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Advances of sclerochronology research in the last decade

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ABSTRACT

Over the past decade, sclerochronological research has continued to develop rapidly and is diversifying with respect to methods, taxa, geographic coverage as well as temporal depth. Chonologically aligned environmental records from bivalves, gastropods, coralline algae, corals, and many other periodically formed biogenic hard parts are integrated to build networks across broad spatial domains and trophic levels. Replication and exact dating ensure that environmental signals are fully preserved and facilitate the integration among chronologies as well as observational records of climatic and biological phenomena. The proliferation of chronologies promises to usher in a new era of synthesis that integrates tropical to polar environments and links with other high-resolution archives such as tree-ring chronologies to assess broad-scale couplings between the ocean and atmosphere across different latitudes. An increasing number of studies also applies sclerochronological methods to fossils from the more distant past and studies paleoclimate variability in deep time. At the same time, rapid advances are being made in developing, optimizing and validating proxies from isotopes, trace and minor elements, and ultrastructures (aka microstructures) of periodically growing skeletal hard parts to reveal new parameters of environmental variability from these exactly dated frameworks. Beyond the importance for paleoclimatology, information recorded in such archives is of increasing relevance to ecology and management to provide insights on life history, population connectivity, productivity, and disentangling the impacts of natural and anthropogenic environmental and climate change. Likewise, environmental information from archaeological samples are providing new insights into long-term interactions between climate variability and dynamics of past human societies. This review paper provides insights into advances in the field of sclerochronology, with an emphasis on mollusks, including trends in the analysis of growth patterns, development and interpretation of proxies, diversity of taxa used in sclerochronological research, as well as the geographic and temporal coverage of sclerochronological research.

1. Introduction

Evidence is now overwhelming that the Earth is warming in response to the anthropogenic use of fossil fuels (IPCC, 2014). Our ability to predict the future climate, in relation to various emission scenarios, strongly relies on complex coupled numerical climate models (Reicher and Kim, 2008; Delworth et al., 2012). Although those models are based on physical and chemical processes observed and described in today's environment, they need to be tested with climate settings not observed on Earth today. To achieve this goal, we rely on paleodata both from continental and oceanic environments. Two types of paleoclimatic archives are available: those that yield a long, continuous record (thousands to millions of years long) but usually with low temporal resolution (typically ranging from decades to centuries), and those providing a much shorter temporal coverage (at best a few centuries) but with high temporal resolution (from days to a few months). Sclerochronology is an important contributor to the second kind of archives, and has provided a wealth of data in recent years. The most comprehensive definition of the term 'sclerochronology' has been provided in the conference booklet of the 1st International Sclerochronology Conference held at St. Petersburg, Florida, USA in 2007, and subsequently quoted by Oschmann (2009) in his introduction to the special issue that

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