Dinosaurs lived in greenhouse climate with hot summers

June 10 2021

Niels de Winter doing research on fossil shells. Credit: Niels de Winter

Paleoclimatologist Niels de Winter and colleagues developed an innovative way to use the clumped isotope method to reconstruct climate in the geological past on the seasonal scale. They show that dinosaurs had to deal with hotter summers than previously thought. The results suggest that in the mid latitudes, seasonal temperatures will likely rise along with climate warming, while seasonal difference is maintained. This results in very high summer temperatures.

Palaeoclimatologists study climate of the geological past. Using an innovative technique, new research by an international research team led by Niels de Winter (VUB-AMGC & Utrecht University) shows for the first time that dinosaurs had to deal with greater seasonal differences than previously thought.

De Winter states that "we used to think that when the climate warmed like it did in the Cretaceous period, the time of the dinosaurs, the difference between the seasons would decrease, much like the present-day tropics experience less temperature difference between summer and winter. However, our reconstructions now show that the average temperature did indeed rise, but that the temperature difference between summer and winter remained rather constant. This leads to hotter summers and warmer winters."

To better characterize the climate during this period of high CO2 concentration, the researchers used very well-preserved fossils of mollusks that lived in southern Sweden during the Cretaceous period, about 78 million years ago. Those shells grew in the warm, shallow seas that covered much of Europe at the time. They recorded monthly variations in their environment and climate, like the rings in a tree. For their research, de Winter and the team used the "clumped isotope" method for the first time, in combination with a method developed by Niels de Winter.

Clumped isotopes in combination with the VUB-UU method—a revolution in geology

Isotopes are atoms of the same element with different masses. Since the 1950s, the ratio of oxygen isotopes in carbonate has been used to measure water temperature in the geological past. However, this required researchers to estimate the chemistry of the seawater, as the isotope ratio of the seawater affects the isotope ratio of the shell, which results in higher uncertainty. About ten years ago, the "clumped isotope" method was developed, which does not depend on the chemistry of the seawater and allows accurate reconstructions. But the clumped isotope method has a disadvantage: it requires so much carbonate that temperature reconstructions at a more detailed level, such as seasonal fluctuations based on shells, were not possible.

De Winter has now developed an innovative method in which measurements of much smaller quantities of carbonate are cleverly combined for temperature reconstructions. The clumped isotope method thus requires much less material and can therefore be used for research on fossil shells, which, like tree rings, hold a great deal of information about their living conditions. The method also allows carbonate from successive summers (and winters) to be aggregated for better reconstruction of seasonal temperatures. For example, Winter found that water temperatures in Sweden during the Cretaceous "greenhouse period" fluctuated between 15°C and 27°C, over 10°C warmer than today.

The team also worked with scientists from the University of Bristol (UK) who develop climate models to compare the results with climate simulations of the Cretaceous period. Whereas previous climate reconstructions of the Cretaceous often came out colder than these models, the new results agree very well with the Bristol models. This shows that variations in seasons and water chemistry are very important in climate reconstructions.

"It is very difficult to determine climate changes from so long ago on the seasonal scale, but the seasonal scale is essential to get climate reconstructions right. If there is hardly any difference between the seasons, reconstructions of average annual temperature come out differently from situations when difference between the seasons is large. It was thought that during the age of the dinosaurs difference between the seasons was small. We have now established that there were greater seasonal differences. With the same temperature average over a year, you end up with a much higher temperature in the summer."

De Winter explains that their "results therefore suggest that in the mid latitudes, seasonal temperatures will likely rise along with climate warming, while seasonal difference is maintained. This results in very high summer temperatures. The results bring new insight into the dynamics of a warm climate on a very fine scale, which can be used to improve both climate reconstructions and climate predictions. Moreover, they show that a warmer climate can also have extreme seasons."

The development has far-reaching implications for the way climate reconstructions are done. It allows researchers to determine both the effect of seawater chemistry and that of differences between summer and winter, thus verifying the accuracy of decades of temperature reconstructions. For his groundbreaking research, De Winter has been nominated for both the annual EOS Pipette Prize and New Scientist Science Talent 2021.

More information: Niels J. de Winter et al, Absolute seasonal temperature estimates from clumped isotopes in bivalve shells suggest warm and variable greenhouse climate, *Communications Earth & Environment* (2021). DOI: 10.1038/s43247-021-00193-9

Provided by Vrije Universiteit Brussel