Understanding the global carbon cycle: Researchers publish results of an iron fertilization experiment

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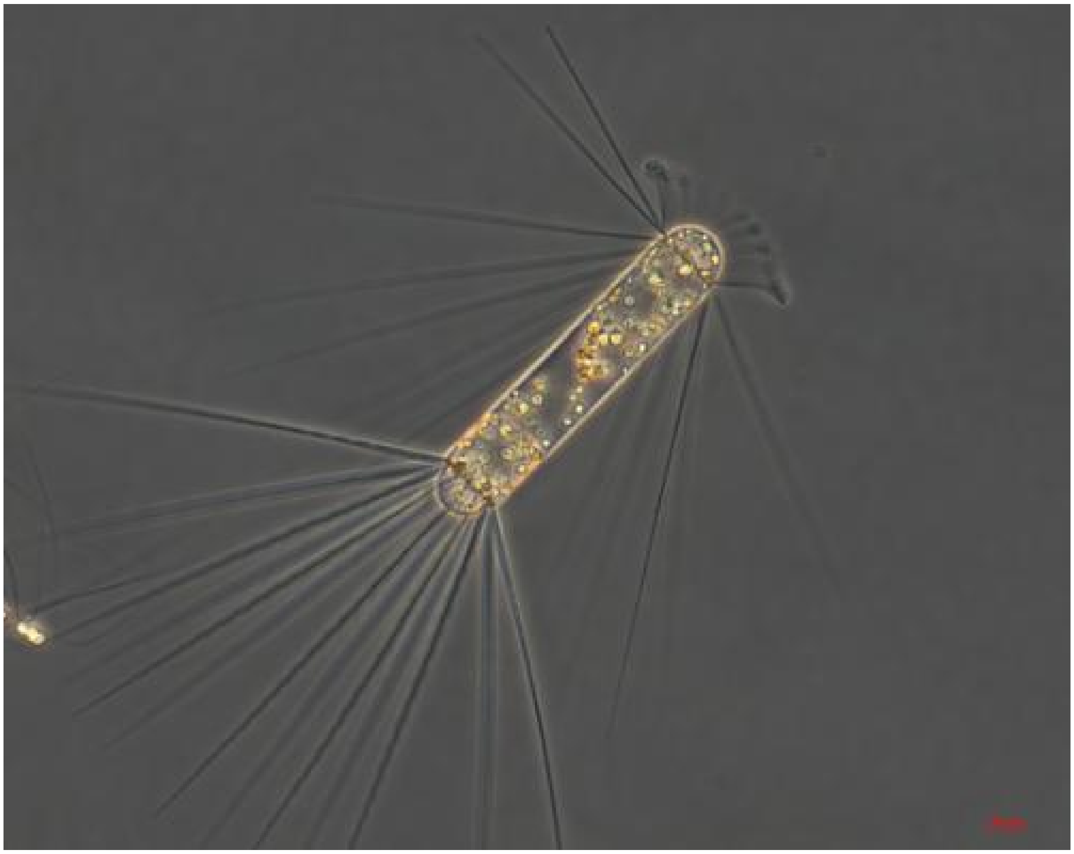
Scientists lift a buoy on board during the EIFEX project in 2004. Photo: Alfred Wegener Institute

An international research team has published the results of an ocean iron fertilization experiment (EIFEX) carried out in 2004 in the current issue of the scientific journal *Nature*. Unlike the LOHAFEX experiment carried out in 2009, EIFEX has shown that a substantial proportion of carbon from the induced algal bloom sank to the deep sea floor. These results, which were thoroughly analyzed before being published now, provide a valuable contribution to our better understanding of the global carbon cycle.

An international team on board the research vessel Polarstern fertilized in spring 2004 (i.e. at the end of the summer season in the southern hemisphere) a part of the closed core of a stable marine eddy in the Southern Ocean with dissolved iron, which stimulated the growth of unicellular algae (phytoplankton). The team followed the development of the phytoplankton bloom for five weeks from its start to its decline phase. The maximum biomass attained by the bloom was with a peak chlorophyll stock of 286 Milligram per square metre higher than that of blooms stimulated by the previous 12 iron fertilization experiments. According to Prof. Dr. Victor Smetacek and Dr. Christine Klaas from the Alfred Wegener Institute for Polar and Marine Research in the Helmholtz Association, this was all the more remarkable because the EIFEX bloom developed in a 100 metre deep mixed layer which is much deeper than hitherto believed to be the lower limit for bloom development.

The bloom was dominated by diatoms, a group of algae that require dissolved silicon to make their shells and are known to form large, slimy aggregates with high sinking rates at the end of their blooms. "We were able to prove that over 50 per cent of the plankton bloom sank below 1000 metre depth indicating that their carbon content can be stored in the deep ocean and in the underlying seafloor sediments for time scales of well over a century", says Smetacek.



Bloomed during EIFEX: The diatom Corethron pennatum has spines like its related species Chaeotceros atlanticum and Chaeotceros dichaeta. However, this diatom consists of one cell while the other two are cell chains. Photo: Marina Montresor, SZN / Alfred Wegener Institute

These results contrast with those of the LOHAFEX experiment carried out in 2009 where diatom growth was limited by different nutrient conditions, especially the absence of dissolved silicon in the chosen eddy. Instead, the plankton bloom consisted of other types of algae which, however, have no protective shell and were eaten more easily by zooplankton. "This shows how differently communities of organisms can react to the addition of iron in the ocean", says Dr. Christine Klaas. "We expect similarly detailed insights on the transportation of carbon between atmosphere, ocean and sea bottom from the further scientific analysis of the LOHAFEX data", adds Prof. Dr. Wolf-Gladrow, Head of Biosciences at the Alfred Wegener Institute, who is also involved in the *Nature* study.

Iron plays an important role in the climate system. It is involved in many biochemical processes such as photosynthesis and is hence an essential element for biological production in the oceans and, therefore, for CO_2 absorption from the atmosphere. During past ice ages the air was cooler and drier than it is today and more iron-containing dust was transported from the continents to the ocean by the wind. The iron supply to marine phytoplankton was hence higher during the ice ages. This natural process is simulated in iron fertilisation experiments under controlled conditions.

"Such controlled iron fertilization experiments in the ocean enable us to test hypotheses and quantify processes that cannot be studied in laboratory experiments. The results improve our understanding of processes in the ocean relevant to climate change", says Smetacek. "The controversy surrounding iron fertilization experiments has led to a thorough evaluation of our results before publication", comments the marine scientist as an explanation for the long delay between the experiment to the current publication in *Nature*.

More information: Victor Smetacek, Christine Klaas et al. (2012): Deep carbon export from a Southern Ocean iron-fertilized diatom bloom. *Nature*, doi:10.1038/nature11229

Summary of the experiment: A patch of 150 square kilometres (circle with a diameter of 14 kilometres) within an marine eddy of the Antarctic Circumpolar Current was fertilized with seven tonnes of iron sulphate on 13/14 February 2004. This corresponds to an iron addition of one hundredth of a gramme per square metre. The resultant iron concentration of 2 nanomole per litre is similar to values measured in the wake of melting icebergs; the iron concentrations in coastal regions tend to be much higher.

The input of iron in regions with high nutrient concentrations (nitrate, phosphate, silicate) and low chlorophyll content (the so-called high-nutrient / low-chlorophyll regions) stimulates the growth of plankton algae (phytoplankton). After fertilization, the development of the plankton bloom was investigated using standard oceanographic methods over a period of five weeks. From the surface water down to a depth of over 3,000 metres, chlorophyll, organic carbon, nitrogen, phosphate and other parameters were measured to follow the development, demise and sinking of the bloom and the associated export of carbon. In addition, the phytoplankton and zooplankton species and bacterial numbers and abundance were determined. The chlorophyll content rose over a period of 24 days after fertilization. Thereafter, phytoplankton aggregates formed and sank within a few days to depths of 3,700 metres. Long spines of these diatoms and mucous substances led to aggregate formation and export of the fixed carbon from the surface to the sea floor. This process was monitored for five weeks after the start of fertilisation.

Provided by Helmholtz Association of German Research Centres

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