Hot Springs, Warm Climate and CO_2

Two oceanographers have found evidence that heightened hydrothermal venting on the seafloor may have been responsible for a rise in carbon dioxide (CO_2) levels and a subsequent warming of the planet 50 million years ago during the Eocene epoch. This finding not only is of interest in the study of the geological past but also could have important ramifications for understanding the global warming or "greenhouse effect" that is projected to develop in the more immediate future.

Robert M. Owen and David K. Rae of the University of Michigan in Ann Arbor report in the Jan. 11 SCIENCE that they were led to these conclusions by the discovery that ocean-floor hot springs have spewed out mineral-rich hot water with the greatest gusto at a few times in the past when the boundaries between the plates that carry continental and oceanic crust were radically altered. This finding counters the expectation of most geoscientists that seafloor venting is related to volcanic activity or to the rate at which new seafloor is created at the mid-oceanic ridges upon which the vents sit.

The cause of the Eocene greenhouse effect — increased hydrothermal activity brought on by global plate rearrangements — is entirely different from the source of the predicted greenhouse effect in the next century, in which deforestation and the burning of fossil fuels are projected to double carbon dioxide levels by the year 2065 (SN: 10/22/83, p. 26). Nonetheless, the Eocene record may provide scientists with a model for carbon dioxide's effect on climate.

"It's pretty clear to scientists that mankind is about to change the climate a lot and no one knows what to do about it, or what the changes will be, because no one can point to a case where it happened before," says Rae. "We think we've made a good case that there is a historical analog —a place in time where we can go to look for what happened to the earth when there was a greenhouse effect."

In order to get an indication of past hydrothermal activity, Owen and Rae first measured the concentration of iron, one of the elements commonly carried by hot-spring waters, in sediment and rock core samples taken at the East Pacific Rise along Leg 92 of the Deep Sea Drilling Project. They found that iron levels 20 to 25 million years ago reached concentrations five to 10 times greater than present values. They also discovered a smaller peak in iron concentrations at 6 to 8 million years ago.

Armed with the knowledge that these peaks were related to the local reorganization of plate boundaries, they then wondered whether enhanced hydrothermal activity could be associated with other times of tectonic upheaval, and if so, how this activity changed the chemistry of the oceans. The last major plate rearrangement occurring on a global scale happened during the Eocene. When Owen and Rae looked at the geological data amassed for that period by other researchers, they found iron levels six times the current value and concentrations of silica, another chemical found in hot springs, up to 20 times greater than present levels — indicating that hydrothermal flow had indeed increased during that time.

The Eocene was also marked by a pronounced climate change. Past research has shown that the temperature increased 5°C above that of the previous epoch (this is about the same magnitude of increase projected for the world in the next century). The data also imply that the air during the Eocene was humid, that there was reduced atmospheric circulation and that the pole-to-equator temperature difference had decreased, indicating that the poles had warmed up. Like other periods of climate change, a few ideas, such as increased volcanism or a change in the tilt of the earth, had been put forth to explain the warmed climate, but by and large none of these has been widely accepted by the paleoclimate community.

Owen and Rae believe that the warm climate can be explained instead by enhanced hot-spring activity, which spewed out calcium among the other minerals. Calcium reacts with bicarbonate in the ocean to form CO_2, which eventually finds its way into the air. The researchers estimate that at present hydrothermal vents account for 14 to 22 percent of all CO_2 entering the atmosphere from natural sources. They predict that if the amount of calcium from vents were to increase by four times (well within the range of increased activity measured by the researchers along Leg 92), the amount of carbon dioxide in the atmosphere would double.

A bit of evidence that supports the idea that CO_2 was produced is that the concentration of calcium carbonate ($CaCO_3$), a by-product in the reaction between calcium and bicarbonate to form CO_2, was doubled worldwide during the Eocene. Moreover, the highest levels were found deposited on shallow shelves, with far less discovered in deep-sea sediments where increased CO_2 leads to the dissolution of calcium carbonate in the shells of marine animals (SN: 12/15/84, p. 376).

One of the major problems common to paleoclimate studies is synthesizing all the geological data that have been dated by different methods. For example, $CaCO_3$ concentrations may have been tacked to the fossil record while other data were referenced to geomagnetic reversal time scales. Geologists are now working to fuse these time scales, but the work is not complete. Within the present limits of geological measurement, it appears that all the data are consistent with a single global-scale hydrothermal event, but the exact timing of all the recorded phenomena is not known, say Owen and Rae. Nor can they prove an actual cause-and-effect relationship for all the steps from plate rearrangement to warmer climates.

However, they have been able to set an upper bound for the time it would have taken the oceans to respond to increased calcium input by producing CO_2—at most a million years. Owen believes that it happened much faster, on the order of 10,000 to 100,000 years. (He notes that this is still much longer than the 100 years it will have taken anthropogenic sources of CO_2 to raise the temperature by a comparable amount.)

The researchers believe that their hypothesis does not preclude the possibility that other mechanisms may be at work to increase temperatures and change climate, although they say that their idea can roughly account for the magnitude of the changes that occurred during the Eocene. The next step, says Rae, is to test the new idea further by taking core samples of more Eocene sections at other spreading centers, especially in the Atlantic and Indian oceans since less geological work has been done there. The researchers also want to examine other times, such as 80 million years ago, when there might have been a major reorganization of plate boundaries. —*S. Weisburd*

Soviet physicist defects

Particle physics is an international specialty. Its practitioners frequently work in foreign countries and in multinational groups. In what seems to be the first such move by a particle physicist, Artem V. Kulikov, who had been working at the Fermi National Accelerator Laboratory in Batavia, Ill., refused to go home to the Soviet Union. Last month, instead of boarding an airplane at Chicago for the return trip, Kulikov asked U.S. Immigration agents for asylum. Asylum was granted on Dec. 26.

Kulikov had worked in the United States on at least two previous occasions. His decision not to return to the Soviet Union is described as a complete surprise to those who knew him at Fermilab. □

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