Palaeogeography, Palaeoclimatology, Palaeoecology 465 (2017) 295–299

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

New research in the methods and applications of sclerochronology

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ARTICLE INFO

Article history:
Received 11 October 2016
Accepted 7 November 2016
Available online 9 November 2016

ABSTRACT

Because the instrumental record is short and does not extend to periods before the initiation of significant human impacts, full understanding of the processes and dynamics involved in the modern phase of very rapid global change depends on the interpretation of high resolution and precisely dated proxy archives. The identification of very long-lived species of bivalve mollusc in the extratropical marine environment has been a crucial recent advance. These molluscs form patterns of periodic (usually annual) banding in their shells that are synchronous within populations, so that long (centennial and millennial) stacked chronologies can be built by crossdating from live collected to fossil shells. The variable growth rates and precisely dated geochemical data from the shell material provide long term real world data that can in principle be used to constrain climate models and to define long baselines for environmental monitoring. However, the signals in these data usually result from the complex interaction of multiple influences, and the deconvolution and understanding of these influences is a major target of the scientific field of sclerochronology.

This special issue presents some of the latest research into the sclerochronology of mollusc shells. It includes contributions to our understanding of shell growth, including the identification of endogenous (non-environmental) growth rhythms that persist throughout ontogeny, and analysis in two papers of variability through ontogeny in the season of growth and the implications of such variability for temperature reconstruction. One paper presents a new network of bivalve chronologies for UK waters, with a 200-year seawater temperature reconstruction. Three papers cover trace element geochemistry, including a novel approach to sampling for LA-ICP-MS that enables giant clam shells to be sampled at daily resolution, an attempt to identify an independent temperature proxy for coastal waters using limpet shells, and a detailed study of the drivers of variability in Sr/Ca and Ba/Ca ratios. One study looks at shell microstructure as a temperature proxy, finding a coherent temperature response in the shape of the prisms.

1. Introduction and background

As the complexity and resolution of global climate models increases, it is becoming more and more important to identify real world data that can be used to constrain model projections (Phipps et al., 2013). The ability of models to simulate the future development of the Earth's climate system under conditions of strong greenhouse forcing is limited by the length of instrumental records which started only about 150 years ago (Jones et al., 2001) and therefore do not record climate variability before anthropogenic greenhouse forcing became significant. Proxy-based records of conditions before the instrumental period are important tools for constraining model projections of equilibrium processes (which may take many centuries) and for understanding modern climate variability in the context of the natural background (Cubasch et al., 2013).

Particularly in the context of decadal and centennial scale model projections (the decadal scale, as the characteristic timescale of human perception, being of greatest concern to policymakers), it is also important to maximise the *resolution* of the proxy record, so that year-on-year and seasonal variability can be constrained. For this reason, the identification, development and interpretation of annually banded archives is a priority area for research. Up until quite recently, most such high resolution archives recorded conditions in the terrestrial environment, and the northern hemisphere in particular is well catered for with an array of tree-ring, ice core and speleothem records providing exhaustive global coverage.

However, the climate system is closely coupled, with the marine and terrestrial systems influencing each other on many different temporal and spatial scales, and a complete picture of the dynamics of past climate variability requires the use of terrestrial and marine proxies dated with equal accuracy and precision (e.g., Black et al., 2014). While corals have provided extensive annually resolved archives for the shallow-water, tropical marine realm (Knutson et al., 1972; Weber

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http://dx.doi.org/10.1016/j.palaeo.2016.11.013
0031-0182/