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Rise in Gases Unmatched by a History in Ancient Ice

By ANDREW C. REVKIN

Shafts of ancient ice pulled from Antarctica's frozen depths show that for at least 650,000 years three important heat-trapping greenhouse gases never reached recent atmospheric levels caused by human activities, scientists are reporting today.

The measured gases were carbon dioxide, methane and nitrous oxide. Concentrations have risen over the last several centuries at a pace far beyond that seen before humans began intensively clearing forests and burning coal, oil and other fossil fuels.

The sampling and analysis were done by the European Program for Ice Coring in Antarctica, and the results are being published today in the journal Science.

The evidence was found in air bubbles trapped in successively older ice samples extracted from a nearly two-mile-deep hole drilled in a remote spot in East Antarctica called Dome C.

Experts familiar with the findings who were not involved with the research said the samples provided a vital long-term view of variations in the atmosphere and Antarctic climate. They say the data will help test and improve computer models used to forecast how accumulating greenhouse emissions will affect the climate.

Some climate experts not involved in the research said the findings also confirmed that the buildup of carbon dioxide and other heat-trapping smokestack and tailpipe emissions was taking the atmosphere into uncharted territory.

The longest previous record of carbon dioxide fluctuations, compiled from ice cores collected at the Russian research station at Vostok, in East Antarctica, goes back slightly more than 400,000 years.

"They've now pushed back two-thirds of a million years and found that nature did not get as far as humans have," said Richard B. Alley, a geosciences professor at Pennsylvania State University who is an expert on ice cores. "We're changing the world really hugely - way past where it's been for a long

time."

James White, a geology professor at the University of Colorado, Boulder, not involved with the study, said that although the ice-age evidence showed that levels of carbon dioxide and the other greenhouse gases rose and fell in response to warming and cooling, the gases could clearly take the lead as well.

"CO2 and climate are like two people handcuffed to each other," he said. "Where one goes, the other must follow. Leadership may change, or they may march in step, but they are never far from each other. Our current CO2 levels appear to be far out of balance with climate when viewed through these results, reinforcing the idea that we have significant modern warming to go."

The new data from the ice cores also provides the first detailed portrait of conditions during ice-age cycles that occurred more than 400,000 years ago - a point in Earth's two-million-year history of cold periods and warm intervals after which some unknown influence lengthened ice ages and shortened and amplified the warm periods.

Both before and after that transition, the ice record shows, there was always a tight relationship between amounts of the greenhouse gases and air temperature.

While the overall climate pattern has been set by rhythmic variations in Earth's orientation to the Sun, the records show that carbon dioxide and methane consistently made the interglacial climate warmer than it would otherwise have been, said Thomas Stocker, one of the researchers and a physicist at the University of Bern in Switzerland.

Last year, the same cores provided new evidence that the current warm period, the Holocene, which began about 12,000 years ago, is similar to the longer warm periods that were typical before 400,000 years ago, and could last at least another 16,000 years.

The European team is analyzing deeper, older sections of the Dome C ice cores, and the researchers said they might be able to take the climate record back 800,000 years, possibly providing information about yet another early warm interval similar to the Holocene.

The new long-term record is essentially creating a subset of climate science, letting scientists compare different warm periods. They can then sort out influences, including greenhouse gases, said Gavin A. Schmidt, a climate modeler at the Goddard Institute for Space Studies in Manhattan.

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