Ocean Islands Fuel Productivity and Carbon Sequestration Through Natural Iron Fertilization

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An experiment to study the effects of naturally deposited iron in the Southern Ocean has filled in a key piece of the puzzle surrounding iron's role in locking atmospheric carbon dioxide (CO2) in the ocean. The research, conducted by an international team led by Raymond Pollard of the National Oceanography Centre, Southampton, and included Matthew Charette, a marine chemist at the Woods Hole Oceanographic Institution (WHOI), found that natural iron fertilization enhanced the export of carbon to the deep ocean. The research was published January 29, 2009, in the journal *Nature*.

Scientists have generally accepted the fact that biological productivity in large areas of the Southern Ocean is limited by the supply of iron, an important micronutrient for phytoplankton. However, downstream of ocean islands in this study area, massive phytoplankton blooms have been observed, leading to the idea that the islands themselves are somehow fertilizing the ocean with iron. The team showed that this natural iron fertilization enhanced phytoplankton growth and productivity and the amount of carbon exported from the surface layer (100 meters) by two to three times. Moreover, they found that the amount of carbon stored at 3,000 meters and in the sediment was similarly two to three times higher beneath the natural fertilized region than for the nearby iron-poor region.

"This work demonstrated for the first time that Southern Ocean phytoplankton blooms fueled by natural sources of iron have the potential to sequester carbon in the deep ocean," said Charette.

The team conducted their experiment in 2004-2005 on the seas around the Crozet Islands and Plateau at the northern boundary of the Southern Ocean, about 1,400 miles (2,200 kilometers) southeast of South Africa. These seas provided a natural laboratory, because each spring the waters north of Crozet experience an enormous bloom containing billions of individual phytoplankton and covering 120,000 square kilometers (the size of Ireland). In contrast, the area south of Crozet experiences only a small, short bloom later in the season.

"Our first question was, 'where does the iron come from?'" said Charette. "Airborne dust wasn't the solution — there isn't enough exposed soil on Crozet for winds to carry iron from the island to the deep water where the bloom occurs. While other studies concluded that upwelling from the deep ocean was the main source of the iron, we wanted to test the hypothesis that the iron was coming from the island itself and the iron-rich sediments in the shallow water and the plateau area around it."

Since the currents move from south to north over Crozet, the researchers reasoned that iron could be entrained in the water column as it flows over the plateau. First, they needed a way to understand how long it would take iron to travel from the island's shore to the bloom site and if the rate of supply was enough to kick-start and sustain the bloom for several months. Iron concentrations in the water wouldn't tell them where it came from, so the team sampled waters around Crozet looking for naturally-occurring radium isotopes, which, like iron, originate in the sediments and can therefore be used to quantify the amount of iron that the islands and surrounding sediments can supply to the bloom area. The decaying isotopes provided a built-in clock for the investigators to determine how quickly the water moves over the plateau and into deeper water. The distribution of radium in the water column demonstrated that the source of the iron was the island and the sediments in the shallow water around it and the plateau.

A second question the team sought to answer was whether the differences in the blooms between the north and south sides of Crozet would result in greater amounts of carbon held in the deep ocean. Using sediment traps and sediment cores, the researchers uncovered the first evidence that carbon deposited at 3,000 meters and in the sediment was two to three times higher beneath the natural fertilized region than for the nearby iron-poor region. In addition, the sediment record shows that this has been so throughout the Holocene (about 10,000 years ago until present).

In recent years, schemes to fight global warming have included sequestering carbon in the deep ocean by fertilizing the ocean with iron to artificially induce plankton blooms. As public interest in these ideas has increased, the authors point out that the amount of carbon sequestered in the deep ocean for a given input of iron falls far short of previous geoengineering estimates, "with significant implications for proposals to mitigate the effects of climate change through purposeful addition of iron to the ocean," wrote lead author Pollard.

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