Frozen methane chunks not responsible for abrupt increases in atmospheric methane

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Icy chunks of frozen methane and water are not responsible for the periodic increases in atmospheric methane recorded in Greenland ice cores, according to a Penn State geoscientist.

"There are two hypotheses for the cause of the rapid increase in methane seen in the ice core records," says Dr. Todd Sowers, research associate in geosciences. "Some researchers believe that clathrates were the source of the methane while other researchers believe it was generated in wetlands."

Clathrates are icy balls of methane and water found in the continental margin sediments – 200 miles out to sea. They form when methanogenic bacteria deep in marine sediments generate methane which rises through the sediment and, if the temperatures and pressures are right, form balls of ice.

Conveniently, methane in clathrates and methane produced from wetlands are produced by different biochemical processes and consequently have differing ratios of the two stable hydrogen isotopes – hydrogen and deuterium. Methanogenic bacteria in marine sediments convert carbon dioxide into methane and water while wetland methane is a byproduct of fermentation. If clathrates suddenly released methane into the atmosphere, the ratio of the heavier isotope of hydrogen, deuterium, to the normal hydrogen would increase due to the elevated nature of the deuterium/hydrogen ratio associated with clathrates.

Sowers looked at methane trapped in the layers of ice preserved in the GISP II ice core. He sampled the layers every 1,000 years between 8,000 and 25,000 years, and every 30 years during periods when atmospheric methane levels increase abruptly to provide a finer assessment of the cause of the elevated methane levels.

"Hydrogen isotope ratios were stable during these abrupt warming episodes," says Sowers in his report in today's (Feb. 10) issue of Science. "The increased methane that accompanied the warming did not come from marine clathrates."

While Sowers can rule out clathrates during the abrupt events, his data do provide new information on the sources of methane that caused the long-term methane increase during the last glacial termination. Sowers observed elevated isotope ratios during the last glacial period compared to today.

There are a handful of factors that may have contributed to the observed change in the isotope ratios. These factors include a change in terrestrial vegetation type, lowered sea level and/or a temperature dependent isotope effect associated with colder glacial temperature.

"Even if these things happened, the total impact on the isotope budget would have been very small and would not account for the elevated isotope ratios during the last glacial period," says Sowers. "That leaves us with two other possibilities, changes in wetland systematics and/or increased natural gas emissions during the glacial period."

If natural gas seeping out of deposits beneath the oceans decreased throughout the glacial termination, then the methane isotope signature would follow the observed record. Methane emissions from natural gas might be higher during the glacial period due to lowered sea level that reduced the pressure on the undersea natural gas seeps allowing more gas to escape directly to the atmosphere.

"This possibility cannot be discounted," says Sowers. "However, I think the answer probably lies in changes in wetland methane emissions."

Climate could alter wetlands in two ways. First, during the termination, methane emissions from wetlands would increase if the areal extent of wetlands increased with warmer climates. Second, if the wetlands were drier during the glacial period, then the methane generated at depth would have a greater chance of being consumed by methanotrophic bacteria inhabiting the oxygenated region immediately above the lowered water tables.

"Methane eating bacteria prefer to consume methane with the lighter hydrogen isotope, which tips the ratio of heavy to light hydrogen in the methane emitted to the atmosphere toward heavy," says Sowers. "This would create a higher hydrogen isotope ratio that is consistent with that found during the last glacial period."

Source: Penn State

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