Geophysical Research Abstracts
Vol. 19, EGU2017-894, 2017
EGU General Assembly 2017

Growth rates and geochemical proxies in Late Campanian bivalves – New insights from micro-X-ray Fluorescence mapping and numerical growth modelling

Niels de Winter (1), Steven Goderis (1), Stijn van Malderen (2), Frank Vanhaecke (2), and Philippe Claeys (1)
(1) Vrije Universiteit Brussel, AMGC, Brussel, Belgium, (2) Universiteit Gent, Faculty of Sciences, Department of Analytical chemistry, Ghent, Belgium

Understanding the Late Cretaceous greenhouse climate is of vital importance for understanding present and future climate change. While a lot of good work has been done to reconstruct climate in this interesting period, most paleoclimatic studies have focused on long-term climate change[1]. Alternatively, multi-proxy records from marine bivalves provide us with a unique opportunity to study past climate on a seasonal scale. However, previous fossil bivalve studies have reported ambiguous results with regard to the interpretation of trace element and stable isotope proxies in marine bivalve shells[2]. One major problem in the interpretation of such records is the bivalve's vital effect and the occurrence of disequilibrium fractionation during bivalve growth. Both these problems are linked to the annual growth cycle of marine bivalves, which introduces internal effects on the incorporation of isotopes and trace elements into the shell[3]. Understanding this growth cycle in extinct bivalves is therefore of great importance for the interpretation of seasonal proxy records in their shells.

In this study, three different species of extinct Late Campanian bivalves (two rudist species and one oyster species) that were found in the same stratigraphic interval are studied. Micro-X-Ray Fluorescence line scanning and mapping of trace elements such as Mg, Sr, S and Zn, calibrated by LA-ICP-MS measurements, is combined with microdrilled stable carbon and oxygen isotope analysis on the well-preserved part of the shells. Data of this multi-proxy study is compared with results from a numerical growth model written in the open-source statistics package R[4] and based on annual growth increments observed in the shells and shell thickness. This growth model is used together with proxy data to reconstruct rates of trace element incorporation into the shell and to calculate the mass balance of stable oxygen and carbon isotopes. In order to achieve this goal, 2D mapping of bivalve shell surfaces is combined with high-precision point measurements and linescans to characterize different carbonate facies within the shell and to model changes in proxy data in three dimensions.

Comparison of sub-annual variations in growth rate and shell geometry with proxy data sheds light on the degree to which observed seasonal variations in geochemical proxies are dependent on internal mechanisms of shell growth as opposed to external mechanisms such as climatic and environmental change. The use of three different species of bivalve from the same paleoenvironment allows the examination of species-specific responses to environmental change. This study attempts to determine which proxies in which species of bivalve are suitable for paleoenvironmental reconstruction and will aid future paleoseasonality studies in interpreting seasonally resolved multi-proxy records.

References

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3 Steuber T. Geology. 1996.
4 R core team, 2004, www.R-project.org