Palaeogeography, Palaeoclimatology, Palaeoecology 484 (2017) 33–47

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Oxygen isotopes from limpet shells: Implications for palaeothermometry and seasonal shellfish foraging studies in the Mediterranean

A.L. Prendergast [a,b,*], B.R. Schöne [a]

[a] Institute of Geosciences, University of Mainz, Germany
[b] School of Geography, University of Melbourne, Melbourne, Australia

ARTICLE INFO

Article history:
Received 30 October 2016
Received in revised form 7 February 2017
Accepted 7 March 2017
Available online 9 March 2017

Keywords:
Sea surface temperature
Mollusc
Stable isotopes
Shellfish foraging
Patella
Sclerochronology

ABSTRACT

Limpet shells are common components of many archaeological sites in the Mediterranean. To test whether $\delta^{18}O$ values from archaeological *Patella caerulea* shells can serve as a reliable palaeothermometer for the Mediterranean and a reliable archive of season of collection information, we collected live *P. caerulea* from eight Mediterranean locations in Croatia, Israel, Libya, Malta, Tunisia, and Turkey. Shell growth patterns were studied in section, and samples for oxygen isotope analysis were milled from the shells and used to calculate sea surface temperature (SST). As with other species of limpet, SST reconstructed from *P. caerulea* $\delta^{18}O$ values were lower than expected from observational records. However, when a correction factor of −0.72‰ was applied, the shells recorded SST within the range of instrumental SST. SST calculated from $\delta^{18}O_{shell}$ values of the most recently formed shell portion of monthly-collected shells from one site in Libya were strongly and significantly correlated with instrumental SST in the region ($R^2 = 0.95$). Oxygen isotope curves from individual shells sampled at high resolution from each of the study sites across the Mediterranean exhibited sinusoidal patterns. Annual growth lines correlated with the lowest $\delta^{18}O_{shell}$ values and were thus formed in summer. However, shell growth rates varied markedly between the sites. Some sites with larger shells recorded less than a year of growth in broad, highly irregularly shaped increments. At other sites, medium sized shells recorded several years of growth with clear, regular growth increments. A sclerochronological approach can therefore be used to pre-screen limpet shell sections before geochemical sampling. The $\delta^{18}O_{shell}$ values from shells sampled at high-resolution recorded the full seasonal range of instrumental SST at each collection site. This reinforces the potential of this species as one of the few sub-seasonal resolution palaeoenvironmental archives in the region. Additionally, the pattern of $\delta^{18}O_{shell}$ variation from the last formed shell portion was studied to determine whether accurate season of collection information could be identified from *P. caerulea* shells. The correct season was interpreted >80% of the time indicating that this species is a good candidate for seasonal shellfish foraging studies using archaeological shells.

1. Introduction

The oxygen isotope chemistry of biogenic carbonates has been used to reconstruct Quaternary climatic variations since the 1950s (Epstein et al., 1951; Emiliani and Mayeda, 1964). Mollusc shell chemistry in particular has gained popularity in the last decades as a reliable high-resolution archive of environmental change (e.g. Schöne and Gillikin, 2013; Prendergast and Stevens, 2014; Surge and Schöne, 2015; Twaddle et al., 2015), and also as a method to detect seasonal shellfish foraging patterns from archaeological sites (e.g. Shackleton, 1973; Bailey et al., 1983; Mannino et al., 2003; Burchell et al., 2013; Prendergast et al., 2016). The usefulness of mollusc shells as high-resolution archives stems from the growth patterns of the shells. Under favourable ambient environmental conditions, most molluscs precipitate shell material at regular time intervals, termed growth increments. Regular periods of slowdown and cessation of growth results in the formation of growth lines that significantly reduce shell formation rate with periodicities ranging from sub-daily to annual. Shell chemistry combined with detailed studies of shell growth provides highly resolved climate records. Depending on shell growth rates, high-resolution sampling of shells can yield environmental information from decadal to sub-daily time scales (Goodwin et al., 2001, 2003; Schöne, 2008).

Molluscs generally precipitate their shells in oxygen isotope equilibrium with surrounding ambient environmental conditions (Epstein et al., 1951; Wefer and Berger, 1991; Lécuyer et al., 2004). The oxygen isotope composition of marine mollusc shells is controlled by water temperature and the isotopic composition of seawater. In modern fully marine environments in mid to high latitudes, the effect of evaporation and rainfall on the stable oxygen isotope composition of seawater is

* Corresponding author.
E-mail address: amy.prendergast@unimelb.edu.au (A.L. Prendergast).

http://dx.doi.org/10.1016/j.palaeo.2017.03.007
0031-0182/