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Sediment cores from the Southeast Pacific as an 8-million-year-old climate archive: Temperature influences global ocean currents

Under the lead of the Leibniz Institute for Baltic Sea Research Warnemünde (IOW), a sediment core from the Southeast Pacific was examined that reflects the last 8 million years of Earth's history. The study shows that the intensity of the Antarctic Circumpolar Current, which connects the world's three major oceans, is particularly sensitive to temperature changes, which in turn significantly influences the exchange of CO_2 between the ocean and the atmosphere. The study was recently published in the journal Nature Communications.

During an expedition with a US research vessel in the central and eastern South Pacific in 2019, researchers from the IOW, the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI, Bremerhaven), the Lamont-Doherty Earth Observatory (LDEO, USA), and MARUM – Center for Marine Environmental Sciences (Bremen) collected several sediment cores. IOW scientist Antje Wegwerth examined one of these cores to draw conclusions about climate development over the last 8 million years. The core was taken at a water depth of 3,800 m near the Drake Passage. This passage runs between the southern tip of South America and the north of the Antarctic Peninsula and is the narrowest point of the Antarctic Circumpolar Current (ACC). The ACC is the world's strongest ocean current and connects the Pacific, Atlantic, and Indian Oceans. For millions of years, the ACC has been circulating not only heat, salt, and nutrients, but also dissolved carbon dioxide (CO_2) around Antarctica. The results of this study will be used for the further development of current climate models and will help to better assess the future climate in the context of advancing global warming.

Algae reveal past sea temperatures

The research team examined a total of 300 sediment samples from the 380 m long core using a technique known as alkenone paleothermometry. This kind of sampling achieved a temporal resolution of approximately 25,000 years over the last 8 million years, which the core covers. The aim of alkenone method is to be able to infer past surface water temperatures. Alkenones are chemical compounds that remain when single-celled calcareous algae die. Calcareous algae secrete calcium carbonate and are found in oceans worldwide. Alkenones differ depending on the prevailing temperatures, and their analysis therefore offers a unique opportunity to draw conclusions about past sea surface temperatures.

The circumpolar current became stronger during cold periods

The researchers found that between 2.2 and 5.3 million years ago, the intensity of the ACC increased during long cold periods lasting about 400,000 years. The increased intensity of the ACC probably led to greater mixing of deep seawater, releasing CO_2 from the ocean into the surrounding air and ultimately into the atmosphere. According to the study's lead author, IOW scientist Antje Wegwerth, the increased intensity of the ACC during such long (400,000-year) cold periods was surprising: "Previous studies of the last 1 million years have shown increased ACC intensity during comparatively short (10,000 years) warm periods rather than during cold periods, suggesting that the interactions between the ocean and the atmosphere differ depending on the time scales studied and therefore need to be investigated in more detail and at different temporal resolutions."

Results contradict previously assumed global cooling

In addition, it was previously assumed that approximately 2.7 million years ago, during the onset of the great glaciation in the northern hemisphere, there was a global cooling. However, the IOW study showed a relatively strong warming of approximately 5°C in the Southern Ocean and especially in the Southeast Pacific at that time. This warming lasted 700,000 years. The research

team concludes that the warming, together with a weakened ACC, led to the accumulation of the greenhouse gas CO_2 in the subpolar deep ocean waters. This was followed by a steady removal of CO_2 from the atmosphere and ultimately a cooling of the global climate. The warming may also have influenced the partial melting of the Antarctic ice sheet, which ultimately led to a weakening of North Atlantic deep-water formation and Atlantic overturning circulation, thereby promoting the glaciation of the Northern Hemisphere.

Current climate models can be improved based on the results

In a follow-up project, the climate and environmental conditions and interactions with neighbouring Patagonia over the last 8 million years will be investigated in a higher temporal resolution than before. This will contribute to a better understanding of the climate and help improve current climate models. The aim is to be able to better assess future climate developments. Particularly from the Southern Ocean, only limited past climate data are available, which is why this study provides an important treasure trove of data for global climate development in the context of advancing global warming.

Original publication:

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