Geological Society of America
Special Paper 395
2005

Reconstruction of subseasonal environmental conditions using bivalve mollusk shells—A graphical model

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ABSTRACT

This paper presents a graphical model for high-resolution qualitative reconstructions of environmental conditions (temperature, food availability, and fresh-water influx) from bivalve mollusk shells. The growth rate–temperature model (GRT model) is based on the observation that temperature is the most important control of shell growth as shown by shells of *Phacosoma japonicum* (Reeve). A highly significant correlation (p <0.0001) exists between daily shell growth rate of this species and water temperature. Nonparametric bivariate density fields (NBDF) describe the area in which 95% of the growth rate–temperature data are plotted (observed temperatures or temperatures reconstructed from oxygen isotope ratios of the shell). Growth rate–temperature values deviating from the NBDF indicate significant variations in food availability and/or fresh-water influx (salinity changes).

The model is applicable to Recent and fossil bivalve mollusk shells. Its strength lies in the combination of sclerochronological (growth rate analysis) and stable isotope analyses. The integration of other environmental proxies (trace and minor elements and elemental ratios) archived in bivalve shells could further improve the GRT model and allow for high-resolution quantitative environmental reconstructions.

Keywords: bivalve mollusk shell, sclerochronology, oxygen isotope, modeling, temperature, food, fresh water.

INTRODUCTION

Bivalve mollusk shells provide an extremely valuable source material for high-resolution (annual, fortnightly, circadian, ultradian) paleoenvironmental reconstructions. Bivalves grow by periodic accretion of skeletal carbonate (Rao, 1954; Morton, 1970; Richardson et al., 1988) and record environmental information during their growth (e.g., Kennish and Olsson, 1975; Turekian et al., 1982; Williams et al., 1982). Periodic accretion of skeletal material partitions the hard parts into time intervals of near equal duration, e.g., in annual (Barker, 1964), fortnightly (Evans, 1972; Pannella, 1976), and daily growth increments (Evans, 1972; Clark, 1975; Schöne et al., 2002a). Growth increments can allow exact calendar dates to be assigned to each portion of the shells (Pannella and MacClintock, 1968; Koike, 1980; Goodwin et al., 2001). Bivalve shells are excellently suited for multiproxy environmental reconstructions as they preserve environmental information in various ways, i.e., chemical properties of their growth increments (e.g., Wefer and Berger, 1991; Mutvei et al., 1994; Goodwin et al., 2001) and in variable growth rates (Jones

Schöne, B.R., Hickson, J., and Oschmann, W., 2005, Reconstruction of subseasonal environmental conditions using bivalve mollusk shells—A graphical model, *in* Mora, G., and Surge, D., eds., Isotopic and elemental tracers of Cenozoic climate change: Geological Society of America Special Paper 395, p. 21–31, doi: 10.1130/2005.2395(03). For permission to copy, contact editing@geosociety.org.