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Preface

Unraveling environmental histories from skeletal diaries — Advances in sclerochronology

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ABSTRACT

High-resolution proxy archives from aquatic settings are essential to better understand processes and mechanisms of global change. During the last decade, it has become increasingly evident that calcified tissues of bivalve mollusks and cold-water corals, in particular, can significantly increase our knowledge of seasonal to multi-decadal paleoclimate and paleoenvironmental variability in the extratropical oceans and coastal marine settings. Daily, tidal, fortnightly and annual growth patterns of periodically formed skeletal hard parts provide a means to place the proxy record in a precise temporal context. Their extreme longevity coupled with the running similarity between growth increment time-series of contemporaneous bivalves opens the possibility of constructing stacked chronologies covering centuries to millennia which provide information on decadal climate and environmental variability and magnitudes of climate variability through time. A current major research focus is on how to translate geochemical properties of the skeletons into quantifiable environmental proxy data and how to eliminate the adverse influence of vital effects on the proxy records.

This special issue presents the most recent advances in the field of sclerochronology, specifically calcified tissues of bivalve mollusks, cold-water corals and tropical shallow water corals. The majority of the contributions deal with the potential reconstruction of temperature, pH and productivity through the analysis of variable growth rates, Sr/Ca, Mg/Ca, Ba/Ca, U/Ca, Li/Ca, $\delta^{13}C$, $\delta^{18}O$ and $\delta^{44/40}Ca$. Four papers present composite chronologies of two long-lived bivalve species and discuss inherent decadal climate variability, and one study demonstrates that sclerochronology can shed light on socioeconomic patterns of past human populations as well as resource use and resource management by people.

1. Introduction

Proxy records of paleoenvironmental conditions are essential to understand climate and ecosystem dynamics prior to the instrumental era (ca. 1860 A.D.; Jones et al., 2001, 2009). To draw a more detailed picture of the past, however, requires seasonally to annually resolved, precisely chronologically aligned and, most importantly, quantifiable proxy data from various geographical settings (IPCC, 2007).

The majority of high-resolution (= annual to subannual) climate and environmental archives come from the terrestrial realm and largely capture atmospheric and/or continental conditions (e.g., tree-rings, speleothems, ice cores). By contrast, paleoenvironmental and paleoclimate records from marine settings are sparse and often have poor temporal resolution. However, well-constrained subannually resolved archives for the marine environment do exist, i.e. in the form of sclerochronological[1] archives. Shallow-water corals have been used to reconstruct high-resolution paleoceanic records from around the tropics (Weber and Woodhead, 1970; Emiliani et al., 1978; Cobb et al., 2003). Shells of bivalve mollusks, fish otoliths, cold-water corals etc. are less utilized, but have significantly increased our knowledge of seasonal to interannual paleoclimate and paleoenvironmental variability in other portions of the oceans, in particular extratropical and coastal marine settings (Tripati et al., 2001; Dutton et al., 2002; Black, 2009; Ivany and Runnegar, 2010; Wanamaker et al., 2012; Yan et al., 2012). The relevance of such data becomes evident when considering that the extratropical oceans play a major role in global heat exchange

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[1] Sclerochronology is defined as the study of physicochemical variations in periodically growing hard tissues of organisms (Oschmann, 2009). Skeletochronology (Castanet et al., 1977), i.e. the study of physical and chemical variations in bones and teeth, should be considered as a sub-discipline of sclerochronology, because studies of skeletal parts (that form by accretion) of some vertebrates such fish otoliths have traditionally been already regarded as sclerochronology.

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