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New climate history study: Cooling periods cause evolutionary surges

Temperatures on Earth have had a significant influence on the course of evolution. A particularly high number of new species of marine animals emerged after geologically short cooling periods that had already been preceded by a much longer cooling period. This is the conclusion reached by researchers from the Universities of Bayreuth and Erlangen-Nuremberg in a new study that has now been published in the journal PNAS. By combining empirical data and computer simulations, they have found that the influence of rapid climate change on biodiversity is significantly influenced by longer-lasting climate trends in previous periods of the Earth's history.

Based on a wealth of geological data, it is been established that there have been several long-lasting glacial and warm periods in the course of the Earth's history. Researchers in Bayreuth and Erlangen have now divided these periods into long-term and short-term trends in order to investigate the effect of geological temperature fluctuations on the formation of species. The short-term trends each had a duration of around six million years and can be described as climate change on a geological time scale.

The results of the research show that the influence of the respective climate change on the emergence of species only becomes apparent when the long-term temperature trends before climate change are included. For example, the probability of species emergence increases by almost 28 percent if a long-lasting cooling is followed by a short ice age. However, if a short ice age occurs after a long-lasting warming period, this probability does not increase.

The calculations based on computer simulations are confirmed by fossil finds and palaeoclimatic data. Thus, in the history of the Earth, there has always been an unusually large increase in new species of marine animals when an ice age occurred after a period of long-term cooling. The authors of the study explain this hype of evolution by the fact that the consequences of the ice-age cooling are amplified by the after-effects of the preceding long cooling period. "The combination of the rectified climate developments caused an increased lowering of sea levels. Particularly off mainland coasts and near islands, the seas became so shallow that many of the marine animals living there could not, or could only rarely, swim out into the open sea. Their mobility was considerably restricted. As a result, widespread populations belonging to the same genus or species were cut off from each other and isolated for many millions of years. This allowed them to evolve and differentiate independently of each other. Coastal marine areas with shallow water depths thus became hotspots of evolution", explains Gregor Mathes M.Sc., lead author of the new study.

The new research results exemplify that the influence of short-term climate change on biodiversity can only be realistically assessed if longer periods of geological history are also taken into account. "Our calculations have shown that short cooling periods following a long temperature rise result in a significantly weaker evolutionary response," says Mathes. In January 2021, the team from Bayreuth and Erlangen already proved in another study that the extent to which short temperature rises affect the extinction risk of species depends not least on the context of geological and climatic history.

The research team from Bayreuth and Erlangen is part of the research group TERSANE ("Temperature-Related Stresses as a Unifying Principle in Ancient Extinctions"), in which scientists from all over Germany are investigating connections between biodiversity and climate-historical processes.

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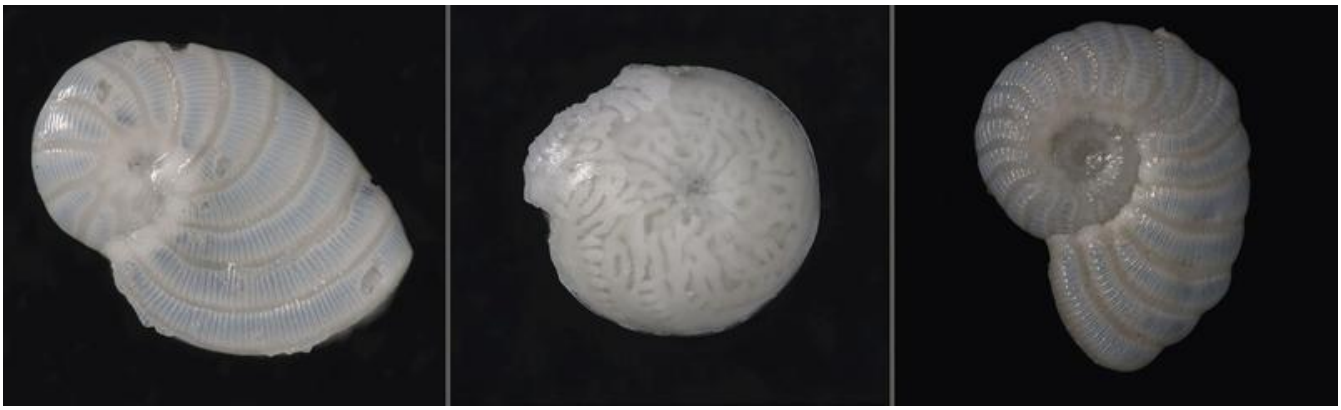

Foraminifera are shell-bearing unicellular marine animals. Most species are between 200 and 500 micrometres in size. The long-lasting cooling in the later Cretaceous period contributed significantly to the emergence of new species.
Images: Gregor Mathes.