Rising CO2 levels at end of Ice Age not tied to Pacific Ocean

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At the end of the last Ice Age, atmospheric carbon dioxide levels rose rapidly as the planet warmed; scientists have long hypothesized that the source was CO_2 released from the deep ocean.

But a new study using detailed radiocarbon dating of foraminifera found in a sediment core from the Gorda Ridge off Oregon reveals that the Northeast Pacific was not an important reservoir of carbon during glacial times. The finding may send scientists back to the proverbial drawing board looking for other potential sources of CO_2 during glacial periods.

The study, which was supported by the National Science Foundation and the University of Michigan, was published online this week in *Nature Geoscience*.

"Frankly, we're kind of baffled by the whole thing," said Alan Mix, a professor of oceanography at Oregon State University and an author on the study. "The deep North Pacific was such an obvious source for the carbon, but it just doesn't match up. At least we've shown where the carbon wasn't; now we just have to find out where it was."

During times of glaciation, global climate was cooler and atmospheric CO_2 was lower. Humans didn't cause that CO_2 change, so it implies that the carbon was absorbed by another reservoir. One obvious place to look for the missing carbon is the ocean, where more than 90 percent of the Earth's readily exchangeable carbon is stored.

The Pacific Ocean is the largest ocean by volume. The deep water mass longest isolated from the atmosphere and most enriched in carbon is found today in the Northeast Pacific, so the researchers focused their efforts there. They hypothesized that the ventilation age in this basin – or the amount of time since deep water was last in contact with the atmosphere – would be older during glacial times, allowing CO_2 to accumulate in the abyss.

"We were surprised to find that during the last ice age, the deep Northeast Pacific had a similar ventilation age to today, indicating it was an unlikely place to hide the missing carbon," said David Lund, a paleoceanographer at the University of Michigan, formerly at Oregon State, and lead author on the *Nature Geosciences* paper.

"This indicates that the deep Pacific was not an important sink of carbon during glacial times," Lund added. "Even more intriguing is that we found the ventilation age increased during the deglaciation, at the exact time that atmospheric CO_2 levels were rising."

The researchers reconstructed the ventilation history of the deep North Pacific, examining the sediments at a site about 75 miles off the coast of southwestern Oregon. There the water is more than a mile-and-a-half deep and is known as the oldest water mass in the modern oceans, Mix said. By radiocarbon dating both the planktonic, or surface-dwelling, and benthic (seafloor-dwelling) foraminifera, the scientists can determine whether the isotopic signatures of the foraminifera match "values predicted by the assumption of oceanic control of the atmosphere."

The organisms that lived on the seafloor have older "apparent" radiocarbon ages than the organisms that lived at the sea surface, Mix said, even though both come from the same sediment sample and are of the same true age. The radiocarbon dating was performed using an advance particle accelerator by the authors' colleague, John Southon of the University of California at Irvine.

"Different sources of CO_2 have different apparent ages, depending on how long they have been isolated from the atmosphere," Mix said. "We use these dates as kind of a 'return address label' rather than to establish precise ages of the events. The bottom line is that the deep North Pacific wasn't the source of rising CO_2 at the end of the last ice age."

The study is important not just in tracing climatic history, scientists say, but in forecasting how the Earth may respond to future climate change. The Earth "breathes carbon in and out," Mix said, inhaling carbon into sediment and soils, while exhaling it via volcanism and a slow exchange between the oceans, soils and plant life with the atmosphere.

When everything is in balance, the Earth is said to be in a "steady state." But on numerous occasions in the past, the carbon balance has shifted out of whack.

"Because the ocean is such a huge repository of carbon, a relatively small change in the oceans can have a major impact," Mix said. "We know ocean circulation changed during the ice ages and that is why many scientists assumed the deep Pacific Ocean was the source for rising CO_2 levels during the last deglaciation."

Lund said it "is conceivable that we are misunderstanding the radiocarbon signal by assuming it is controlled by ocean mixing."

"These are volcanically active regions, so the input of carbon from volcanoes, which lacks radiocarbon because of its great age, needs to be looked at," Lund pointed out. "But it is premature to draw any conclusions."

The researchers' next step will be to look for chemical traces of volcanic influence.

Another source of carbon could be from land, though the authors say it would be difficult to account for the magnitude of atmospheric carbon increase and the apparent radiocarbon age of released carbon by pre-industrial terrestrial sources alone.

"If we can better understand how carbon has moved through the Earth's systems in the past, and how this relates to climate change, we will better predict how the carbon we are now adding to the atmosphere will move in the future," Mix said.

Provided by Oregon State University