Quaternary Science Reviews 350 (2025) 109068

Contents lists available at ScienceDirect

Quaternary Science Reviews

journal homepage: www.elsevier.com/locate/quascirev

Molluscan isotope sclerochronology in marine palaeoclimatology: Taxa, technique and timespan issues

Andrew L.A. Johnson [a,*], Bernd R. Schöne [b], Sierra V. Petersen [c], Niels J. de Winter [d], Harry J. Dowsett [e], Jean-François Cudennec [a], Elizabeth M. Harper [f], Ian Z. Winkelstern [g]

[a] School of Science, University of Derby, Derby DE22 1GB, UK
[b] Institute of Geosciences, University of Mainz, 55128 Mainz, Germany
[c] Department of Earth and Environmental Sciences, University of Michigan, Ann Arbor, MI 48109, USA
[d] Department of Earth Sciences, Vrije Universiteit Amsterdam, 1081 HV Amsterdam, the Netherlands
[e] U.S. Geological Survey, Florence Bascom Geoscience Center, Reston, VA 20192, USA
[f] Department of Earth Sciences, University of Cambridge, Cambridge CB2 3EQ, UK
[g] Geology Department, Grand Valley State University, Allendale, MI 49401, USA

ARTICLE INFO

Keywords:
Cenozoic
Marine palaeoclimatology
Global
Sclerochronology
Mollusc
Bivalve
Oxygen isotope
Clumped isotope

ABSTRACT

Study of the accretionary biomineralised hardparts of organisms (sclerochronology) can make a useful contribution to palaeoclimatology. Ontogenetic sequences of isotopic data ($\delta^{18}O$ and Δ_{47} values) from the shells of marine molluscs are a source of information on seasonal sea-surface temperatures that can be used for detailed and rigorous evaluation of the outputs of numerical climate models. In situations where there is significant seasonality, and where shell preservation is adequate, accurate information about winter and summer surface temperature can be obtained from shallow-water benthic forms (bivalves and gastropods), in particular the early ontogeny of fast-growing species. Accurate information about winter surface temperature can also be obtained from individuals that lived at mid-shelf depths (20–40 m), but summer seafloor values from these need upward adjustment to derive a plausible surface temperature if thermal stratification of the water column occurs in this season. Ontogenetic $\delta^{18}O$ profiles from planktonic pteropod gastropods are a potential source of insight into seasonal surface temperatures in the ocean basins; these organisms merit investigation for provision of information to complement shelf data.

Temperature profiles constructed from shell $\delta^{18}O$ require an estimate of the $\delta^{18}O$ value of ambient seawater, which can be derived by back-calculation from the Δ_{47}-temperature supplied by the same shell material. Alternatively, through appropriate sampling and data processing, seasonal temperatures can be obtained directly from Δ_{47} profiles. Climate parameters are defined in terms of the mean state over a period of 30 consecutive years, a statistic (e.g., for seasonal temperatures) which can be derived from the long isotopic temperature records obtainable from bivalve species that live for many tens or hundreds of years. Efforts should be made to acquire such records, especially averaged data from crossdated shells, to specify climate parameters for precise times in the past. Information for precise times would be of particular value for icehouse intervals like the late Cenozoic, characterised by high frequency (high amplitude) climate fluctuation. Short records from non-crossdated shells can nevertheless provide useful insights into climate, particularly if a large dataset is obtained, supplying a reliable picture of the mean state and range of variation in climate parameters over the interval represented by the shells.

1. Introduction

Although contemporary climate change is commonly discussed in terms of global mean surface temperature, it is more marked in certain areas of the planet, and may be manifested unevenly over the seasons. For instance, the increase in annual mean surface air temperature over the last 50 years in the Arctic is more than twice the global average, and the temperature increase there in winter is nearly double that in summer

* Corresponding author.
E-mail address: a.l.a.johnson@derby.ac.uk (A.L.A. Johnson).

https://doi.org/10.1016/j.quascirev.2024.109068
Received 1 June 2024; Received in revised form 25 October 2024; Accepted 5 November 2024