

Approaching prehistoric skills: experimental drilling in the context of bead manufacturing

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ABSTRACT

From the very Early Neolithic in the Balkans two categories of objects are recognized as having been involved in prehistoric drilling activities. The first is beads and other decorative and prestigious items made of bone, shell, pottery and various minerals. The second comprises toolkits of micro-perforators/borers found among the flint assemblages of several sites.

This paper presents experiments in drilling different materials with the aim of testing several practical issues. A series of micro-borers were produced and used for manual and mechanical drilling (with a pump drill). Various samples (mainly prepared thin plates) of minerals and rocks were used, ranging in hardness (on Mohs scale) from 3 (marble, limestone, calcite) to 6.5 (amazonite, nephrite). Biominerals were also used: aragonite (shells) and apatite (bones). Actual bead production was approached by manufacturing 16 delicate beads of 5 different materials using fine sand and water abrasion. Though not conclusive, the experimental work was instructive in many of the parameters, procedures and technical details of prehistoric drilling.

KEYWORDS

Prehistoric skills, micro perforators/borers, pump drill, drilling, experiments, beads, (bio)minerals, Mohs scale

Introduction

One of the most spectacular prehistoric artefact categories consists of various decorative objects, such as pendants, necklaces and beads made of minerals, shell, bone and pottery. They are impressive not only by the variety of colour and shape, but by the manner of manufacturing which still represents a challenge or even an enigma.

The best way to understand these beautiful and sophisticated objects and the narratives embodied within them is to reconstruct the range of abilities and skills that had been developed by the people who produced them.

The paper presents a series of experiments in drilling different materials that were undertaken with the aim of testing several practical issues relating to tool efficiency for drilling and optimal parameters for bead fashioning. The experimental programme at its initial stage did not focus on strict procedural protocols of experimentation. Rather, the purpose was to accumulate a basic empirical dataset of observations on concrete tasks – perforation

of materials of different hardness and production of delicate and thin cylindrical beads using different instruments, drilling techniques and final fashioning. This empirical knowledge will be used for tracing a chain of further experiments and establishing a deeper analytical procedure including comparative criteria and statistics of different operations (drilling, grinding, abrading), tool efficiency on identical *vs* different materials, use-wear patterns of differently worked tools and technological traces of differently produced holes, etc.

Prehistoric background

From the very Early Neolithic in the Balkans two categories of objects are recognized as having been involved in prehistoric drilling activities. The first category is represented by beads and other decorative and prestigious items made of bone, shell, pottery and various minerals such as marble, serpentinite, malachite, nephrite and jadeite. The second comprises toolkits of micro-perforators/borers found in the flint assemblages of several sites. There are some notable examples, as follows:

- A toolkit of 'micro-points' (borers) was recovered from Neolithic contexts at Franchthi Cave (Argolid, Greece). The association with cockle shell beads led Catherine Perlès to suggest the existence of a workshop for shell bead manufacturing at Franchthi during the Early Neolithic (Perlès 2001, 223-224, and fig. 10.5). In a later publication Perlès argued that the abundance of the 'micro-points' and borers in conjunction with the careful raw material selection, the evident standardization in their form and technique (representing a homogeneous techno-morphological toolkit), and the large quantity of shell beads supported the hypothesis of bead making as craft production beyond the needs of the local community (Perlès 2004, 153). Perlès' conclusions about the Franchthi workshop were heavily influenced by the results of a detailed experimental study by Ricou and Esnard (2000), in which some 3000 cockleshell beads were mass produced using a pump drill equipped with flint drill bits fixed in position with a mixture of pine resin and beeswax. Equally challenging and instructive is the experimentation and subsequent meticulous analysis of an *Oliva* shell pendant, performed by E. Melgar (Melgar 2010).

- Excavations in progress at the site of Schela Cladovei in Romania (Iron Gates region) have revealed a similar association of micro-perforators/borers with beads in various stages of preparation and made of different materials (mainly stones)¹. The assemblage of toolkits and beads are under study, the results of which should add significantly to our understanding of prehistoric mineral bead manufacturing.

- The Early Neolithic site of Kovačevo in south-west Bulgaria represents a particularly interesting case study of abundance of micro-perforators/borers; more than 100 examples were found, made of local flint and showing a broader range of morpho-metrical characteristics (fig. 1). The tips of the tools are from short to medium (3-9 mm), not always clearly separated from the body (with convergent rather than parallel lateral edges), sometimes asymmetrical, and fashioned by semi-steep to abrupt bilateral retouch. The morphological characteristics of the micro-perforators suggest they were used for making perforations, but there is no clear contextual association between this toolkit and the perforated objects from the site². Use-wear analysis of the large series of micro-perforators from Kovačevo

1 Bonsall C., Boroneanţ A. Balkan flint in the Romanian Iron Gates. Paper presented at the 15th Annual Meeting of the European Association of Archaeologists, Riva del Garda (Trento, Italy), 15-20 September 2009.

2 The jewellery and prestigious objects from the site are still under study. The artefacts from the site

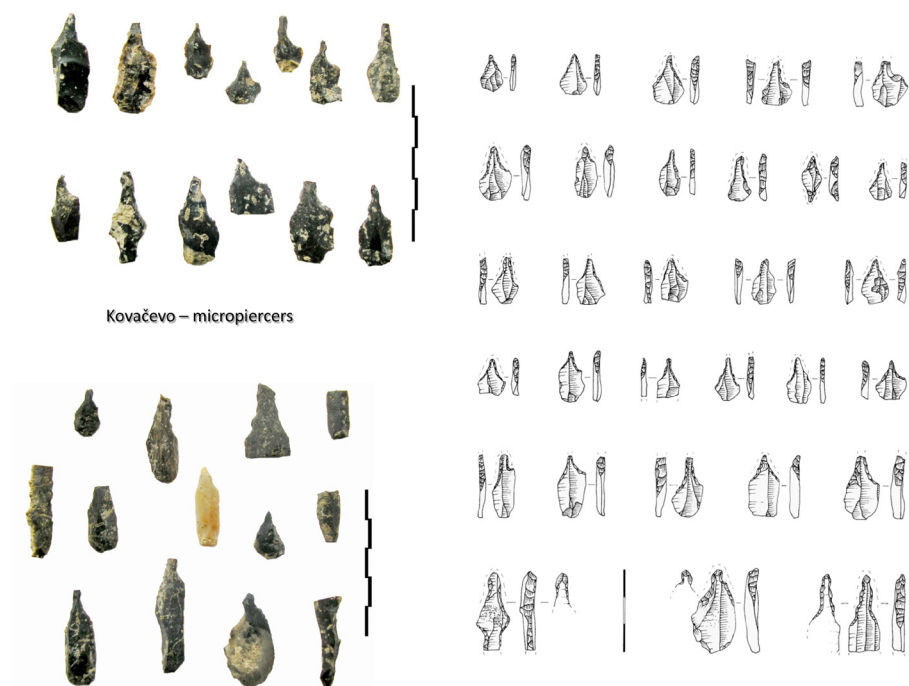


Fig. 1. Micro-perforators/borers from the Early Neolithic site of Kovačevo (south-western Bulgaria). Photo, drawing and figure by M. Gurova

Обр. 1. Микро-пробои/свредели от раннеолитното селище Ковачево (югозападна България). Снимки, рисунки и аранжимент – М. Гюрова



Fig. 2. Necklaces from the Early Neolithic site of Galabnik (western Bulgaria).

Photo and figure by M. Gurova (courtesy of A. Bakamska)

Обр. 2. Наниз от мъниста от раннеолитното селище Гълъбник (западна България)

Снимки и аранжимент – М. Гюрова

(с любезното съдействие на А. Бакъмска за достъп до материала)

reveals used implements (with generally well-developed microtraces), broken pieces (possibly through utilisation) and unused tools. Further study focusing on comparative correlative observations on micro-perforators and drilled objects is needed in order to clarify many of the interpretive issues associated with these two categories of artefacts. Here, it is worth recalling the analysis of drill bits and beads from Mezra Teleilat (southeast Turkey) by Güner Coşkunsu (2008), which stands out as an example of the integrated study of a toolkit and its products and their functional and processual interpretation.

- A particularly interesting case of incomparable prehistoric necklaces comes from the Early Neolithic site of Galabnik (western Bulgaria)³. The combined length of the necklaces exceeds 8 metres! X-ray analysis revealed the mineral composition of the beads as marble, limestone, schists and nephrite (jadeite, serpentinite?) (Костов, Бакъмска 2004). The most remarkable feature is that the holes/perforations consistently have a diameter of 1.2 mm (fig. 2).

Against this background, one of us (MG) initiated an experimental programme⁴ that was designed to approach the skills involved in prehistoric drilling activities, the archaeological remains of which inevitably evoke interest and curiosity among prehistorians.

Material and method

Various samples (mainly prepared thin bifacially polished plates from 2 to 4 mm in thickness) and some mineral and rock blanks (debris) from Russian jewellery production, which were obtained by MG some years ago in Saint Petersburg, were prepared for use (fig. 3: 1, 4). These ranged in hardness (on Mohs scale) from 3 (marble, limestone, calcite) to 6–7 (nephrite, jasper, aventurine)(fig. 3:1)⁵. Biominerals were also used: aragonite (from shells of the bivalves, *Anodonta cygnea* and *Mytilus galloprovincialis*) and apatite (pieces from long bones of pig and calf)(fig. 3: 2-3)⁶. Details of the minerals used in the experiments are presented in table 1.

A series of perforators/borers were fashioned by E. Anastassova and M. Gurova using debitage pieces from the Kovačevo site, which had been discarded because they lacked contextual information. Their morphometric parameters were more suitable for use in the hand as simple thumb drill,⁷ rather than hafted as part of a mechanical device, such as a pump- or bow drill. Another series of micro-borers with elongated abruptly retouched bits pronouncedly separated from the body of the tool were prepared by B. Bradley (fig. 3: 5). The blanks came from improvised cores of high quality black flint (available in the Experimental Archaeology Laboratory at Exeter University), Balkan Flint (a nodule collected by CB from the Danube floodplain in southern Romania) and bicoloured jasper from the

are not yet fully published and one of the authors (M.Gurova), who is studying the flint can only share some preliminary observations on her typological and functional study.

3 Excavated by M. Chohadziev. Information about the necklaces was provided by A. Bakamska to whom the authors express their gratitude.

4 This programme started during the tenure of a European Research Fellowship awarded to M. Gurova by the Caledonian Research Foundation and the Royal Society of Edinburgh, with nominator of the project - Prof. Clive Bonsall.

5 The plates of mineral samples were prepared by Prof. R.I. Kostov and made available along with information about the hardness of the samples and their provenance.

6 The bone samples were obtained with the help of Dr K. Dimitrov.

7 The short drill bit is held between the thumb and fingertips and rotated back and forth.



Fig. 3. Materials and equipment used in the experimentation: 1 – polished plates of various minerals; 2 – bivalve shells; 3 – bones of pig and calf; 4 – mineral debris from original Russian jewellery production; 5 – micro-borers made by B. Bradley; 6 – pump drills made by K. Verkooijen.

Photo and figure by M. Gurova

Обр. 3. Материали и инструменти използвани в експериментите: 1 – полирани плочки от различни минерали; 2 – раковини; 3 – животински кости (от свиня и теле); 4 – минерали (остатъци от руско ювелирно производство); 5 – микро-пробои/свредели направени от Б. Бradley; 6 – съставни свредели (дрелки) направени от К. Веркойен.

Снимки и аранжимент – М. Гюрова

Rhodope Mountains in southern Bulgaria. This series of drill bits were of an appropriate shape and size to be used for mechanical drilling with a pump drill. Two pump drills (fig. 3:6) were made available by Katharine Verkooijen (Exeter University). There is no incontrovertible evidence for the use of the pump drill at any of the Early Neolithic sites mentioned above, although some objects interpreted as 'spindle whorls' could have been 'flywheels' for pump drills. This type of drill was successfully used for experimental studies of the drills from Çayönü in Anatolia (Altınbilek et al. 2001), as well as for making replicas of shell beads from the Artenacien sites in southwest France (Ricou, Esnard 2000). No attempt was made to use a bow drill in our experiments. Nor did we attempt to use the 'piquetage' (pecking) and additional percussion technique for making holes in bead roughouts, as was suggested for the manufacture of carnelian beads from Iraq (Tixier et al. 1982), or the rather sophisticated knapping technique attested for the manufacture of barrel-cylinder carnelian beads in Harrapan times (for experimentation and description of this last-mentioned technique, see Roux et al. 1995).

Mineral/Rock (Variety)	Transparency/ Colour	Hardness on the Mohs scale	Thickness	Time of drilling one hole	Source
Minerals					
Feldspar (microcline - amazonite)	non-transparent; pale green	6-6.5	3 mm	130 min	Brazil
Lazurite	non-transparent; dark blue	5.5	3 mm	202 min	Russia
Malachite	non-transparent; green	3.5-4.5	3.5-4 mm	10 min	Russia
Rocks (mineral aggregates)					
Serpentinite (antigorite)	pale to dark green	4	3 mm	7-8 min	Bulgaria
Limestone (calcite)	biogenic; yellow	3	3 mm	3 min	Bulgaria
Marble (calcite)	coarse-grained; pale gray	3	2.5-3 mm	12 min	Bulgaria
Biominerals					
Bones		5	2 mm	12 min	Bulgaria
Shells		4	2-3 mm	10 min	?

Table 1. Details of the materials used in the bead-making experiments.

The experimental programme

The bead production *sensu stricto* was approached by manufacturing several delicate discoid beads of serpentinite, limestone, bone, shell and marble using fine sand and water for abrading each bead individually on a grinding slab of metamorphic schist⁸. A detailed photographic record (still images and videos) was made by M. Gurova using a Canon Power Shot A610 digital camera. Micro-photographic documentation of the artefacts and beads was made using a Keyence VHX-100 digital microscope (at magnification $\times 20$ to $\times 100$) belonging to the Conservation Laboratory of NIAM-BAS. The detailed results of a use-wear analysis of the experimental artefacts, and comparison with the archaeological implements, will be the subject of a separate paper. The descriptions and observations presented below relate to the initial stages of our experiments, their challenges, impediments, empirical knowledge and ability acquired, and our ideas for improvements in future work.

Biomineral processing

- As mentioned above two species of shell (hardness 4 on Mohs scale) were used in the experiments – *Anodonta cygnea* drilled mechanically and *Mytilus galloprovincialis* drilled with both mechanical and handmade holes; the results do not differ significantly under microscopic observation (figs. 4, 5). It should be stressed, however, that about 10 minutes of work with the pump drill produces a rather regular hole with pronounced rotational striations and there is no need for drilling from the opposite side of the shell. A shell of *Mytilus*

⁸ The bead fashioning was undertaken by M. Gurova in Bulgaria, assisted in the serpentinite processing by E. Anastassova.

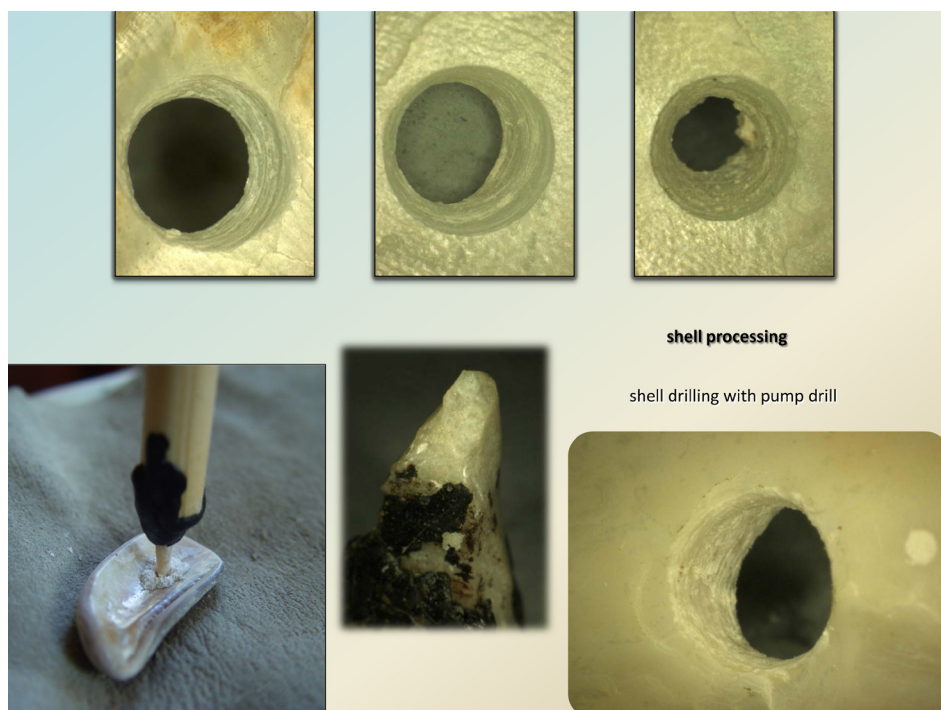


Fig. 4. Shell processing – mechanical hole making. Photo and figure by M. Gurova

Обр. 4. Обработка на раковини – механично пробиване.

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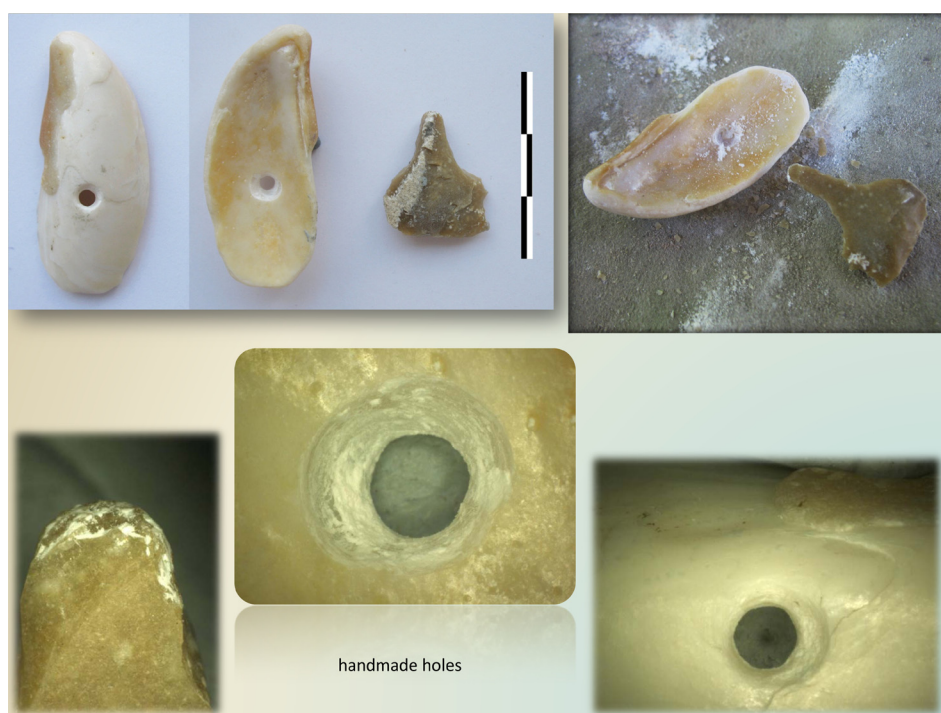


Fig. 5. Shell processing – handmade holes. Photo and figure by M. Gurova

Обр. 5. Обработка на раковини – ръчно пробиване. Снимки и аранжимент – М. Гюрова

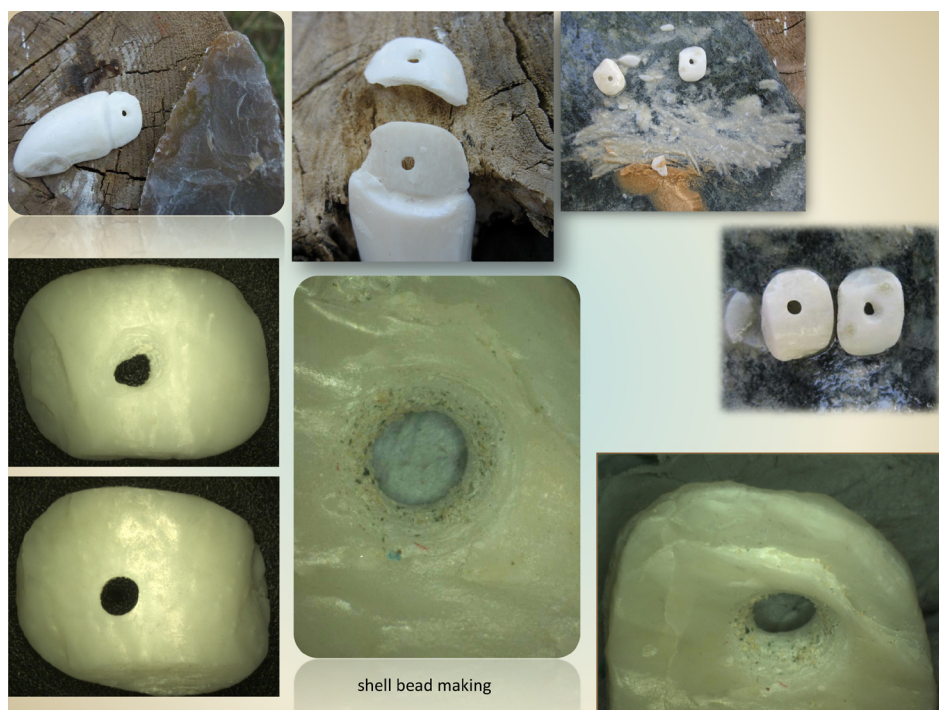


Fig. 6. Shell processing – bead making. Photo and figure by M. Gurova

Обр. 6. Обработка на раковини – оформяне на мъниста.

Снимки и аранжимент – М. Гюрова

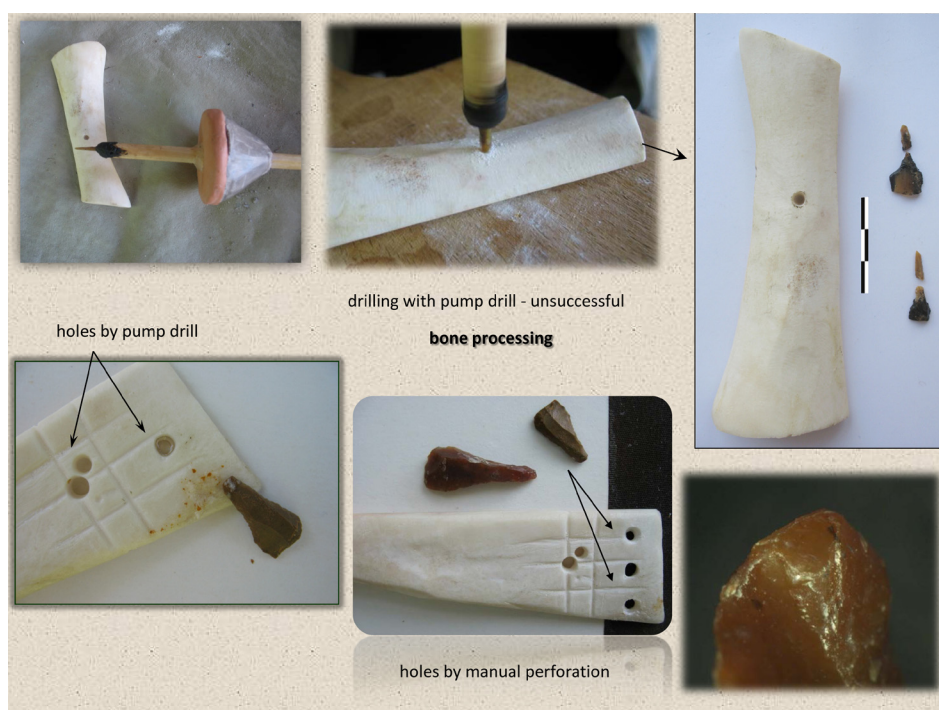


Fig. 7. Bone processing – drilling techniques. Photo and figure by M. Gurova

Обр. 7. Обработка на кости – техники на пробиване. Снимки и аранжимент – М. Гюрова



Fig. 8. Bone processing – details of bead manufacturing. Photo and figure by M. Gurova

Обр. 8. Обработка на кости – детайли от оформяне на мъниста.

Снимки и аранжимент – М. Гюрова

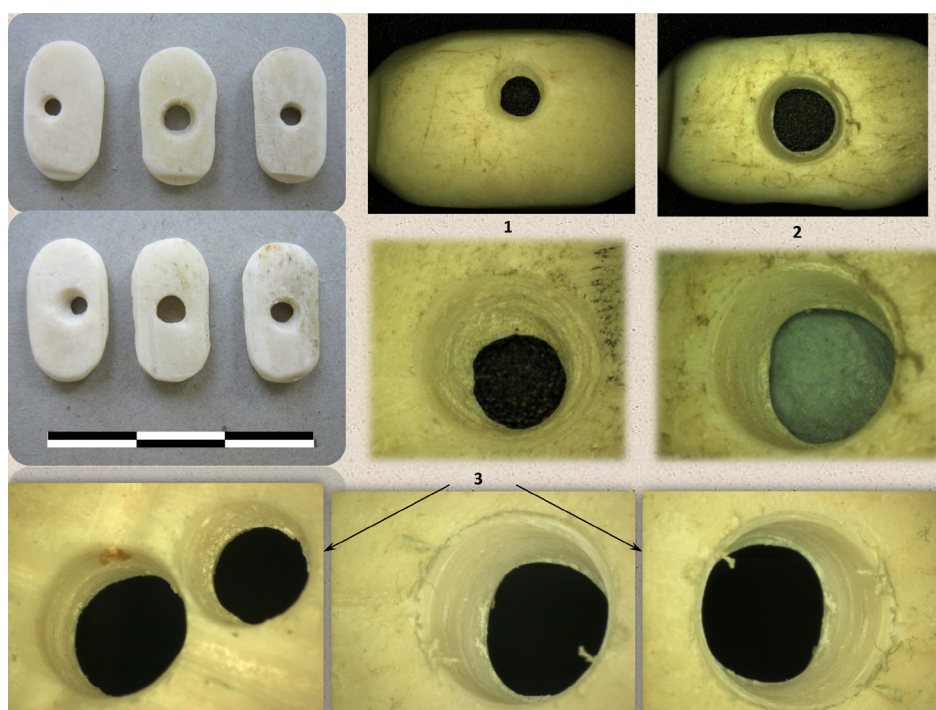


Fig. 9. Bone processing – details of holes: 1 and 3 – mechanical; 2 – manual.

Photo and figure by M. Gurova

Обр. 9. Обработка на кости – детайли от различно оформени дупки: 1 и 3 – механично; 2 – ръчно пробиване. Снимки и аранжимент – М. Гюрова

galloprovincialis with a manual hole made in 10 min was chosen for cutting and bead shaping. The shell blank broke accidentally (through lateral splitting) into 2 pieces, which individually proved very fragile for friction and other shaping procedures. Two small beads were produced from this blank, which took 35 min in total (fig. 6).

- Drilling of bone (5 on Mohs scale) produced some surprising observations regarding the frequency of fragmentation of flint tools, as well as the efficiency of hand drilling (fig. 7); bone beads were easy to shape after sawing with an untretouched flint blade, followed by abrasion/grinding on metamorphic rock (schist) slabs with fine sand and water. Three holes (1 mechanical and 2 handmade – the latter more conical in profile) were produced in 38 min; the sawing of the bone took 30 min and a similar amount of time (35 min) was taken up by the shaping of the 3 beads (figs. 8 and 9). The total time consumed by the fashioning of the bone beads was 1 h and 43 min.

Rock/ mineral processing

Seven rocks/minerals were used in drilling experiments with a pump drill: marble and limestone (3 on Mohs scale); serpentinite (4 on Mohs scale); malachite (3.5–4.5 on Mohs scale); lazurite (5.5 on Mohs scale); amazonite (6–6.5 on Mohs scale). A piece of nephrite (tremolite) with the hardness of amazonite was also included in the experiments, but attempts to perforate it made no impression and the experiment was abandoned.

- the piece of **amazonite** was shaped in 40 min and drilled in 15 min without visible results, a second piece without any modification by abrasion was drilled in 30 min with 2 borers (one of which was quickly broken) and again the result was a less than 2 mm cavity in the material with no prospect of creating a complete perforation; rounding and a polish spot was observable on the tip of the flint drill bit. The shaped piece was additionally worked with 50 min of mechanical drilling on the side previously worked and 60 min drilling on the opposite side. Finally the piece was halved after 2h 5 min mechanical and 5 min handhold perforationand thus the intention to use it as bead failed (fig. 10).

- quite instructive was an experiment with a button-like piece (jewellery blank) of **lazurite**, which was made thinner by sand and water abrasion, but 20 min drilling produced almost no visible cavity in the material (fig.11). The next stage of drilling this piece consisted of 62 min mechanical drilling with water and sand additives. Subsequently, the piece was drilled on the other side in order to make a biconical hole. In total 115 min were needed till the hole was made. It took a further 5 min to enlarge the hole with another borer with a suitable fine tip, because the borer tip used in the pump drill was already too rounded (fig. 12). Thus this lazurite, 3 mm-thick piece was perforated for 3h 22 min in total without subsequent fashioning for obtaining finished bead parameters.

- **malachite** processing consisted of a very nice biconical cylindrical hole made by BB in 10 min with water added as a lubricant to speed up the process; noticeable rounding of the borer was produced with many mineral residues on the flint tool and many microchips of flint in the hole created (fig. 13). No subsequent alteration was made to this malachite piece (the experiment will be continued at a later date);

- drilling of a plate of grey **marble** started in Exeter with a hole made in 8 min by BB, but the plate was accidentally crushed when later on MG tried to separate a piece for bead shaping. Subsequently a small button-like bead blank was produced in 5 min by sand and water abrasion, with drilling taking 12 min: thus the bead was made in only 17 min. It is worth noting that use of a flint drill-bit on marble produced the most significant micro features of use: rounding, smoothing and bright spotted polish with

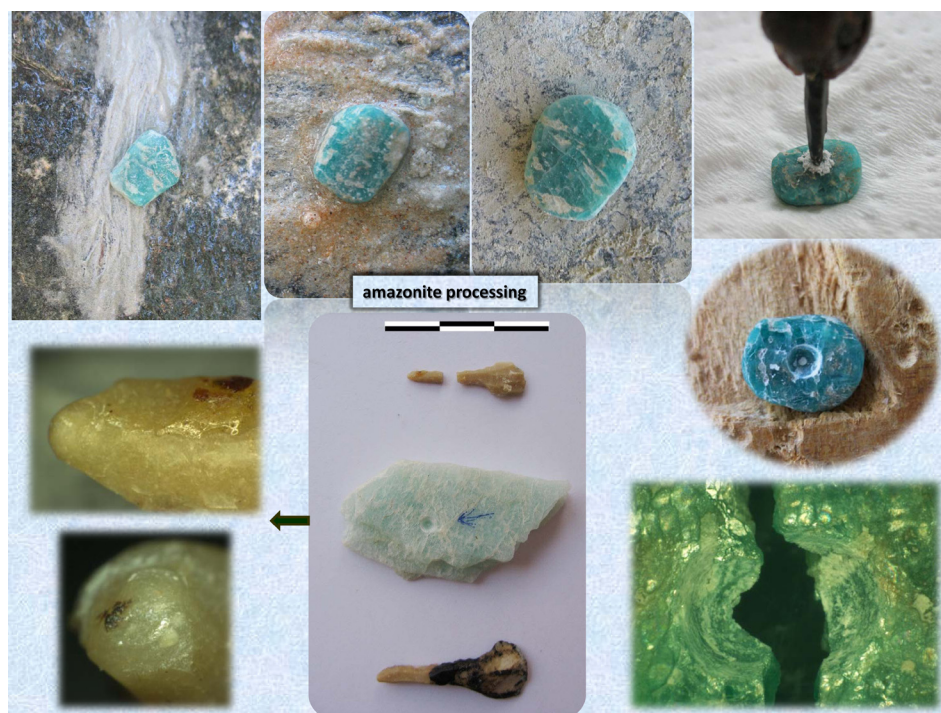


Fig. 10. Amazonite processing – stages and details. Photo and figure by M. Gurova
Обр. 10. Обработка на амазонит – етапи и детайли. Снимки и аранжимент – М. Гюрова

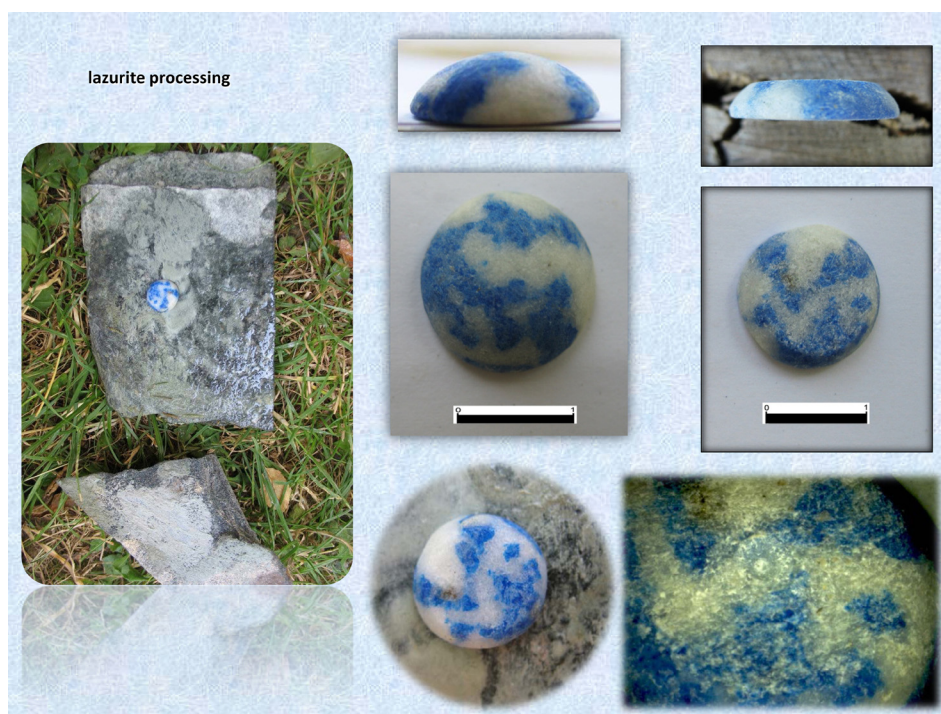


Fig. 11. Lazurite processing – initial stages. Photo and figure by M. Gurova
Обр. 11. Обработка на лазурит – начални етапи. Снимки и аранжимент – М. Гюрова

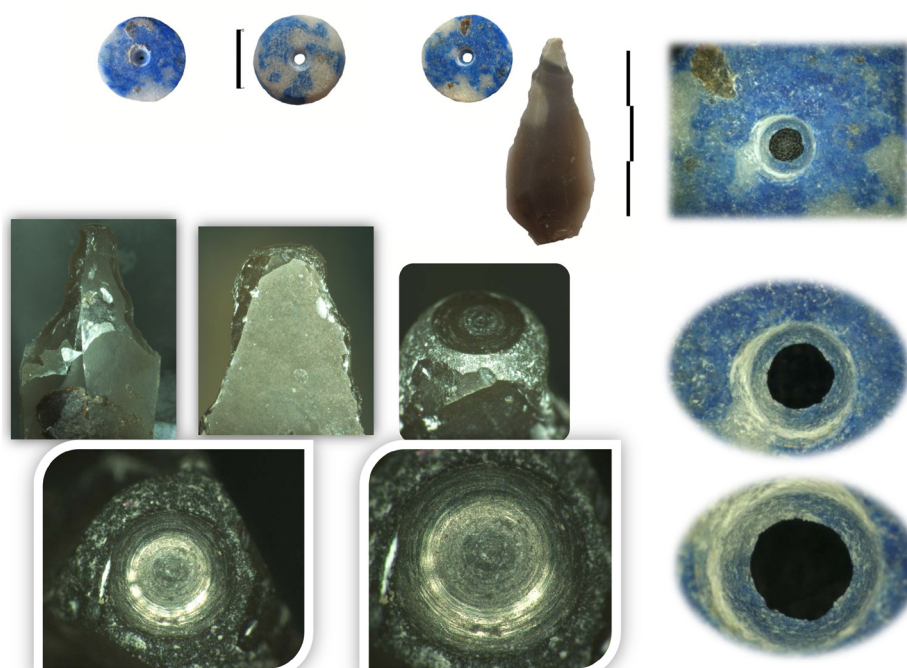


Fig. 12. Lazurite processing – details and use-wear traces (circular striations and polish) on the flint borer. Photo and figure by M. Gurova

Обр. 12. Обработка на лазурит – детайли и следи от употреба (кръгова линейност и излъскване) на кремъчния свредел. Снимки и аранжимент – М. Гюрова

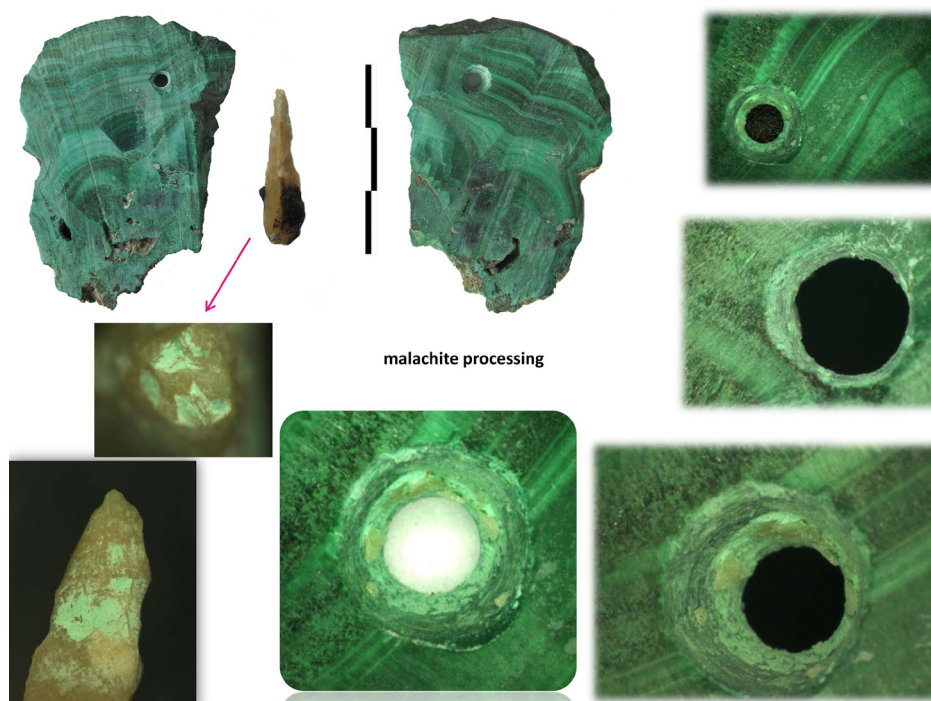


Fig. 13. Malachite processing – details of the hole and the borer. Photo and figure by M. Gurova

Обр. 13. Обработка на малахит – детайли на пробитата дупка и кремъчния свредел. Снимки и аранжимент – М. Гюрова

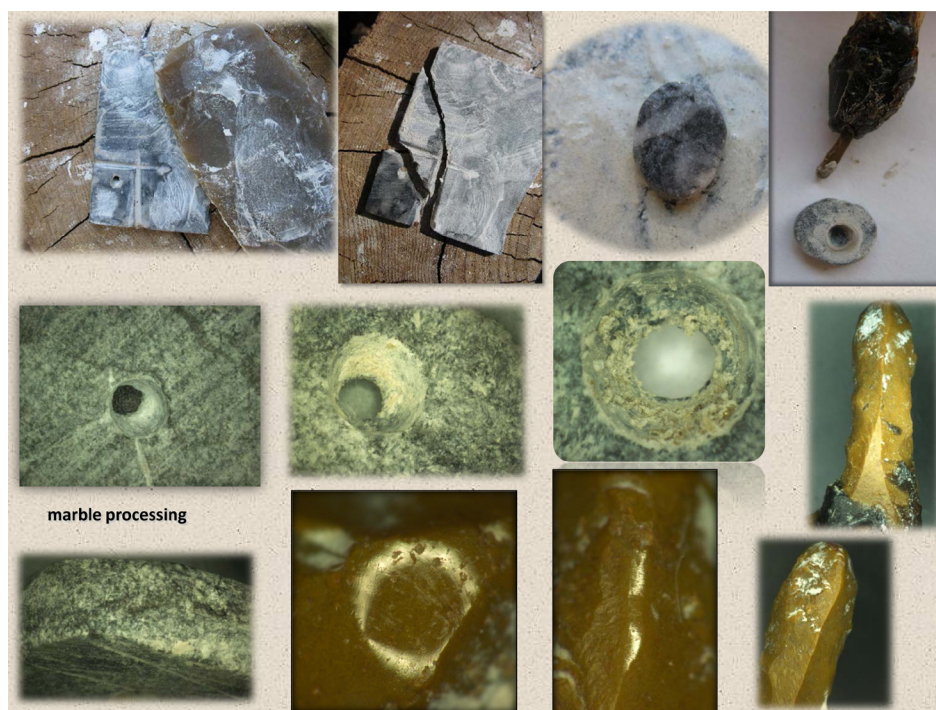


Fig. 14. Marble processing – details and use-wear traces (bright polish) on the flint borer.

Photo and figure by M. Gurova

Обр. 14. Обработка на мрамор – детайли и следи от употреба (ярко излъскване) на кремъчния свердел. Снимки и аранжимент – М. Гурова

transverse striations (fig. 14).

- a series of 6 **limestone** beads were manufactured, starting with cutting the limestone in 35 min with a bifacial point (made by BB) which served as a very efficient knife. Thus 6 rectangular pieces were produced, which were subjected to fine abrasion with sand and water resulting in 6 disc-shaped blanks after another 35 min (fig. 15). The drilling of a hole in each bead with a pump drill took about 3 min, the manufacture of all 6 beads taking altogether 1h and 28 min of working time (fig. 16);

- the most successful of the experiments in bead manufacturing was the work on **serpentinite** – a beautiful and relatively easy to work greenish mineral. The '*chaîne opératoire*' started with the use of a nice plate in which 4 holes were made with a pump drill in 30 min with noticeable rounding and smoothing of the flint borer (fig. 17); sawing and separating of the perforated pieces took 13 min with a further 60 min of abrading of each bead on the grinding slab using fine sand and water, resulting in 3 disc-shaped beads (fig. 18). Technological traces of bead manufacturing (abrasion) are easily observable on the perimeters of the items, although no rolling of the beads on slabs (as described by Wright et al. 2008) was performed for additional smoothing and faceting of their edges (fig. 19). The best example of a serpentinite bead, less than 1 cm in diameter and with a very regular shape and smooth periphery was made by EA in 1h with a delicate and careful fashioning approach, including treatment with a small hand held abradar and short individual rolling of the piece into a schist slab (fig. 20). These, undoubtedly the most beautiful of the beads fabricated in our experiments, were produced in 2h and 43 min.



Fig. 15. Limestone processing – initial stages. Photo and figure by M. Gurova
 Обр. 15. Обработка на варовик (калцит) – начални етапи.
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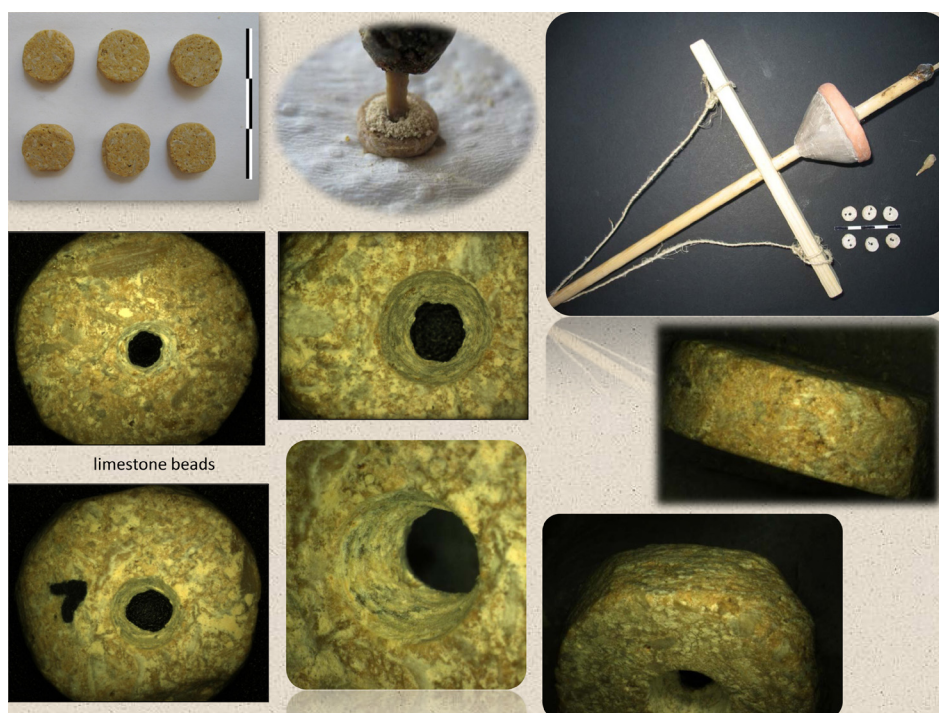


Fig. 16. Limestone processing – bead manufacturing and details. Photo and figure by M. Gurova
 Обр. 16. Обработка на варовик (калцит) – оформяне на мъниста и детайли.
 Снимки и аранжимент – М. Гюрова



Fig. 17. Serpentine processing – details of tool efficiency and micro smoothing of the working edges. Photo and figure by M. Gurova

Обр. 17. Обработка на серпентинит – детайли на механично пробиване и на латералното загладяване на работните ръбове на кремъчния свредел.
Снимки и аранжимент – М. Гюрова

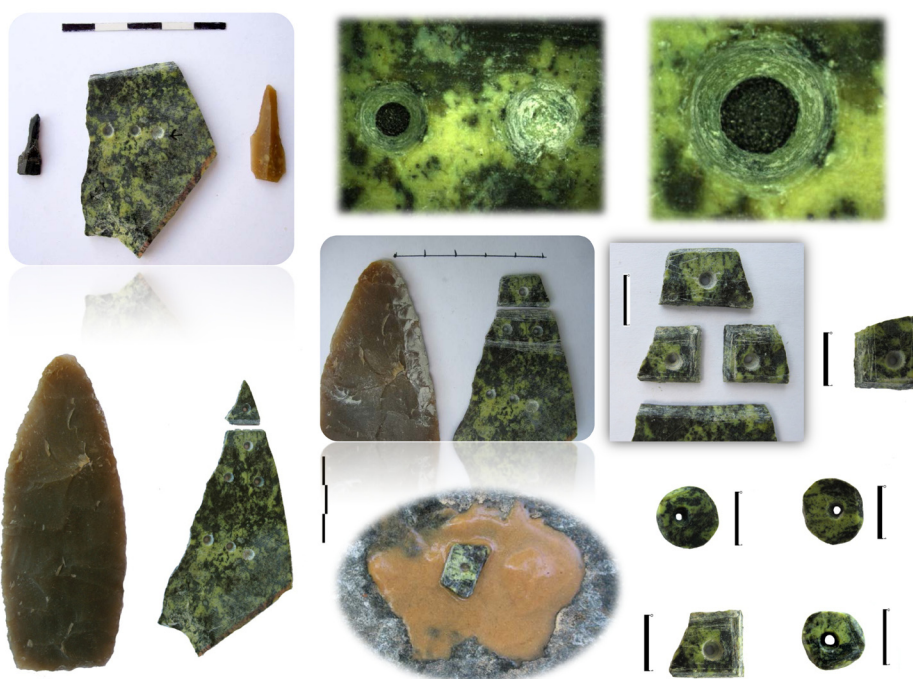


Fig. 18. Serpentine processing – details of bead making. Photo and figure by M. Gurova

Обр. 18. Обработка на серпентинит – детайли от оформянето на мъниста.
Снимки и аранжимент – М. Гюрова

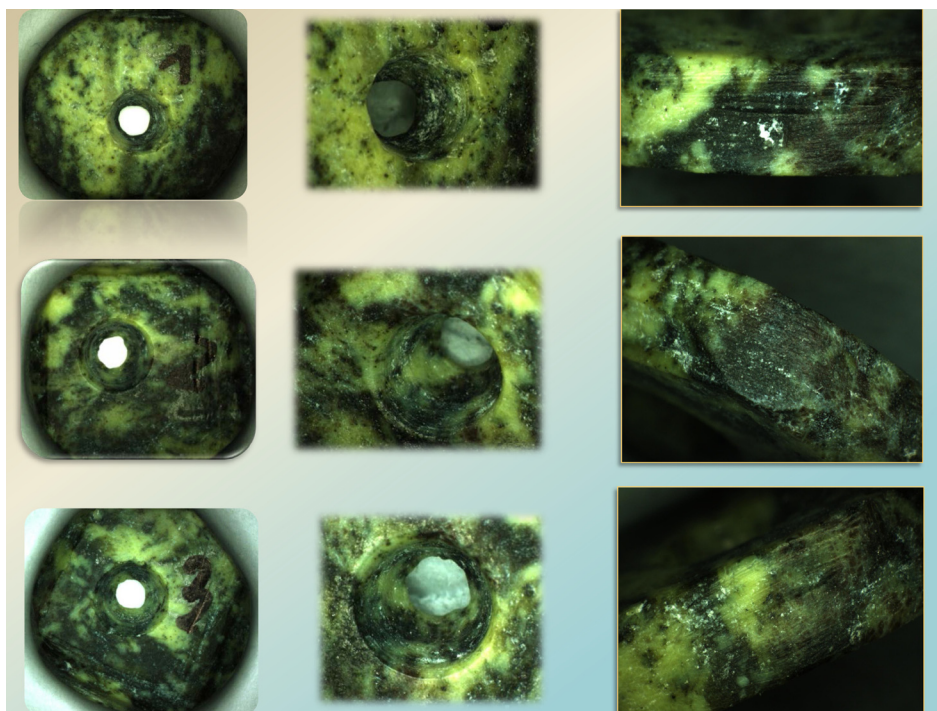


Fig. 19. Serpentinite processing – details of technological traces on discolored beads.

Photo and figure by M. Gurova

Обр. 19. Обработка на серпентинит – детайли на технологичните следи върху мънистата. Снимки и аранжимент – М. Гюрова

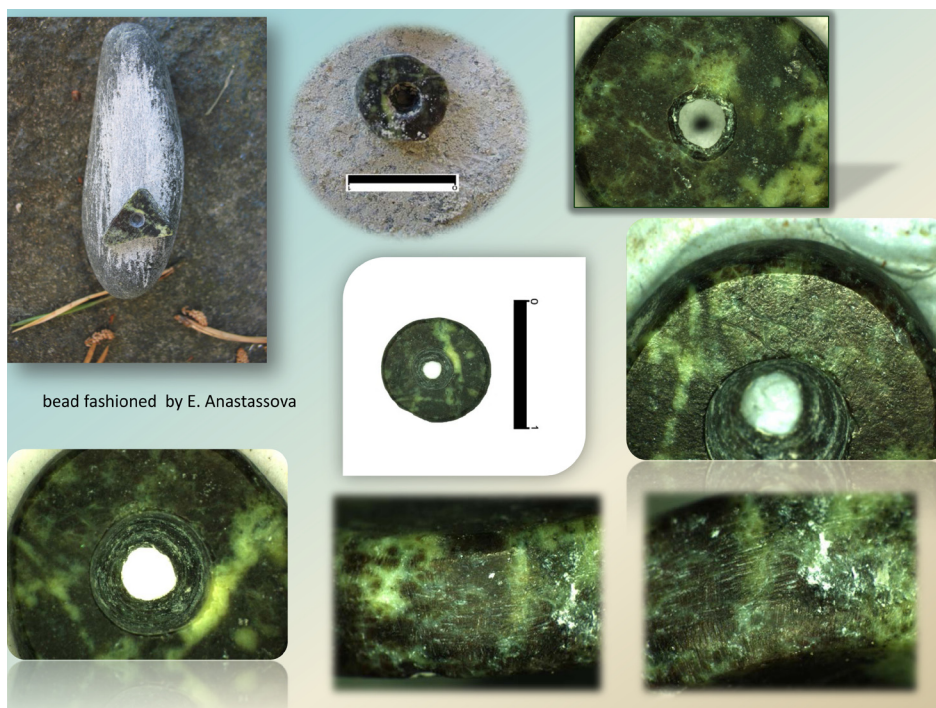


Fig. 20. Serpentinite processing – details of the finest bead made by E. Anastassova.

Photo and figure by M. Gurova

Обр. 20. Обработка на серпентинит – детайли от най-финото мънисто, изработено от Е. Анастасова. Снимки и аранжимент – М. Гюрова

Results and general remarks

At this stage of the experimentation programme no definitive conclusions are being drawn. Nevertheless, some observations can be put forward on the basis of empirical data and detailed documentation of the experimental procedure, as follows:

- there is a relationship between the morphology of the perforators/borers and their potential/actual use: the pieces inserted into a pump drill must have pronounced pointed parts, i.e. must be 'drill bits/borers' (in French, 'forets à mèche'), and not simple perforators with short amorphous tips;
- there is no evidence to link the breakages/torsion fractures of the borers with the manner of perforating (manual or mechanical) and/or the hardness of the worked material. Some borers break very easily and quickly after perforating begins (i.e. within the first minute);
- the rounding and matt smoothing are typical micro-wear features appearing on borers after prolonged friction with the worked material. Bright polish appeared only in 3 cases: in drilling marble, amazonite and lazurite;
- in general the perforators used in the experiments can serve as preliminary indicators and comparative examples when considering archaeological collections of similar items; in this respect the assemblage/toolkit from Kovačevo is more likely to have been used in hand processing activity;
- holes produced with a pump drill and by manual boring, respectively, are easier to distinguish on biominerals (bone, shell) than on fine-grained minerals. The distinction is more recognizable in the case of conical *vs* bi-conical/bipolar holes;
- the hardest materials that were drilled successfully were bones and malachite – 4–5 on Mohs scale (attempts to produce beads from carnelian, turquoise, tremolite [nephrite] and other minerals harder than 6 on Mohs scale were unsuccessful in the current series of experiments, and represent a challenge for the future). In this perspective once again the work of E. Melgar on Mexican lapidary artefacts could be instructive and helpful (Melgar et al. 2012);
- the experiments suggest that serpentinite and limestones are suitable (and aesthetically valuable) materials for bead manufacturing;
- both drilling and bead shaping are more efficient with the addition of water; water and fine sand were essential additives for bead abrasion and shaping in the case of both mineral and biomineral beads;
- as a final note – the small heterogeneous necklace shown in fig. 21 comprises 6 limestone, 4 serpentinite, 3 bone, 2 shell and 1 marble beads: the total time required for its preparation was 6 h and 46 min, but the fact must be kept in mind that pre-prepared mineral plates were used, which facilitated the bead manufacturing process enormously.

Discussion and Conclusions

Apart from the acquisition of valuable empirical knowledge, the experiments prompted new questions, which would not have arisen outside the context of our research into prehistoric skills and techniques. Different questions arise on the level of a concrete experimentation programme, when compared to that of more general reasoning based on experimentation and the extrapolation of its results to archaeological remains from different contexts.



Fig. 21. The heterogeneous necklace of the experimentally fashioned beads.

Photo and figure by M. Gurova

Обр. 21. Нанизът от експериментално изработените мъниста.

Снимки и аранжимент – М. Гюрова

On the first level many challenging issues are envisaged for further work, building on our initial research. These we were only able to take into consideration in connection with the complexity and obvious infeasibility of the many of skills involved in the production of a necklace such as that from Galabnik in Bulgaria (*vide supra*). Our further and more detailed experimental programme will include the following variations on our preliminary work: a series of mechanical drillings by different types of borers in the same material in order to reveal differences in efficiency due to the morphometrical and technological characteristics of the tools; successive drillings using one type of borer on different materials in order to reveal the effect of the raw material on the tool's resistance; a series of drillings on roughouts of varying dimensions versus drilling of shaped beads, in order to gain a more comprehensive understanding of the '*chaîne opératoires*'.

On the level of fashioning beads there are also variations of challenging opportunities/procedures to be tested and observed (see below). One of the crucial objectives of further experimentation will be to produce a significant number of used tools and undertake their careful use-wear analysis, assuring sufficiently reliable results for comparison with archaeological toolkits. One of the ambitions of the research team is to succeed in drilling and manufacturing beads of nephrite, replicating as closely as possible the archaeological examples in terms of manufacturing sophistication and aesthetical perfection.

At the second more general level of consideration, other issues may be listed. One question is to what degree the manufacture of varying toolkits for perforating/drilling is due to functional anticipation or decision making based on practical experience. When the association between toolkits and drilled products is not obvious, doubts arise about the efficiency of the toolkits presumed to have been for perforation. For example, the fragility

of the extremely fine drill bits from the late PPNB site of al-Basît (Jordan) led Rollefson to doubt their mechanical use (Rollefson, 2002; Rollefson, Parker 2002); moreover the differences in morphology among the various micro-drills recovered from sites in the Mississippi River valley were confusing with respect to their functional interpretation, and only use-wear analysis resolved the problem (Yerkes 1983).

Experimental bead manufacturing *sensu stricto* should balance between examples already done and illustrated in the specialized literature, and taken as a matrix for subsequent reproduction of the know-how, and the spontaneous decisions and ad hoc approaches during the experimental manufacturing. However, very few real innovations are expected in this field, which already contains many detailed descriptions of '*chaîne opératoires*' and analytical technological approaches (e.g. Kenoyer et al. 1991; Roux et al. 1995; Wright et al. 2008).

The only relevant approach seems to be one that requires a combination of the experience gained through experimentation and detailed artefactual analysis of the archaeological remains (both toolkits and beads) in order to formulate (and hopefully answer) the right questions arising from and belonging to a specific context. This will be the objective of a further programme of experimentation and cognitive quest based on the initial study presented in this paper.

Other questions we hope to investigate as our research into bead manufacturing in the Early Neolithic of southeast Europe continues concern the acquisition and use of raw materials, for the production of both the beads and bead making equipment. Were materials obtained locally or from distant sources? What characteristics other than hardness influenced the choice of raw materials for bead making? Why did some communities make extensive use of mollusc shells for bead making, while others (who had access to shells) hardly used them at all and focused instead on lithic materials? There remains the challenging question of the relationship between the morphometric parameters of the stone piercers/borers and the drilling techniques and devices used in bead manufacturing. Further experiments are needed in order to obtain more reliable results and conclusion. Although our initial experiments have shown that relatively soft stones like limestone and serpentine can be perforated quite easily using flint drills, how did Early Neolithic people manage to drill through harder materials like jadeite and nephrite?

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Към праисторическите умения: експериментално пробиване и изготвяне на мъниста

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(резюме)

Сред раннонеолитните археологически свидетелства на Балканите са известни две категории артефакти, които се отнасят към праисторическите умения и сръчност, и по-специално – към пробиването на различни материали.

Първата категория включва мъниста и други перфорирани декоративни и престижни изделия, изработени от кост, раковини, керамика и различни минерали. Втората категория обекти е съставена от инструменти/оръдия, включващи микро-пробои и свредели, които в основната си част са направени от кремъчни суровини.

Тази статия представя експерименти по пробиване на различни материали и последващо оформяне на мъниста с оглед придобиване на практически познания за етапите на производствения процес. Бяха подготвени серии от микро-пробои, впоследствие използвани за ръчно и механично пробиване (с помощта на изготвен за целта и лесно използваем съставен свредел – своеобразна дрелка). Опитите предоставиха съществена информация в няколко аспекта: относно употребата и ефикасността на различни кремъчни пробои/свредели и тяхното износване в процеса на утилизацията им; относно техниките на пробиване и на моделиране на мъниста.

В експеримента бяха използване различни материали (главно под формата на плочки с дебелина между 3 и 5 мм): минерали и скали, чиято твърдост по скалата на Мос варира от 3 (мрамор, варовик, калцит) до 6.5 (амазонит, нефрит). В употреба влязоха и биоминерали: арагонит (2 вида раковини) и апатит (подготвени животински кости). В резултат бяха оформени 16 мъниста от 5 различни материала. Когнитивният аспект на този начален експеримент се свежда до възможността за по-адекватна интерпретация на праисторически кремъчни пробои и свредели, както и за по-адекватна оценка на изключителните познания и умения на древните майстори, изготвили сензационни образци на ювелирното дело.