An Upper Palaeolithic shell scraper from Ksar Akil (Lebanon)

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A B S T R A C T

The vast majority of Palaeolithic tools that survive in the archaeological record are lichics. Tools made of marine shell are rarely found in Western Eurasian contexts, regardless of the time period. This paper reports the discovery of a Glycymeris valve from the Upper Palaeolithic level of Ksar Akil (Lebanon), excavated in the 1940s and stored in a museum since then. The shell comes from level IX, whose lithic industry is attributed to the Levantine Aurignacian. Careful macroscopic and microscopic analysis revealed that the shell had been worked deliberately into a scraper-type tool. The shell was directly dated, at ~37 ka BP, an age much older than expected for its context, which was anticipated to be ~30 ka BP. This illustrates the potential problems relating to the AMS radiocarbon dating of bivalve shell material from the Levantine coast.

1. Introduction

The ability to modify raw materials into functional tools is regarded as one of the central proxies for cognitive and behavioural attainment by early hominins (Toth and Schick, 1993). Given the scarcity of human fossil remains, it is mainly on the basis of lithic tool assemblages that cultural entities and their temporal relationship are historically identified. Established typological repertoires and chaînes opératoires, patterns of raw material provisioning and modes of tool use and discard map cultural progression into modernity — and even define it (Toth and Schick, 1993; Ambrose, 2001; Davidson and McGrew, 2005; Nowell and Davidson, 2010).

The vast majority of Palaeolithic tools found in Western Eurasian contexts are made of stone varieties like flint/chert, limestone, obsidian and quartz. Very rarely, non-lithic implements come to light, let alone tools made on molluscan shell. In this paper, I report the re-discovery of a shell scraper amongst Upper Palaeolithic molluscan shell remains from the Levantine typesite, the Ksar Akil (Lebanon).

2. The site

The rockshelter of Ksar Akil is located in central Lebanon, at the northern tributary of Wadi Antelias, approximately 10 km NE of Beirut (Fig. 1). The site was systematically excavated by a team of American Jesuits led by Rvds. J.G. Doherty and F. Ewing in 1937–38 and 1947–48 (Ewing, 1947, 1949) and by a French team from 1969–1975 (Tixier, 1970, 1974). Owing to the deteriorating political situation excavations of the site were halted prematurely.

Ksar Akil has revealed an unparalleled 23 m deep Palaeolithic sequence containing Levantine Middle Palaeolithic, Transitional (Emiran, or Initial Upper Palaeolithic), and typical Upper Palaeolithic (Ahmarian and Aurignacian) phases. These correspond to levels XXXVII–XXVI; XXV–XXI/XX and XX/XIX–VI, respectively (Fig. 1). The site has yielded a vast number of lithic implements, large faunal assemblage which included several hundreds marine specimens, and the remains of three humans: a probable Neanderthal maxilla in level XXV, and a modern human skeleton and one extra mandible in level XVI (Ewing, 1947, 1949, 1963, 1966; Hooijer, 1961; Altena, 1962; Inizan and Gaillard, 1978; Tixier and Inizan, 1981; Azoury, 1986; Bergman, 1987; Ohnuma, 1988; Bergman and Stringer, 1989; Tillier and Tixier, 1991).

3. Description of the shell tool

The large molluscan assemblage from Ksar Akil was initially studied by Altena (1962). Following his study, the collection remained housed in the Netherlands and was eventually incorporated in the Naturalis Natural History Museum (Leiden, The Netherlands). In 2007, during sampling for radiocarbon dating by an Oxford team consisting by the author and Dr. T.F.G. Higham, a shell valve with unusual edge chipping was noticed. Careful macroscopic and microscopic examinations confirmed this to be
a deliberate, man-made modification of the valve into a shell scraper (Fig. 2; also see Section 5.2).

The tool is made from the right valve of a thick, medium sized, Glycymeris bimaculata (Poli 1795), an infaunal marine bivalve usually found in sandy and muddy substrates (Poppe and Goto, 1993). It preserves some of the original surface pigmentation and ornamentation such as reddish concentric lines and minute radial lines running from dorsal to ventral margins (for the technical terminology see Fig. 3). Internally, the hinge plate and the teeth are thick and well preserved, as are the adductor muscle scars. The crenulae along the inner valve margins are still visible some of them, however, are reduced in size due to the knapping process (Fig. 4c). The umbo, a natural weak spot of bivalves and often the first area to abrade (Rogalla and Amler, 2007), shows no evidence of damage. An elongated missing chip in the interior surface, right beneath the anterior adductor muscle scar (Fig. 4c) must have occurred before or during the retouching process. Surface polishing along the posterior and anterior dorsal margins is very noticeable, possibly the result of prolonged use or beach abrasion (Fig. 5a–c).

Since no methodology for analyzing archaeological worked shell exists, principles of lithic tool classification are used to describe the scraper from Ksar Akil. In terms of technological characteristics, the ventral and, to a much lesser extent, the posterior and anterior shell margins are unifacially retouched with several percussions performed from the internal, concave side of the valve outwards and perpendicular to the margins. The modification was conducted with the purpose of sharpening the edge and the reduction sequence consistently follows the shell’s normal growth line (Fig. 4a–b). Some of the flake scars are more invasive than others and create a relative irregularity in the retouching result, especially along the anterior margin (Fig. 4d). The ancient modification, around 13 cm in total length, is partially covered by brecciated residue and different in colouration from the rest of the valve surface.

Overall, the round shell scraper from Ksar Akil seems an ideally symmetrical implement, but its precise use remains a matter of conjecture. Functionally, it may have been used on soft tissues such as hides and flesh, for peeling roots and extracting plant fibres, for scraping wood or shaping bone or antler blanks into a point or awl similar to those reported by Newcomer (1974). Microscopic observation revealed that, apart from the posterior and anterior dorsal margins near the umbonal region which are heavily polished, the retouched areas of the ventral margin are lightly polished in microregions and display a pattern similar to that produced experimentally by Cristiani et al. (2005) who used Callista chione shells to cut and scrape wet hides (Fig. 5d). G. bimaculata is the thickest and heaviest of all Glycymeris species in the Mediterranean, composed entirely or aragonite arranged in two layers, an outer crossed-lamellar and an inner complex crossed-lamellar (Taylor et al., 1973). Limited replication experiments were performed in order to identify and characterize signatures of production. Two G. bimaculata valves from the coast of Israel where retouched (not worked) using a stone and a heavy bone anvil. The results as to the exact production stage,
4. Provenance and age

According to the accompanying label, the artefact comes from square G 4, level IX and 8.00 m below datum, most probably from Ewing’s 1947–1948 excavations. The excavation year is not included but it was deduced from the description provided by Hooijer (1961) regarding the labeling of the rest of the faunal material. In terms of cultural affinities and chronological attribution, level IX corresponds to the transition from the Ahmari-Aurignacian (XIII–IX) to the classic Levantine Aurignacian (VIII–VII) phase, as recently redefined by Goring-Morris and Belfer-Cohen (2006). The lithic industry assigned to level IX is characterized by a high scraper-index, abundant retouched blades and bladelets, and some el-Wad points (Bergman and Goring-Morris, 1987; Bergman, 1987; Williams, 2006). However, its uppermost spits are considered mixed with level VIII in which 60% of the lithics are end-scrapers and which, interestingly, has yielded the majority of the osseous artifacts in the site (Bergman, 1988).

Ewing’s level IX seems to correspond to Tixier’s layer 12 (Mellars and Tixier, 1989). The latter is associated with a radiocarbon date (MC-1192: 32,000 ± 1500) produced in the 1970s, while level IX was recently dated at ~30 ka ^14C BP (OxA-20023: 30,360 ± 140). To validate the age of the scraper, the shell was directly dated using AMS ^14C in the Oxford Radiocarbon Accelerator Unit (ORAU). A few milligrams of calcium carbonate were drilled from the internal side of the hinge plate and part of it underwent mineralogical determination using X-Ray Diffraction (XRD) to check for possible diagenetic alteration. Since Glycymeris shells consist entirely of aragonite (Taylor et al. 1973; Rogalla and Amler, 2007), any post-mortem mineralogical alteration would result in the formation of low-magnesium calcite, and possible carbon isotopic exchange. The XRD spectrum of the shell powder revealed 100% aragonite, showing no secondary alteration. The sample was prepared for dating using routine methods (Brock et al., 2010) and yielded a radiocarbon age of 37,210 ± 230 ^14C BP (OxA-20022).

5. Discussion

5.1. Age of the shell scraper

The date of the artifact is at odds with the rest of the available dates for level IX. Even when corrected for the marine reservoir effect (~400 years; Reimer and McCormac, 2002) and accounting for the pulse in radiocarbon production around this period, the date is several millennia too old in calendar terms. It is very difficult to imagine that material from lower levels corresponding to ~37 ka ^14C BP reached level IX through post-depositional processes, which would mean uplift through several meters (~5–7 m) of deposits. Also it is unrealistic to suggest that the shell tool was in constant use for 7000 years until it was discarded in level IX.

There are two possible explanations: (i) the mollusc died at around 37 ka ^14C BP and its shell was modified shortly after, but the attribution to level IX is erroneous due to post-excision mixing, or (ii) the implement was made at around ~30 ka ^14C BP, on an “old” shell collected from a nearby beach.

With regards to the first point, although difficult to prove without considering further analytical data (e.g. direct dates of

Fig. 2. The Glycymeris bimaculata valve with evidence of edge modification. Top row: Internal and external views. Bottom row: ventral margin with evidence of retouch and dorsal area showing the intact umbo.
other shell remains in the assemblage), there is little indication of serious post-excavation mixing in the collection, which appears generally well-labeled. Ewing (1949) mentions the painstaking in situ studying, labeling and wrapping of the finds and Hooijer (1961) notices the remarkable packaging of all faunal material (including the malacofauna) from the site. Furthermore, most specimens — including the valve under discussion — are still accompanied by the original label that indicates square, level and depth from datum, exactly as described by Hooijer (1961).

The second hypothesis requires further consideration. The use of old shells either from fossil outcrops or from time-averaged beaches is not surprising. Molluscan shells have a long post-mortem life and depending on the depositional conditions may survive intact over long periods of time. A shell, now on the surface, may have undergone repeated burial/exhumation cycles due to physical reworking of the host sediment in taphonomically active zones (Kidwell, 1998) but it is also possible that sand-dwelling borrowers such as Glycymerididae, die within the sediment and their shells stay there for long periods until they are washed ashore several hundred or thousand years later by bottom currents or bioturbation. These specimens will show minimum degradation, abrasion or bioerosion signs (Nielsen, 2003; M. Zuschin, personal communication January 2009) just as the Ksar Akil valve.

Recent studies support the hypothesis that the remains of well-preserved, millennia-old bivalves can be found in present-day beach deposits along the eastern Mediterranean coast (Sivan et al., 2005). As to their age-span, taphonomic studies have demonstrated that there is very strong skewness in the age distribution of time-averaged shell beds, meaning that while some old shells may exist, these tend to be rare (Olszewski, 1999; Kosnik et al., 2007). In the case of the Levantine Glycymeris concentrations, however, old shells seem to persist longer (Sivan et al., 2005) and were probably available for collection by the Ksar Akil dwellers too.

Circular as may be the argument, the older age of the Ksar Akil valve relative to its context strengthens its utilitarian use and adds to the argument for this being an implement: the prospect of food collection is obviously dismissed and, unlike several other valves and gastropods from the site, no perforation or ochre residues exist to support ornamental use.

5.2. Authenticity of modification

The Ksar Akil valve shows a consistent retouching pattern parallel to the growth line along the full length of its ventral margin but not around the rest of its perimeter, especially at the anterior and posterior dorsal margins and the umbonal area. There, severe edge polishing and rounding is observed (Fig. 5a–b).

In order to securely determine whether this is a human modification, all possible processes responsible for altering molluscan valve edges were examined. According to Zuschin et al. (2003) these can be categorized in pre-mortem ecological interactions (predation, high-energy impacts and bioturbation), followed by

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**Fig. 3.** Drawings of the Ksar Akil shell with explanatory terminology used in the description of the valve's anatomical elements and modification. Drawings by K. Douka.
post-mortem biostratigraphic processes acting between death and burial (bioerosion, dissolution, abrasion) and, finally, depositional/diagenetic processes (compaction, tectonic stress or shear) and sample handling.

Post-mortem processes should be examined first since these have been affecting the valve for much longer. Setting to one side the margin modification and the expected loss of the organic peri-ostracum, the specimen under examination carries very few (if any) traces of beach-wear, wave or sand abrasion or other traces of post-mortem degradation. For an archaeological specimen, pedoturbation processes, essentially trampling in uneven cave-floors or beach deposits, should also be considered. Human trampling has been suggested to cause very small damage to living bivalve shells (e.g. Bally and Griffiths, 1989; Povey and Keough, 1991) and the author did not find any published experimental work with fossil/sub-fossil Glycymeris specimens having undergone trampling. In any case, if this was indeed the cause for the edge modification, signs of damage should be distributed along all natural edges of similar thickness (Stiner, 1993) and some scarring should exist on the shell surface too. This is not the case in the Ksar Akil specimen where flaking scars clearly stop at two thirds of the anterior and posterior margins only to be followed by edge polishing. Such pattern of selective polishing along the upper dorsal margins and around the umbonal area (unlike the evidence presented by Rogalla and Amler, 2007) may suggest repetitive friction applied to this particular area of the shell during use, either due to hafting or direct

Fig. 4. a. Detailed view of the reduction sequence that follows the shell’s growth line. b. Close-up of the retouching pattern. c. Crenulae reduced in size due to the knapping process, and missing elongated chip from the anterior margin, internal view. d. Detail of the anterior margin, external view, where flaking scars are more invasive than others.
rubbing with softer materials. No trampling evidence is present in any other part of the shell; the largest surfaces (shell wall and hinge plate) for example, are unaffected by any kind of damage.

In addition to traces caused by biostratinomic and diagenetic processes, shells may also carry evidence of pre-mortem predation by durophagous organisms. Bivalves are preyed upon by several animals, including boring molluscs of the families Naticidae and Muricidae, octopods (e.g. the common Mediterranean Octopus vulgaris) and flatworms, birds, crabs, lobsters (e.g. the Mediterranean slipper lobster Scyllarides latus) and fish (for reviews see: Carter, 1968; Vermeij, 1983, 1987). Boring carnivorous organisms drill holes which are typically neat perforations at the wall or edge of shells (Thomas, 1976; Kabat, 1990; Kelley and Hansen, 2003; Harper, 2005). Epifaunal organisms, such as birds and crabs, armed with scissor-type weapons (beaks, claws) cause very localized, usually complementary, U-shaped scars, peeled margins or irregular punch holes and fractures (Vermeij, 1982; Kowalewski et al., 1997; Kowalewski and Flessa, 2000). It should be noted that crabs tend to readily examine and reject dead bivalves (half valves), therefore post-mortem attack is less likely by these predators (Walker and Yamada, 1993). Fish will actually crush the shell with their strong teeth or grinding palate to access the soft part of the bivalve, and the broken shell will be discarded from the mouth (Carter, 1968); fracture of the valve should be expected. Burrowing bivalves (such as Glycymeris sp.) may also suffer from self-inflicted damage during rapid reburrowing through hard gravelly sediments (e.g. Checa, 1993).

Fig. 5. Microscope pictures produced by a digital camera connected to a Prior MP3502K optical microscope, at 20x and 40x magnification using external illumination a–b. Heavy surface polish of the dorsal anterior margin. c. Light polish developed locally on the internal side of the retouched ventral margin. d. Detail of the retouched edge which has developed light polish at microregions of the outer shell layer (crossed-lamellar microstructure). The inner shell layer (complex crossed-lamellar) has remained serrated.
but see Ramsay et al., 2001), however if the damage to the Ksar Akil specimen had happened pre-mortem the entire shell should display the same colouration caused by subsequent weathering of the valve and its damaged areas.

Finally, rodents could prey upon living molluscs (Parisi and Gandolfi, 1974) and gnaw their shells but the inflicted damage is expected to consist of distinct shallow serial, parallel or subparallel grooves and not flaking scars.

Clearly, examination of the published evidence for predatory scars on bivalve shells and especially on Glycymeridae revealed that such direct damage does not compare favorably to that of the modified edges from the Ksar Akil specimen. The latter displays a continuous and almost regular flaking pattern and certainly not localized and/or randomly distributed scarring or crushing as is expected from predators’ attacks even when these are recurrent.

Based on both experimental and archaeological results, Schmidt et al. (2001) suggest that the only valves that contain retouch and/or use-wear can definitely be classed as tools, and retouch is indeed evident in the Ksar Akil implement. The presence of sediment attached to the original flake scars along the ventral margin supports the antiquity of the modification (Fig. 4a,d). Most importantly, the sharp contrast in color between the modified edge and the rest of the shell surface is also consistent with a time lag between the death, initial deposition and surface discolouration of the shell, and the time of its subsequent retouch during which whiter inner aragonitic parts were exposed.

All things considered, it is highly unlikely that pre-mortem ecological or post-mortem biostratigraphic or diagenetic processes caused the edge modification at the Ksar Akil Glycymeris valve. Human involvement is the most likely explanation for the origin of the modification.

During an initial screening of the mulluscan assemblage from Ksar Akil, we failed to identify any comparable scrapers, although many of the valves with similar morphology show evidence of beach-wear such as pitting, heavy polishing and edge rounding and, in some cases, only a crescent-shape part of the ventral margin is preserved. Most of these types of damage are consistent with sand abrasion, however, since the assemblage has not been studied in detail yet it is unclear whether some of these alterations were caused by humans. What is clear is that many of the Glycymeris valves brought to the site were already dead and often beach-worn, therefore may be regarded not as shell food refuse but as having other utilitarian or symbolic uses. Altena (1962) considered some of the Glycymeris specimens to have served as spoons.

5.3. Utilitarian shell during the Middle and early Upper Palaeolithic

Over the past few years, shell artifacts have gained a prominent position in the discussion of human behavioural and cognitive attainment, especially when they relate to symbolic activities or when they suggest exploitation of aquatic resources and adaptation of human groups to diverse ecozones (Erlanson, 2001; Klein et al., 2004; D’Errico et al., 2005; Marean et al., 2007; Bar-Yosef Mayer et al., 2009; Zilhão, 2007). Additional discussions have focused on the selection of shell as raw material for the production of tools (Szabó et al., 2007), and the implications this choice has on traditional views of ‘modernity’.

Shell tools form an interesting feature of human adaptation, an invention similar to the lithic tool traditions (Choi and Driwanto, 2007). Yet, they are rare finds in prehistoric sites and there are only a handful of Middle Palaeolithic sites in Europe with evidence of deliberate conversion of marine shell into tools. These sites are all associated with Mousterian (Neanderthal) industries. In Italy, these include the sites of Grotta del Cavallo (Palma di Cesnola, 1965, 1966), Grotta dell’Alto and Grotta Uluzzo C (Borzatti von Löwenstern, 1966), Grotta Mario Bernardini (Borzatti von Löwenstern, 1970), Grotta dei Giganti (Blanc, 1959), Grotta dei Moscerini (Vitaglione, 1984; Stiner, 1993, 1994) and along the Ligurian coast (ex-Casino, Riparo Mochi and Barma Grande). Only one site is known from Middle Palaeolithic Greece, that of Kalamakia Cave (Darlas and de Lumley, 1989). In all cases, C. chione specimens were intentionally broken to make simple scraper tools and some have been unifacially retouched. Yet, Neanderthals stop exploiting this material at around 60–50 ka BP, if not earlier, long before their extinction in the respective regions, and according to current data, they do not produce shell tools again. In early Upper Palaeolithic contexts, of comparable age to Ksar Akil, the earliest shell tools were reported from Golo Cave in Indonesia (Szabó et al., 2007). In Europe or the Levant no other instances are known to the author until much later prehistoric periods.

Molluscan shell is often considered a “substitute” raw material for tool manufacturing and the intentional use of this resource is often interpreted as an action of necessity that reflects lack of good quality lithic resources (Toth and Woods, 1989; Szabó et al., 2007). The scarcity of fine-grained lithic material for the southernmost Middle Palaeolithic Italian sites and the Indonesian case, must have led human groups to occasionally exploit non-flint stone varieties and readily available molluscan shells (Szabó et al., 2007; Riel Salvatore and Negrino 2009).

At the Ksar Akil rockshelter, we lack a comprehensive study of the surrounding environment and available raw material resources. Flint, however, of Cretaceous and Eocene age, appears accessible in the vicinity of the site, although its availability in the past could not have been constant. With the exception of a handful of bivalves, the Middle Palaeolithic levels of Ksar Akil are bare of marine shells. By contrast, several hundred gastropods and bivalves were recovered from the Transitional and Upper Palaeolithic levels of the site (Altena 1962; Kuhn et al., 2001). The collection and transportation of mulluscan shell to the site indicates deliberate, repetitive use of this material during these particular periods. Yet, the shell scraper reported here is not a typical example of recurring tool production. It reflects an occasional action, possibly associated with experimentation with new material types and forms and essentially revealing a “direct transference of lithic techniques to the medium of shell” (Szabó et al., 2007, my emphasis).

Palaeolithic archaeologists sought to carefully investigate shell remains prior to classifying them as simple food refuse. Revisiting previously excavated Palaeolithic archaeomalacological collections might bring further insights into aspects of utilization of this material. A notable example is the recent re-analysis of a shell assemblage from Iberia that revealed the presence of perforated shells with pigment traces (Zilhão et al., 2010).

5.4. Cautionary note for the use of shell in radiocarbon dating

Marine shell is an excellent material for radiocarbon dating, resistant to most contaminants that provide a constant hindrance to the proper application of the technique on archaeological remains. Limiting factors intrinsic to this material have been discussed by various authors (Berger et al., 1964; Mangerud, 1972; Grant-Taylor, 1972; Bezerra et al., 2000) and include the global and local reservoir effect and uncertainties over its quantification and temporal variability, the calibration of the marine radiocarbon age, the question of the hard-water effect and the incorporation of exogenous carbon atoms during the recrystallization of the original carbonate, and the “old shell” effect (Douka et al., 2010). The last issue is worth re-examining in the light of the radiocarbon date obtained for the shell scraper (OxA-20022). The “old shell” effect (Rick et al., 2005) describes the issue arising when a shell is deposited in an archaeological site, hundreds or thousands of years after the actual death of the animal. As a result, the age of the shell
matrix carries an inbuilt age that does not relate to that of the archaeological event or horizon. This is illustrated in the case of the Ksar Akil valve, where the age of the implement is much older than the age of its context. Yet the occurrence of an “old shell” in this particular context is not surprising given that is well known that empty Glycyrmeris valves are washed along the eastern Mediterranean coast (Sivan et al., 2005).

On the other hand, it is important that archaeologists are not dissuaded from dating shell remains. Recent radiocarbon results ($N \sim 130$) obtained within a project focusing on the direct dating of the earliest Palaeolithic shells in Europe, revealed that only a small number of specimens was affected by the “old shell” issue.

Attention should be drawn to careful sample selection and, ideally, a series of dates from short-lived material throughout an archaeological sequence should be also obtained. This way, any anomalous dates can be identified and excluded from further consideration by using Bayesian statistical approaches (Bronk Ramsey, 2009a, 2009b).

6. Conclusions

Based on its context, the unique shell artefact from level IX of the Palaeolithic rockshelter Ksar Akil, is assumed to be the handiwork of Homo sapiens. This contribution is dedicated to the late Dr. Roger Horney, A.G., Libby, W.F., 1964. Radiocarbon dating of bone and shell from their technical components in the Middle Palaeolithic. Geologie en Mijnbouw, 43, 112–147.


