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Technical data and experiments on corded ware

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\begin{abstract}
Studies of the typical late Neolithic Corded Ware beakers are usually undertaken from a morphological point of view, and describe the shape and decoration of the vessel. Interesting details can, however, also be identified via the technical description of the twisted cord impressions. In this paper, a clear methodology of such a technical analysis is presented. This analysis points out different quality standards of both the vessels and their patterning. The cord impressions have also been correlated with organic finds of cords from the same period. With the help of experimental archaeology, facts were investigated which elucidate the possible raw material used for the cord impressions, the quality of the clay, and the surface condition of the beakers.
\end{abstract}

1. The Corded Ware Culture in the lower Traisen Valley, Austria

In the first half of the third millennium BC, the Corded Ware Culture was distributed across wide areas of Central and Northern Europe (Fig. 1). The term ‘Corded Ware’ is related to the typical decoration of cord impressions, usually found on the necks of beakers. In Austria, finds of this culture have been known since the 1930s (Stroh, 1940). Ruttkay identified a close relationship between these artefacts and those belonging to the Moravian Corded Ware Culture (Ruttkay, 1981).

The Traisen is a river that springs in the Alps, and, running to the north, it reaches the Danube near Traismauer, approximately 40 km west of Vienna. Although this north-south oriented valley is very fertile, the lower terraces have a history of being used for gravel extraction, resulting in a number of rescue excavations. The settlements and graves that these excavations have uncovered span the Early Neolithic through to medieval times, and have made the Traisen Valley one of the best-known archaeological areas in Austria (e.g. Neugebauer et al., 2000). About 160 graves of the Corded Ware Culture have been excavated (Neugebauer and Neugebauer, 1992; Neugebauer-Maresch and Neugebauer, 2001). No settlement areas dating from this period have yet been found.

In the context of the project “The Endneolithic in the Traisen Valley”, finds from about 160 graves of the Corded Ware Culture (and about 25 graves of the Bell Beaker Culture) were investigated (Kern, in preparation). Grave goods made of stone, bone and antler were found. Most of the graves also contained ceramic vessels (beakers, jugs, bowls, cups, large and small amphorae, and jars). Twelve beakers are decorated with cord impressions (Fig. 2).

2. Technical description of Corded Ware patterns

While the patterning and shaping of Corded Ware vessels has been a part of many morphological, typological and chronological studies, technical data about the cord impressions is usually neglected. To date, only Corded Ware in western Switzerland has been analysed in technical detail, by Giligny and Michel (1995). Descriptions of cord impressions were published by Gibson and Woods (1990: 128 f.) and Gibson (2002). In the latter publication, experiments with whipped cord are mentioned (Gibson, 2002: 59). Only a few articles address the technical analyses of decorations with impression and experiments (Liddle, 1929; Neugebauer, 1976a; Berman and Hutcheson, 2000; Drenth and Prummel, 2006); thus far, only the impressed decorations on the late Neolithic Bell Beakers have been a focus for broader research concerning technique (e.g. Prieto Martinez and Salanova, 2009).

2.1. Methods

The methodology we have adopted for the technical analysis of the cord impressions from the Traisen Valley (the sites of Fränkhausen
and Gemeinlebarn) embraces a clearly defined and standardised description of the technical data (see also Fig. 3):

a) *twist direction of the impression* (S- or Z-turn): the twist direction seen on the impressions is a reversed image of the twist direction of the cord.

b) *twist angle*: describes the intensity of the twist (loose or tight), as defined by Emery (1966: 11), where a loose yarn has a twist angle of 10°; a medium yarn is defined by values between 10 and 15°, while a tight yarn has a 25–40° twist angle.

c) *width of impression*: this feature defines the actually measurable width seen on the pot. On each pot, up to 5 measurements were taken at different points. If a margin of deviation was registered, the minimum and maximum size was counted.

d) *width of cord*: this is an estimated figure, depending on the depth of the impression. If the impression is about 50% of the cord diameter, we know that the width of the impression matches the width of the cord used. In cases where the cord was less deeply impressed, the width of the cord is calculated from the width and the curve of the impression. In all these measurements, we assume that the cord had a circular diameter.

e) *depth of impression*: the depth of impression indicates what percentage of the cord diameter was pressed into the clay.

f) *number of twists within 2 cm*: the number of twists is counted in combination with the thread diameter, to separate very fine and coarse cords. The number of twists also relates to the twist angle. A high number of twists is usually coupled with a tight twist angle, while a low number of twists on a yarn of similar diameter as the first one is related to a very loosely twisted yarn.

There is a terminological problem concerning the cords that must be recorded as such: in the Central European prehistory, the terms ‘thread’, ‘cord’ and ‘rope’ are clearly defined and distinguished by diameter (Rast-Eicher, 1997: 305, 313). A thread is considered to be up to 2 mm in diameter, a cord between 2 and 8 mm. If the sample has a diameter of more than 8 mm, it is referred
to as 'rope'. Some of the impressions on 'Corded Ware' are less than 2 mm in diameter. Nevertheless, we decided to employ the term 'cord' for all the impressions, in keeping with the name of the cultural group, 'Corded Ware'.

2.2. Catalogue of recorded vessels and data (Table 1 and Fig. 4)

Franzhausen II, grave 723: pattern: irregularly placed horizontal cord rows on the neck of the vessel. Cord impressions of fine tightly twisted cords (Z-twist), impressions irregular in depth.

Franzhausen II, grave 730: rows of horizontal cord impressions with 0.7–1 cm distance between one another on the neck of the vessel. Cord impressions of coarse cords, tightly Z-twisted, impressions 20% of the thread diameter.

Franzhausen II, grave 761: pattern: 4 horizontal bands of 3 rows of cord impressions next to each other on the neck of the vessel. Cord impressions of coarse cords (Z-twist), executed carefully and evenly.

Franzhausen II, grave 768: irregularly and with less care placed horizontal rows of cord impressions with 0.7–1 cm distance between one another on the neck of the vessel. Cord impressions

Fig. 2. Traisen Valley: Corded Ware beakers (drawing: M. Imam).
of coarse irregularly twisted cords (Z-twist), impressions irregular in depth.

Franzhausen II, grave 2112: alternately, 3 horizontal close rows of cord impressions and rows of notch-like imprints on the neck of the vessel. Cords loosely Z-twisted, coarse and carefully deep impressed.

Franzhausen II, grave 3386: pattern: 4 horizontal bands of 3 rows of cord impressions next to each other; intermediate rows of notch-like imprints on the neck of the vessel. Cord impressions of fine loose cords (Z-twist), executed carefully and evenly.

Franzhausen II, grave 3409: densely placed horizontal cord rows on the neck of the vessel. Cord impressions: carefully executed tight Z-twisted cords, impressions uniform and even.

Franzhausen II, grave 3419: pattern: 3 rows of notch-like imprints intermediate irregularly placed horizontal bands of 3 cord rows on the neck of the vessel. Cord impressions of fine tightly twisted cords (Z-twist), impressions irregular in depth.

Franzhausen III, grave 1: alternately, 3 horizontal rows of cord impressions and one row of notch-like imprints on the neck of the vessel. Coarse cords, tightly Z-twisted, carefully deep impressed.

Franzhausen III, grave 1055: pattern: 4 carefully placed horizontal rows of cords below the rim; below, 2 rows of oblong imprints and 2 more rows of cord impressions on the neck of the vessel. Cord impressions: fine cords, carefully Z-twisted, impressions uniform.

### Table 1

Corded Ware from Traisen Valley: recorded technical data.

<table>
<thead>
<tr>
<th>Site/grave</th>
<th>Twist direction imprint</th>
<th>Twist angle (plied yarn)°</th>
<th>Width imprint mm</th>
<th>Width cord mm</th>
<th>Depth imprint %</th>
<th>Number of twists 2 cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franzhausen II, gr. 723</td>
<td>Z</td>
<td>40–50</td>
<td>2</td>
<td>2–2.5</td>
<td>25–75</td>
<td>6–8</td>
</tr>
<tr>
<td>Franzhausen II, gr. 730</td>
<td>Z</td>
<td>40–50</td>
<td>2</td>
<td>2.5</td>
<td>25–30</td>
<td>6–7</td>
</tr>
<tr>
<td>Franzhausen II, gr. 761</td>
<td>Z</td>
<td>30–40</td>
<td>2</td>
<td>2</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>Franzhausen II, gr. 768</td>
<td>Z</td>
<td>20°</td>
<td>1.5–3</td>
<td>2–3</td>
<td>25–50</td>
<td>4</td>
</tr>
<tr>
<td>Franzhausen II, gr. 2112</td>
<td>Z</td>
<td>30</td>
<td>1.5–2</td>
<td>2</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>Franzhausen II, gr. 3386</td>
<td>Z</td>
<td>20–30</td>
<td>0.7–1</td>
<td>1</td>
<td>25</td>
<td>8–9</td>
</tr>
<tr>
<td>Franzhausen II, gr. 3409</td>
<td>Z</td>
<td>40</td>
<td>2</td>
<td>2</td>
<td>35</td>
<td>5</td>
</tr>
<tr>
<td>Franzhausen B, 3419</td>
<td>Z</td>
<td>30°</td>
<td>1–1.5</td>
<td>1.5</td>
<td>30–50</td>
<td>7–8</td>
</tr>
<tr>
<td>Franzhausen III, gr. 1</td>
<td>Z</td>
<td>40–50</td>
<td>2</td>
<td>2–2.5</td>
<td>50</td>
<td>5</td>
</tr>
<tr>
<td>Franzhausen III, gr. 1055</td>
<td>Z</td>
<td>40–50</td>
<td>1.5</td>
<td>1.5</td>
<td>50</td>
<td>6–7</td>
</tr>
<tr>
<td>Gemeinlebarn gr. 3351</td>
<td>Z</td>
<td>40–50</td>
<td>1.5–2</td>
<td>2</td>
<td>50–75</td>
<td>6</td>
</tr>
<tr>
<td>Gemeinlebarn gr. 6783</td>
<td>Z</td>
<td>30–40</td>
<td>3</td>
<td>3</td>
<td>50</td>
<td>4–5</td>
</tr>
</tbody>
</table>

The impressions are Z-twisted, and therefore the original cords have to be S-plied. The cord impressions stretch once around the entire vessel, and sometimes the meeting points can be recognised by overlaps (Franzhausen II, gr. 2112, Fig. 4). There are no indications of the use of different cords in the decoration of a single vessel.  

It is known that pots shrink as a result of drying and firing; thus, the cord impressions on the vessels would therefore be slightly thinner than the original cords. Our general conclusions are not affected by this slight difference.  

3. Experimental archaeology: making cord impression with various raw materials  

Experiments were designed to provide a better understanding of the Corded Ware impressions. The aim was to undertake a series of tests using different raw materials and then to compare the experimental impressions with those from the original beakers. The analysis was carried out by optical microscopy (Microscope: Wild M3Z, magnification ×10–×40). Additionally, the microstructure of the experimental impressions was analysed with a Scanning Electron Microscope (LEO EVO 60) at the Vienna Institute for Archaeological Science (VIAS) (Fig. 8).
3.1. Questions and modus operandi

The principles and methodology of experimental archaeology have been discussed in many publications (e.g. Coles, 1973; Reynolds, 1999; Lammers-Keijser, 2005). All of these authors state that it is important to define a clear hypothesis with respect to a specific archaeological problem, a modus operandi, and to compare the results of the experiment with the archaeological data.

1) The first question concentrated on the quality of the clay. This is important as the original Corded Ware beakers from the Traisen Valley suggest that different qualities of clay may affect the quality of the impression.

2) The second question regarded the establishment of the condition of the clay at the time the impressions were made. This included its wetness and other treatments, such as burnishing.

3) Finally, the most important question for the present study concerned the raw material that was used for the production of the cords, which formed the impressions on the Corded Ware vessels.

To address the first question, small clay tablets (with a diameter between 5 and 7 cm) were made using clay of varying quality (fine, medium fine, coarse, highly tempered). Fifteen tablets of each clay quality were produced using local deposits from Lower Austria (Laa an der Thaya, Maiersch and Gars/Thunau). In order to address the second question, impressions were made on the clay surface under different conditions. First, the patterning was carried out directly in the fresh clay; for the next series, the surface of the clay was dried; and for the third series, the clay tablets were slightly burnished in a not fully dried condition — as can be observed on the original pots. Different cord materials were impressed in all the tablets of different clay quality, with the surface treatments as described (Fig. 5).

Different raw materials were selected for the test cords in order to address our final question. Each of the five raw material groups of lime-bast (*tilia*), grass (*graminae*), flax (*linum usitatissimum*), sheep wool, and hair (horse hair from the tail and human hair) was accessible to the people in the first half of the third millennium BC. Analyses of plant material from circum-alpine lakeside settlements, especially from Switzerland, have produced a clear picture of various textile products, such as cordage, mats, basketry or woven fabrics (Schibler et al., 1997: chapters II, IV and V; Rast-Eicher, 1997: 310 ff.). In the Late Neolithic, oak-bast and lime-bast were preferred as cordage materials. The use of reed begins in the Horgen Culture and becomes very frequent in the Corded Ware Culture, while in this period flax is used infrequently.

Each step of the tests undertaken for this research was documented by digital photography and additional written records detailing the handling, working rhythm, and problems encountered, as well as the ideas that arose in the process. The clay tablets were marked so that clay quality, the surface condition and the cord raw material were all clearly identifiable. All parts of the experiment (cords and clay tablets) are now housed at the Museum of Natural History in Vienna for further investigation and as reference material for future comparisons.

Fig. 5. Experimental Archaeology: clay plates of different quality and surface treatment with cord impressions.
3.2. Results of the experiments

3.2.1. Clay quality

It was assumed that the quality of the impression depends on the quality of the clay, its condition and surface treatment. The experimental impressions are as visible on fine as on coarse clay. While the beakers from the Traisen Valley are sometimes made of very finely prepared clay, the more normal material is medium fine clay with some inclusions; however, sometimes even coarse clay with a lot of inclusions was used for cord impressed beakers. The finer the clay, the more clearly visible is the microstructure of smoother cords, such as those made from flax. Surprisingly, strong and stiff cords, such as grass and bast cords display their microstructure equally well on both fine and coarse clay.

3.2.2. Surface condition

The best results can be obtained when pressing the cords directly into the fresh (wet) clay. Slightly smoothed surfaces on partially dried clay do not affect the impression very much, but, as might be expected, a dried surface makes the patterning difficult. For the cord impressions to work on dried surfaces, a great deal of pressure is necessary. This can be carried out on the flat tablets used for our experiments, but pressing the cords on vessels at the leather-hard stage would cause deformation or breakage. Additionally, the cords cannot be pressed very deeply into the clay. If we compare this with the data from the original beakers, we can be sure that the impressions were made on fresh or smoothed surfaces.

3.2.3. Cords of different raw material

Some interesting observations regarding the qualities of raw materials came to light during the manufacture of the different cord types used for the impressions. As previously noted, the prepared cords (Fig. 6) are about 2 mm in diameter, which is comparable to the impressions on the original vessels. The shrinkage of the clay does not affect the results very much, because it is in the range of the variability of the original cord impressions.

Lime bast and flax are very elastic, soft and smooth, so it is very easy to twist them and make a cord with different twist angles and different numbers of twists per centimetre (as we know from the original impressions).

While working with grass, it was noticed that fresh grass is as soft as lime bast, but because of the variable thickness of the leaves, it is not easy to make a completely even cord of the sort obtained from flax, which has more even fibres. Also, a cord made of fresh grass tends to disintegrate within a few days, as the grass dries out. The experimental use of dried grass for cordage indicated that it is a very stiff and hard material, making it impossible to ply a cord with a dense number of twists or a high twist angle.

It was interesting to note that there is a difference in terms of cordage between horse hair from the horse’s tail and human scalp hair. The former has thick fibres and is a stiff material, comparable to dried grass but without the associated problems. Human hair is smoother, and cords of different twist angles can be easily made of it. Both human and horse hair result in cords with a very fine microstructure, caused by the fine even fibres.

Wool is very soft and smooth, so it is easy to produce cords in any required thickness out of this material.

The process of making the actual impressions with cords of the different raw materials (Fig. 7) brought more interesting features to light. Woollen cords are useless for Corded Ware impressions. Wool is too soft, the impressions are diffuse and do not even show the characteristic ‘structure’ of a cord. As pointed out above, bast and grass cords are made of single elements (fibres) of inconsistent thickness. Therefore, impressions of bast and grass are characterised by an irregular microstructure. Impressions made of hair and flax have an evenly fine microstructure, those of flax being even finer than those of horse hair (Fig. 8).

If we compare the impressions derived from the experiments with the data from the original beakers, we usually see a slightly irregular microstructure on the latter impressions. It seems as if the original impressions were executed with cords made with a raw material, which was not very finely prepared — such as bast or grass cords (Fig. 8). However, even though we identified clear analogies between the experimental and the original impressions (for example, the impression from Gemeinlebarn 6783 corresponds to the experimental grass impression in Fig. 7), it remains possible that fibres of other plants, which we did not test (such as hemp, as speculated by Sherratt, 1995: 31) could result in the same kind of traces.

The beakers from Graves 723 and 3386 at Franzhausen II are two exceptions. The impressions show a very fine microstructure, corresponding to a cord made of finer raw material — perhaps flax; however, so far we have not identified a sharp fine microstructure as in the cords made of human or horse hair.

4. Cord impressions on Corded Ware beakers from the Traisen Valley

Analysis of the technical data pertaining to Corded Ware impressions showed that the influence of the fabric on the decoration is not high. Impressions are seen as clearly on fine as on coarse clay. Most of the beakers show traces of burnishing. This was probably done after impressing the decoration on a fresh or smoothed surface.

Two principal cord types were used for the impression; both consist of 5-plied cords, which result in a 2-plied impression on the vessel. Cords with a coarse microstructure (most probably bast or grass) and a diameter of about 2–2.5 mm were preferred. A very coarse example is known from a good quality beaker at Gemeinlebarn, Grave 6783. It is 3 mm in diameter and has only 2 twists per centimetre. Very fine cords were also used to make finer patterns (e.g. Franzhausen, Graves 3386 and 1055). Usually their microstructure is fine and even, and presumably a flax cord was used.
Such cord impressions are just 0.7–1.5 mm thick, they have a high number of twists per centimetre (4–5), and a high twist angle of about 50°, which strengthens the stability and stiffness of the cord.

The depth of impression varies. Usually the cord impressions are very clear, with impression about 50% deep, indicating that the full diameter of the cord can be seen and the structure of the cord is clearly visible. Sometimes the impressions are irregular.

It is interesting to note that irregular impressions correspond to irregularly executed patterns and coarser beakers (e.g. Franzhausen II, Graves 761 and 768). For example, the cord from the beaker Franzhausen II, Grave 768, has a great variety of twists per 2 cm (between 2 and 7), illustrating the irregularity of the twist.

5. Technical decisions and social implications

The analysis of technical data derived from Corded Ware from the Austrian Traisen Valley has shown that we can clearly identify two different categories of quality in relation to the beakers and their patterning. On the one hand, some of the artefacts are carefully made beakers with even patterning; the cords used for the impression are carefully twisted and the impressions are done with constant deep pressure so that the structure of the cord is clearly visible. Meanwhile, there are other examples of coarser, irregularly shaped beakers, decorated with irregular rows of cord impressions. Even the cords used are irregularly twisted. Perhaps differences between
good quality beakers with regular impressions and somewhat sloppy, coarse pots with irregular shaping and patterning are indicative of the work of ‘masters’ and ‘apprentices’.

Another noticeable feature is that all of the cord impressions derive from S-plied cords, which cause Z-plied impressions. As pointed out by Antoinette Rast-Eicher (1997: 310 ff.), more than 80% of the organic cords found at Swiss lacustrine settlements from the Corded Ware Culture are also S-plied. According to this aspect, the author inferred that, for a right-handed person, S-plying is ‘ergonomically’ easier than working the cord in the Z-direction. The percentage of S- and Z-plied cords may therefore correspond to the percentage of right- and left-handed persons within the Corded Ware society.

The analysis of Corded Ware in the same area (Switzerland) (Giligny and Michel, 1995: Fig. 4) has shown that the majority of impressions are caused by using S-plied cords (Z-plied impression). Our Traisen Valley data are comparable with these results.

6. Conclusion

In the present paper, archaeological experiments have been used to improve archaeological knowledge concerning the possible raw materials employed to manufacture the cords used for pottery decoration and the way in which these impressions were actually made. As a result of these experiments, we can exclude the use of woollen cords for the impressions. Bast-fibre and grass seem to have been used for the majority of the decorations. Some cord impressions show a very fine microstructure that is analogous with that of the experimental impressions made with flax.

The impressions were made on a fresh or possibly smoothed surface. The quality of the clay does not significantly affect the quality of the impressions. A correlation between irregular cord impressions and less carefully made vessels was observed.

Acknowledgements

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