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Neanderthal Shell Tool Production: Evidence from Middle Palaeolithic Italy and Greece

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Abstract The vast majority of tools recovered from Palaeolithic sites are made of stone varieties. Only rarely do non-lithic implements come to light, let alone tools produced on marine mollusc shell. Interestingly, a good number of shell implements made on *Callista chione* and *Glycymeris* sp. valves have been reported from 13 Middle Palaeolithic (Mousterian) sites in southern peninsular Europe. Of these, more than 300 specimens display evidence of deliberate edge retouch. They are all considered products of Neanderthals and date from ~110 ka BP to perhaps ~50 ka BP. In this paper, we review the evidence for Mousterian shell tool production in Italy and Greece—the only two countries in which such tools have been securely identified—and present experimental results obtained in the effort to understand the production process and typo-functional role(s) of the artefacts. We examine the general provisioning pattern of raw materials, as well as the typological, species-related and chronological data pertinent to the production of shell tools by Neanderthals. The data suggest that the Mousterian shell scrapers are a response to poor availability of lithic raw material in the areas of occurrence, and may be best described as an extension of chipped stone technologies to specific types of marine shell, their form defined by an existing mental template. As such, they constitute evidence for refined adaptation strategies and advanced provisioning of resources amongst Neanderthals, and may lend further support to the idea that these hominids displayed a degree of complex behaviour.

Keywords Shell tools · Scrapers · Neanderthals · Marine shell · *Callista chione* · Middle Palaeolithic · Italy · Greece

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Introduction

The utilization of marine shells in the Palaeolithic has gained particular attention in the last decade, when the antiquity of shellfish remains has been extended both spatially and temporally and has been associated with the notion of 'behavioural modernity' and the origins and spread of anatomically modern humans (e.g. Wadley 2001; Henshilwood and Marean 2003; Mellars 2005; Hovers and Belfer-Cohen 2006; Szabó et al. 2007). An earlier generation of researchers (Binford 1968; Washburn and Lancaster 1968; Osborn 1977) argued that marine resources and aquatic habitats—as opposed to land resources and terrestrial environments—were not systematically used by humans until relatively recently, mainly towards the Terminal Pleistocene and early Holocene (Erlandson 2001). Even then, the exploitation of marine resources was only seen as a response to demographic pressures caused by rapid population growth, migrations or climate-forced fluctuations of resource availability (Bar-Yosef 2004). On Gamble's (1994) catalogue of the ten ecological settings most significant to human evolution no aquatic habitat was listed. While this neglect of marine resources is thought to have stemmed from the extreme scarceness of archaeological marine remains in Palaeolithic sites (Erlandson 2001), it often overlooks a critical fact: sea level fluctuations. At the onset of the Holocene, in particular, large tracts of land were inundated and coastal archaeological horizons were submerged (Lambeck and Chappell 2001). As a result, what currently appears a coastal site may have been positioned several kilometres inland during the Last Glacial (e.g. Lambeck 1996; Lambeck and Bard 2000; Erlandson 2001); evidence of marine remains is, not surprisingly, scarce.

In recent years there has been a paradigm shift. The exploitation of marine resources by early hominids, and especially by Neanderthals, whether for subsistence purposes (Stiner 1994; Stringer et al. 2008; Zilhão and Villaverde 2008; Colonese et al. 2011; Douka and Higham 2012), symbolic activities (Zilhão et al. 2010) or tool production (Dantoni 1980; Vitagliano 1984; Stiner 1993), has become more widely accepted.

This review paper is an effort to gather and report the full evidence for tool production on marine shell during the Middle Palaeolithic in southern peninsular Europe, particularly Italy and Greece where this behaviour is most pronounced.

Middle Palaeolithic (Mousterian) Tools

Mousterian lithic tools have been systematically studied for over a century. In Europe, they are currently associated with Neanderthal populations. The classical typological approach conventionally classifies the end-products of the manufacturing process—the formal tools (Bordes 1961)—while the technological approach (Tixier et al. 1980; Boëda 1986; Pelegrin et al. 1988; Delagnes and Meignen 2006) is focused on the *chaîne opératoire* (Leroi-Gourhan 1964) and seeks to analyze the entire fabrication process, from the idea of the maker (Boëda et al. 1985; Pelegrin 1985; Boëda 1994) to the final discard. In addition, many researchers have stressed the 'life' of the object, in order to shed light on all the modifications it incurs in its use life (Frison 1968; Jelinek 1976).

Several dimensions of stone tool variability are often subsumed under the concept of lithic technological organization (Binford 1973; Shott 1986; Kelly 1988; Nelson 1991). According to this concept, the way tools are designed, produced, recycled, and discarded is closely linked to forager land-use practices, which in turn are associated with environmental and resource exploitation strategies (Odell 1988; Torrence 1989; Bamforth 1991).

In this context, Mousterian scrapers play a major role for two reasons. Firstly, scrapers of different morphologies (Bordes 1961) are the most common Mousterian tool. Secondly, since the studies of H. Dibble in the 1980s (Dibble 1984, 1987), it has been assumed that the morphology of the scrapers varies throughout a use-life in which they play a variety of roles. The majority of Palaeolithic stone tools, including scrapers, are produced on flint/chert, quartzite, limestone and obsidian. Since scrapers are so useful to the Mousterians, did they produce them from hard material other than stone?

Shell as Raw Material

The choice and procurement of raw material by early hominids, and their implications for territorial land-use and exchange networks in foragers' systems (Bamforth 1990, 1991), have received particular attention over the years (Demars 1980; Geneste 1985; Turq 1990). In the Mousterian, provisioning of almost exclusively local raw material has been considered the norm (Féblot-Augustins 1993, 2008), although recent studies have suggested a different pattern (Slimak and Giraud 2007), particularly in regions where high-quality lithic raw materials are hard to come by (Spinapolice 2008, 2012) and in which exotic sources are becoming important.

Mousterian implements made on materials other than stone have received considerably less attention, a fact possibly reflecting their scarceness and reduced likelihood of surviving in the archaeological record of the period. An interesting alternative to stone is marine mollusc shell, a polycrystalline biomineral with excellent mechanical properties (Liang et al. 2008; Barthelat et al. 2009) and high chances of survival compared to other organic materials.

Choi and Driwantoro (2007) suggested the exploitation of marine shell for the production of tools by early members of *Homo erectus* in Southeast Asia at about 1.6 Ma ago. In the case of European Neanderthals, the use of shell as raw material for tool manufacture was initially identified during the mid-twentieth century in southern Italy, where the first humanly-modified shells were unearthed (Blanc 1958–1961). Over the subsequent decades, numerous Italian sites were reported to contain similar evidence (Dantoni 1980; Vitagliano 1984), and recently, the occurrence of Mousterian shell tools was confirmed in southern Greece (Darlas and de Lumley 1995). Shellfish remains associated with Neanderthal populations have also been found in Iberia (Álvarez-Fernández 2010), for example, the shell assemblage of Cueva de los Aviones in Spain (Zilhão et al. 2010), but neither use-wear nor retouch was reported on any of the specimens; this case will not be examined further in this paper.

Mousterian Shell Implements in Italy and Greece

In southern peninsular Europe, the exploitation of shell as a raw material for the production of tools has been identified in 13 Mousterian contexts: 12 cave and open-air sites in Italy and one cave in Greece (Fig. 1). Overall, four major geographical site clusters can be identified (Fig. 1):

i. eight sites in southern Italy, Salento Peninsula (Uluzzo Bay and Capo di Leuca)
ii. one site in central Italy, Latium
iii. three sites in northern Italy, the Grimaldi caves complex
iv. one site in southern Greece, Mani peninsula.

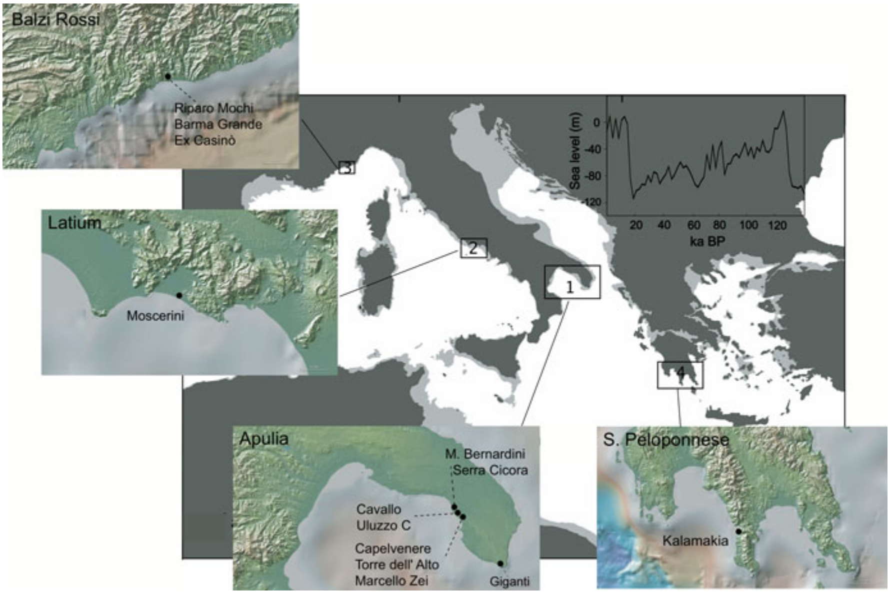

Fig. 1 Map of Mousterian sites with identified industries on *Callista chione* shell. Four spatial clusters are shown (see text for details). In the central map, the *lighter grey line* corresponds to the Mediterranean shelf at −100 m (modified after Colonese et al. 2011). The fluctuation of sea level during the last 120 ka is shown on the *top right corner* in relation to modern level (point 0) (data from Siddall et al. 2003)

The following section gives some background information on these sites and reviews the published data on the shell industries. Many of these sites were excavated over half a century ago, but are still very poorly known. The shell of the marine bivalve *Callista chione* (Linnaeus 1758) of the Veneridae family is by far the shell of preference for Neanderthals and dominates all assemblages containing humanly modified shell tools.

A modern *C. chione* valve and the terminology of anatomical features used in the text for the description of the shell implements, are shown in Fig. 2.

Grotta del Cavallo

The Site

Grotta del Cavallo (40°9′18.85″N, 17°57′37.27″E) opens on the rocky coast of the Bay of Uluzzo, near Nardò, in Apulia (Fig. 1). The cave was excavated in a series of excavations during the 1960s (Palma di Cesnola 1963, 1964, 1965a, 1965b, 1966) and from 1984 to 2008 (Sarti et al. 1998–2000; Sarti et al. 2002).

Grotta del Cavallo has become a reference site for the Middle Palaeolithic and Uluzzian industries of southern Italy, as it preserves an exceptionally long stratigraphy (Palma di Cesnola 1967, 1996). The basal layer, a Tyrrhenian (Last Interglacial, Oxygen Isotope Stage 5) beach (Layer NII), is directly capped by about 7 m of archaeological deposits, which include—from bottom to top—a series of Mousterian layers (M IV-F) followed by Uluzzian layers (E–D), an Epigravettian/'Romanellian' stratum (Layer B), and a layer attributed to the Neolithic and/or more recent periods (A) (Fig. 3.1). In 2011, two molars found in the Uluzzian layers of Cavallo were shown to belong to the earliest anatomically

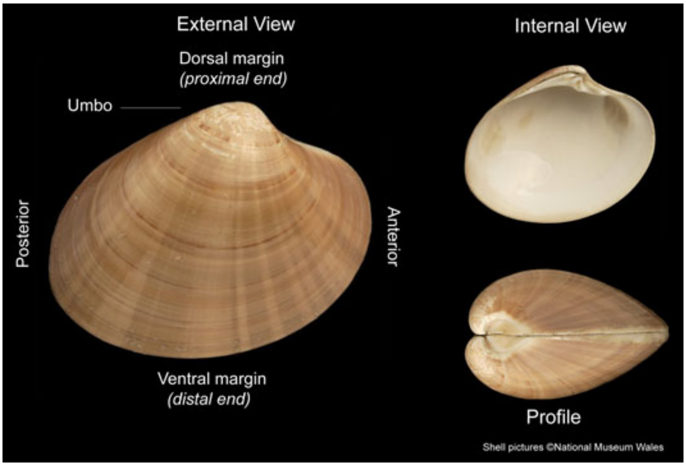

Fig. 2 Internal, external and profile views of the shell of *C. chione*. Terminology of anatomical features used in the description of the shell implements is indicated. Images copyright National Museum Wales

modern humans in Europe and were dated by association to between 43 and 45 ka cal BP (Benazzi et al. 2011).

The lower layers have more relevance to this paper. Layer M is attributed to a Quina Mousterian of the Charentian tradition (Palma di Cesnola 1966, 1996). It is characterized by large tools on limestone and smaller implements in flint and jasper. Scrapers dominate the assemblage and a significant number of Mousterian points were also found there (Palma di Cesnola 1996). The lithic assemblage of Layer I is defined as a Denticulate Mousterian, possibly marking the end of the local Charentian cycle (Palma di Cesnola 1966, 1996; Sarti et al. 1998–2000; but see Thiébaut 2005). Sidescrapers and Mousterian points are manifestly reduced while retouched flakes and denticulates are abundant. The youngest Mousterian levels, F3 and F2-1, Evolved Levallois Mousterian and Final Denticulate Mousterian respectively (Palma di Cesnola 1967), are technologically characterized by Levallois reduction methods and are rich in formal tools such as scrapers, endscrapers and points.

The Mousterian industries in Layers M to F were produced on both local raw materials, such as limestone, siliceous limestone and shells, and exotic ones, such as flint, quartzite and jasper.

Shell Industry

Shell tools were found in three Mousterian layers at Cavallo: M, L and I (Figs. 4, 5).

The uppermost cuts of Layer M (Sub-layer I) yielded only a few *C. chione* implements; their overall number is low and no exact description is available.

In contrast, Level L, directly on top, yielded about 300 fragments of *C. chione* shells. Forty-five of these show evidence of deliberate edge retouch and are classified as tools (Palma di Cesnola 1966, 1989). Due to the predominance of shell elements in this layer (about 400 were lithic implements), Palma di Cesnola (1967) defined the assemblages from horizons LII and LI as a 'Mousterian on *C. chione*' facies. Unfortunately, the excavation method, as well as the limited size of the excavated area, makes it difficult to evaluate the exact proportion of shells with respect to the entire lithic assemblage of Layer L.

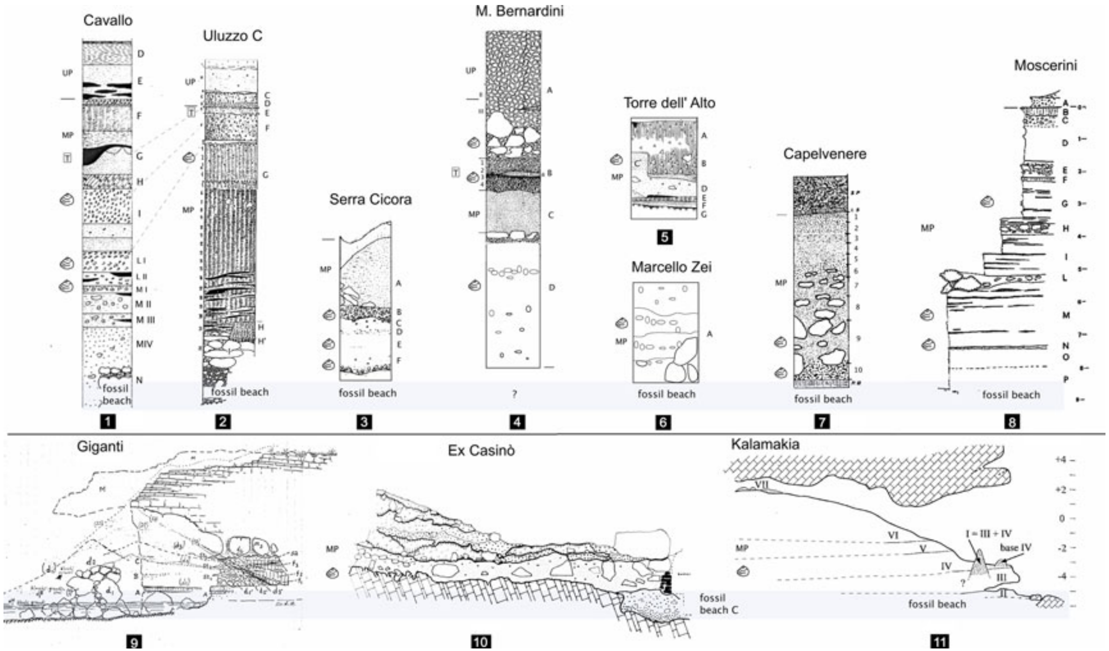

Fig. 3 Drawings of stratigraphic sections of the sites mentioned in the text. *1*. Grotta del Cavallo; *2*. Grotta Uluzzo C; *3*. Grotta di Serra Cicora A; *4*. Grotta Mario Bernardini; *5*. Grotta Torre dell'Alto; *6*. Grotta Marcello Zei; *7*. Grotta di Capelvenere; *8*. Grotta dei Moscerini; *9*. Grotta dei Giganti; *10*. ex-Casinò; *11*. Kalamakia. Modified after Palma di Cesnola (1969), Borzatti von Löwenstern (1966), Borzatti von Löwenstern and Magaldi (1969), Borzatti von Löwenstern (1970), Vicino (1974), Vitagliano (1984), Campetti (1986), Lebreton et al. (2008), Spinapolice (2009)

In contrast to Layer L, there were few shells in Layer I. Amongst about 510 lithic implements, only a small (unknown) number of tools were manufactured on *C. chione* shells (Sarti et al. 2002).

Cristiani et al. (2005) briefly reviewed part of the shell industry from Layer L. They found that it includes blanks (considered 'manufacture waste' in their publication) and straight-edged tools with inverse retouch on the external surface (inverse retouch occurs on the external face of the shell, that which in lithic analysis would be termed the ventral surface). Typologically, the Cavallo shell tools can be classified as scrapers. The retouch is scalar, invasive and, sometimes, overlapping (Cristiani et al. 2005).

Grotta Uluzzo C

The Site

Grotta Uluzzo C (40°9′31.28″N, 17°57′35.03″E) is a karstic cave also located on the Uluzzo Bay, between Grotta del Cavallo and Grotta di Uluzzo (Fig. 1). Discovered in 1961, the cave was excavated from 1963 to 1968 by E. Borzatti von Löwenstern (Borzatti von Löwenstern 1965, 1966; Borzatti von Löwenstern and Magaldi 1969).

A small trench, about 6.5 m deep, revealed dense archaeological levels, rich in artifacts, fauna and hearths. The archaeological sequence of Uluzzo C comprises Mousterian, Uluzzian and Epigravettian levels (Fig. 3.2).

At the base of the stratigraphy, three marine horizons, H, I and L, probably relate to the beginning of the Last Interglacial (Oxygen Isotope Stage (OIS) 5e). Level L is a fossil beach with few marine shells (*Ostrea* sp., *Nassarius* sp. and *Trochus* sp.). A similar marine conglomerate is located at the front of the cave, and demonstrates the same range of molluscan fossils. Layers G to E yielded Mousterian lithic artifacts. According to Borzatti von Löwenstern (1966), Layer D stratigraphically contains the transition from the Middle to Upper Palaeolithic. Layer C is attributed to the Uluzzian, Layer B is sterile, and Layer A has yielded Upper Palaeolithic 'Romanellian' lithic industry (Riel-Salvatore 2007).

The Mousterian industry of Layer G has recently been reviewed by one of us (Spinapolice 2008). The richest part of the layer is the middle part, from Spits XI to XVII. The reduction sequences are characterized by the utilization of the Levallois methods coupled with more expedient techniques.

The raw materials are mostly local (up to 86 % of the assemblage from G). Formal tools are often produced on local materials, while the occasional presence of flint is mostly linked to highly curated tools (Spinapolice 2008). Scrapers are the most common tool; they are normally simple, but double and transverse scrapers are also present. Borzatti von Löwenstern (1965, 1966; Borzatti von Löwenstern and Magaldi 1967) defined this assemblage as 'Quinson Mousterian', but more recent analysis (Spinapolice 2008) suggests that this cultural attribution needs to be reviewed on the basis of raw material economy, which has strongly influenced the organization of technology at the site.

Shell Industry

Layers I and L, which correspond to the Tyrrhenian beach, yielded fragments of *Patella* sp., *Ostrea* sp., *Nassa* sp. and *Trochus* sp.

According to Borzatti von Löwenstern (1966), retouched and unretouched shells of *C. chione* and *Glycymeris glycymeris* (or *pilosa*) were found in the upper parts of Layer G

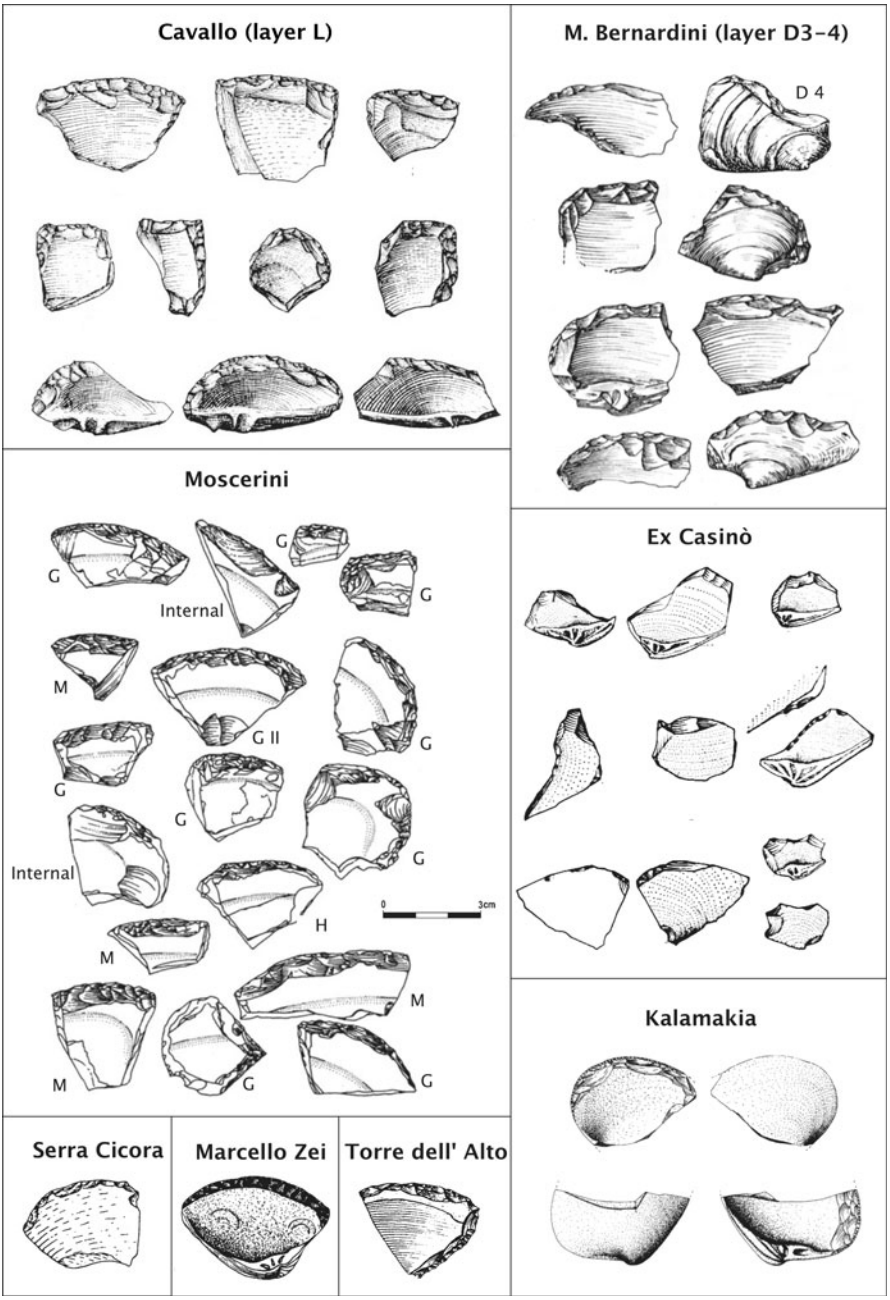

Fig. 4 Illustrations of Mousterian scrapers made on *Callista chione* shells from Grotta del Cavallo, Grotta Mario Bernardini, Grotta di Serra Cicora A, Grotta Marcello Zei, Grotta Torre dell'Alto, Grotta dei Moscerini, ex-Casinò and Kalamakia Cave. Modified after Palma di Cesnola (1965b), Borzatti von Löwenstern (1971), Campetti (1986), Dantoni (1980), Borzatti von Löwenstern (1966), Vitagliano (1984), Vicino (1974), Darlas (2007)

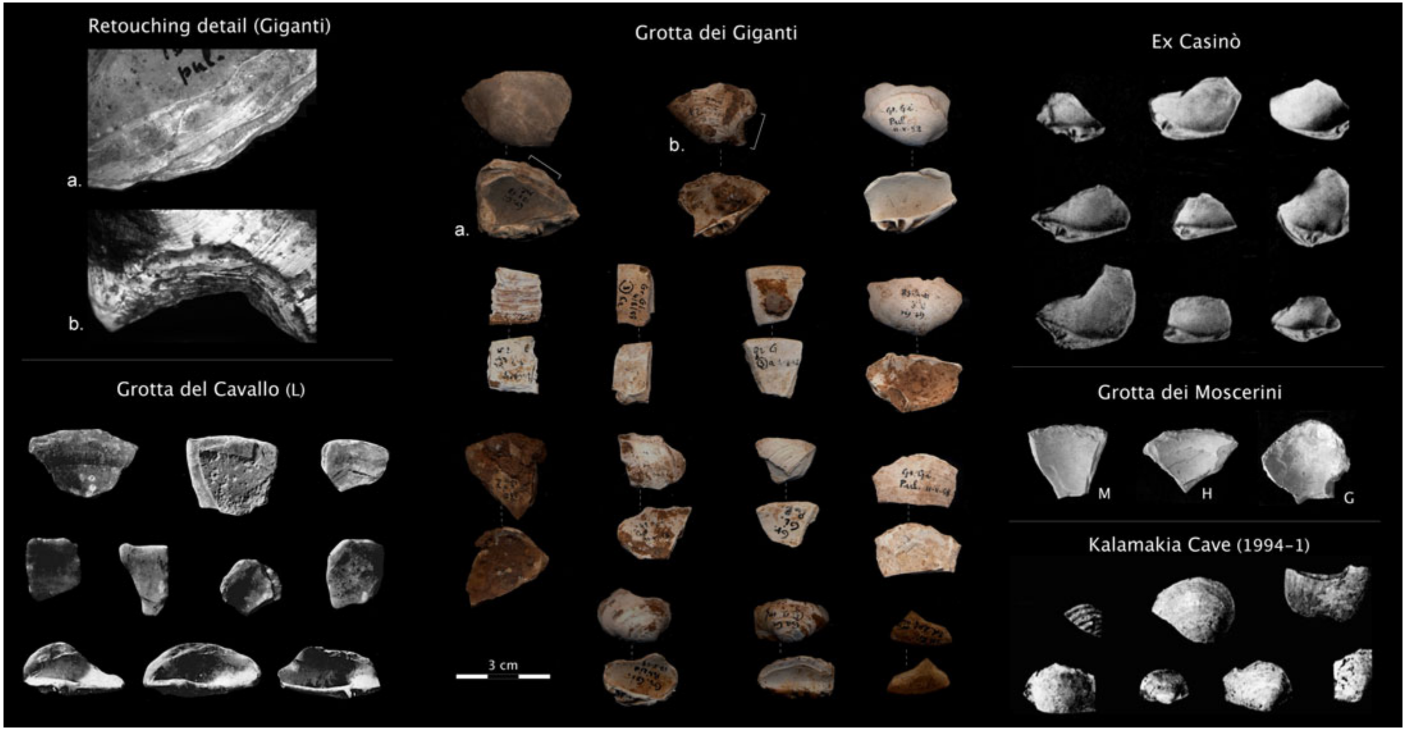

Fig. 5 Mousterian *Callista chione* scrapers from Grotta del Cavallo (Layer L), Grotta dei Giganti (interior and exterior shell surfaces), ex-Casinò, Grotta dei Moscerini (Layers M, H and G) and Kalamakia cave (Horizon 1994–1). On the *top left corner*, detail of retouching pattern of two shells from Giganti is shown. Modified after Palma di Cesnola (1965b), Vicino (1974), Bietti and Cremonesi (1995), Darlas and de Lumley (1995), Cristiani and Spinapolice (2009)

(Spit I). Campetti (1986) mentions that there were three implements (possibly referring only to the retouched ones), but no detailed description exists for any of these tools. Dantoni (1980) regarded the shell scrapers from G, Spit I, as chronological and cultural markers, comparable to the shell tools from Layer A at the Mario Bernardini cave (see below), which were attributed to the Late Mousterian. The two sites are the only ones in which worked examples of both *C. chione* and *G. glycymeris* have been found.

Grotta di Serra Cicora A

The Site

Grotta di Serra Cicora A (40°10′24.96″N, 17°56′53.06″E) is located north of the Uluzzo Bay caves, 37 m asl and only a few metres from the actual seashore (Fig. 1) (Campetti 1986). The cave was discovered in 1978 and was excavated by Borzatti von Löwenstern. There are two stratigraphic series for the site, one for the external part (1978 season; Fig. 3.3) and one for the internal part (1979 season).

The lower part of the internal stratigraphy (Campetti 1986) starts with six Middle Palaeolithic (Mousterian) Layers (A–F), and continues with Upper Palaeolithic deposits, in the external series only (Spennato 1981). The excavated deposit is 2.20 m thick, although the bottom of the Mousterian was never reached.

The Mousterian lithic assemblage consists of 1,084 lithic implements (29 % tools, 1.5 % cores, 64 % unretouched blanks). All lithic artefacts have been attributed to the same, technologically homogenous complex divided into three 'horizons' (B–C, D–E, F) on purely stratigraphic grounds (Campetti 1986). The industry has been defined as 'Charentian of Quina type'.

All commonly used local raw materials (limestone, slabs of siliceous limestone and valves of *C. chione*) are present, but about 55 % of the retouched tools are made of imported flint (Spinapolice 2008). The toolkit includes mostly scrapers, Mousterian points, *limaces* and denticulates.

Shell Industry

Thirteen fragments of *C. chione* were found, 12 in Layer B–C, one in Layer E–F, and one in Layer F. Of these, only the edge-retouched shell from Layer B–C (Spit 1) has been illustrated (Fig. 4). The remaining shells from B–C and E–F are reported as having irregular edges (Campetti 1986), but since they are unpublished, no further remarks can be made.

Grotta Mario Bernardini

The Site

Grotta Mario Bernardini (~40°10′17.37″N, 17°56′52.60″E) is located in the vicinity of Serra Cicora A, slightly inland from the Bay of Uluzzo (Fig. 1). When it was discovered in 1961, the cavity was completely filled with about 10–15 m of deposits. Four major archaeological Layers (A–D) were found in situ and were sub-divided into 26 levels (D1–14, B1–4, A I–IX) (Fig. 3.4). Layers D and B were attributed to the Middle Palaeolithic, while Layer A marks the Middle–Upper Palaeolithic transition. Levels A IX –V are attributed to the Late Mousterian, and levels A IV–I to the Uluzzian lithic tradition (Borzatti von Löwenstern 1970, 1971). Late Upper Palaeolithic and some proto-historic elements were also discovered at the top of the sequence.

The lithic industry of Layer D is defined as 'Quina Mousterian', and the 'Quinson facies' has also been identified at the bottom of the sequence (Borzatti von Löwenstern 1971). The formal tools are comparable to those from other Mousterian sites in the region, and scrapers, Mousterian points, and some denticulates dominate the assemblage. The lithics are mostly made on local siliceous limestone (60 %), and imported raw materials form about 20 % of the entire assemblage (Spinapolice 2008).

Shell Industry

The *C. chione* shells were discovered mainly in Layer D (Spits 3–4), but Layers A and B also contained a few specimens (Borzatti von Löwenstern 1970, 1971).

Layer D yielded 3049 lithics, of which 771 were formal tools. The shell assemblage consists of 45 fragments (Figs. 4, 5), most of which come from Level D3. They are severely damaged by the acidity of the deposit.

Level B3, beneath the volcanic horizon (α), yielded a very damaged fragment of *G. glycymeris*. A valve of *G. glycymeris*, as well as a valve of *C. chione*, were found further up, in Level A VIII (Dantoni 1980). Borzatti von Löwenstern (1971) refers to them as worked, but Campetti (1986) considers them unretouched. None of these attributions can be confirmed, since the shell specimens were never properly described or illustrated.

Grotta di Torre dell'Alto

Grotta di Torre dell'Alto (40°8′35.16″N, 17°58′35.61″E) is located on the limestone cliff under the monument of Torre dell'Alto on the bay of the same name (Fig. 1). When discovered in 1961, it was completely filled with sediment. An initial test trench revealed a thick Mousterian sequence capped by an Iron Age layer (Borzatti von Löwenstern 1966; Borzatti von Löwenstern and Magaldi 1967). In 1964 and 1967, part of the interior sequence was excavated over a small surface area ($\sim$3–4 m^2) and to a depth of 2.20 m.

Eight archaeological layers were identified (A′, A to G) (Fig. 3.5), all of aeolian origin (Borzatti von Löwenstern and Magaldi 1967). Elements of a volcanic source were also recognized in the stratigraphy. Layer B has yielded an—as yet unpublished—human tooth.

The lithic industry of Layer B comprises 2766 lithic implements, 90 % unretouched blanks, 2 % cores and 8 % formal tools (Borzatti von Löwenstern 1966; Spinapolice 2008). They are mostly produced on limestone (65 %), and only 15 % on flint. One third of the flint implements are retouched; a similar pattern is revealed at nearby sites (Spinapolice 2009). Simple scrapers are the most common formal tool and Mousterian points form up to 12 % of the toolkit. The retouch is scalar and the tools are thick. Due to the regular use of limestone, as well as the presence of limestone handaxes in the lower layers, the lithic assemblage of Grotta di Torre dell'Alto has been traditionally considered an 'archaic' Mousterian phase (Borzatti von Löwenstern 1966; Palma di Cesnola 1996). So far, no absolute dates exist to corroborate this hypothesis.

Layer B presents a shift in the provisioning of exotic raw materials, which become less common than in other layers.

Shell Industry

Three fragments of *C. chione* shells were found in Layer B, one of which is retouched (Borzatti von Löwenstern 1966) (Fig. 4). Considering the large quantity of lithics from this layer, as well as in other layers of the site (about 20,000 in total), the utilization of shell material here is truly rare. It is worth keeping in mind that only a very small part of the deposit was excavated and different parts of the deposit may have revealed a more intense pattern of shell exploitation.

Grotta Marcello Zei

The Site

Grotta Marcello Zei (40°8′39.82″N, 17°58′37.36″E) is located on the Santa Caterina shore, about 200 m from Grotta di Torre dell'Alto (Fig. 1). It is found at an elevation of about 50 m asl, on a limestone fault, and features a collapsed roof (Dantoni and Nardi 1980). The site was discovered in 1972 and was excavated in 1973 and 1978. The walls of the rock shelter preserve evidence of two marine transgressions, attributed to the two previous Interglacial sea highstands. The archaeological deposit has been strongly eroded by the action of the sea, with only ~90 cm preserved at the back of the site. A single archaeological layer (A) was identified (Fig. 3.6), and was sub-divided into 4 spits. The lowermost part of the sequence, A4, lies directly on the fossil Tyrrhenian beach (OIS 5e).

The excavated deposit yielded 887 stone implements. The lithic industry is made on local limestone and siliceous limestone slabs; exotic raw material is rare. The Levallois method has been reported but not further described (Dantoni and Nardi 1980). Typologically, the toolkit includes scrapers, points and *limaces*. The industry has been defined as a 'Quina Mousterian'.

Shell Industry

Ninety-six fragments of *C. chione* have been found at the site. They all come from Layer A; two are retouched (Dantoni 1980). The first shell, from Horizon A2, is a distal scraper produced on an entire valve. It bears a continuous, carefully performed retouch along the ventral margin (Fig. 4). The second specimen has not been described or illustrated.

Together with the *C. chione* valves, various other marine shells were found in the deposit of the cave, both in situ—in the excavated Layer A, and in secondary positions. A list of species is given by Dantoni and Nardi (1980). The abundance of molluscan remains raises several questions about the exploitation of marine shellfish at the site. Since none of the shell remains have been studied from a taphonomic point of view, or techno-typologically in the case of the *C. chione* specimens any hypothesis as to the economy of marine shells as a raw material (provisioning, transportation, use and discard) is very tentative.

Grotta di Capelvenere

The Site

Grotta di Capelvenere (40°8′34.67″N, 17°58′45.09″E) is located on a small headland along the route that connects the village of Santa Caterina with Torre dell'Alto (Fig. 1). It formed in a Cretaceous limestone, about 100 m from the current seashore. At its discovery in 1960 it was completely filled with sediment (Borzatti von Löwenstern 1961) and was only partially excavated in 1971, 1974 and 1975 (Giusti 1979, 1980; Palma di Cesnola 1996). Ten Mousterian layers (1–10) were identified in the 3 m thick stratigraphic sequence (Fig. 3.7). The Pleistocene deposits were covered by a stalagmitic layer, while the sediment is mostly of aeolian origin (Patriarchi 1980).

The Mousterian lithic assemblage consists of 989 implements (Giusti 1979, 1980), mostly unretouched blanks (86 %). They are flaked primarily on limestone and siliceous limestone. Simple scrapers dominate the toolkit; Mousterian points and denticulates are also present. The overall density of lithic material is relatively low when compared to the excavated volume of deposits. Given the homogeneity of the faunal assemblage throughout the sequence, rapid filling of the cavity, within a period of a few hundred years only, has been suggested.

Shell Industry

Layers 9 and 10 were reported to contain a few *C. chione* scrapers (Giusti 1979; Dantoni 1980; Palma di Cesnola 1996), but the exact number, morphology or any other description is not available. The shell industry is associated with *Equus asinus hydruntinus* faunal remains, which led certain scholars (Dantoni 1980; Campetti 1986) to suggest that the shell scrapers from Capelvenere must be the oldest occurrence of these tools in the region (*but* see Discussion below).

Grotta dei Giganti

The Site

Grotta dei Giganti (39°47′45″ N,18°20′15″ E) is a semi-submerged limestone cavity located on the tip of the Salentian peninsula (Fig. 1). It was discovered by G.A. Blanc in 1936, and was further investigated by A.C. Blanc (1958–1961) and L. Cardini in 1958, and by L. Cardini and M. Piperno in 1974.

A marine conglomerate attributed to the Last Interglacial forms the base of the stratigraphy (Level 3g). The sequence (Fig. 3.9) is divided into two main units. The first (Level 3f–c) is a series of paleosoils with layers of detrital origin on the top, about 2.75 m thick. The deposit of this unit shows a high degree of anthropogenic input; it was extremely organic and contained alternating silty red soils and hearths rich in charcoal. A stalagmitic floor (Level 3b) seals this phase, separating it from the overlying Level 3a. This upper level of cryoclastic sediment is about 1.50 m thick and forms the second archaeological horizon of the site.

The lithic assemblage is relatively poor (466 lithic implements) and consists of a wide range of raw materials. Limestone, fine-grained limestone and shells are local, while flint, quartzite and jasper are exotic, most probably derived from secondary sources about 150 km to the north (see below; Spinapolice 2008, 2009, 2012). While the tools produced on imported raw material show a high degree of curation, tools made from local materials are often expedient. The technology is mainly Levallois for the production stage, and is characterized by high levels of human involvement (burning, accidental breaking) revealing longer use and maintenance, especially of the flint tools. The modification stage (shaping and retouch) shows a high degree of reduction. Retouch on flint is continuous and scaled.

The percentage of formal tool types is rather high (55 %) forming mainly *limaces* and proto-*limaces* and very small convergent scrapers (shaped like small, thick points), usually no longer than 2 cm. The retouch on flint is continuous and scaled. The assemblage is often called *Micromousterian* (Palma di Cesnola 1996).

Shell Industry

Blanc (1958–1961) was the first to report on the presence of shell implements at the site. The collection includes 18 shell fragments (Fig. 5), all of which are shells of *C. chione* and come from the uppermost archaeological level, 3a. Their preservation varies greatly, but no entire valve was recovered at the site (Cristiani and Spinapolice 2009; Spinapolice 2008).

Eight valve fragments are retouched and seven preserve impact marks, mainly found in the vicinity of the umbo, either along the anterior or posterior valve margins, or at the centre of the valve. In five out of seven cases the direction of the impact is from the interior to the exterior of the valve. The presence of a distinct technological production system is certainly attested by the analysis of the shell implements.

Typologically, the retouched artefacts are classified as scrapers, transverse or straight (Table 1), similar to the flint scrapers found at the site. The management of the raw material aimed at producing artefacts of small dimensions, about 2 cm long and wide, from the proximal or distal part of the shell (see terminology in Fig. 2).

Grotta dei Moscerini

The Site

Grotta dei Moscerini Cave (41°13′27.15″N, 13°31′25.69″E) is located near Gaeta in Latium, on the Tyrrhenian coast of west-central Italy (Fig. 1). It is situated 9 m asl and 10 m from the current coastline. It was discovered in 1947 and was excavated in 1949 by A.C. Blanc, who discovered a long stratigraphic sequence, about 8 m thick, at the entrance of the cave (Fig. 3.8). A test pit at the interior of the cave revealed a more compressed stratigraphic series (Stiner 1993). The Tyrrhenian beach forms the base of the sequence. Layers A to N yielded Mousterian lithics on small flint pebbles, the classic 'Pontinian'(Kuhn 1995).

Shell Industry

Marine shells are abundant and a particular preference is shown for bivalve species. These include mainly *C. chione* and *Glycymeris* sp. (N = 1,583) and *Mytilus galloprovincialis* (N = 1537) specimens. Other marine bivalves (*Cardium* sp., *Cerastoderma* sp.) and gastropods are also present but at much lower frequencies (Stiner 1993). The molluscan remains show every indication of having been brought into the cave and processed there by humans (Stiner 1991, 1993). The provisioning is linked to the presence, during glacial marine regression, of a large coastal plain directly in front of the cave (Blanc 1942). In her analysis (Stiner 1993) found that the *C. chione* and *Glycymeris* specimens (and the *Cerastoderma* sp. in certain layers) are the species most affected by beach polishing, while mussels, for example, showed none. This reinforces the idea of an exclusive subsistence utilization of the latter species but different roles for the former species. In addition, the

Table 1 Inventory and technological characteristics of the *Callista chione* assemblage from Grotta dei Giganti

N	Shell part	Impact	Impact position on the shell	Impact localisation	Retouch	Retouch direction	Retouch position	Retouch type	Typology
1	Prox	✓	Lateral next to umbo	Internal	✓	Inverse	On fracture	Scalar	Convex scraper
2	Prox	✓	Lateral next to umbo	Internal					
3	Prox	✓	Central	External					
4	Prox	✓	Lateral	Internal					
5	Prox	✓	Lateral	Internal					
6	Prox				✓	Inverse	On fracture	Scalar	
7	Distal	✓	Lateral next to umbo	Internal	✓	Inverse	On fracture	Invading	Simple scraper
8	Distal				✓	Inverse	Natural edge	Scalar	Convex scraper
9	Distal				✓	Inverse	Natural edge	Scalar	Convex scraper
10	Prox				✓	Inverse	On fracture	Scalar	
11	Distal				✓	Inverse	Natural edge	Scalar	
12	Distal				✓	Inverse	On fracture	Scalar	Retouched blank
13	Distal								
14	Prox								ind.
15	Prox								ind.
16	Prox	✓	Lateral next to umbo	External					
17	Prox								ind.
18	ind.								ind.

Prox proximal, *ind.* indeterminable

shells of *C. chione* and *Glycymeris* sp. indicate more frequent exposure to fire (possibly for altering the properties of the shell) than other species do.

About 200 valve fragments of *C. chione* were retouched to make tools (Figs. 4, 5). The majority come from Layer G, but occurrences in Layers H, M and N have also been reported (Vitagliano 1984).

Typologically the shell scrapers are classified as distal transversal, with inverse and scalar retouch (Vitagliano 1984). They constitute a homogeneous ensemble and are manufactured usually on the distal part of the valve, the ventral margin (Fig. 2 for terminology, Figs. 4, 5 for illustration), so the umbo is constantly missing. According to Vitagliano (1984), the decision to retouch this part of the shell reflects the exploitation of the longest available edge. Occasionally, two adjacent sides are retouched. Some scrapers are characterized by few retouches, while some others converge in a point. The retouch occurs only on the internal lip (inverse retouch). According to Stiner (1993), because of the natural curvature of the shell, such retouch is only feasible by striking or pressing from the external surface of the valve inwards. Force applied from the internal side outwards generally results in square-edged breaks, similar to those observed experimentally (Cristiani and Spinapolice 2009; also see below, Experimental Work).

Technologically, the *Callista* shells may have been fractured intentionally to produce blanks for retouch, usually with a portion of the shell body truncated by a sharp, clean blow.

The morphology of the shell scrapers is very similar to that of the 'Pontinian' lithic scrapers from the site, which further supports the deliberate retouch of the molluscan material. The absence of similar flaking on species other than *C. chione* (for example, *Glycymeris* sp., the other common bivalve with smooth, porcelain-like shell of similar morphology) also confirms this hypothesis. If marginal retouch were caused simply by trampling or other disturbance, the same damage should be more evenly distributed on the natural margins of all shells having similar valve characteristics (Stiner 1993). Instead, we see that—just as in Salento and Liguria (see below)—the inhabitants of Moscerini preferred using *Callista* shells. The presence of numerous shell fragments at the site seems to suggest that the manufacture of the tools took place within the cave (Vitagliano 1984).

The Balzi Rossi (Grimaldi) caves

The Balzi Rossi caves open at the foot of a 100 m high Upper Jurassic dolomitic limestone rock that constitutes the coastline between Ventimiglia (Imperia, Italy) and the French border (Fig. 1). The complex consists of several contiguous caves and rockshelters, and has been the focus of intense investigations from the nineteenth century to the present day.

The occurrence of shell tools has been reported for the Mousterian levels of at least three sites, Riparo Mochi (10), Barma Grande (11) and ex-Casinò (13).

For the first two, Riparo Mochi and Barma Grande, the only available information is confined to simple mentions by Blanc (1958–1961) and Vicino (1974), respectively. It is likely that in his statement as to the occurrence of shellfish in the Mousterian layer of Riparo Mochi (most probably Layer I), Blanc merely refers to shell fragments of the edible shellfish *Trochus* sp. and *Mytilus* sp., which are indeed numerous, and not to truly worked shell remains. We ought to bear in mind that, at the time these comments were made, exploitation of marine resources by Neanderthals was considered unlikely, therefore the presence of any form of shells in Mousterian contexts was significant. Worked shells from

Mochi—if they ever existed—have never been illustrated and are not stored with the rest of the shell collection from the site.

Similarly, the single reference to worked shells close to the Tyrrhenian beach at the basal levels of Barma Grande (Oxilia 1974), or to a single implement (Vitagliano 1984), has not been supported—to our knowledge—by further work or illustration of the specimen(s).

ex-Casinò

The Site

The open-air site of ex-Casinò (43°47′1.19″N, 7°32′5.92″E) was discovered in 1968 during a rescue excavation (Vicino 1972, 1974). Thick detritic Mousterian layers directly overlay the Tyrrhenian beach (Fig. 3.10). The latter was found in three different locations, namely Beaches A, B and C (Vicino 1972, 1974).

The lithic industry has been recently re-examined (Negrino 2002; Porraz 2005). The lower Mousterian layer yielded 382 lithic implements, and the upper layer 1273 lithics. No major technological or typological differences have been described for the two layers, except a higher degree of alteration in the oldest one.

The lithic industry was manufactured from local materials, principally from the Ciotti conglomerate (Negrino and Starnini 2003). Imported materials account for 3 % of the beach layer, and 6 % of the uppermost one; they are mostly on quartzite coming from San Remo (15 km to the east). Among the flaking methods, Levallois, discoid and anvil percussion have been identified (Porraz 2005). Tool production was carried out on the site, but blocs were imported, probably prepared. Tools constitute up to 20 % of the lithic assemblage of the two layers. In addition, 21 tools were found directly on the Tyrrhenian level; these were mostly scrapers.

Shell Industry

Various marine shells were found in situ on the Tyrrhenian beach: the reference shell of *Strombus* sp., indicative of the Last Interglacial, as well as the shells of *Patella* sp., *Haliotis* sp., *Gibbula* sp., *Columbella* sp., *Murex* sp., *Dentalium* sp., *Glycymeris* sp. A complete list is given in Vicino (1974).

Among these, Oxilia (1974) identified about 40 shell implements made on shells of *C. chione*. According to the authors, these shells are fractured and deliberately retouched. The pattern of the breakage shows the constant presence of a sharp edge opposite to the umbo, along the ventral margin. The fragments (Figs. 4, 5) exhibit many characteristic features, such as squared and sharp edges, similar to the *C. chione* industries from Latium and Salento.

Oxilia (1974) classified the scrapers on a typo-technological basis:

1. Tools with umbo:
   - Transverse scrapers with distal retouch always obtained through breakage, or retouch performed from the internal side of the valve. The retouch is placed close to the hinge, transverse to the main shell axis, so that the maximum thickness and the maximum length of the shell are used. These edges often have a marginal retouch that may indicate use-wear.

- Distal scrapers with inverse retouch, manufactured through an invasive and flat retouching, parallel to the maximum width of the shell. The retouch is often located on the convergent part of two edges.
- Denticulates, made by multiple inverse 'Clactonian' notches opposite to the umbo or adjacent to form a bec.
- Becs, made by two adjacent inverse notches.

2. Tools without umbo:

- Sharp-edged.
- Distal scrapers with inverse retouch.
- Small fragments without retouch.

The main concern as to the authenticity of these specimens relates to their recovery directly from the fossil beach, together with a number of other molluscs and lithic implements. If they were deliberately retouched this could be a sign of strong preference by Neanderthals, who overlooked all the other species around and chose only *C. chione* shells for tool manufacture. However, since the rest of the shell assemblage has not undergone systematic analysis, we cannot exclude the possibility that other species were used as tools too. Morphological comparison of the ex-Casinò implements with the *C. chione* tools from other sites, for example in Moscerini—where their attribution to actual archaeological horizons is more secure—supports the hypothesis of human involvement. Given the lack of a detailed study of the effects of *C. chione* trampling on a similar beach substrate, the intentional character of the retouch is difficult to prove without further experimental work.

Kalamakia Cave (Greece)

The Site

The cave of Kalamakia (36°40′33.83″N, 22°21′51.75″E) is situated 2 km northwest of Areopolis, on the west coast of the Mani peninsula (South Peloponnese, Greece) (Fig. 1). The cave opens at 2.3 m asl and overlooks a Tyrrhenian beach (Fig. 3.11). The current seashore is only few metres away, although during periods of glaciation the distance would have been greater.

The archaeological component of the cave (about 7 m thick) consisted of seven stratigraphic units (de Lumley and Darlas 1994; Darlas and de Lumley 1995, 1999, 2002) (Fig. 3.11). The sedimentary succession starts with a fossil shingle Tyrrhenian beach (Unit II), possibly dating to OIS 5c, followed by continental sandy-clay deposits in Units III, IV, V and VI. The archaeological levels are contained in Unit III (wind blown sandy dunes) and Unit IV (angular gravel with sandy-clay matrix). There, Mousterian lithics, faunal remains, hearths (some structured), accumulation of ashes, and several occupation floors were discovered (de Lumley and Darlas 1994; Darlas 2007). Layers III and IV have yielded a dozen Neanderthal remains, mainly individual teeth, a skull fragment and a vertebra (Darlas 2007).

The lithic industry is typical Mousterian, characterized by Levallois reduction methods for the final products (~20 % of all flakes) and thick retouch. The assemblage is dominated by scrapers (77 %) and finely retouched Mousterian points; denticulates and notched pieces are rare (Darlas 2007).

Flint, green andesite, quartz and quartzite were all used for the production of tools, but are not local. It seems that the raw material was brought to the cave in the form of prepared cores, as flakes, or even as retouched tools. Among the phases of the *chaîne opératoire*, the most frequent is the retouching (or re-sharpening) of tools, which results in large quantities of very small flakes as debitage.

Shell Industry

The retouched marine shells are all made on valves of *C. chione* (initially misidentified as *Glycymeris violascens*; Darlas and de Lumley 1995). They preserve a continuous and very regular retouch of the ventral margins, which resembles that of the sidescrapers (Darlas 2007). Darlas and de Lumley (1995) report the presence of at least six fragments of *C. chione* shells and one *Cardium* sp. (Figs. 4, 5), all found at the same occupation Horizon 1994–1 (internal trench, top of Layer IV, 170 cm below datum).

Three *Spondylus gaederopus* shells were also unearthed from Horizon 2001–1 (internal trench, Layer IV), but they do not demonstrate any traces of deliberate transformation and the excavators consider them mere manuports (Darlas and de Lumley 2002).

Experimental Work: Methods and Results

Despite the wealth of excavated material, our understanding of the techno–typological processes involved in the manufacture and of the functional roles of Mousterian shell tools has been rather vague. In the past few years, two experimental studies have been performed with special reference to Neanderthal shell tool production in Grotta dei Giganti and Grotta del Cavallo (Cristiani et al. 2005; Cristiani and Spinapolice 2009). We will briefly describe them below.

Grotta dei Giganti

Materials and Methods

The aim of this work was to examine the shells of *C. chione* in the same way as all other raw materials imported to the site, and to analyze all the different steps in their reduction sequence (Cristiani and Spinapolice 2009). The experimentation was carried out at the University of Rome, by one of us (E.S.) and Dr. E. Cristiani (University of Cambridge) on 50 modern shells of *C. chione* (Fig. 6a) collected from the Tyrrhenian Sea. It involved two stages: reconstructing first the production phase, and then the transformation phase of the reduction sequence. A hard stone hammer and a limestone anvil were used.

During the first stage, different ways of fracturing shells by percussion were studied. These included: (i) direct percussion on complete bivalve; (ii) anvil percussion on complete bivalve; (iii) direct percussion on internal surface of single valve; (iv) direct percussion on external surface of single valve; (v) anvil percussion on internal surface of single valve; (vi) anvil percussion on external surface of single valve.

The transformation phase was tested by performing: (a) direct retouch on external edge of entire valve; (b) inverse retouch on external edge of entire valve; (c) direct retouch on one edge of shell fragment; (d) inverse retouch on one edge of shell fragment.

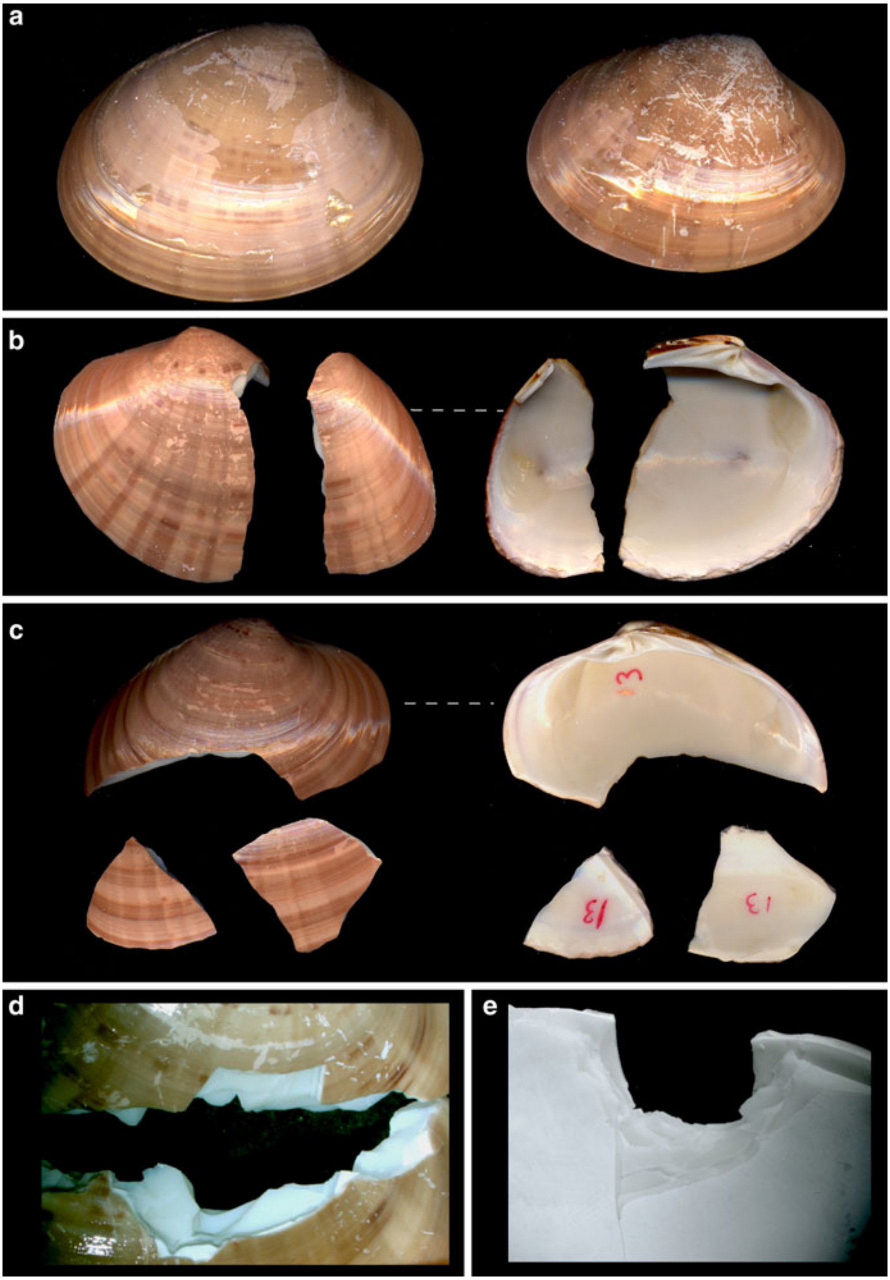

Fig. 6 Experimentation on modern *Callista chione* (Cristiani and Spinapolice 2009). **a** Two unmodified modern valves; **b** A *C. chione* valve after anvil percussion performed from the internal to the external part of the valve. Two fragments were obtained; **c** *C. chione* after anvil percussion performed from the external to the internal part of the valve. Three fragments were obtained; **d** Experimentally retouched edge; **e** Detail of the impact caused during the blow from the internal to the external part of the valve; note similarities of (**e**) with detailed view of archaeological implement from Grotta dei Giganti in Fig. 5b. Images courtesy of E. Cristiani

Results

The experimentation resulted in the production of small scrapers with direct or inverse retouch, very similar to those found in the Italian Middle Palaeolithic record. The material resulting from experimentation was used as a comparative base for identifying the morphology of impact scars on archaeological shells. The fracture under direct percussion produced two or three fragments characterized by sharp, squared edges (Fig. 6; to compare the breakage pattern see archaeological material in Fig. 5). As Choi and Driwantoro (2007) point out, the fracture process is uncontrollable; however, initial fracturing of shells gives the advantage of a larger exploitable surface with longer edges.

Comparison of the archaeological shells from Grotta dei Giganti with experimentally produced tools revealed a high correspondence between the two, and impact scars similar to the experimental ones were observed on seven archaeological shell fragments (Fig. 6). Most of them ($N = 6$) are found close to the umbo. In five archaeological cases, the impact has derived from percussion from the internal towards the external part of the valve, and in only two from the external surface inwards. Impact deriving from the internal part of the valve outwards was intended to produce blanks (Fig. 6c) and is not, therefore, evidence for processing the shell for food consumption, which would result in an impact from the external part inwards. This corroborates the suggestion that the *C. chione* valves were intentionally collected for modification with the aim of producing blanks, which were either retouched or used unmodified. It also appears that the raw material economy aimed at small blanks: the seven fragments that preserve impact marks are small, less than 2 cm long and wide. This could be interpreted as the first step of a reduction sequence followed by the selective transformation of blanks.

During experimentation, it was noted that it was much easier to retouch a recent fracture than the natural edge of the shell. This is confirmed by the presence of retouch mostly on already fractured edges in the archaeological shells.

The comparison of the scrapers obtained from the experimental work fits well with the morphology and the typology of the archaeological tools from Grotta dei Giganti, as well as with the shells from other Salentian caves. What is also interesting is that the dimensions of the scrapers on *C. chione* overlap with the flint toolkit from Grotta dei Giganti which has been attributed to a 'Micromousterian' facies (Fig. 7).

Grotta del Cavallo

Materials and Methods

Cristiani et al. (2005) tried to replicate the mode of production and use-wear of 59 shell tools from Layer L of Grotta del Cavallo. Their aim was to verify the dynamics of use-wear development and distribution on both unmodified shells and their retouched edges.

Their experimental procedure involved the modification of 10 modern *C. chione* shells by direct percussion using an anvil. The ventral margins of the shells were retouched with the same stone pebble that was also used as a hammer tool.

In addition, three scrapers of *Callista* produced experimentally were used in working wet hide, cutting tanned hide, and for scraping wood soaked in water. Hide treatment was carried out in two steps, each lasting for 15 minutes, so that the development of the wear traces would be observed and recorded.

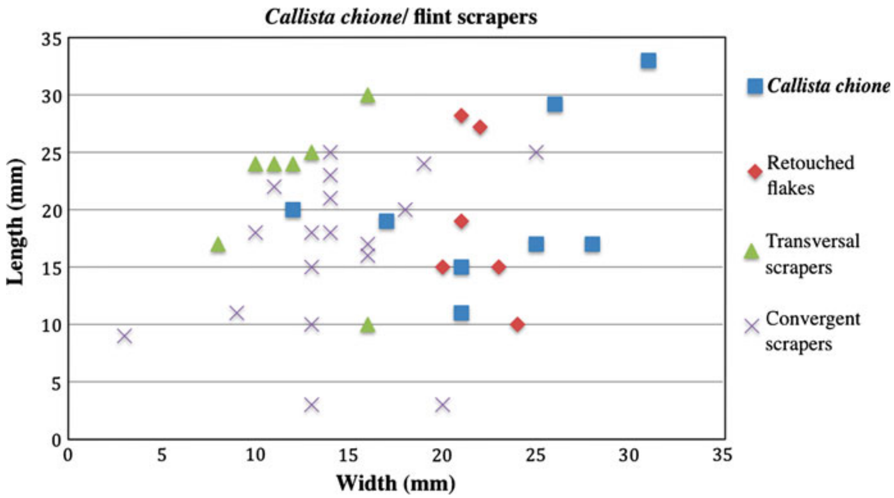

Fig. 7 Correlation of flint ('Micromousterian') and shell scraper dimensions from Grotta dei Giganti

Results

Unlike in the previous study, the authors found it easier to retouch the *C. chione* valves in their natural shape and then reduce them into smaller fragments by knapping. The retouch produced scalar, invasive and overlapping scars maintaining the fine edge angle (25°–40°) of the natural shell. These scars also gave a light denticulated form to the edge.

The dimensions of the retouched archaeological shell tools from Cavallo were similar or smaller to the those of the ones produced experimentally. Cristiani et al. (2005) suggest that the small size of the Cavallo worked shells is the result of a specific function instead of the single impact on the umbo. Such fragmentation could also reflect intensive use and repair of the active edge.

With regards to use-wear traces, hide cutting and scraping caused small edge chips that eventually got rounded and only slightly polished. In contrast, the authors found that a harder material, such as wood, continuously produced damage to the shell edge, which remained serrated but still polished. The polished edges exhibited clear texture and topography, with many short striations indicating the direction of movement as the activity was carried out. By studying eight archaeological specimens under a stereomicroscope and a metallographic microscope, the authors identified surface polishing and striations similar in morphology to those produced experimentally. The striations had longitudinal orientation in seven cases and transversal in one. Despite this, the authors were not able to identify securely the exact materials on which the shells were used (Cristiani et al. 2005).

Discussion

There are four major points pertinent to the use of marine shell by Neanderthals in southern peninsular Europe, viz. (i) the collection of the shell of a very specific bivalve species, the smooth venus *Callista chione*, over a wide geographical area, (ii) within a distinct framework of raw material provisioning, (iii) for the production of tools of similar morphology, and (iv) during a broadly concurrent period.

Provenance and Selection of *Callista chione* Shells

The archaeological evidence, both in Italy and Greece, demonstrates that there is an unmistakable persistence in the collection and exploitation of a single shell species for the manufacture of Middle Palaeolithic shell tools by Neanderthals. The smooth clam *C. chione* (Linnaeus, 1758) (Bivalvia: Veneridae) is the molluscan shell of preference, although some *Glycymeris* sp. valves have been used intermittently. *C. chione* is a subtidal, shallow-burrowing filter-feeding organism that occupies sandy substrates from just offshore to a depth of about 130 m (Leontarakis and Richardson 2005). At present, it is common in the Mediterranean and the east Atlantic coasts from the British Isles to the shores of North Africa. In fact, it is among the most abundant species inhabiting shallow soft-substrate shores and, locally, the most prominent suspension-feeding bivalve (e.g. Metaxatos 2004). The shell of *C. chione* is porcelain-like, thick and oval, with an external pale green, reddish or light brown lustrous colour interrupted by cream concentric growth lines (Fig. 2). Internally it is pure white or cream. The largest specimens can grow up to 11 cm, but the most common specimens range between 6 and 8 cm. Due to their profusion in the benthos of the Mediterranean, *C. chione* shells are present and often abundant in the surrounding modern-day beaches. Their presence on Pleistocene fossiliferous raised marine terraces (e.g. Gaki-Papanastassiou et al. 2009; Lucchi 2009) makes it very likely that they were also visible and ready for collection at Late Pleistocene beaches.

In terms of provenance, the most parsimonious explanation is that the bivalves (whether dead or alive) were collected at the nearby littoral zone. Shells could have also been gathered on the fossil beaches close to the sites, such as the Pliocene conglomerates in the Salento region (Delle Rose and Medagli 2007). This, however, would have involved extracting the valves from the substrate, and the hypothesis lacks verification. With the exception of the implements from Moscerini and Giganti, the Mousterian shell tools in discussion have not been studied from a taphonomic point of view. No detailed description exists of the state of preservation, traces of beach-wear (e.g. wave-abrasion, pitting) or other indication (e.g. bore-holes) that could cast light on the mode of provisioning and clarify whether the bivalves were already dead at collection or were by-products of other activities (e.g. food consumption).

The distance of the sites to the Pleistocene shoreline was highly variable. Today all 13 sites lie within a few hundred metres of the sea, and one (Giganti) is semi-submerged. They are located on rocky shorelines that do not support *C. chione* communities. Although never more than 5–15 km from the sea, these sites were actually inland during most of the period they were occupied by Neanderthals and were surrounded by very different ecological habitats.

Since there is no absolute chronological indication as to the exact period when the shell implements appear at each site (see below), land mass exposure and shoreline reconstruction are challenging. Several potential sea-level highstands should be considered: a relatively high interstadial (~OIS 5e); an intermediate during OIS 5d–a, and a lower glacial level (OIS 4–3) (see detail of sea-level changes in Fig. 1). If occupied around 120 ka BP, shortly after the marine transgression of OIS 5e, when sea level was similar to that experienced today, the distance of the sites from the sea would be very comparable to the modern day. During the later parts of OIS 5 (sub-stages d–a) the sites would lie progressively farther from the coastline as the sea stood from 30 to 60 m below present levels. For most of the period 110–30 ka BP (OIS 4–3), glacial advances and the considerable increase in continental ice volume resulted in sea level dropping to about 80 m below present (Lambeck 1996; Siddall et al. 2003). At that time, the previously coastal sites were positioned 5 –15 km from the sea, based on moderate estimates, on fully steppe or forest-like settings, some surrounded by large open coastal plains (Fig. 1). Marine shells were certainly not readily available. They would have had to be brought to the sites from a significant distance, so accidental inclusion or natural agency cannot explain their presence so far afield.

Setting the issue of provenance aside, it is evident that, despite the large geographical distance separating the four site-clusters (Mani, Salento, Latium and Grimaldi), Neanderthals particularly favoured the shell of the *C. chione* for the production of tools. Such strong preference cannot be attributed to molluscan biogeography. While biotic communities are expected to exert powerful background effects on the composition of any archaeological shell assemblage, natural changes in the coastlines during several marine transgression–regression cycles of the earlier parts of the Last Glacial must have affected taxonomic diversity and particularly the availability of *C. chione* shells along the shores of the Mediterranean. *C. chione* remained a long-term favourite of Neanderthals, and we attribute this preference to culturally-bound human selectivity, possibly responding, to a degree, to attractive properties of the *Callista* shell structure. Any suggestion as to the exact mechanisms by which this strong preference was formulated, communicated and expressed, from the southern Peloponnese through to Liguria, or as to its exact spatio–temporal pattern, can only qualify as speculation.

Patterns of Raw Material Provisioning

Stone availability is not stable because it depends heavily on the geological characteristics, climatic variations (e.g. snow-covered terrain, vegetation covering) and geomorphological transformations affecting a particular area. These issues render visibility and acquisition of certain lithotypes quite variable through time and across regions (Rolland 1981; Turq 2005). Human-related reasons, such as the exhaustion of sources or even symbolic motivations—often attested in recent hunter-gatherer/nomadic groups—may also shape the patterns of raw material provisioning.

In the context of tool production, the intentional use of molluscan shell is normally interpreted as an action of necessity, reflecting lack of good-quality lithic resources (e.g. Toth and Woods 1989; Szabó et al. 2007). Shell is considered, therefore, a ‘substitute’ raw material. Steering away from generalizations, we believe that the economy of shells as raw material can be better understood when linked to the local setting and the entire pattern of raw material procurement in the sites where shell implements occur.

In the Balzi Rossi, in northwestern Italy, Neanderthals exploited both local (the Ciotti flint) and sub-local (the Sanremo quartzarenites) lithotypes. Exotic material, from a distance of up to 200 km, was also imported, but was much less abundant (Negrino 2002; Porraz 2005).

In coastal Latium, the lithic industry is almost completely produced on small flint pebbles. While precise source attribution is not feasible, the flint pebbles were most likely found on local or circum-local, active or remnant fossil beach deposits representing the Tyrrhenian sea highstand of OIS 5e (Kuhn 1995). Yet no exposed pebble beds were discovered in an archaeological survey of the Fondi Basin, near Grotta dei Moscerini (Bietti et al. 1988) and the closest primary sources of flint are 50–100 km inland, at the Monte Genzana in Abruzzo (Kuhn 1995).

The region of Salento demonstrates a rather more complex pattern because the absence of good quality raw materials is even more pronounced. The stone varieties identified in the Mousterian sites include flint, limestone, quartzite, jasper, and thin slabs of poor-quality siliceous limestone ('*liste*'). Based on the surveys carried out in the region (Spinapolice 2008, 2009) only limestone and siliceous limestone appear to be local or circum-local; no sources of flint, jasper or quartzite are known to exist in the region. According to Milliken (1998, 2007) and Spinapolice (2008, 2012), fine-grained stone would have had to be imported over great distances from northern sources located in the Basilicata Apennines piedmont (the Bradano basin). The Salentian Mousterian assemblages, therefore, show a mixed provisioning on local and exotic raw materials. In the Grotta dei Giganti, for example, imported materials make up 45 % of the assemblage, while at other sites, such as Grotta di Torre dell'Alto, the reliance on local material is almost complete.

In Kalamakia cave in Greece, the stone industry is nearly entirely made from imported stone. Flint was carried from a distance of about 15–20 km north, where it is found in small polyhedral nodules. Green andesitic lava—a local speckled variety known as *krokeatis lithos*—comes from about 20–25 km east, and quartz was imported from various sources. As with the Italian sites, the character of the industry and the strategy of raw material procurement are certainly imposed by the rarity and quality of the available raw materials. This is reflected in the small dimensions of the products (the majority fall in the 2–3 cm group), the lack of cortical flakes and rarity of cores, and the high rates of transformation of the formal tools (Darlas 2007).

Two major conclusions can be drawn from this examination of the raw material provisioning patterns at the four site-clusters yielding Mousterian shell tools.

First, the geographical regions in which *Callista* scrapers have been found demonstrate absence of good-quality lithic sources (Salento and Mani), or limited presence of poor-quality lithotypes (Liguria and Latium). This imposes particular limitations on production of suitable tools, due either to poor knapping properties or to their small dimensions (Bietti et al. 2004; Darlas 2007). The absence of high-quality, fine-grained lithotypes not only resulted in the import of superior exotic material, through long exchange-networks or direct acquisition, but also led Neanderthals to adapt to the local conditions and exploit a wider spectrum of resources, such as limestone, fine-grained limestone and molluscan shells, which were readily available in the vicinity of their sites (Riel-Salvatore and Negrino 2009; Darlas 2007; Spinapolice 2008, 2009). In other words, the procurement of lithic material in Italian and Greek sites confirms that the utilization of *C. chione* shells should indeed be considered an additional response of Neanderthals to the scarcity of appropriate, high-quality stone varieties. This response can be also seen as a particular form of material procurement, with shells used within a 'provisioning of sites' strategy (sensu Kuhn 1994). In the context of molluscan shells, larger-than-needed quantities of raw material were often brought to the residential location, and only some shell valves were eventually retouched. The rest may still have played different roles for which retouch was not required. Another possibility is that shellfish were collected and brought to the site as food, and (some of) the discarded valves were then retouched. However, this suggestion assumes proximity of the sites to the littoral zone, and hence high sea levels; its validation would require, apart from dating, further examination of the remains from a zooarchaeological and taphonomic point of view (anatomical parts representation, right/left valve ratio, structural damage, fire damage), similar to Stiner's (1993) approach in the case of the Moscerini shell assemblage.

The second conclusion pertains to the degree of ecological adaptation and environmental control deployed by Neanderthal groups. It is often assumed that anatomically modern human populations were better adapted to their local environments than were the Neanderthals (Bar-Yosef 2002; Mellars 2005). The transportation of raw material over great distances reflects exactly such landscape control and wide networking. While the evidence we present here does not cast doubt on the fact that social networks in the Upper Palaeolithic may indeed have been better established, the systematic procurement of exotic material by early Neanderthals, and their obvious optimal adaptation to the local environment through the incorporation of lower-quality raw materials, whether limestone or marine shell, must be taken as an indication of adequate landscape control and ‘planning depth’ as early as ~110 ka BP.

Techno–Typological Aspects of Shell Tools

The shell implements from all sites share similar techno-typological features and possibly comparable functional properties. They are all defined as scrapers. In most cases (e.g. Giganti, Kalamakia, ex-Casinò) the shell scrapers are similar in shape, retouch and dimension to the flint scrapers. This suggests to us that (the form of) the final product, whether on shell or flint, was decided in advance, carefully planned and skilfully executed. In lithic studies this has often been characterised as a ‘mental template’ (Chase 2008).

The entire shell is retouched only at Grotta del Cavallo, while on other occasions mostly proximal or distal fragments are retouched. Intentional breakage has been noted at four sites: Moscerini, Giganti, ex-Casinò, Kalamakia. One or two shell edges are retouched in Moscerini and Giganti. Inverse retouch (i.e. on the external shell surface) is present at nine sites and direct retouch at three (Table 2). Only two sites (ex-Casinò and Cavallo) show evidence of bidirectional retouch. Scalar retouch is present at four sites (Cavallo, Giganti, Moscerini and Kalamakia).

Unfortunately, technological analyses of the implements are only available for a few sites, and the record requires direct re-examination to allow better understanding of shared features. In particular sites (Giganti and Moscerini), the presence of a true reduction sequence has been identified, while in others (e.g. Cavallo) the entire shell was retouched. In the last case, the tool produced would have had larger dimensions; however, shell fragments might have been better suited to cutting or to use as inserts in larger, composite tools with non-surviving organic components.

Chronology

The manufacture of shell tools by Neanderthals in Italy and Greece falls within a broad chronological framework stretching from the Last Interglacial at ~115 ka BP (5e termination) to the Last Glacial, at ~50 ka BP. The vast majority of the assemblages (Fig. 3) lie directly on or just above Tyrrhenian beach deposits, which act as a *terminus post quem* for dating the initial production of these shell tools.

At the sites of Cavallo, Mario Bernardini and Uluzzo C, the presence of tephra layers in the middle or upper parts of the sequences also acts as a *terminus ante quem* for dating the deposits underlying them. In Cavallo, a thick tephra deposit composes Layer G. Preliminary analysis indicates that the chemical composition of the ash matches that of the widespread Mediterranean tephra X-6 (B. Giaccio, personal communication 2010). The tephra is an important stratigraphic marker for palaeoclimatic and palaeoenvironmental reconstructions. It is thought to date to c. 107 ± 2 ka BP (Keller et al. 1978; Brauer et al.

Table 2 Technological features of the *Callista chione* industry at 11 sites in Italy and Greece

SITE	Entire shell	Distal shell	Proximal shell	Fragment	Direct retouch	Inverse retouch	Scalar retouch	Single edge	Two edges	Intentional break
Moscerini		✔		✔		✔	✔	✔	✔	✔
Giganti			✔	✔		✔	✔	✔	✔	✔
Cavallo	✔	✔	✔	✔	✔	✔	✔	✔		
Marcello Zei	✔					✔		✔		
Serra Cicora		✔				✔	✔			
Mario Bernardini		✔	✔	✔	✔	✔	✔			
Torre dell'Alto		✔				✔			✔	
Uluzzo C	No available information									
ex-Casinò			✔		✔	✔				✔
Capelvenere	No available information									
Kalamakia		✔	✔			✔	✔	✔		✔

2007) and falls at the end of the Last Interglacial in the Lago Grande di Monticchio varve record and other Mediterranean marine cores (Wulf et al. 2006; Brauer et al. 2007; Paterne et al. 2008). In Cavallo, if both identification and dating of the tephra in Layer G are correct, approximately 3.5 m of shell-tool-bearing deposits at the base of the sequence were accumulated in less than 10,000 years (sedimentation rate of 0.35 mm/year), from the beginning of the sea regression at $\sim$115 ka BP until the deposition of the tephra at $\sim$107 ka BP (B. Giaccio personal communication 2010). A similar tephra layer has been identified in nearby caves Uluzzo C (horizon γ at the base of Layer D), and Mario Bernardini (horizon α at the base of Layer B) (Fig. 3.2, 3.4).

Absolute dates exist only for two sites, the caves of Moscerini and Kalamakia. In Grotta dei Moscerini, a series of ESR dates were produced on red deer tooth enamel, from the lower part of the sequence. They cluster between 100 and 80 ka BP (Schwarz et al. 1991; Stiner 1994). In Kalamakia, a single radiocarbon date on charcoal from the uppermost layer on top of unit IV gave an infinite age (>40,000) while a series of U/Th dates reported by de Lumley and Darlas (1994) is considered unreliable (Darlas 2007). Regrettably, in both cases the determinations fail to decipher the absolute chronology of the sites.

Despite the lack of absolute chronological data or secure identification of other chronometric markers, Borzatti von Löwenstern (1971), Dantoni (1980) and Campetti (1986) suggested two distinct chronological clusters in the Salento context, which is the richest of all, both in terms of shell implements and number of sites. The oldest group includes the shell tools from Cavallo L-M, Mario Bernardini Layer D 3–4,Torre dell'Alto B, Capelvenere, Marcello Zei A, Giganti, and Serra Cicora, all of which come from the basal parts of the respective sequences and postdate the Tyrrhenian transgression. This is also the case for the sites of Moscerini and ex-Casinò.

A second, somewhat younger group has been identified in the upper horizons (A VIII) of Mario Bernardini and Layer G I of Uluzzo C, which, however, are not considered contemporaneous by some (Dantoni 1980) but are related on a typological basis. Layer B of Torre dell'Alto is included in this younger cluster by Campetti (1986). The occurrences from Kalamakia IV, and possibly Mochi, may fall in this group, too, based on stratigraphic and technological comparisons.

The terrestrial faunal remains from most sites comprise horses (*Equus equus caballus*, *Equus asinus hydruntinus),* aurochs (*Bos primigenius*), and red deer (*Cervus elaphus*), as well as limited rhinoceros, possibly *Stephanorhinus kirchbergensis* (Merck's Rhinoceros), and elephants (*Elephas antiquus*). Because the last two species are traditionally associated with the Last Interglacial, similar remains at the sites of Marcello Zei and Grotta dei Giganti have been considered a significant chronological and environmental marker (Campetti 1986). However, in Italy rhinoceros are now thought to have survived well into the Last Glacial period and possibly until the beginning of OIS 3 ($\sim$60 ka BP: Gliozzi et al. 1997; Stuart 1999), so their remains no longer provide a reliable age constraint for the shell industries. Equally, the extinction of *Elephas antiquus,* traditionally placed at the end of the Last Interglacial and no later than OIS 5a (e.g. Stuart 2005), has also been questioned in recent years (de Mol et al. 2007). As a whole, the recovered fauna is indicative of a diversity of environments, but chiefly of forests and woodlands, and more open landscapes related to coastal plains and moist conditions. Unfortunately, the absence of absolute chronometric data does not allow any solid inference of synchronism between sites.

Given that most of the sites were excavated many decades ago, direct dating of the shell tools is the ideal, and perhaps the only, way forward in order to securely identify the period(s) during which Neanderthals produced this kind of implement. Despite several technical limitations in the dating of marine carbonates beyond the radiocarbon limit, we hope that this will become the focus of future research and the basis for better understanding this particular aspect of Neanderthal adaptation.

Conclusions

Since 1958, when C.A. Blanc first identified Mousterian tools produced on the shell of *C. chione* (Blanc 1958–1961), similar implements have become an interesting aspect of Neanderthal handiwork at several locations in Italy and, recently, Greece. Such is the extent of this particular adaptation at certain sites that Palma di Cesnola (1967) characterized the industry of level L of Grotta del Cavallo as 'Mousterian on *Callista chione*'.

In the last two decades, Middle Palaeolithic shellfishing has attracted particular attention from a zooarchaeological point of view, and efforts to integrate marine resources into a prehistoric subsistence and provisioning pattern heighten the importance of Mousterian shell tools. Shell remains are considered direct evidence for the exploitation of marine resources by early hominids and their adaptation to diverse ecozones (Colonese et al. 2011; Stiner 1993; Erlandson 2001; Marean et al. 2007; Fa 2008; Stringer et al. 2008). At the same time, Mousterian shellfish remains have been studied as carriers of symbolic value, or as instrumental in facilitating symbolic activities (d'Errico et al. 2008; Bar-Yosef Mayer et al. 2009; Zilhão et al. 2010). Very little information exists on the utilitarian roles of shell remains in the Palaeolithic, and it is only recently that some published reports have elucidated aspects of these in Lower and Upper Palaeolithic periods (Choi and Driwantoro 2007; Szabó et al. 2007; Douka 2011). For Middle Palaeolithic contexts, fragmentary information on the evidence from Italy has been presented previously (Dantoni 1980; Vitagliano 1984; Stiner 1991, 1994) but an accessible full review of all available data was absent; our paper has aimed to redress this.

Our observations suggest that on one or more distinct occasions in their evolutionary history, Neanderthals adopted the shell of *Callista* (and, to a much lesser extent, that of *Glycymeris* sp.) as an alternative material for the manufacture of simple scrapers. Overall, more than 300 retouched implements have been reported from 13 sites in Italy and Greece. Given the fact that most Late Pleistocene coastal sites now lie submerged, the use of marine shell is certainly underrepresented in the archaeological record of the period. Even so, it is clear that Neanderthals extended their toolkit beyond typical lithic varieties and organic materials, and considered molluscan shell as a further solution for the production of tools in areas where good quality lithotypes were scarce. The production of shell scrapers is certainly defined by raw material properties (shape, size, microstucture, breakage pattern), but the final products bear a close resemblance to their lithic counterparts; hence certain technological aspects of their production must have been predetermined ('mental template'). It is possible that some shell fragments were used unretouched, since the breakage pattern produces sharp edges, while the natural edge is rather dull. This hypothesis needs to be investigated by use-wear analyses of unretouched fragments found at the same contexts as the retouched shell tools. Limited experimental butchery (Toth and Woods 1989; Choi and Driwantoro 2007) and scraping (Cristiani et al. 2005) have been carried out, but it is clear that further experimental work with *C. chione* shells is required to clarify the potential use of these tools. Technologically, although there is a distinct, culturally-bound preference for the shell of *C. chione* across a wide geographical area, the *chaîne opératoire* for the production of tools seems to have differed between sites.

The shell tools from Italy and Greece confirm the early exploitation of marine resources by Neanderthal populations, a feature previously underrated due to climatic, taphonomic and interpretive biases. The current review presents us with the tools to better assess the relationship of early Neanderthal groups with their environment, through the lens of adaptation strategies, resource management and raw material provisioning.

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