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Ostracodological studies in archaeological settings: a review

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ABSTRACT

During recent years, geo-archaeology has been revitalised and much effort has been made to combine geo-archaeological sciences like geomorphology, sedimentology, micropalaeontology and geochemistry with the cultural archaeological approach. The first definition of geo-archaeology dates back to the late seventies and since then has evolved to include more and more multidisciplinary studies. In this perspective, ostracods play a crucial role since they are valuable palaeoenvironmental indicators in all aquatic habitats, from freshwater to marine. Despite their potential, the integration of ostracods in archaeological studies has not been immediate. Only in the nineties did ostracod geo-archaeology seem to finally take its place, including a systematic approach to ostracod studies in archaeological excavations. Since then, many geo-archaeological investigations have included ostracod analyses, exploiting their potential as multitask tools. The research papers composing this special issue, demonstrate that ostracods can be used in the most diverse settings as tracers of archaeological material provenance, proxies for palaeoenvironmental and palaeoclimate reconstructions as well as clues to human impact.
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1. Introduction

In the last few decades, geo-archaeology has boosted its multidisciplinary approach including applying micropalaeontology to study the environmental context of the studied sites. In 1976, Davidson and Shackley's volume "Geo-archaeology: earth science and the past" provided the first definition of geo-archaeology as a tool to understand the context of the archaeological findings. Despite their potential, the integration of ostracods in archaeological studies was introduced much later and the first published paper with formal ostracod analyses dates from 10 years later (Robinson, 1984). In the nineties, ostracod geo-archaeology seemed to finally take its place with, among others, studies about Maya agriculture (Bradbury et al., 1990), Neolithic human occurrence in Central Sahara (Carbonel, 1991), prehistoric human occupation in North America (Palacios-Fest, 1994) and also a systematic approach to ostracod studies in archaeological excavations (Griffiths et al., 1993). In recent years, the significance of ostracods in archaeological studies, to reconstruct past landscape and climate conditions through the autoecological preferences, including temperature, of species and assemblages and the isotopic and chemical signature of their low magnesium calcite carapace has become evident (Holmes and Chivas, 2002; Holmes et al., 2010; Horne et al., 2012). In particular, the methodological paper of Marriner et al. (2010) provided a new input to geo-archaeology applied to ancient harbours. In combination with other proxies, the value of ostracods is particularly strong (Boomer et al., 2007; Pepe et al., 2013; Delile et al., 2014).

The aim of this issue is to propose different applications of ostracod analysis within geo-archaeological studies. It is likely that ostracods are the most frequent microfossils found in archaeological excavations, due to their occurrence in a wide range of aquatic environments. In freshwater environments, for instance, other microfossils such as foraminifera are absent and diatoms are not always preserved due to insufficient silica content (Anadón and Gabàs, 2009; White et al., 2013). In inland water-bodies, both permanent and temporary, ostracod assemblages can provide extremely detailed information on the evolution of the water body and, through the integration with modern data, can be used to create a conductivity transfer function (Mischke et al., 2014). In some cases, ostracods can be so well preserved that the soft tissues can be observed within the valves (Kalbe et al., this issue). Ostracods are also commonly used in marginal marine environments where oligotypic foraminifer assemblages cannot provide the required information and diatom assemblages may contain mixed

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material washed from rivers, tributaries and sea (Boomer et al., 2003). Along the Mediterranean coasts many coastal harbours have been studied with a geoarcheological approach that includes the use of ostracod analyses, as in Alexandria in Egypt (Goiran et al., 2000), Marseille in France (Morhange et al., 2003), Luna and Portus in Italy (Bini et al., 2012; Mazzini et al., 2011; Goiran et al., 2010), ancient Tyre in Lebanon (Marriner et al., 2008), Kition in Cyprus (Morhange et al., 2000) and Ephesus in Turkey (Stock et al., 2013). In continental settings, ostracods have recently been used to reconstruct the salinity and aquatic environments in the Neolithic Rio Sizandro, Portugal (Lord et al., 2011), to shed light on the complex fluvial, sea-level and archaeological history of the Thames River at Swanscombe, England (White et al., 2013), to investigate the palaeoenvironment and palaeoclimate at Boxgrove, England (Holmes et al., 2010), and to study the long-term evolution of the Paleolithic sites in a desert oasis in Syria (Le Tensorer et al., 2007).

Most of these studies were performed on sediment cores, some on stratigraphic sections or took advantage of modern infrastructure constructions (Bridgland et al., 2013), but all of them used a multi-proxy approach, combining the ostracodological analyses with other palaeontological proxies, such as pollen or mollusc analyses and sedimentological, geochemical and geo-chronological data.

2. Ostracods as tracers of archaeological material provenance

Microfossils have been found in a wide range of material from archaeological sites. Their use for provenance purposes is not very frequent, requiring the destruction of the investigated material through thin sections or mechanical/chemical treatment. Thus, this research can be performed only on sherds or less important archaeological material. The most common studies concern the study of microfossil assemblages in ceramics to pinpoint the exact provenance of the raw material used by the ancient potters (see Quinn and Day, 2007a for a review). Ostracods have been used in different settings together with other calcareous microfossils. They were used in Germany to assess the provenance of the mosaic stones of the villa suburbana in Friedberg and in Unterbaar (near Ausburg) (Flügel, 1999). In Crete (Greece) they have been fundamental for assessing the provenance of Bronze Age Aegean ceramics (Quinn and Day, 2007b) and generally to assess the provenance of cooking ware and amphorae in the Mediterranean (Capelli and Bonifay, 2014). In many of these cases, ostracods were analysed in thin sections and their determination to a generic or specific level was impossible. Thus, their occurrence together with other microfossils usually studied in thin sections, especially foraminifers, could be used to determine the provenance area. The final aim was to understand the provenance of the objects, thereby contributing to knowledge of the commercial and transport routes in ancient Greek and Roman times.

The question of provenance of building materials has also been analysed from a palaeontological perspective, using foraminifera and ostracods in particular. The main aim in this case was to understand how man exploited the surrounding territory for his own purposes (Wilkinson et al., 2008). Lately, both methodologies have been at the same site, to assess the provenance of late Iron Age potsherds and of the clay from the till at the Burrough Hill fort, England (Williams et al., this issue).

3. Ostracods as key proxies to reconstruct ancient wetland palaeoenvironments

Wetlands are defined as "areas of marsh, fen, peat-land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low-tide does not exceed 6 m" (Ramsar Convention Secretariat, 2013). In such environments ostracods thrive, many species being tolerant to high ranges of salinity variation and having developed long-term (diapausing eggs) or short-term (juveniles and adults protected by a closed carapace) strategies to survive desiccation (Aguilar-Alberola and Mesquita-Joanes, 2011). Wetlands have always been linked to human history, thus being of particular interest for archaeological excavations and geo-archaeological studies. Wetlands can be related to river deltas and estuaries, to coastal areas in lacustrine and marine settings, where climatic, environmental and social changes are amplified. Geo-archaeological studies in wetland areas mainly deal with ancient harbour basins, and the role ostracod assemblages play in their palaeoenvironmental reconstructions has been highlighted by Marriner et al. (2010). In what they defined as "coastal harbour parasequence", ostracod assemblages play a key role in differentiating natural and artificial environments. This approach has been used in many geoarcheological studies on Mediterranean coastal harbours (Mazzini et al., 2011; Pint et al., this issue). The same approach has been used in a lacustrine setting, in the harbour system of Magdala, by the Sea of Galilee in Israel (Rossi et al., this issue) and in the sahelian area in Africa (Fontes et al., 1985). When not involving harbour constructions directly, ostracods become very useful in reconstructing past coastal environments, in particular when coastal dynamic effects cause changes in salinity, and human management affects coastal hyperhaline lagoons (Vittori et al., this issue). Generally, the genus *Cyprideis* is the most common ostracod found in the unstable lagoonal environments or in those environments characterised by salinity variations. The ecophenotypical plasticity of *Cyprideis* (Wouters, 2002) and in particular of the living euryhaline species *Cyprideis torosa*, has been studied in detail with regards to the soft parts, surface ornamentation, sieve pore shape and size (Rosenfeld and Vesper, 1977; Van Harten, 1996, 2000; Wouters, 2002; Keyser and Aladin, 2004). In particular, the occurrence of noded and un-noded forms of *C. torosa* or some other ostracod groups such as *Limnocythere* have often been used as a proxy of palaeoenvironmental changes (Aladin, 1993; Mourguiart and Carbonel, 1994; Kalbe et al., this issue; Rossi et al., this issue; Lord et al., 2011). When *Cyprideis* is found in inland waterbodies, its occurrence poses questions about the salinity of the water and could be interpreted as a signal of increased salinity linked to evaporation, or as the witness of the occurrence of saline springs which affect locally the freshwater body (Hula Valley, Israel, in Kalbe et al., this issue).

4. Ostracods, palaeoclimate and human impact

Human occupation of a territory is linked to several factors: climatic conditions, environmental conditions and adaptive capabilities. Both prehistoric and historic societies have been affected by climatic changes. The migrations that occurred in Europe during the Neolithic (Paschou et al., 2014) or the occupation of the Eastern Sahara during the Holocene humid period (Manning and Timpson, 2014) and in the east African rift (Carbonel et al., 1983; Peypouquet et al., 1983) are just some of many examples. Ostracods can be helpful not only in identifying humid periods in continental settings but also to characterise newly formed water-bodies (Mayr et al., this issue). However, human occupation often triggers environmental changes that can in turn affect society as well, leading to settlement abandonment and migration. In Mesoamerica, for instance, during the Early to Middle Pre-classic Periods (1800–350 B.C.) the landscape was devastated by deforestation, as recorded in many sedimentological records (McNeil, 2012). Pre-classic populations caused significant environmental damage throughout the Maya lowlands as they first experimented with

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