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Reviewed Article:

Probable Measure Estimating Tool Employed by the Aeneolithic Potters

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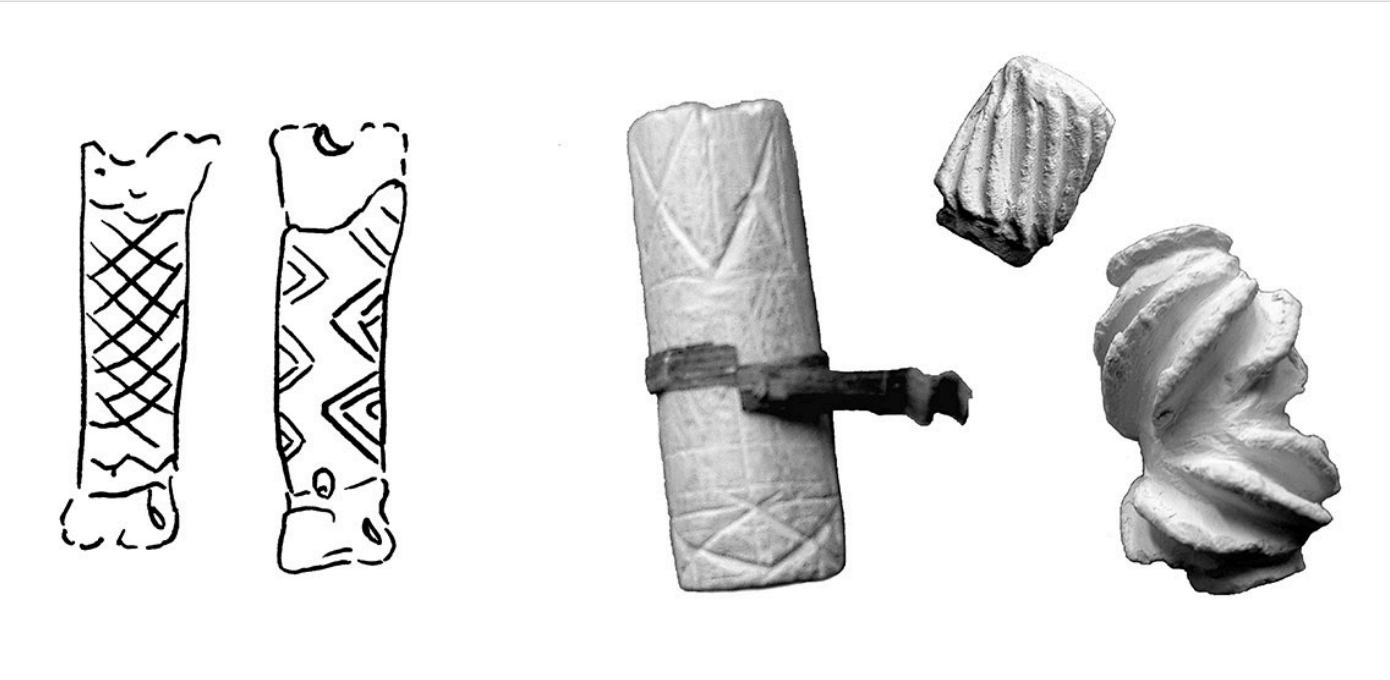

The article proposes that an item, ornamented with a geometric pattern with inscribed diagonal cross and attributed to the Afanasievo culture (Aeneolithic, South Siberia), represents a primitive tool reflecting practical knowledge of basic geometry by the ancient potters. The article suggests an experimental reconstruction method for crafting the proposed instrument, and techniques of its application in estimating and reproducing the 'egg-shaped' ceramics. It is proposed that the tool under review is not unique to the

Afanasievo culture and might have been adopted from cultures dated to earlier chronological horizon.

> “The appearance of archaeological artefacts often provides with the possibility of existence of some relevant equipment employed during manufacturing processes.

With the advance of the technological studies in archaeology, the necessity of clarifying the premises and possible technical sources of typical features of archaeological series becomes an important research aim (Kozhin 1989; 2002). An inclination to measurement could be fundamental for prehistoric societies, especially for those defined as the wheeled cultures (Anthony 2008). Potential estimation systems (for example devices, instruments) developed by the ancient manufacturers might be one of the reasons for the rise of the standard characteristics observed in archaeological series.

One such early example of standardisation is the ceramic shape of the Afanasievo culture, dated to the Aeneolithic (circa fourth millennium BC, South Siberia).
The 'egg-shaped' ceramic is described as unique to the Afanasievo culture, and distinguishes it from other archaeological strata of the region (Derevyanko et al. 1994a). The group shows inner consistency in terms of prolonged chronological frame, and a number of local variants as well.

Since the ceramics display general and particular resemblance to the Late Neolithic – Aeneolithic materials from distant territories, the researchers regularly use this fact to support their theories of the origin of the culture (Derevyanko et al. 1994a; Anthony 2008). On the other hand, the existence of certain common technological features, which repeatedly levelled tendency to the manifestation of cultural specific of pottery production, could not be excluded either.

The present paper proposes that the standard appearance of the Afanasievo ceramics might be due to implementation of a geometric pattern used as a chart to make necessary estimates to build a shape. Application of a unified tool may lower differences between ceramics attributed to different cultures.

Reconstruction of the Afanasievo geometric pattern

Among the artefacts attributed to the Afanasievo culture, one defined as a bone item (Avdusin 1977), attracts special interest as a potential candidate for an estimating device (See Figure 1). Its décor consists of diagonal crosses; each is inscribed into an elongated rectangle. At the first glance the item might be considered merely as a decorated object. However, taking into account the complex appearance of the Afanasievo culture (mostly its widely accepted migration origin and likely the fast pace of crossing of vast territory almost without traces), the object could be interpreted as an artefact reflecting some basic knowledge of practical geometry. Namely, some characteristics of the item, such as a rectangular shape, a compact order of basic divisions, and logistic positioning of 'diagonals' allow it to be classified as a stereotypical sample of a wider pattern used as an instrument for geometric estimation. If we recognise the artefact as a device which serves a potential measuring purpose, we may further propose that the parameters of the pattern would determine stability of its crafting and application.

To assess the characteristics of the supposed Afanasievo pattern, the proportion of a division with inscribed diagonal cross could be specified through the hypothetical format for early geometric designs (Lamina 2008).

In particular, it seems logical to suggest it had uses other than just a tool for ornamentation. For example, it could be employed to estimate quantity of required (or available) material. Such estimation will be targeted to a search to express ratio between size of a roller and length of material. In other words, it could serve to find a trade off between the concepts of spiral and circumference.

The approach to the problem of identification of potential applicability of the item for geometrical estimation purposes might be based on the following facts.

The format describes every spiral turn as consisting of three conventional parts. Since the sizes of rollers may be considered equal, every spiral turn could be represented as consisting of three equal components.

Since any circle could be transformed into a spiral on the roller of the lesser size in a cross-section, and vice versa, the same description could be extrapolated as well on a circumference.

Made along the spiral, the vertical summation of the format is described on a plane with at least two images containing slightly different number of conventional widths, which in terms of required/available material would be ranging from 'enough' to 'probably slightly excessive' (See Figure 2a). In its turn, the spiral may be unfolded on a plane into circumferences; the number of those would be comparable approximately as 6:4 with number of spiral turns.

Matching the practical observation with the basic scheme (See Figure 2b) allows some additional considerations. For example, the roller may be described through the length of both of circumference and spiral turn. Basically, ratio of vertical and horizontal dimensions of the basic division would be revolving around the size of ideal roller (two thirds of spiral turn).

Apparently, the pattern under review would sum three perimeters of the roller (half of basic scheme) that would yield the ratio of the basic division as 2:1. The approximated initial estimation as well as summation of the pattern's components could be marked with the positioning of diagonals. The reverse ratio (4:6) indicates the proportion between the length of circumferences and the corresponding length of the spiral. In its turn, proportional alternating of the basic unit provides possibility to make scaling.

The pattern clearly shows a potential to be re-converted into a cylindrical roller. The level of its generalisation may be also evaluated in terms of reproduction and expansion.

Experimental application of the geometric pattern to the ceramic décor

The only systematic experimental study of décor techniques of the Aeneolithic ceramics has been conducted for the Altai Mountains region (Stepanova 1998). The researcher has not discussed any decors based on rotary motion. Ignoring combination of stamping with rotation as a possible decoration technique looks quite reasonable from practical standpoint.

However, when considering the Afanasievo materials compared to objects related to the cultures with adjacent regional and chronological attribution, the possibility of employment of a roller stamp does not look unrealistic at all. The geometric designs executed on the sub-cylindrical surfaces are not absolutely unusual in Siberian collections dated before Andronovo Period. The pendants ornamented with rhombic net (Bronze Age; Southwest Siberia) are particularly interesting (Molodin 1995: Figure 12: 28, 29). These items are made from animal joints (Figure 5a), and demonstrate that the execution of a net décor on cylindrical shapes did not necessarily involve crafting this kind of surface and could be performed with minimal equipment.

The attribution of the ceramic with rolled décor to the Afanasievo culture might be disputable. However, the experimental reconstruction of a roller stamp based on the geometric pattern under review may highlight the range and sequence of relevant calculations. The first task of reconstruction is to divide the perimeter of a roller into three equal parts. Assuming that the pattern is based on certain ratios provides a possibility to make some method of scaling. On the other hand, the proportions involved are definitive and tied together across an area, thus they do not allow visual comparison. Still, during the estimation of the size of a roller through a spiral turn, the alternated fraction may be employed as a 'divider' (Figure 3a). Reducing initial length by this factor gives the odd total. In its turn, the absolute magnitude of final length may be converted again into one, yielding the even sum of sections, three of which would form the sought perimeter of the roller.

The similar manner of alternating the magnitude and proportion of the initial size may be demonstrated by means of zigzag pattern, for example, as in the Okunevo art style, a culture whose sites are considered to immediately succeed to the Afanasievo horizon. Folding every side of the circumference into equal fractions produces only an even number of parts. At the same time, it may be observed that accumulation of lacking sections (which are needed to make three times folding) occurs within the spiral turn (Figure 3b). The number of required fractions could be specified through increasing partition (Figure 3c). Thus, for each 'half' of circumference the lacking part would be a quarter divided by two, total one eight taken three times (Figure 3d). In terms of the initial length this change would be equal to the "divider" which transforms 12 initial fractions into the proportionally bigger eight (Figure 3e).

The evaluating of the vertical dimension of the proposed roller stamp would depend on the choice either to keep on the obtained odd division (and the corresponding products), or to return to the even partition (See Figures 4a and 4b). The resulting nets would be slightly different (See Figure 5b).

Alongside with chosen proportions (recognisable from the angle) the final appearance of the roller stamp on ceramic walls could be dependent on the practical skills of an executor (See Figure 5c; Figures 9b, 9c, and 9d).

Description of the vessels' shape through the geometric pattern

The central principle of the reconstructed roller stamp is that geometric pattern is executed separately as one of the facets of folded formation, which would be transformed into the net design on a plane. This basic rule applied in inverse sequence would convert the two-dimensional image into a space figure. The specific ways of projection of the 3D figure on a plane might be reliably observed on containers made on flexible organic materials.

Unfortunately, there is almost nothing to count on as an example in the available archaeological collections from that region. The survived Afanasievo vessels made from birch bark are described as being of a likely cylindrical shape with traces of stitches (Derevyanko et al. 1994a) without further specification of constructive details. Indirect evidence of alternation of dimensional depth of image may be found in the materials attributed to the Andronovo culture, namely, these are observation on a helmet as sewn of separate ribbons, which form a cone when folded (Kiselev 1949).

However, assuming trans-cultural manifestations of archaic technologies observed by means of method of analogies the ways to depict container on plane may be considered through wide background of prehistoric applied art. In this sense, the various arch in plane items widespread in Eurasia since the Late Neolithic (Avdusin 1977; Molodin 1995; Bader et al. 1987) are of special interest. Keeping in mind involuntary geometric basis of shape-making techniques, the curve may be measured as a visualisation of a rounded surface in perspective.

In its turn being described through the multiplied geometric pattern the arch delineating has shown applicability for crafting of a cone-shaped container. Made according to the archaeological 'templates' (See Figure 6), the experimental sample was cut following the logic of the pattern as three spiral details of the same height (See Figure 7a; Figure 8). The ratio between the lengths of the separate parts demonstrates the minimum of elaboration (3:2:1). Moveable position of the spiral section on the horizontal minimises sources of error and allows rearrangements. Since the details are dependant on each other both on horizontal and vertical dimensions any significant improvisation would cancel the given proportionality and modify the shape. The condition that the conic vessel could be described by means of the geometric configuration provides the opportunity to visual estimation of vessels basic dimensions in units of the pattern (See Figure 7).

Following variation of lengths related to circumference gives an option to translate the dimensions into the clay version (Figure 7b). Another way might be observations on reduction of the perimeter and corresponding alternation of area inside the pattern (Figure 7c). The resulting ratio of 9:7:5 observed on the perimeter would be approximately the same ratio 3:2:1 when related to the areas. The method suggests some knowledge of geometry basics by the ancient potters. The copious shaded triangles on the Andronovo ceramics do not allow ruling out this possibility.

Experimental samples (See Figure 9) have shown that despite the plasticity of clay complicates the control of proportional height of the separate parts, alternating lengths on this or that program on horizontal would assign the comparable to a cone contour. With a rim as a finishing touch the conic profile transforms into an 'egg-shaped' one.

The resulting technique allows simultaneous formation of the vessel. In general it would be consistent with technological descriptions of the Afanasievo ceramics; substantial thickness of walls, frequent over-dried connections between separate parts, minimal traces of additional shape making procedures (Ivanova 1968), and practice of the same shape for different sizes (Avdusin 1977; Okladnikov 1968).

Conclusion

Even though it seems to be elusive, the appearance of archaeological artefacts often provides with the possibility of existence of some relevant equipment employed during manufacturing processes. The most difficult part regarding the possible estimating techniques might be finding means of their particular expression.

Patterns of the visual representation seems to be important in terms of establishing and functioning of tradition, which by definition is based on appropriate directions.

Geometric-like designs attributed to the Okunevo culture may indicate that the set of instructions brought by the Aeneolithic population was successful. The occurrence of the diagonal cross in the chronologically subsequent materials is described as massive; and the pattern itself is considered as a diagnostic characteristic of the Okunevo artistic style (Kubarev 2002).

Since geometric designs occasionally occur in Upper Paleolithic materials, including Siberian sites (Derevyanko et al. 1994b), tradition of operating with formalised objects may be rooted more deeply in time than is usually thought. Thus, the pattern under review might not entirely be a new concept in the region, but rather a continuation of traditions adopted in even more ancient cultures.

Keywords ceramics

Country Russia

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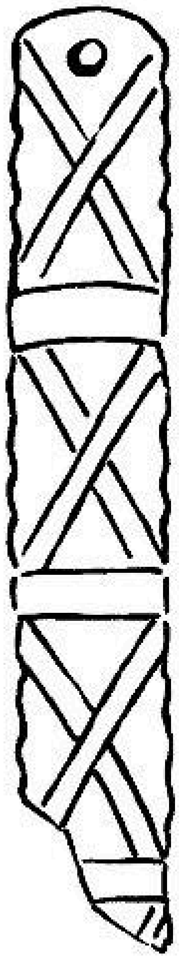

Fig.1 A bone item ornamented with the geometric pattern (South Siberia, the Aeneolith, the Afanasievo culture from Avdusin 1977: Fig. 28: 10)

FIG 1. A BONE ITEM ORNAMENTED WITH THE GEOMETRIC PATTERN

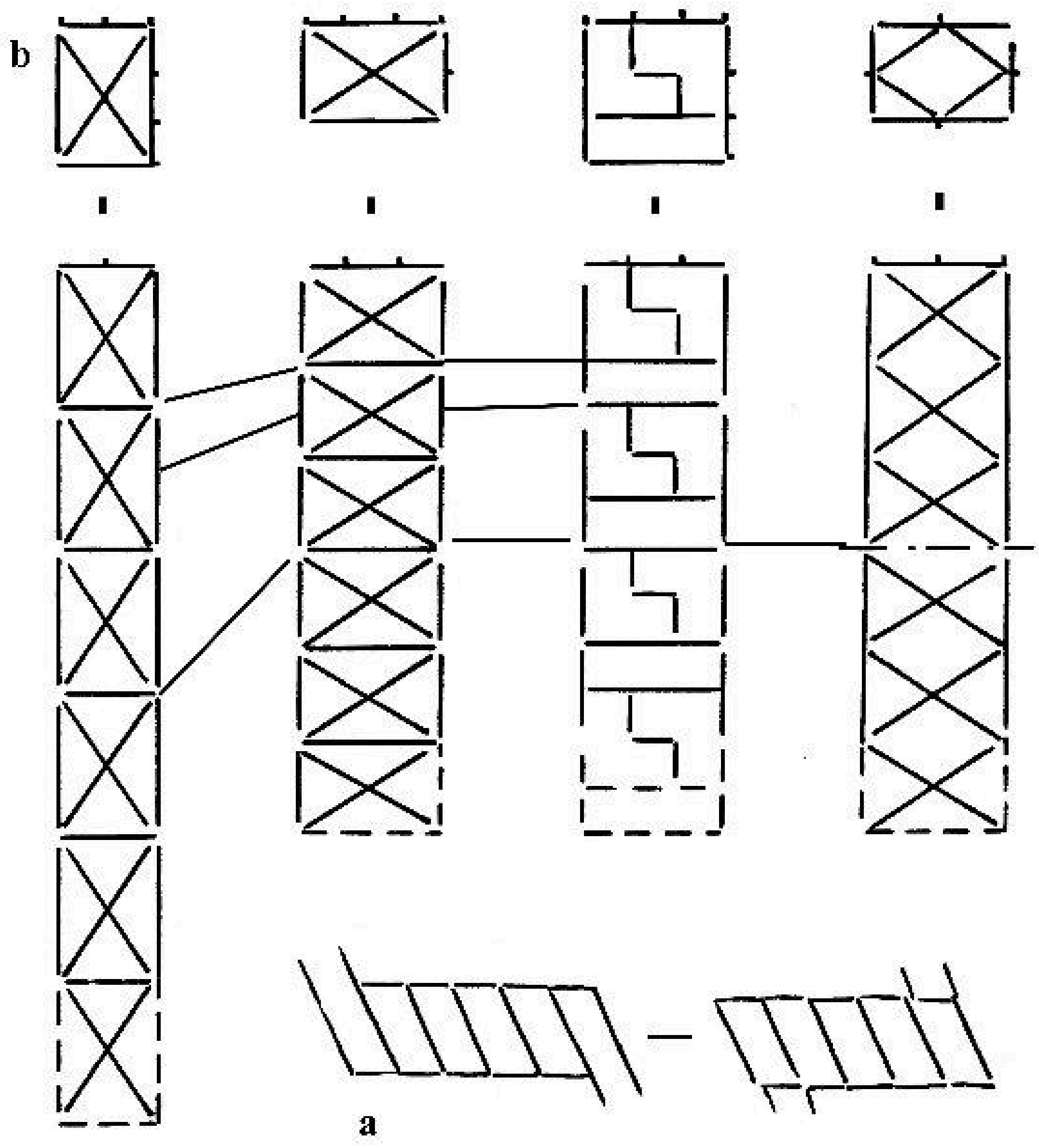

Fig.2. Reconstruction of the Afanasievo geometric pattern

FIG 2. RECONSTRUCTION OF THE AFANASIEVO GEOMETRIC PATTERN

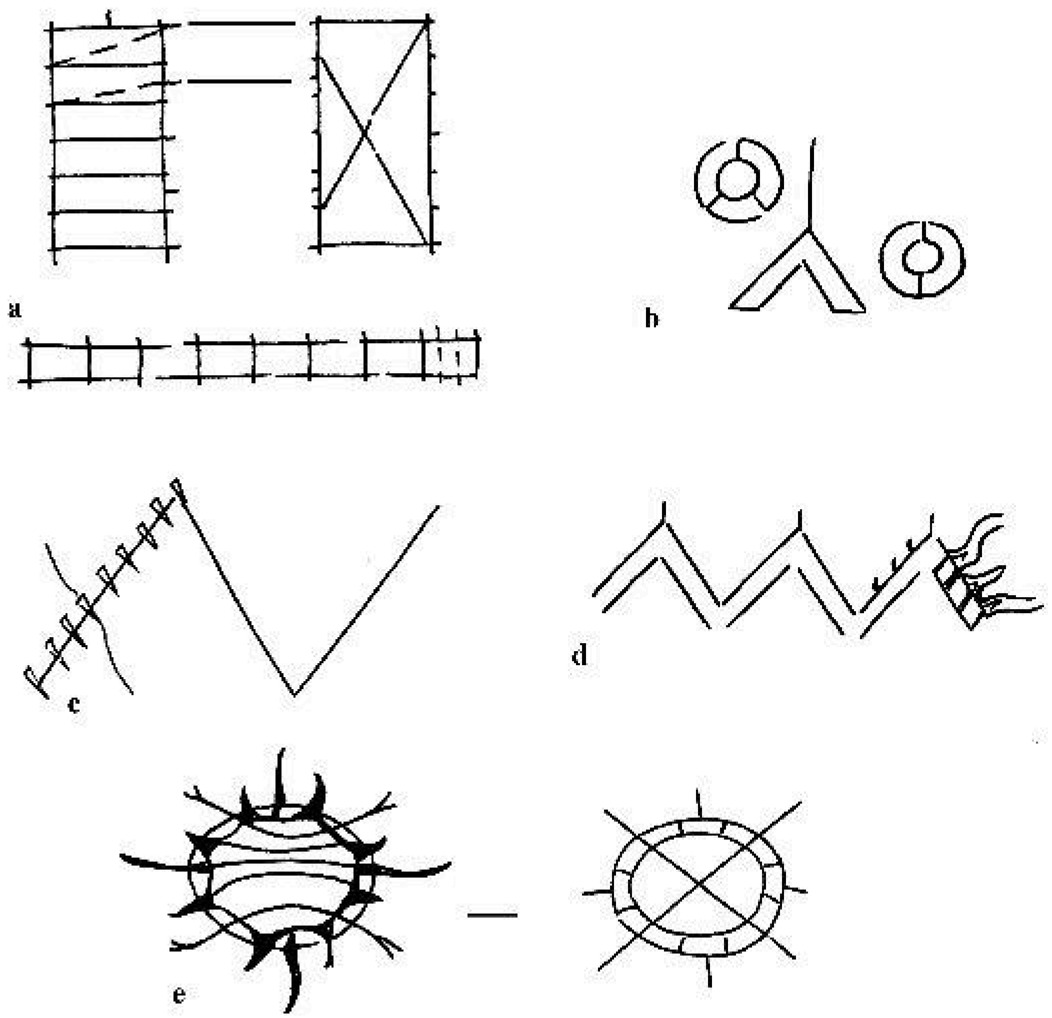

Fig.3. Method of scaling of a spiral turn

FIG 3. METHOD OF SCALING OF A SPIRAL TURN

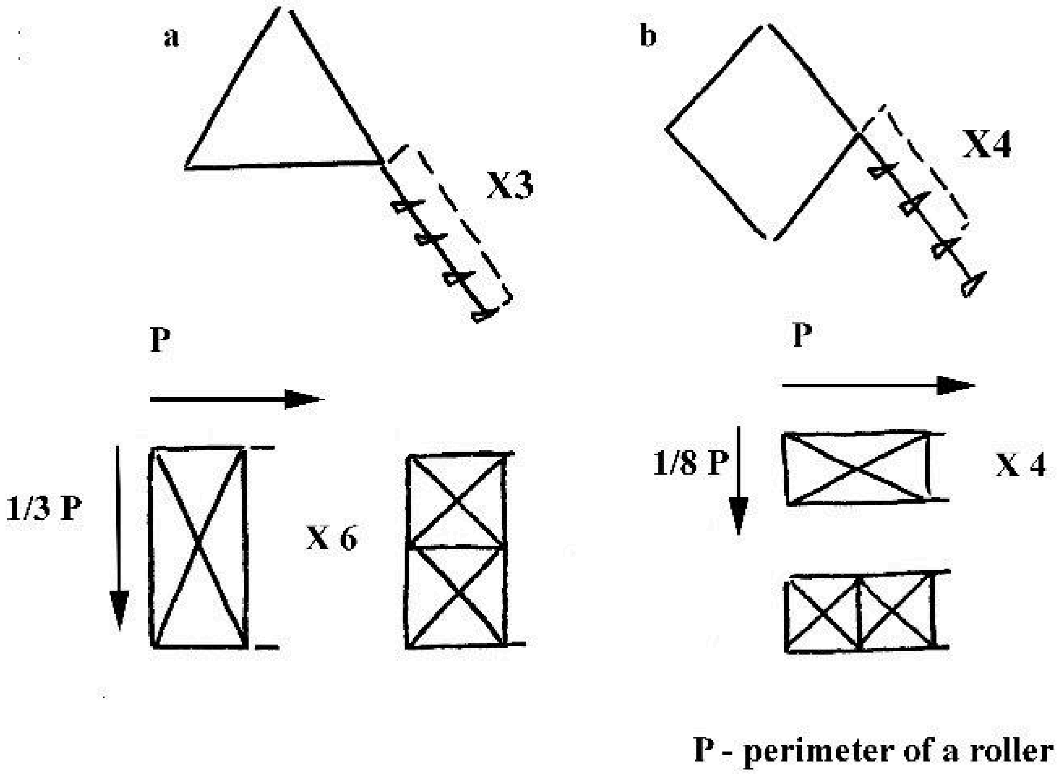

Fig. 4 Horizontal and vertical dimensions of the proposed roller stamp

FIG 4. HORIZONTAL AND VERTICAL DIMENSIONS OF THE PROPOSED ROLLER STAMP

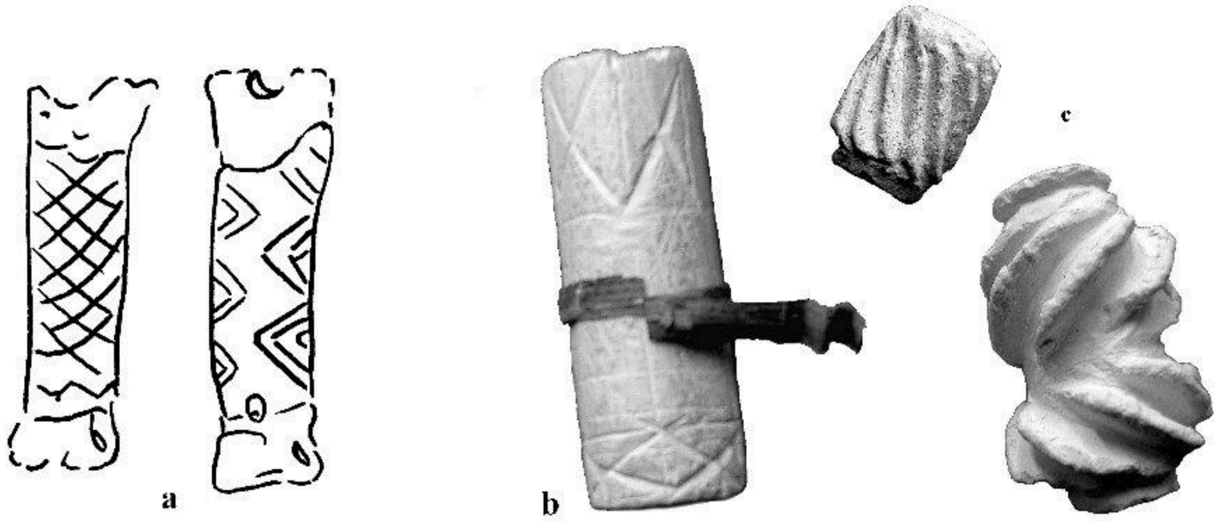

Fig. 5 Experimental reconstruction of the proposed roller stamp

a – Original items ornamented with a rhombic net design (Western Siberia, the Bronze Age from Molodin 1995: Fig. 12: 28, 29)

FIG 5. EXPERIMENTAL RECONSTRUCTION OF THE PROPOSED ROLLER STAMP

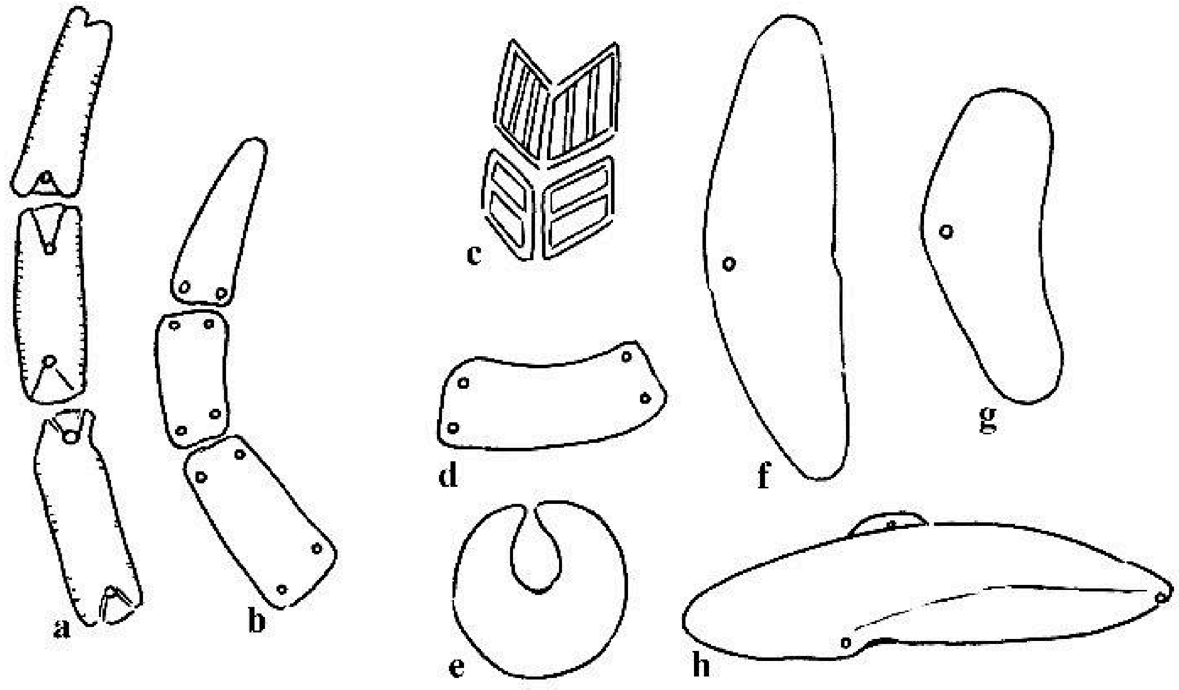

Fig. 6 Arch-shaped items (Neolith- Bronze Age of Eurasia)
a, b, d, h - from Avdusin 1977: Fig. 13: 10, 15, 14; **17:** 7;
c, e - from Bader et al. 1987: Fig. 9: 22; **124:** 9 **(fragment);**
f, g - from Molodin 1995: Fig. 7: 7, 12

FIG 6. ARCH-SHAPED ITEMS (NEOLITH- BRONZE AGE OF EURASIA)

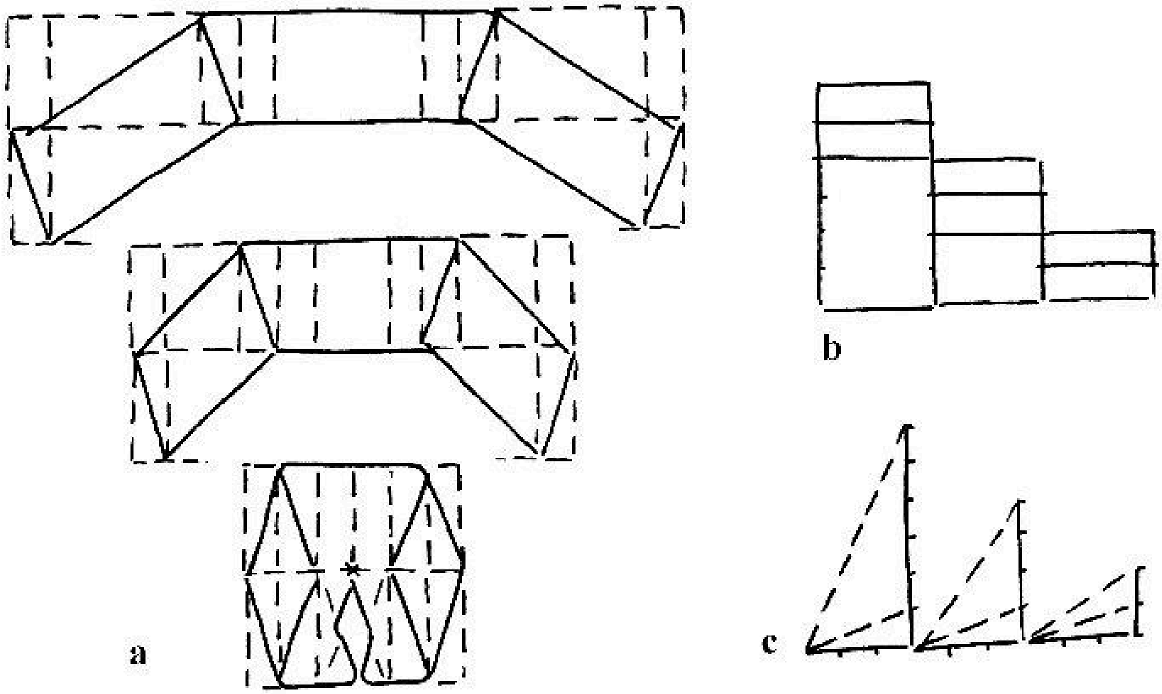

Fig. 7 Basic description of a cone-shaped vessel via the geometric pattern

FIG 7. BASIC DESCRIPTION OF A CONE-SHAPED VESSEL VIA THE GEOMETRIC PATTERN

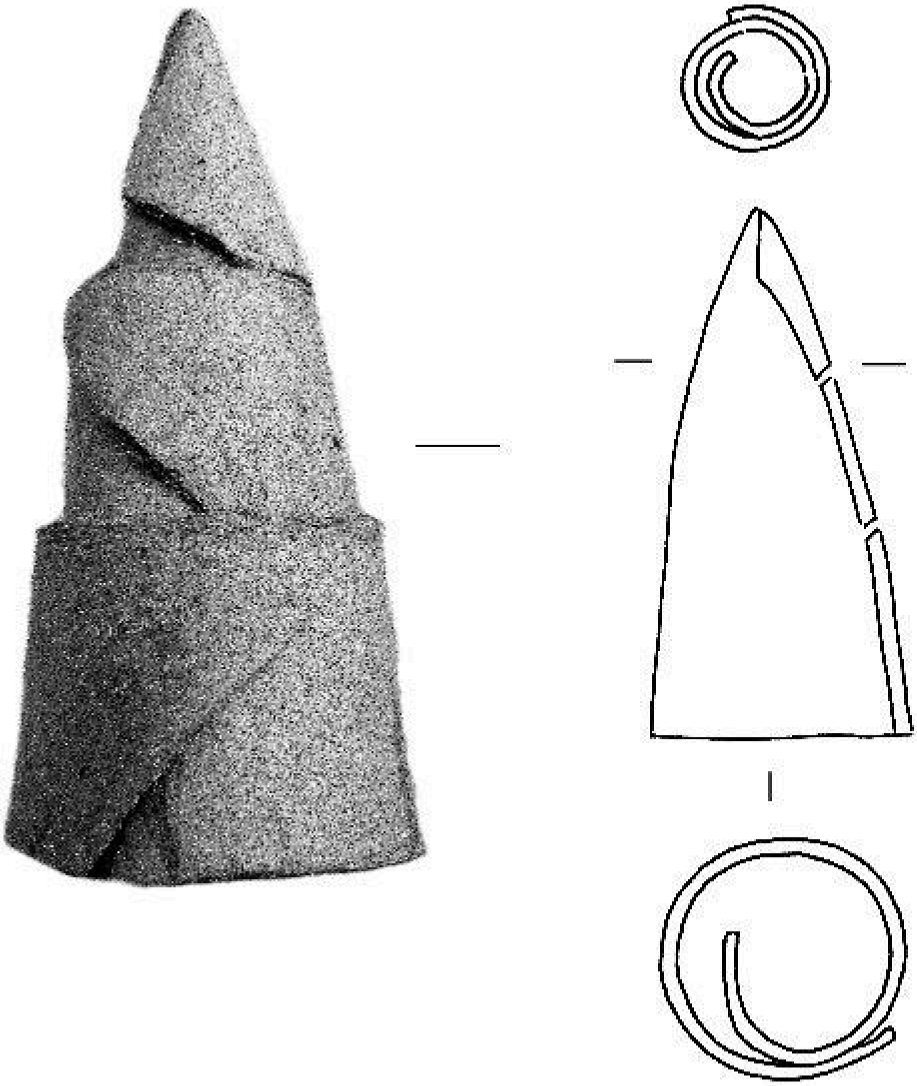

Fig. 8 Basic description of a cone-shaped vessel via the geometric pattern Experimental sample

FIG 8. BASIC DESCRIPTION OF A CONE-SHAPED VESSEL VIA THE GEOMETRIC PATTERN EXPERIMENTAL SAMPLE

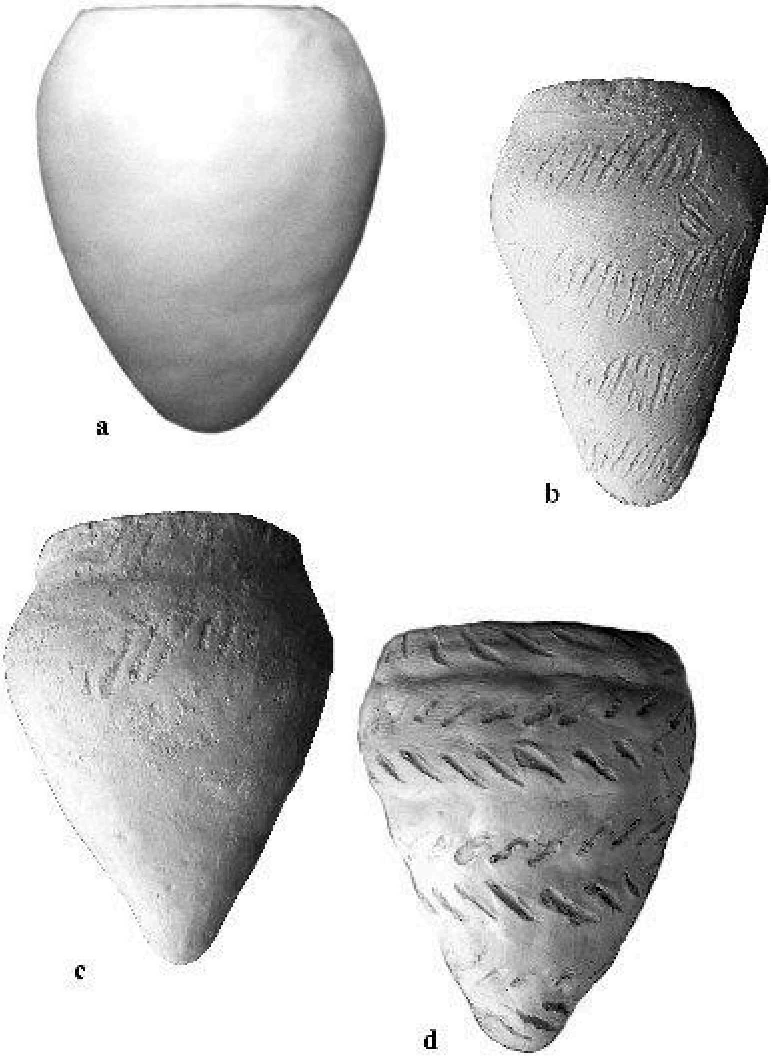

Fig. 9 Estimation of the vessels' shape through the geometric pattern. Experimental samples

FIG 9. ESTIMATION OF THE VESSELS' SHAPE THROUGH THE GEOMETRIC PATTERN. EXPERIMENTAL SAMPLES