Sea-ice ecosystem possibly triggered evolution of baleen whales and penguins

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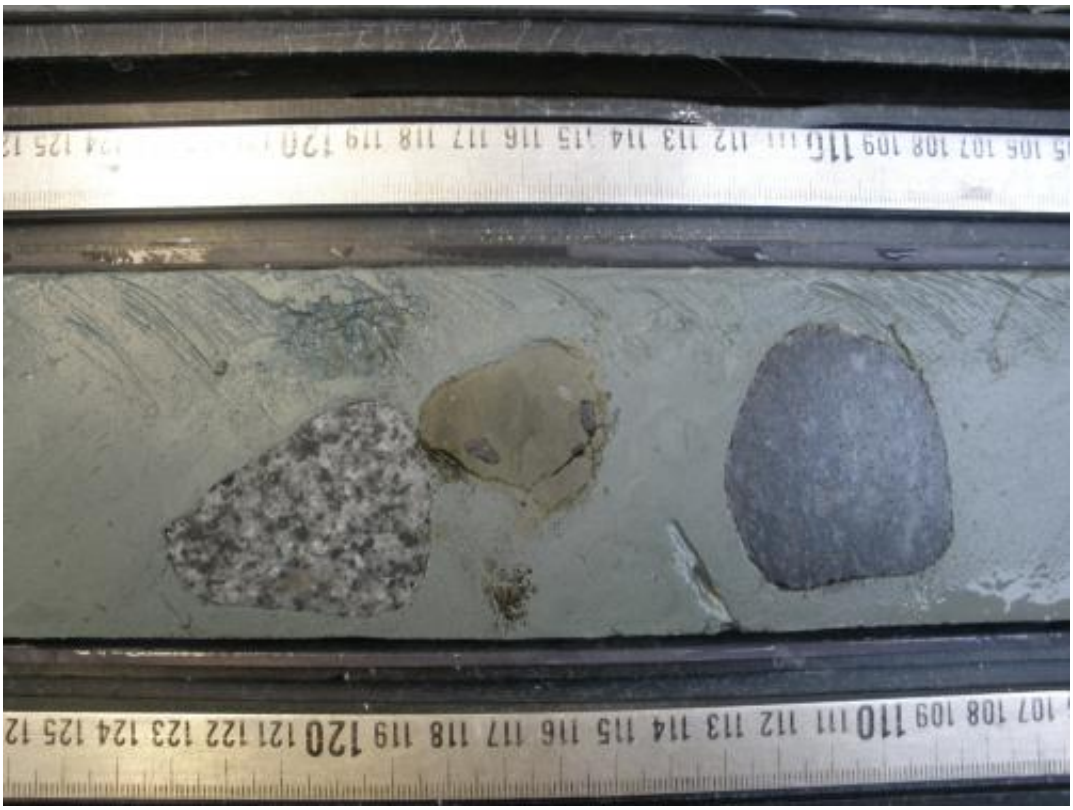
This is the ocean drilling vessel JOIDES Resolution with which the IODP brought drill cores from the Antarctic coastal waters to the surface in 2010. Credit: IODP

The circum-Antarctic Southern Ocean is an important region for global marine food webs and carbon cycling because of sea-ice formation and

its unique plankton ecosystem. The origin of its ecosystems can be traced back to the emergence of the Antarctic ice sheets approximately 33.6 million years ago. This discovery was made by an international team including scientists from the Goethe University and the Biodiversity and Climate Research Centre in Frankfurt, Germany. Their study, published today in *Science*, shows that the development of the sea-ice ecosystem possibly triggered further adaptation and evolution of larger organisms such as baleen whales and penguins.

The scientists analysed sediment samples from drill cores on the seafloor, which were obtained in 2010 off the coast of Antarctica, as part of the Integrated Ocean Drilling Program (IODP). The cores reach nearly 1000 meters beneath the seafloor and provide new insights into a long gone past.

A study published in 2012 demonstrated that subtropical plants covered Antarctica about 53 million years ago. In the course of the following 20 million years, the global climate cooled continuously. The new study focuses on the interval 33.6 million years ago when within a short time an enormous ice sheet covered Antarctica. This changed the life conditions and the ecosystems on the Antarctic continent and the surrounding Southern Ocean dramatically.



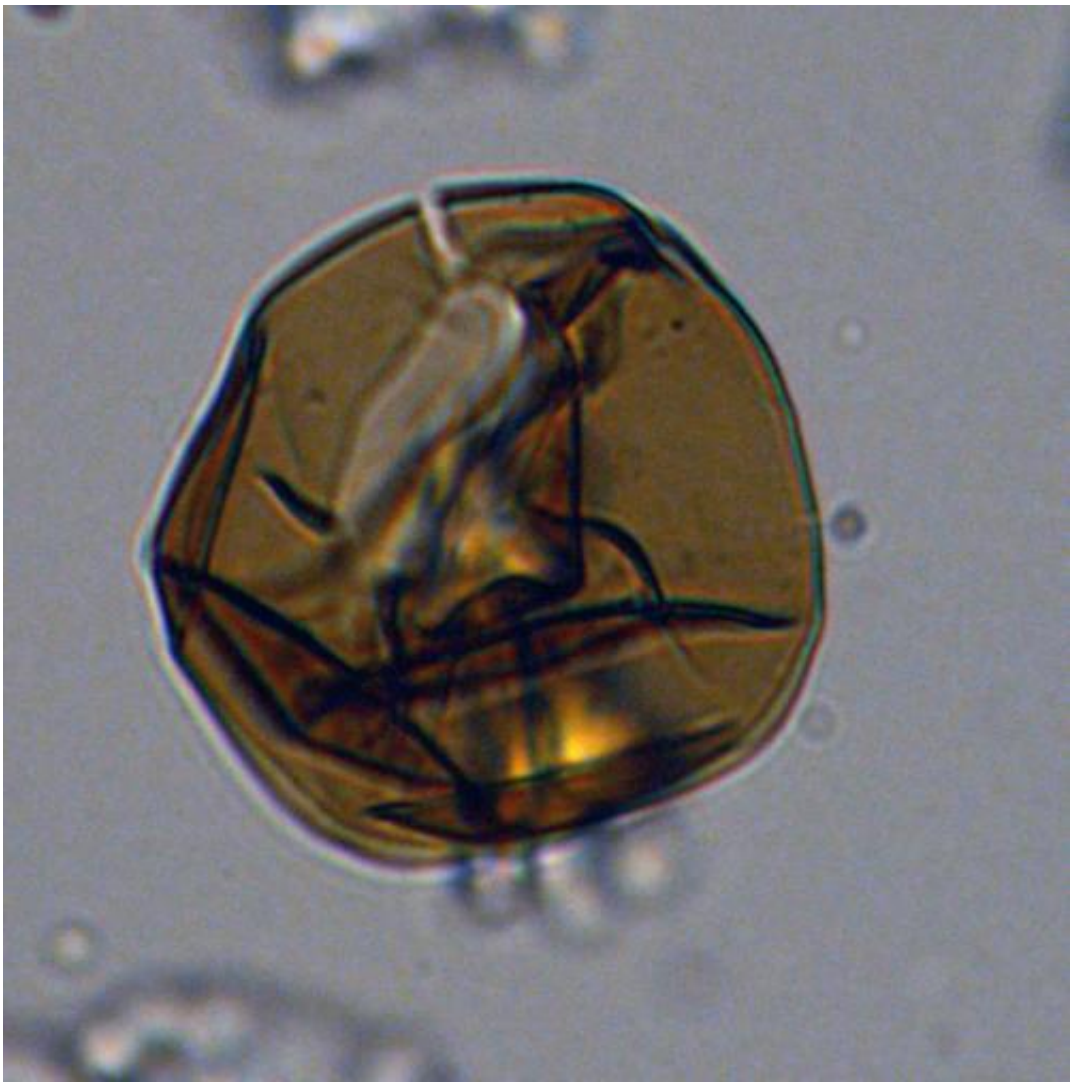
This shows pebbles in a sediment core from the Antarctic coastal waters. The pebbles were taken to open sea by icebergs and ultimately fell to the ocean floor. Credit: Saiko Sugisaki

Tiny witnesses: Dinoflagellates

The ocean plankton mainly consist of algae, most of which are not preserved in sediment samples from drill cores. In contrast, single-celled dinoflagellates, a group of algae containing organic fossilizable substance, do preserve in sedimentary sequences over millions of years. This makes them a valuable tool to reconstruct environmental.

The researchers found that when Antarctica was sub-tropical and ice-free, the surrounding seas were inhabited by a diverse array of dinoflagellates characteristic for relatively warm climates. However,

from the moment that the ice cap formed, the diversity suddenly collapsed, and from that moment, only species occurred that are adapted to temporary sea-ice cover and characterize modern sea-ice environments around Antarctica. They are present in high numbers only when the sea ice melts in spring and summer, and therefore are available as a food source for higher organisms only during a short period of the year.



This is a characteristic dinoflagellate cyst about 50 micrometers found in sediments dating back to the early Oligocene (33 million years ago). Credit: Alexander Houben

New species due to food shortage

The seas around Antarctica play a critical role in the food web of the ocean. Algal blooms only occur in summer, when the sea ice melts. These blooms are a key food source for both small single-cell organisms such as certain species of dinoflagellates and for larger organisms.

"The sudden turnover in the dinoflagellate assemblages indicates clearly that the entire plankton ecosystem of the Antarctic waters had changed", explains Prof. Jörg Pross, co-author of the study and paleoclimatologist at the Goethe University and the Biodiversity and Climate Research Centre (BiK-F) in Frankfurt, Germany. "The explosion of dinoflagellates adapted to a temporary sea-ice cover testifies to an in-depth reorganization of the food web in the Southern Ocean."

Larger animals higher up in the ocean's food chain probably adapted their diet because the algal growth season became shorter and more intense. Jörg Pross sums up: "Our data suggest that this change may have promoted the evolution of modern baleen whales and penguins". These results stress that major climate change is often accompanied by particularly rapid biological evolution.

More information: "Reorganization of Southern Ocean Plankton Ecosystem at the Onset of Antarctic Glaciation," by A.J.P. Houben et al, *Science*, 2013.

Provided by Goethe University Frankfurt

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