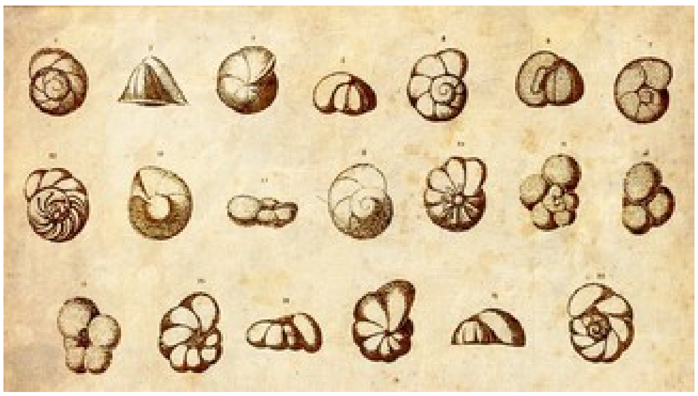
Clues to paleoclimate from tiny fossils

November 25 2013



Credit: Wikimedia Commons

New insights into the growth dynamics of minuscule marine organisms could help put the study of Earth's climate, both present and prehistoric, on a more solid footing.

For hundreds of millions of years, the tiny shells of single-celled marine organisms called foraminifera have been accumulating on the ocean floor. Their shells contain clues about the composition of the seawater they lived in. In a recent cooperation between EPFL and the Alfred Wegener Institute, researchers lay out a new explanation for how these organisms take up the elements they use to grow their shells, offering climatologists a better understanding into a common tool to study the Earth's climate history. Their results were published in the journal *Biogeosciences* in late October, and highlighted in the November 22 issue of *Science*.

Scientists often rely on secondary evidence, from ice or sediment cores, to reconstruct the prehistoric climate. Studying sediment cores containing foraminifera, scientists have reconstructed temperature timelines and analyzed the planet's ice cover based on the composition of the shells. But as coauthor Anders Meibom explains, because they are the result of complex biological processes, foraminifer from sediment cores cannot be interpreted easily using data from inorganically formed minerals.

Not just passive transport

Foraminifera build their shells by using calcium, carbon, and oxygen that they find in seawater. Until now, scientists thought that the microorganisms used tiny "carrier bubbles," or vacuoles, to transport seawater into them. There, calcium carbonate would precipitate from the water, forming the shell.

Scientists have long been baffled by the low magnesium concentrations in the shells. Seawater has five times more magnesium than calcium, so if minerals only entered the shells through vacuoles, they would contain large amounts of magnesium – unless it was somehow removed from the organism. Researchers have proposed a number of ways that the magnesium could be removed; yet none of them have ever been proven.

Molecular pumps that select for calcium

Instead of being taken up in vacuoles, the authors of this recent paper hold that most of the calcium is let in through transmembrane transport, which selects for calcium, but block magnesium. The fact that the shells nevertheless contain small amounts of magnesium means that both mechanisms could act in tandem, with non-selective vacuole transport accounting for the traces of magnesium found in the shells.

Based on the magnesium-calcium ratio in the surrounding seawater, the researchers developed a model to predict the magnesium-calcium ratio in the foraminifera shells. "We tested our predictions against three different experiments where foraminifera were grown in an aquarium, and the fit was almost perfect," says Anders Meibom. According to lead author Gernot Nehrke from the Alfred Wegener Institute, their model is the first to predict the composition of the foraminifera shells without having to resort to unconfirmed theories of magnesium removal.

Beyond ice fields

"Foraminifera can provide all sorts of information on the climate, but until now, they have been treated as a black box. With this research we are beginning to understand, at a sub-cellular level, how these organisms develop, giving us a better idea about both the accuracy and the limits of sediment core measurements to reconstruct the climate of the past," says Meibom.

Provided by Ecole Polytechnique Federale de Lausanne