Diatoms explain release of CO_2

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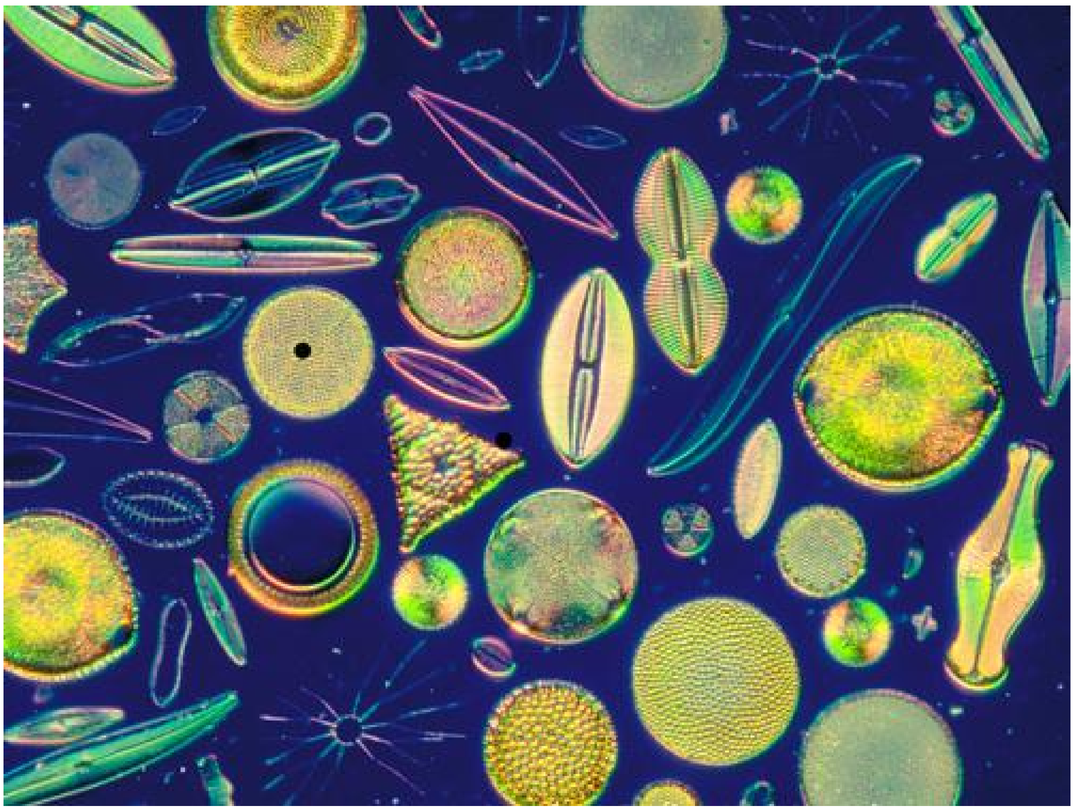

Miniscule life forms in many shapes and forms: diatoms and their mass occurrence can explain how CO_2 sequestered in the sea is released into the atmosphere at the end of ice ages. Credit: Carolina Biological Supply Company / flickr.com

(Phys.org) —Scientists have found unexpectedly high concentrations of opal, a mineral containing silicate, in marine sediments during the transition periods from ice ages to warm phases. The explanation as to what caused these high concentrations can also clarify how oceans release sequestered carbon dioxide. The underlying mechanism is still unexplained today.

To date there is no clear answer to the question of how the Earth emerges from a cold phase. The increase in the content of carbon dioxide in the atmosphere plays a decisive role. But it is still not clear what sets this increase in motion. A study just published in *Nature* now supports a theory first put forward in 1998.

Peak in opal marks end of ice age

The impetus for the study was provided by the geochemical analysis of a drill core from the subtropical Atlantic, carried out by Nele Meckler from ETH Zurich's Geological Institute. During the analysis, the researcher came across opal deposits. Opal is a mineral that contains silicate, and stems from the skeletons of diatoms that have died off. Surprisingly, the deposits of high silicate concentrations in the sediment core were found to occur roughly every 100,000 years, in each case during the transition from a cold to a warm phase. The core itself encompasses a timeframe of 550,000 years of sedimentary history. But the fact that diatoms in the subtropical waters from which the sediment core stems are particularly numerous during the transition from a cold to a warm phase does not fit into the picture.

According to a widely accepted hypothesis on how the oceans release CO2 that they had sequestered during the cold phase, the surface water at this location should be low in silicate during the transition times. The reason for this is that a large amount of melt water is believed to have entered the North Atlantic after the last ice age. This input of melt water probably stopped the formation of deep water there by placing a freshwater lid over the Northern Ocean. The processes this triggered in the Northern Hemisphere are thought to have caused a shift in the global wind systems in a southerly direction closer to the Antarctic. This could have increased the upwelling of deep water in the south and brought CO_2 to the surface. The CO_2 then entered the atmosphere there. That is what the widely accepted theory suggests.

However, such a wind-driven upwelling of the Southern Ocean would also lead to increased transportation of mid-depth water masses in the direction of the North Atlantic. But these water masses would be very low in silicate, because the opal skeletons of the diatoms – which are very abundant in the Southern Ocean – only disintegrate slowly while sinking to the bottom of the sea. This is why the silicate mainly accumulates in the deep water.

Diffusion as a driving force

The researchers therefore propose an alternative mechanism as to how such concentrations of opal and the emission of CO_2 came about. According to this new hypothesis, the water masses stagnated. This meant that the influence of natural diffusion, driven by differences in concentration, increased, which is why silicate from the deep water reached the surface waters and led to noticeable diatom blooms. After the diatoms died off, their skeletons caused the opal deposits in the sediment.

The researchers conclude that if diffusion is possible from the bottom up, then warm surface water could also diffuse into the deep – driven by differences in temperature. This in turn would change the density in the deep water. The density difference would result in circulation, which would bring the CO_2-rich deep water to the surface and the greenhouse gas into the atmosphere. This in turn would lead to a further rise in the global average temperature. "Once this process has been set in motion, then the end of the cold phase advances", says Meckler.

Large-scale diatom bloom

According to the researchers, the fact that there are five opal sites in the sediment core that each coincide with the end of a cold phase indicates that the changes in the ocean circulation are essential components of the processes that initiate the end of a cold phase. According to Meckler, the connection to other data from sediment cores also indicates that the diatom bloom is a large-scale event. Now the task is to clarify the extent to which the phenomenon is widespread in the Atlantic.

"Our findings clearly contradict the currently widely accepted 'wind hypothesis' and instead favour a hypothesis that has been less established thus far", says Meckler. Her study, she says, is a further piece of the puzzle to add to the data already collected to date. Her research objective is to understand the entire system with its processes better. The researcher emphasises that some observations of paleo-oceanographic studies that are explained with the changed wind systems theory put forward could also be easily explained using the "diffusion hypothesis", but that this is not the case the other way round.

The study published in *Science* a week ago, which involved further scientists from the group of the ETH professor Gerald Haug, fits well with her findings, emphasises Meckler, who is working in the Haug group as part of the Marie Heim-Vögtlin Programme of the Swiss National Science Foundation (SNSF).

More information: Meckler AN et al. Deglacial pulses of deep-ocean silicate into the subtropical North Atlantic Ocean, *Nature* (2013), 495, 495-499, doi: 10.1038/nature12006

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