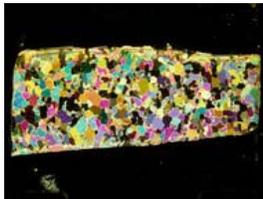


Study of Ice Age Bolsters Carbon and Warming Link

By JUSTIN GILLIS
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A meticulous new analysis of Antarctic ice suggests that the sharp warming that ended the last ice age occurred in lock step with increases of carbon dioxide in the atmosphere, the latest of many indications that the gas is a powerful influence on the earth's climate.

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Frédéric Parrenin

A thin sample taken from the Talos Dome ice core, which was collected in 2005-06 in Antarctica. Polarized light highlights the ice crystals that make up the sample.

Previous research suggested that as the world began to emerge from the depths of the ice age about 20,000 years ago, warming in Antarctica preceded changes in the global carbon dioxide level by something like 800 years.

That relatively long gap led some climate-change contrarians to assert that rising carbon dioxide levels were essentially irrelevant to the earth's temperature — a side effect of planetary warming, perhaps, but not the cause.

Mainstream climate scientists rejected that view and argued that carbon dioxide, while it certainly did not initiate the end of the ice age, played a vital role in the feedback loops that caused a substantial warming. Still, a long gap between initial increases of temperature and of carbon dioxide was somewhat difficult for the scientists to explain.

A wave of new research in the last few years has raised the likelihood that there was actually a small gap, if any.

The latest [paper](#) was led by Frédéric Parrenin of the University of Grenoble, in France, and is scheduled for publication on Friday in the journal Science. Using relatively new, high-precision chemical techniques, his group sought to reconstruct the exact timing of the events that ended the ice age.

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Scientists have long known that ice ages are caused by variations in the earth's orbit around the sun. When an intensification of sunlight initiates the end of an ice age, they believe, carbon dioxide is somehow flushed out of the ocean, causing a big amplification of the initial warming.

Since the 1980s, scientists have been collecting a climate record by extracting long cylinders of ice from the ice sheets in Greenland and Antarctica, and from glaciers atop high mountains.

Air bubbles trapped in the ice give direct evidence of the past composition of the atmosphere. And subtle chemical variations in the ice itself give an indication of the local temperature at the time it was formed.

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The trouble is that air does not get sealed in the ice until hundreds or even thousands of years after the snow has fallen, as it slowly gets buried and compressed.

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That means the ice and the air bubbles trapped in it are not the same age, so it becomes tricky for scientists to put reconstructed atmospheric composition and reconstructed temperature onto a common time scale.

With its improved techniques, Dr. Parrenin's group sought to clarify the dating of previously recovered ice cores from Antarctica. Instead of the 800-year lag between temperature and carbon dioxide increases found in some previous research, their work suggests that the lag as the ice age started to end was less than 200 years, and possibly there was no lag at all.

"Before, because of these wrong results of CO₂ lagging temperature, people were interpreting it as a weak role for CO₂ in the climate variation of the past," Dr. Parrenin said.

Indeed, though most climate scientists have never seen the supposed gap as a major conceptual problem, it has been invoked repeatedly by American politicians who want to delay action on [global warming](#).

In 2007, for example, former Vice President Al Gore was testifying to Congress about the science in his documentary "An Inconvenient Truth." He came under attack by Representative Joe L. Barton, a Texas Republican.

"CO₂ levels went up after the temperature rose," Mr. Barton said, citing a scientific paper from 2001. "The temperature appears to drive CO₂, not vice versa. On this point, Mr. Vice President, you're not just off a little. You're totally wrong."

The emerging evidence suggests that Mr. Gore was right.

Richard B. Alley, a climate scientist at Pennsylvania State University who was not involved in the new work, said by e-mail that it essentially confirmed previous scientific understanding.

"What this does, again and more clearly than ever, is to show that the large temperature changes are tightly coupled to the large CO₂ changes," he said.

Dr. Parrenin's paper is the third in recent years to suggest that the gap in the climate records between polar temperature and CO₂, if it exists at all, is relatively small. And Jeremy Shakun, a visiting scholar at Harvard, pointed out in a paper last year that the timing of the temperature increase in Antarctica could not be assumed to be representative of the world as a whole. When he compiled a global temperature record for the end of the ice age, he found that increases of carbon dioxide came first, and rising temperatures came second.

The tight relationship in past climate between temperature and carbon dioxide is a major reason scientists have warned that modern society is running a big risk by burning CO₂-producing fossil fuels.

The level of carbon dioxide in the atmosphere has jumped 41 percent since the Industrial Revolution began in the 18th century, and scientists fear it could double or triple unless stronger efforts are made to control emissions.

Even at the current concentration of the gas, the evidence suggests that increases in sea level of 25 feet or more may have already become inevitable, albeit over a long period.

"We're just entering a new era in earth's history," Dr. Shakun said. "It will be an unrecognizable new planet in the future. I think the only question is, exactly how fast does that transformation happen?"

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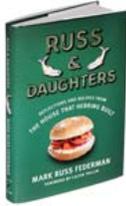
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