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Mollusk carbonate thermal behaviour and its implications in understanding prehistoric fire events in shell middens

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ABSTRACT

Archaeological shell middens are particularly important for reconstructing prehistoric human subsistence strategies. However, very little is known about shellfish processing, especially when related to the use of fire for dietary and disposal purposes. To shed light on prehistoric food processing techniques, an experimental study was undertaken on modern gastropod shells (*Phorcus lineatus*). The shells were exposed to high temperatures (200–700 °C) to investigate subsequent mineralogy and macro- and microstructural changes. Afterwards, the three-pronged approach was applied to archaeological shells from Haua Fteah cave, Libya (*Phorcus turbinatus*) and from shell midden sites in the United Arab Emirates (*Anadara uropigimelana* and *Terebralia palustris*) to determine exposure temperatures. Results indicated that shells from the Haua Fteah were exposed to high temperatures (600–700 °C) during the Mesolithic period (ca. 12.7–9 ka), whereas specimens from the Neolithic period (ca. 8.5–5.4 ka) were mainly exposed to lower temperatures (300–500 °C). The thermally-induced changes in *A. uropigimelana* and *T. palustris* shells from the South East Arabian archaeological sites were similar to those seen in *Phorcus* spp. suggesting a broad applicability of the experimental results at an interspecific level. Although heat significantly altered the appearance and mineralogy of the shells, $^{14}C_{AMS}$ ages obtained on burnt shells fit within the expected age ranges for their associated archaeological contexts, indicating that robust radiocarbon ages may still be obtained from burnt shells. Our study indicates that the combination of microstructural and mineralogical observations can provide important information to infer shellfish processing strategies in prehistoric cultures and their change through time.

1. Introduction

Shells grow incrementally throughout the lifetime of mollusks and function as protection and support structures. Shells also serve as excellent palaeoenvironmental archives (i.e. Jones, 1983; Schöne et al., 2004; Butler et al., 2013), because they faithfully record the physical and chemical conditions of their ambient environment and temporal changes to these. Such information is stored in the form of geochemical and structural properties (Epstein et al., 1953; Goodwin et al., 2001; Schöne, 2008). Sclerochronology is the research field that studies the temporal context of shell chemical composition (i.e. stable isotopes and trace elements) and physical accretionary patterns to produce extremely highly resolved palaeoenvironmental reconstructions (Schöne et al., 2005; Miyaji et al., 2007; Milano et al., 2017; Oschmann, 2009). For example, shell oxygen isotope content ($\delta^{18}O_{shell}$) is routinely used as paleothermometer (Schöne et al., 2005; Ferguson et al., 2011; Prendergast et al., 2013; Prendergast and Schöne, 2017).

A rapidly growing interest in the research field of sclerochronology supports the spread of its methodologies and approaches to different disciplines such as archaeology and environmental biomonitoring (Mannino and Thomas, 2002; Andrus, 2011; Steinhardt et al., 2016; Schöne and Krause, 2016). The analysis of mollusk shell material is especially relevant within the framework of prehistoric archaeology. Shellfish have been an important dietary component since the

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