has been churning briskly for the last 35,000 years, through the chill of the last ice age and warmth of modern times, suggesting that at least one arm of the system of global ocean currents that move heat around the planet has behaved similarly under vastly different climates.

"The Arctic Ocean must have been flushed at approximately the same rate it is today regardless of how different things were at the surface," said study co-author Jerry McManus, a geochemist at Columbia University's Lamont-Doherty Earth Observatory.

Researchers reconstructed Arctic circulation through deep time by measuring radioactive trace elements buried in sediments on the Arctic seafloor. Uranium eroded from the continents and delivered to the ocean by rivers, decays into sister elements thorium and protactinium. Thorium and protactinium eventually attach to particles falling through the water and wind up in mud at the bottom. By comparing expected ratios of thorium and protactinium in those ocean sediments to observed amounts, the authors showed that protactinium was being swept out of the Arctic before it could settle to the ocean bottom. From the amount of missing protactinium, scientists can infer how quickly the overlying water must have been flushed at the time the sediments were accumulating.

"The water couldn't have been stagnant, because we see the export of protactinium," said the study's lead author, Sharon Hoffmann, a geochemist at Lamont-Doherty.

The upper part of the modern Arctic Ocean is flushed by North Atlantic currents while the Arctic's deep basins are flushed by salty currents formed during sea ice formation at the surface. "The study shows that both mechanisms must have been active from the height of glaciation until now," said Robert Newton, an oceanographer at Lamont-Doherty who was not involved in the research. "There must have been significant

melt-back of sea ice each summer even at the height of the last ice age to have sea ice formation on the shelves each year. This will be a surprise to many Arctic researchers who believe deep water formation shuts down during glaciations."

The researchers analyzed sediment cores collected during the U.S.-Canada Arctic Ocean Section cruise in 1994, a major Arctic research expedition that involved several Lamont-Doherty scientists. In each location, the cores showed that protactinium has been lower than expected for at least the past 35,000 years. By sampling cores from a range of depths, including the bottom of the Arctic deep basins, the researchers show that even the deepest waters were being flushed out at about the same rate as in the modern Arctic.

The only deep exit from the Arctic is through Fram Strait, which divides Greenland and Norway's Svalbard islands. The deep waters of the modern Arctic flow into the North Atlantic via the Nordic seas, contributing up to 40 percent of the water that becomes North Atlantic Deep Water—known as the "ocean's lungs" for delivering oxygen and salt to the rest of world's oceans.

One direction for future research is to find out where the missing Arctic protactinium of the past ended up. "It's somewhere," said McManus. "All the protactinium in the ocean is buried in ocean sediments. If it's not buried in one place, it's buried in another. Our evidence suggests it's leaving the Arctic but we think it's unlikely to get very far before being removed."

More information: Persistent export of ^{231}Pa from the deep central Arctic Ocean over the past 35,000 years, *Nature*, 2013.

Provided by Columbia University