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ANTHROPOLOGIE UND PRÄHISTORIE

Freshwater gastropods as Neolithic adornment: size selectiveness and perforation morphology as a result of grinding techniques

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(With 1 textfigure and 3 plates)

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Zusammenfasung

Schalenperlen finden häufig Erwähnung in archäologischen Berichten. Die angewendeten Techniken, um die Löcher zu produzieren, werden jedoch meist nur sehr oberflächlich diskutiert, ohne näher auf die Vermutungen einzugehen. Hier versuchen wir eine Methode der Lochung experimentell an Schalen der Flussschnecke *Lithoglyphus naticoides* nachzuahmen. Als archäologisches Vergleichsmaterial dient eine "Population" an Schalenlöchern, die aus einem frühneolithischen Grab (Linearbandkeramik – LBK) aus Kleinhadersdorf in Österreich stammt. Ziel ist es zu testen, ob die durch Anschleifen erzielten Öffnungen lediglich Zufallsprodukte sind, oder, ob der neolithische Handwerker bereits versucht hat bestimmte Vorgaben einzuhalten. Die statistische Analyse dokumentiert eine deutliche Bevorzugung bestimmter Schalengrößen und Lochungsparameter. Das Fehlen von sehr großen, adulten Schnecken lässt eine ästhetische Komponente bei der Wahl der Objekte vermuten. Andererseits deutet die geringe Varianz der Lochparameter und das Fehlen von besonders kleinen Schalen auf technisch-praktische Komponenten: Die gleichförmige und repetitive Schleiftechnik begünstige Perforationen mit relativ ähnlichen Durchmessern, und kleine Schalen wurden wahrscheinlich aufgrund der schwierigeren Handhabung und der geringere Stabilität vermieden.

Die Anschleifexperimente zeigten, dass überraschend wenig Zeit aufgebracht werden muss, um die Öffnungen zu erzeigen. Die 124 Schnecken aus der neolithischen Fundstelle könnten in deutlich weniger als einer Stunde perforiert worden sein.

Schlüsselwörter: Neolithikum; Linearbandkeramik; Schalenperlen; Schleiftechnik; Dekoration

Summary

Shell beads are frequently mentioned in archaeological reports. The associated piercing technique, however, is often merely cursorily discussed without giving evidence for the proposed method. Herein, we document the methodology of perforating the shells of the fluvial gastropod *Lithoglyphus naticoides* based on experimental comparison. We focus on one "population" of piercings found in an early Neolithic

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grave in Kleinhadersdorf in Austria (Linear Pottery Culture – LPC) to determine whether these artificial openings are a random product of grinding or whether the Neolithic craftsmen already tried to meet distinct parameters. The statistic analysis documents a clear selectiveness within the used shell sizes as well as within the perforation parameters. The lack of large-sized shells within the size class distribution of the shell-beads suggests some aesthetic component when choosing the shells. In contrast, the narrow range of perforation parameters accompanied by the lack of small-sized shells suggest a quite technical approach, which resulted in comparable openings due to a very mechanical, repetitive technique. They also suggest a selectiveness against very small shells due to their lower stability and difficulties in handling.

Grinding experiments showed that producing the perforations consumed surprisingly little time. The total number of shells (n=124) used for the decoration could have been perforated in distinctly less than one hour.

Keywords: Neolithic; Linearbandkeramik/Linear Pottery Culture; shell beads; grinding techniques; decoration

Introduction

Shells and ivory beads are widely used decorative elements in Palaeolithic and Neolithic cultures. Especially, the use of shells with natural perforations due to hydrodynamic breakage and abrasion is widely recorded from prehistoric sites (Borrello 1990; Pauc & Reinhard 2002). In the Austrian Vienna Basin and the North Alpine Foreland Basin, such adornments of fossil (Miocene) and imported marine shells have been reported by Bachmayer & Papp (1956). In this area, especially fossil shells of scaphopods and gastropods were utilised, supported by common occurrence of fossiliferous Middle Miocene deposits throughout the basin. Scaphopods were preferred because of their tube-like, hollow morphology (e.g. from the Aurignacian of Senftenberg in Lower Austria (Bachmayer & Papp 1956). Similar adornments from fossil scaphopods are also widespread in the Neolithic of Europe (Fernámdez et al. 2003). Among the gastropods, shells with natural borings created by preying naticid and muricid snails occur in the archaeological sites. Both categories document a human selectiveness for "ready-mades". In contrast, extant shells deriving from riverine settings did not display this advantage because drilling gastropods do not occur in freshwater.

Therefore, recorded perforations for sewing or beading of those shells can only be referred to natural, hydrodynamic breakage or to artificial activity. The usage of artificially produced shell beads was already widespread and well established throughout Central and Eastern Europe during the late Palaeolithic (Kölbl 2003; Kölbl & Conard 2003; Rähle 1978; 1994; Sinitsyn 2003). Many late Palaeolithic examples show raw artificial openings (e.g. *Cyclope nerita* from the Aurignacian of Krems in Lower Austria; about 35,000 years (Bachmayer & Papp 1956; Strobl & Obermaier 1909), which were most probably fashioned by piercing the shell wall, through the aperture, with a sharp object. This simple method is already recorded for the oldest known artificial holes in shell beads of *Nassarius* from the 78 ka old deposits of the South African Blombos Cave (d'Errico et al. 2005). This Palaeolithic drilling technique, however, results in irregular openings lacking predictable, well-defined morphologies.

Evidence of shell ornaments from the European Mesolithic is frequently recorded as well (Grünberg 2000), but in most cases technological details are lacking. In the early Neolithic, aside from the simple piercing techniques, the more advanced grinding technique also became established. Typical examples are described from the Linear Pottery

Culture of southern Germany (BRINK-KLOKE 1990; NIESZERY 1995) and from Bandkeramik graves in Austria (NEUGEBAUER-MARESCH et al. 2002). In the central European Linear Pottery Culture the continuation of the simple piercing technique performed on *Lithoglyphus naticoides* shells is documented by HLADIKOVÁ (2002) from one of the oldest cemeteries in Vedrovice, Moravia. Early grinding techniques are discussed for *Theodoxus danubialis* shells from the Bavarian cemetery of Essenbach-Ammerbreite (BRINK-KLOKE 1990) and other large LPC-cemeteries in Bavaria (NIESZERY 1995).

According to the mentioned references, only 39 graves out from 2500 early Neolithic graves in Central Europe contained shell-bead ornaments. Marine shells dominate in the in the German Rhineland and west of it, whereas the fluvial gastropods *Theodoxus danubialis* and *Lithoglyphus naticoides* have been utilised from Bavaria eastwards (JEUNESSE 1997). About 50 % of the graves contain women and 25 % represent men and children respectively (see LENNEIS 2007). Most of the shell ornaments are found around the head and/or around the neck, and partly also on the body. Most probably they have been sown on bonnets and on the clothes. A recently published reconstruction of a bonnet or hair net of a 60 year old lady from the Bavarian cemetery Aiterhofen also interpreted the shell beads to have been sown on a sort of hairnet (LÜNING 2005). In some cases, the shells have been arranged along a cord (e.g. Aiterhofen grave 60 in NIESZERY 1995). Only few findings from the Rhineland and France suggest necklaces or bracelets (e.g. Ensisheim: GALLAY & MATHIEU 1988). During the early Bronze Age, such shell decorations were sometimes composed of enormous numbers of shells; e.g. 1500 shells were used for a head and chest decoration in the Austrian Unterwölbling Group (NEUGEBAUER-MARESCH & NEUGEBAUER 1997).

Usually, the authors provide no detailed descriptions of the artificial openings and do not discuss the interference between assumed aesthetic selectiveness and technical limitations resulting in certain shell-bead patterns. An assemblage of decorative shell beads from a Neolithic grave at Kleinhadersdorf in Lower Austria (Linearbandkeramik /Linear Pottery Culture) is thus used to evaluate an advanced perforation technique which allows very well-defined shape and size parameters to be met.

Material and origin of the shells

In total, 124 perforated specimens of *Lithoglyphus naticoides* (PFEIFFER, 1828) are available from a single early Neolithic grave within the LPC – cemetery of Kleinhadersdorf in Lower Austria (Fig. 1; NEUGEBAUER-MARESCH & LENNEIS 2006). The perforated shells were found as band-like pattern on the head of a small child, covering the area between sutura coronalis via the parietal bones back to the occiput (LENNEIS 2007), indicating that they had been part of a head decoration. A priori, there are 2 possibilities to reconstruct this decoration: the shells may have been sown on a sort of baby-bonnet or a string with the shells might have been put around the head just as a decoration for the funeral. Only 100 of the shells are preserved well enough to allow detailed measurements of shells and of the perforations. The other shells are usually adapically fractured and have been excluded from analysis. The shells are stored at the Museum Poysdorf in Lower Austria (excavation C. NEUGEBAUER-MARESCH 8.8.1988, Verf. 26).

The small-sized sub-spherical gastropod occurs in shallow-water areas of rivers and rivulets of Central and Eastern Europe. There, adult specimens of *Lithoglyphus naticoides* attain a maximum height of 9 mm. Ložek (1964) reports it from the Thaya and Morava rivers, which are potential origins of the considered shells based on their closeness to the discovery site. The distance from Kleinhadersdorf to the Thaya River in the north is about 17 km, to the Morava about 25 km. There, *Lithoglyphus* forms small populations along the banks and can be collected alive or dead. The material was therefore regionally available and easy to collect. An anthropogenic import of the gastropod shells from eastern or south-eastern Europe for Neolithic *Lithoglyphus* occurrences in central Europe, is unlikely. This species was well established in central Europe and is frequently recorded in the central European fossil record from the late Miocene (Lueger 1979), the Pliocene (Hladiková 2002) and the Pleistocene (Ložek 1964).

Abbreviations:

BDA – Bundesdenkmalamt, Vienna, Austria

Morphology and size class distribution

Shells

The 124 white, aragonitic shells are well preserved, displaying hardly any diagenetic corrosion. One hundred of these allow a detailed morphometric measurement. The studied shells range from 4.91 to 7.63 mm in height and 4.27 to 7.38 mm in width (Fig. 2) and represent subadult to adult specimens. Shell height and shell width are well correlated ($r^2 = 0.67$). Despite the broad range of sizes used for the decoration, the distribution of size classes does not reflect the near-normal distribution of naturally occurring populations. A grouping into size classes reveals an asymmetric, right-skewed distribution with a positive skewness of 0.4 (Fig. 3). The lower bound is formed by rare, small-sized shells between 4.9–5.5 mm, contrasted by a narrow size class peak between 5.5–6.5 mm. After another strong break, the frequency gradually declines towards large-sized shells. Thus, fully grown adult shells are rare and the maximum size of extant *Lithoglyphus naticoides*, attaining 8–9 mm, is even missing.

Perforations

All shells display a marked perforation (Plate 1). The ovoid perforations have a width between 1.19–3.79 mm and a height of 1.05–2.82 mm (Fig. 2B). The margins of the perforations form a flat plane and lack any cylindrical parts. The ovoid outline, thus, results from a flat cutting plane along which a subspherical segment of the gastropod whorl was removed. Due to that geometry, the width and height of the perforations are well correlated ($r^2 = 0.4$). The frequency of size classes indicates a normal distribution (skewness: 0.007) with a peak at a perforation width between 2.51 and 2.80 mm (Fig. 3B). The difference between normal-distributed perforation size and right-skewed shell size is also evident in the complete lack of correlation between these measurements ($r^2 = 0.03$; Fig. 2C).

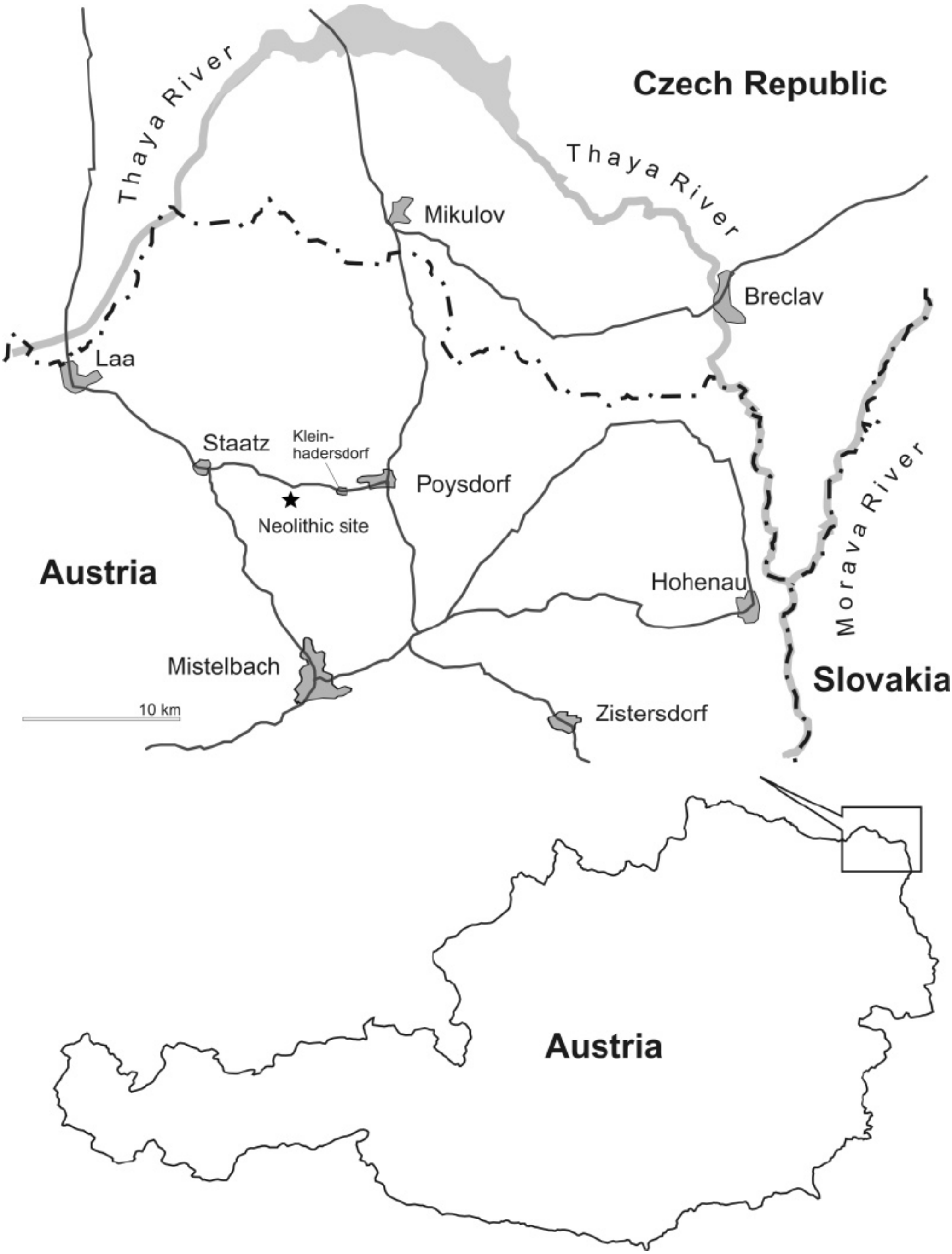

Fig. 1: Geographic position of the archaeological site Kleinhadersdorf in Lower Austria along the margin of the Vienna Basin. The Morava and Thaya rivers in the east and north are the most likely origin of the investigated shells.

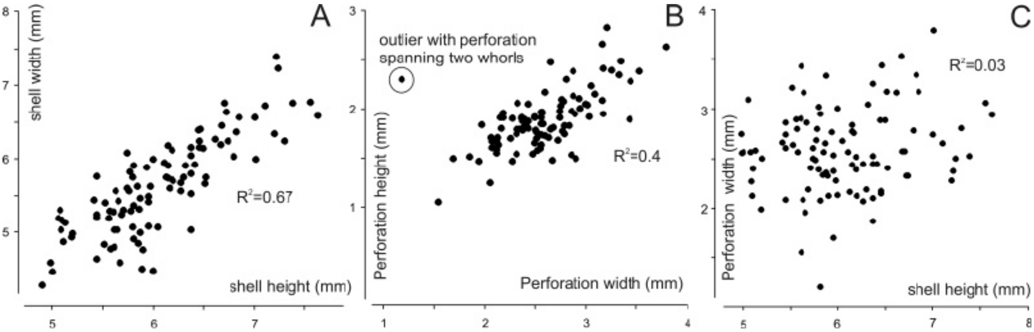

Fig. 2: Morphometric analysis of 100 *Lithoglyphus naticoides* shells from the Neolithic grave. **A**: Shell height and shell width show a fairly high correlation of 0.67. **B**: Width versus height of the perforations; the moderately high correlation (0.4) is related to the grinding technique, which produces a flat cutting plane as the border of the perforation. The singleton outlier is a perforation spanning two whorls. Hydrodynamic, natural breakage would not cause the predictable correlation of the perforation parameters. **C**: No correlation exists between shell height and perforation diameter. The routine grinding technique focused on comparable perforations, irrespective of shell size.

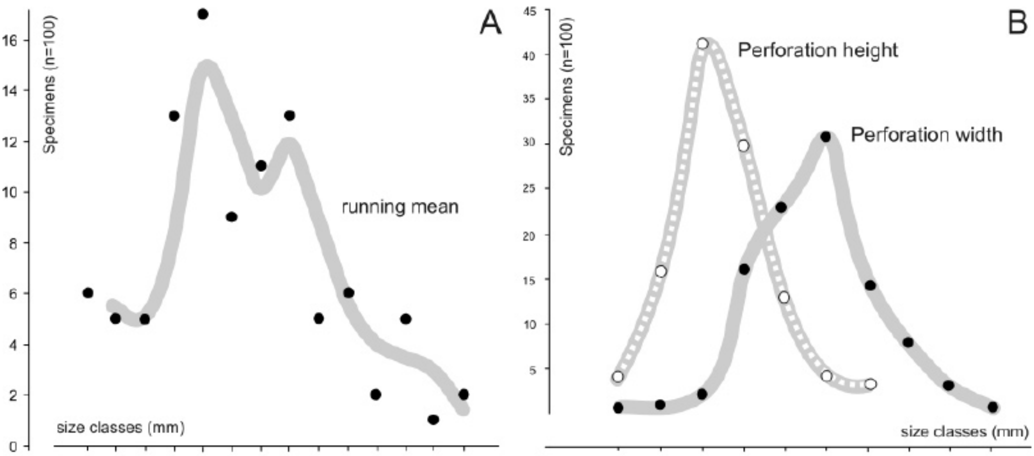

Fig. 3: Size class distribution of shell beads and perforation parameters. **A**: The frequencies reflect a right-skewed distribution with an abrupt decline towards small sizes, reflecting pronounced size selectiveness. The distribution is visualised by adding the running mean, which emphasises the size peak between 5.5 and 6.5 mm. **B**: Size class distribution for the perforation parameters width and height; both measurements display near normal distributions with unimodal peaks indicating a precise and oriented procedure.

The holes are restricted to the body whorls of the gastropods and are exclusively found within the segments 6–8 of the shells (Fig. 4B). Only a single specimen displays a perforation reaching up to the penultimate whorl. Several shells bear subparallel scratches close to the anterior (adapertural) and posterior (adapical) margins of the perforations (Fig. 5).

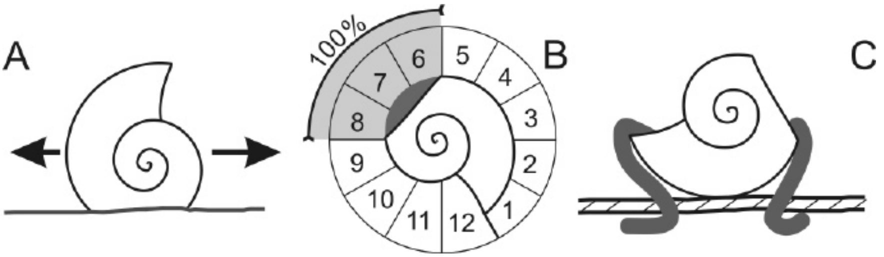

Fig. 4: **A**: Position of the gastropod shells during grinding experiments; the shells were grinded with subparallel movements across a sandstone slab. **B**: Experimental grinding yielded perforations in the same shell sectors as documented for the Neolithic ones. **C**: Hypothetical stitching position of the shells based on the abrasional marks along the adapertural margins of 38% of the perforations.

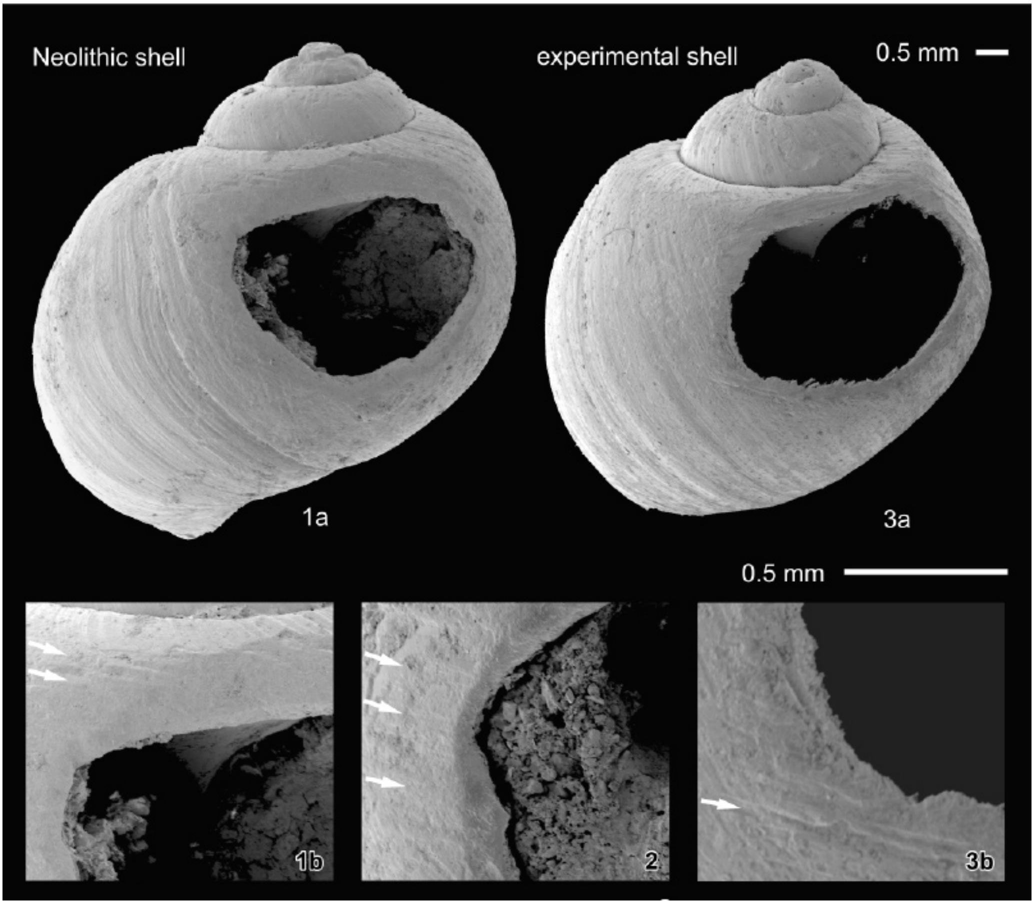

Fig. 5: Comparison between a Neolithic perforation (**1–2**) and an experimental one (**3**) achieved by grinding with a sandstone slab. Size, morphology and outline are identical. The SEM photos also show highly similar details on the surface close to the perforation margins (arrows). These subparallel scratch marks are caused by larger quartz grains in the sandstone slab.

Whilst the upper and lower parts of the margins are usually well preserved and sharp, the anterior and posterior parts bear traces of abrasion. Typically, small parts of the shell are broken out, leaving sharp fractured margins, or these areas are abraded, forming smooth indentations (see Plate 1/4). These marks occur at a ratio of 38 % anterior (adapertural, = segment 5 in Fig. 4B) versus 4 % posterior abrasions; the remainder of the shells (n = 100) lack such marks.

Discussion

Size of shell beads – aesthetic selectiveness or technical imperative?

The size class distribution is clearly not a normal one but reveals a strong cluster of shells spanning only 1 mm within a range of 5.5 to 6.5 mm height (Fig. 3A). This size category, containing 63 % of the shells, is framed by an abrupt drop towards small-sized (16 %) and a less severe drop towards larger shells (21 %). This right-skewed distribution implies a distinct selectiveness which might be triggered by three hypothetical factors: 1. only adult and probably already empty shells were collected; 2. small shells were hard to handle during the grinding procedure; 3. small shells were largely rejected because of aesthetic reasons.

The first hypothesis is invalidated by the fact that adult, fully grown *Lithoglyphus naticoides* attain a regular height between 7 and 9 mm. These large shells were not the preferred target for the decoration. The technical aspect might be of some importance because small shells turned out to be difficult to hold in experiments. Moreover, the apertures where the shells were fixed between the fingers during the experiments tended to break in juvenile shells. Hence, the lower bound of the preferred size class seems to be simply a matter of technique. By contrast, the few large-sized shells used for the decoration suggests that the aesthetic aspect might have been the main reason for the selective use.

Perforation – experimental reconstruction of techniques

The most striking feature of the holes is the flat cutting plain that determines the margins of the perforations. This morphology is the key for understanding the process that created the holes. Naturally occurring, hydrodynamic breakage cannot have produced such features: such processes yield openings with irregular margins whose edges are more or less perpendicular to the shell surface. Furthermore, natural perforations are typically confined to the exposed part of the shell opposite to the apertural plane (see Plate 1/8, segments 3–5 in Fig. 4B). Similarly, a punctuated fracture by perforating the shell with a sharp object cannot explain the geometry of the holes. In contrast, the Neolithic shells display sharp edges and the perforations are strictly confined to a well-defined shell segment (6–8 in Fig. 4B). Therefore, even a selective sampling of naturally broken shells for subsequent manipulation is extremely unlikely.

Both the flat cutting edge and the subparallel scratches on the shell surfaces close to the perforations (Fig. 6) suggest an abrasive grinding technique for hole production. Most probably, the shells were held at the aperture between thumb and index finger (segments 12, 1, 2 in Fig. 4B) and then moved in parallel directions across a grindstone. Drilling and piercing techniques can be excluded, as these would result in (sub)cylindrical or irregular walls (BOLUS 2003; TABORIN 1993). A slightly irregular roughness of the flat grinding surface is indicated by the unsteady occurrence of the scratch marks. Sandstone is therefore a realistic candidate as a grinding stone.

To test this hypothesis, recent shells of *Lithoglyphus naticoides* from the Danube River were used for an experimental reconstruction. A slab of Miocene fine to medium sand sandstone was chosen as a grindstone because this rock is common and easily accessible in the investigation area. By grinding the gastropod shell with parallel movements as indicated in Fig. 4A, perforations comparable to the Neolithic ones were achieved within 10, 14 and 22 seconds. These holes resulted from 21 to 35 parallel see-saw scratching movements. According to these experimental benchmarks, the grinding of all 124 shells might have taken about 20 to 45 minutes.

The position of the perforation on the shell is largely predetermined by the possibility to hold the shells on the aperture. Further evidence for the reliability of this interpretation of the perforation technique is the similarity of the subparallel scratch marks as preserved on the Neolithic shells with those of the experimental perforations.

Necklace or decoration – from wear to wear

The complete lack of correlation between shell size and perforation diameter (Fig. 2C), as well as the near normal distributions with unimodal peaks of the perforation parameters, documents that the Neolithic producer tried to achieve perforations of comparable diameter independent of shell size. This intentional production suggests subsequent usage either as a beaded necklace or as stitched decoration. Abrasion wear along the perforation might help to decide this question. The high percentage of anterior abrasion (= segment 5 in Fig. 4B) of the perforation margin points to a stitched fixation of the shells. Accordingly, the apertures of the shells were directed towards the viewer (Fig. 4C). The lack of such traces of wear along the aperture margin reflects the much more stable structure of that part of the shell compared to the fragile and thinned margin of the artificial perforation. This interpretation as a stitched decoration of a hood or cap is strongly supported by the position of the shell beads along the back of the head.

The traces of wear document that the decoration was already in use for some time, resulting in abrasion and minor damage. It had not been produced solely for the burial and might thus have been a regular garment of the infant.

Conclusions

Shells of the freshwater gastropod *Lithoglyphus naticoides* from an early Neolithic grave in Austria allow a reconstruction of prehistoric grinding techniques. The shells, used as decoration, display characteristic perforations which can be produced within 10–22 seconds by grinding the shells in a subparallel see-saw movement across a sandstone slab. The outline and morphology of the perforations achieved by this method using modern shells correspond fully to archaeological ones. Due to practical reasons – holding the shells at the aperture as the most stable position – only a narrow, well-defined shell segment is predestined for the perforation. Similar reasons probably account for the observed selectiveness of size classes, because small-sized shells are harder to handle. The use of 5.5 to 6.5 mm shells and the few larger, fully grown gastropods suggest a mainly aesthetic aspect for the selectiveness. A lack of correlation between shell size and perforation width provides evidence for a size-independent grinding procedure which was adjusted to achieve holes of about 2.5–2.8 mm width. Based on the subparallel scratch marks and the flat margins of the perforation, a drilling technique can be excluded. This technique, however, was not "outdated" at that time in this region. Hence, a Neolithic grave in Moravia contained about 300 specimens of *Lithoglyphus naticoides* which are reported by HLADIKOVÁ (2002) to have been perforated quite roughly by drillings.

The traces of fixation, preserved as abrasive marks mainly along the anterior margin of the perforation, contradict a usage as beads on a necklace but rather indicate that they were stitched on a no longer preserved material. Accordingly, based on the position on the back side of the head, the infant was probably buried with a shell-decorated hood. The abrasion documents that the decoration was already in use and was not produced solely for the burial.

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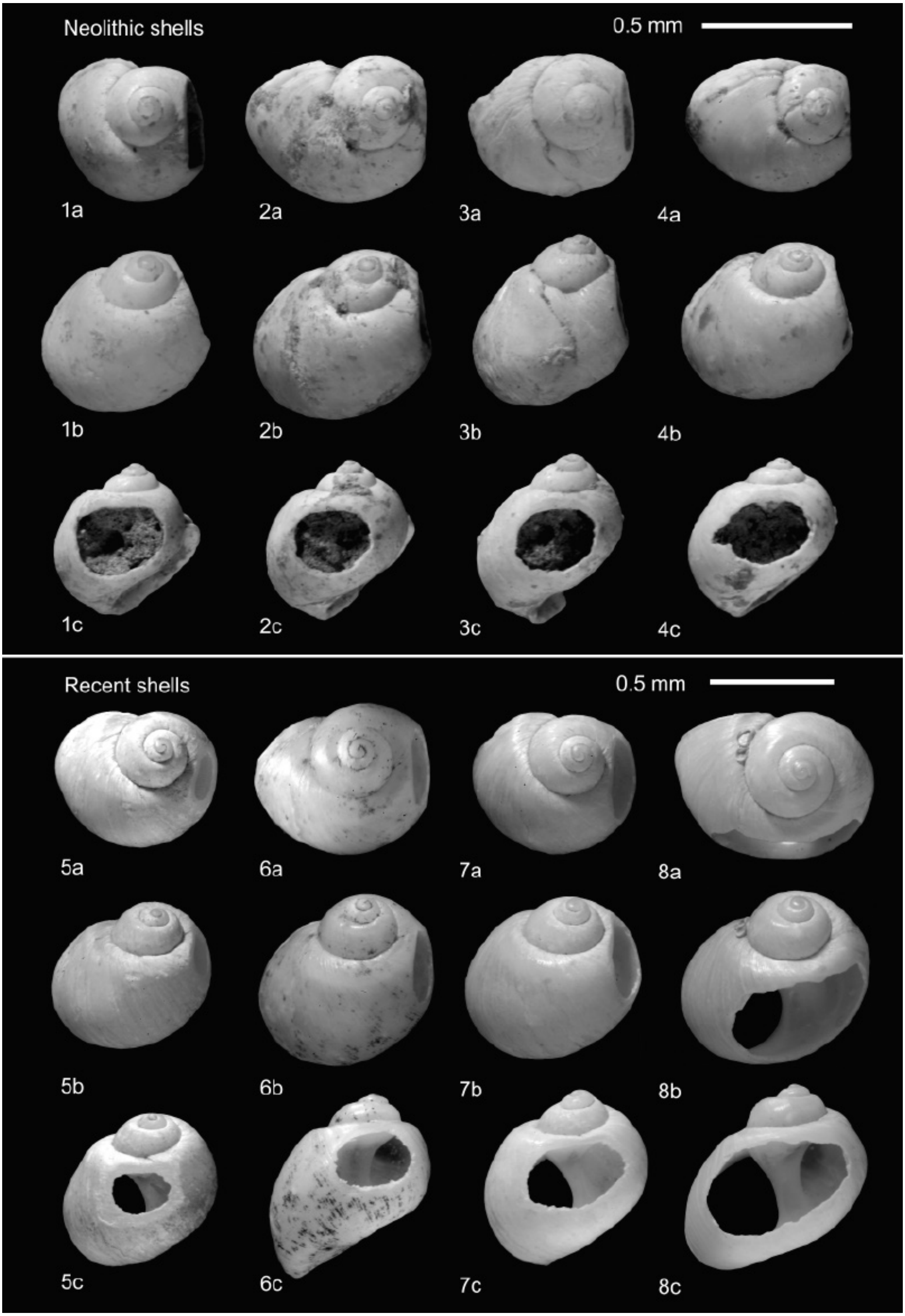
Plate 1

***Lithoglyphus naticoides* (Pfeiffer, 1828)**

Figures 1–4: Four shells of *Lithoglyphus naticoides* from a Neolithic grave at Kleinhadersdorf (Lower Austria) in posterior, oblique and lateral view. Note the low variability of the position of the perforation and the flat cutting plain of the margins. Figure 4 shows a characteristic notch in the adapertural edge of the perforation due to the fixation with a cord or string. All shells are stored in the collection of the Museum Poysdorf in Lower Austria (BDA 8.8.1988, Verf. 26).

Figures 6–7: Recent shells of *Lithoglyphus naticoides* from the Danube River with two stages of experimental perforation. The large perforations of Figure 6 and 7 correspond fully in position, shape and outline to those of the Neolithic ones.

Figure 8: Recent shell of *Lithoglyphus naticoides* from the Danube River with natural perforation due to hydrodynamic breakage. Under natural conditions, only the exposed part of the shell opposite to the aperture is prone to perforation. This clearly excludes that naturally perforated shells had been collected as a basis for artificial improvements by grinding. (All recent shells are stored in the Geological collection of the Natural History Museum Vienna.)


Neolithic shells
0.5 mm
1a
2a
3a
4a
1b
2b
3b
4b
1c
2c
3c
4c
Recent shells
0.5 mm
5a
6a
7a
8a
5b
6b
7b
8b
5c
6c
7c
8c