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ARCHAEOMETRIC INVESTIGATION OF MEDIEVAL WALL MOSAIC FRAGMENTS OF SZÉKESFEHÉRVÁR, HUNGARY

Introduction

The present theme is a significant part of a current research deals with the analysis of floor and wall mosaic findings brought to light by archaeological excavations from the Roman period and from the medieval times in Hungary. Each examined site has different characteristics retaining imprint of a historical era as well. The aim is not only the examination and comparison of the findings and phenomena of similar ages, but with more perspective, keeping track of changes in the use of materials and techniques, as well as the continuity of their preparation. The mosaic findings closely link to their original architectural environment; in aesthetics and in materials they carry information of temporal and local fingerprints. The *tesserae*, the mortars, and preparation methods are equally under investigation. The systematic research of these characteristics can give help to fit the small, but particular Hungarian mosaic heritage into the international context.

Background

Székesfehérvár was a significant pilgrim station towards the Holy Land. The basilica was built in the beginning of eleventh

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century by King Stephen the first, after his successful Bulgarian offence. This basilica became the prestigious burial place of Hungarian kings through the centuries. The excavation of the site began in the second half of the 19th century. According to the findings, probably the apse of the basilica was decorated by sumptuous figural mosaics dated back round the eleventh century.

The exact time of the creation of this mosaic remained only in fragments is unknown. The kings followed each other on the throne in these centuries. Almost all of these rulers had some Venetian and Byzantine ties, and Székesfehérvár was a highlighted city along the most important trade routes. The basilica was burnt several times. During the Ottoman conquest the basilica was destroyed. Nowadays only its ruins indicate the former, large-scale presence.

Painted mortars

The role of the painted mortars has a paramount importance among the wall mosaic preparation methods. One of these is the *sinopia* painted on the basic mortar layer, which can be properly equivalent with *arricchio* in the fresco glossary. And the painted bedding mortar *intonaco*, which directly supports the *tesserae*. In the most cases we can calculate with some quick drawing, sketch, or guidelines of the composition painted to help the mosaicist during the work.

Details of the red and the dark grey hued outlines can be observed on the surface of the remained fragments, and there is no connection between the hue of the lines and the colours of the tesserae. The basic mortar generally contained a large amount of vegetal elements; the imprints of those are well-preserved on the backside of the fragments. The average thickness of the setting bed applied could be around 2 cm. The lime-based mixture consists of limestone particles too.

Aims

The aims of this work are: to provide a chemical characterization of the mosaic *tesserae* from the apse of the Basilica, to determine the

opacifiers and colouring agents employed for their production; to compare the chemical data of the samples from Székesfehérvár with other well-known examples from the mentioned period, in order to understand whether the material of the Hungarian decoration could be the result of similar production technology with that of one-or other glass-making centre.

Investigation of the tesserae

X-ray diffraction experiments were performed on the opaque samples to detect and identify crystalline phases dispersed in the glass matrix. The crystalline phases determined in the samples were: metallic copper in the red opaque *tessera*, quartz and cristobalite in green-grey, blue, and deep purple *tesserae*. Their chemical characteristics are far more similar with those of some Venetian medieval glass *tesserae*. The main opacifier used in the production of the tesserae from Hosios Loukas was also quartz beside the presence of cristobalite (the higher temperature polymorph of silica).

The red coloration of the sample from Székesfehérvár was obtained by a colloidal dispersion of metallic copper. The optical properties were analysed under polarized light using the thin section prepared from this sample. Colloidal particles dispersed in the glass matrix result the red colour and opacity. The colouring agent occurs streaked in the basic glass matrix (Fig. 1). These chromophore metallic copper particles show high-birefringence. High-refractive index and highly visible reflectance pleochroism, the so called bi-reflexion could be observed.

The flesh tones of the human figures were made of stone *tesserae*, according to the preserved fragment. We could distinguish a whitish, red, and brown types. A kind of white *tessera* from the finds of Székesfehérvár is very specific and unique one. It is pure magnesite ($MgCO_3$) measured by X-ray diffraction investigation. According to the natural appearance magnesite is white, microcrystalline, porous, dull material, it looks like unglazed porcelain. Among the excavated *tesserae* there are round-shaped pieces. Magnesite is quite rare raw material to use as white *tessera*; it can be a useful finding

for the further investigation to determine the source and the date of this mosaic.

We can differentiate two main kinds of gold leaf *tessera*. The hue of the translucent glass support of the first type tends to yellow. Its *cartellina* is totally colourless. The other main component of the apse mosaic is a translucent, light purple hued glass. Most of them lost the metal leaf and/or the *cartellina* as well. A remained geometrical motif (Fig. 2) contains also both types of *tessera* above mentioned. The metal foil can be observed only in small traces on the surface of the slightly purple translucent glass *tesserae*.

This observation raises some interesting questions: why this type is more sensitive, what are the causes of their quite distinct damage processes, what are the essential differences between the two types of metal leaf *tessera*. We found the answers by examination of their chemical properties.

The X-ray diffraction examination proved that the gold layers of the two types of metal foiled *tessera* has different crystallographic orientation[1]. After this result, during the handheld XRF examination the presence of mercury was detected in the gold derives from the sample Szfv 14, while the other sample (Szfv6) showed the almost pure gold content. We could diagnose that a different preparation technique could lead to the different degradation process and the general state of the *tesserae*. The presence of the mercury can be the result of two types of gilding technique. During one of the cases the mercury is used as an adhesive. This technique is mentioned in the literature as cold mercury gilding. The other possibly method is the amalgam gilding, when the gold powder is firstly mixed with liquid mercury to gain an amalgam, than it was heated to a temperature high enough to eliminate most of the mercury by evaporation. It is important to note that this way to produce metal leaf tesserae was not usual; it was used more on metals.

Among the stored *tesserae* we could find quite a lot of *cartelline* detached, so the manufacture of these kind of metal leaf *tesserae* is

[1] The direction of the orientation of gold from the sample Szfv6 is 1-0-0, what is the prefered orientation of gold leaf, while the gold from the sample Szfv14 orients 1-1-1. This orientation is not typical for metal leaf.

really differing. The possibility of an early restoration was incurred, but the structure of some other tesserae is in contradiction with this premise. In these cases we can see the rounded edge of the *piastra*, where the thin layer of molten glass, the *cartellina*, bent over the original glass support wearing the metal layer (Fig. 3). These cases can likely the evidences of the complexity and originality of the complete body of the *tesserae*, and the re-gilding of the original support can be probably excluded.

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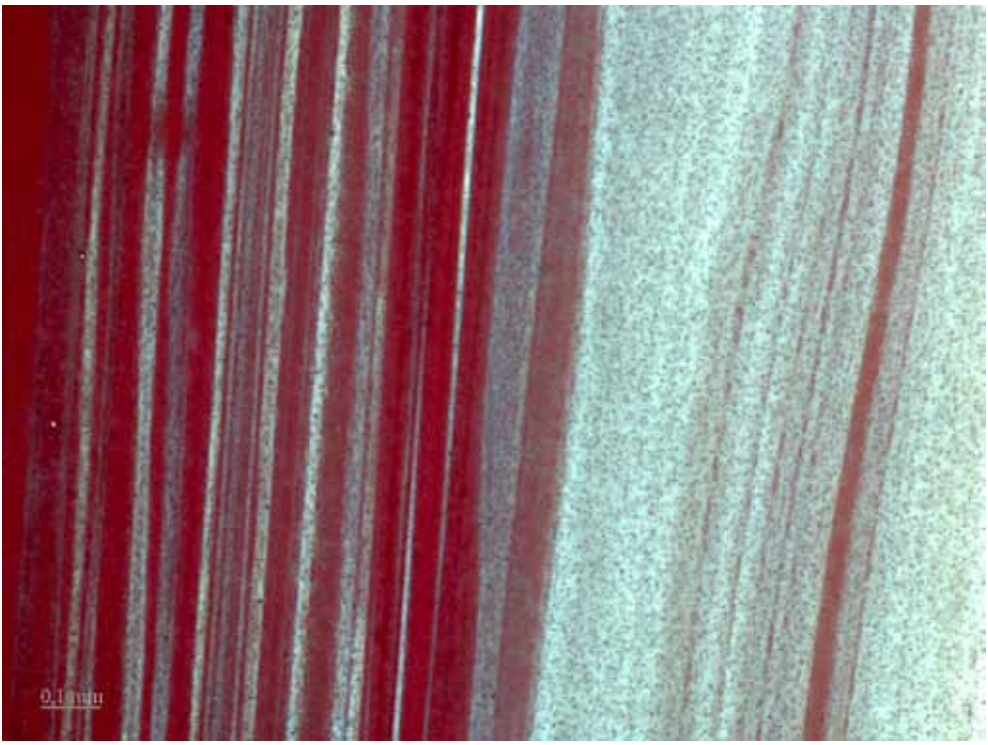

Fig. 1 - Colloidal metallic copper particles dispersed in the glass matrix result the red colour and opacity of the tessera.

Fig. 2 - The remained geometrical motif from the former Royal Basilica of Székesfehérvár. In the background only the translucent purple glass supports have remained, almost without metal layer and cartellina. In the central part the other type of gold leaf tesserae are intact.

Fig. 3 - Stereomicrograph of a translucent purple glass based tessera with gold, and with original cartellina from the findings of the Royal Basilica of Székesfehérvár (Szfv13).

Kitty Laméris

DIFFERENCES BETWEEN EARLY FILIGRANA GLASS AND ROSENBORG CASTLE TYPE FILIGRANA GLASS

There are many differences between the early filigrana glasses (Fig. 1) and the type of filigrana glasses given to the King of Denmark in 1709 in Venice, still exhibited in the Rosenborg castle in Kopenhagen (Denmark)[1]. In this article I will call the group of later glasses 'Rosenborg castle glasses', even though many glasses of the same type are in collections all over the world (Fig. 2).

It is still difficult to understand when exactly they started making these glasses. In recent publications glass specialists suggest several different dates. Baumgartner[2] for examle compares the models of Rosenborg castle glasses with models of glasses made in the seventeenth century and calls them second half of the seventeenth, early eighteenth century, others like Theuerkauff-Liederwald[3] date them around 1700 while for example Bova[4] dates a glass like this even more precisely 1700-1710.

For the moment I will date the Rosenborg castle glasses around 1700.

Most glass experts will immediately recognize these glasses. Especially if they have the same form as the glass now in the Rosenborg castle. Only when the form is different from the examples in Rosenborg castle, does it become more difficult.

In these cases it can be usefull to know the exact difference between the two types. The following list is based on the results

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[1] Boesen 1960.

[2] Baumgartner 2003: 108, 109; fig. 50.

[3] Theuerkauff-Liederwald 1994: 155; fig. 131.

[4] Bova 2010: 358; fig. III. 36.

of my study of filigrana glass executed in 2012[5] and some later observations.

Nine differences between early filigrana glasses and the Rosenborg castle glasses:

1. *Two layers versus one layer*
   The earlier glass has two layers, the Rosenborg castle glass has only one layer.
   This is a result of the way they were made. The earlier glass is made with a pick up on a bubble technique[6] or with the sbruffetto technique[7], the Rosenborg castle glasses are made with the pick up on a collar technique[8].
   The glasses made with two layers have a layer of canes on the ouside and a layer of cristallo on the inside. The glasses with one layer consist only of canes.
   Looking closely at the edge of the glass it is possible to see the difference (fig.1.1). It is easier to feel it: a glass with two layers is smooth on the inside and has relief on the outside. A glass with only one layer has relief on both sides.
   (N.B. Rosenborg castle glasses do have two layers when they are very large).
2. *One set-up versus two or more set-ups*
   The early glasses are made of one set-up. The same bubble or parison is used for the bowl and the foot or for the bowl, the stem and the foot.
   Therefore the amount of canes is the same in the bowl as in the stem or foot.
   The tazza of figure 1 has an extra feature that makes it easy to illustrate this (1.2): because of a mistake in the pattern with alternating a fili and a retortoli canes, at one point one a fili cane is missing. Because of this two a retortoli canes are next to each other. This mistake occurs in the bowl, the stem and the

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[5] Laméris 2012.
[6] Laméris 2012: 30, 31.
[7] Laméris 2012: 34.
[8] Laméris 2012: 34, 35.

foot, which makes it obvious that the same bubble was used.
The Rosenborg glasses are mostly made of different set-ups: the amount of canes used in the bowl and foot differ from each other (Fig. 2.2).
One group of glasses is an exception to this rule: Saxon footed beakers. These glasses usually have different amounts of canes in bowl and foot, like the Rosenborg castle glasses.

3 *Canes with external decoration versus canes with internal decoration: ballotini*
One can date a glass, only by looking at the canes. The early glasses were only made with a retortoli canes with external decorations: most of the time a rete canes (Fig. 1.3). The Rosenborg castle glasses are also made with a rete canes, but in combination with a new type of cane: canes with ballotini (Fig. 2.3).

4 *Mixed canes with a fili and external decoration versus mixed canes with ballotini and external decoration*
Sometimes one finds mixed canes used in early glasses: combinations of the then existing canes: a fili canes with an external decoration. For example a cane with one thread in the centre and two groups of five threads around it (see for an example used in Rosenborg castle glass Fig. 2). The thread in the cane can be put in the centre for a straight line or a bit off centre for a wavering effect.
Since the discovery of the ballotini cane, many more combinations can be and are made of canes with ballotini inside and an external decoration around it (Fig. 3).

5 *One or two versus three or more types of canes*
The early glasses are mostly made with only one or two types of canes (Fig. 1.5). The result of the possibility to make so many different types of canes, is that the Rosenborg castle type glasses are usually made with more types of canes: two or three (Fig. 2.5), rarely even four.
The use of a fili canes becomes very rare.

6 *Thin versus thick canes*
In glasses of comparable sizes, the canes of the earlier glasses are thinner than the canes of the Rosenborg castle type (Fig. 1.6 versus Fig. 2.6).

7 *A rete canes with 5, 6 or 8 threads versus more and thinner threads: 10 to 24 threads*
The white threads are much thinner in the later canes and the canes themselves are wider, therefor there can be more threads in each cane. The a rete canes of the glass in Fig. 1 (1.7) are made with five threads, the a rete canes of the glass in Fig. 2 are made with twelve threads, the cane of the enlargement, taken from another Rosenborg castle glass (Fig. 2.7), with ten threads.

8 *White versus whiter*
The white of the Rosenborg castle glasses is of a clearer white than the white used in the older glasses.

9 *Blown foot versus applied solid foot*
Sometimes an applied cristallo solid foot is added to the Rosenborg castle type glasses.

These differences between the two types of filigrana glasses were found studying hundreds of glasses in different collections. I have found some exceptions to these 'rules'. I found for example one exception to point 1: a pilgrim flask held in the Wallace collection, appears to have only one layer of glass, a feature of the later Rosenborg castle glasses, even though the model is typical for the sixteenth century[9].

I also found one exception to point number 2: an early glass which was made with two bubbles instead of one. However, the lid of that glass had the same amount of threads. Bill Gudenrath came with a beautiful explanation for this exception.

I hope to describe these exceptions (including the comment of mister Gudenrath) and other thoughts about filigrana glass in a future publication. In most cases, however, these nine points can be applied to date filigrana glasses.

[9] Higgott 2011: 78, 79; fig. 13.

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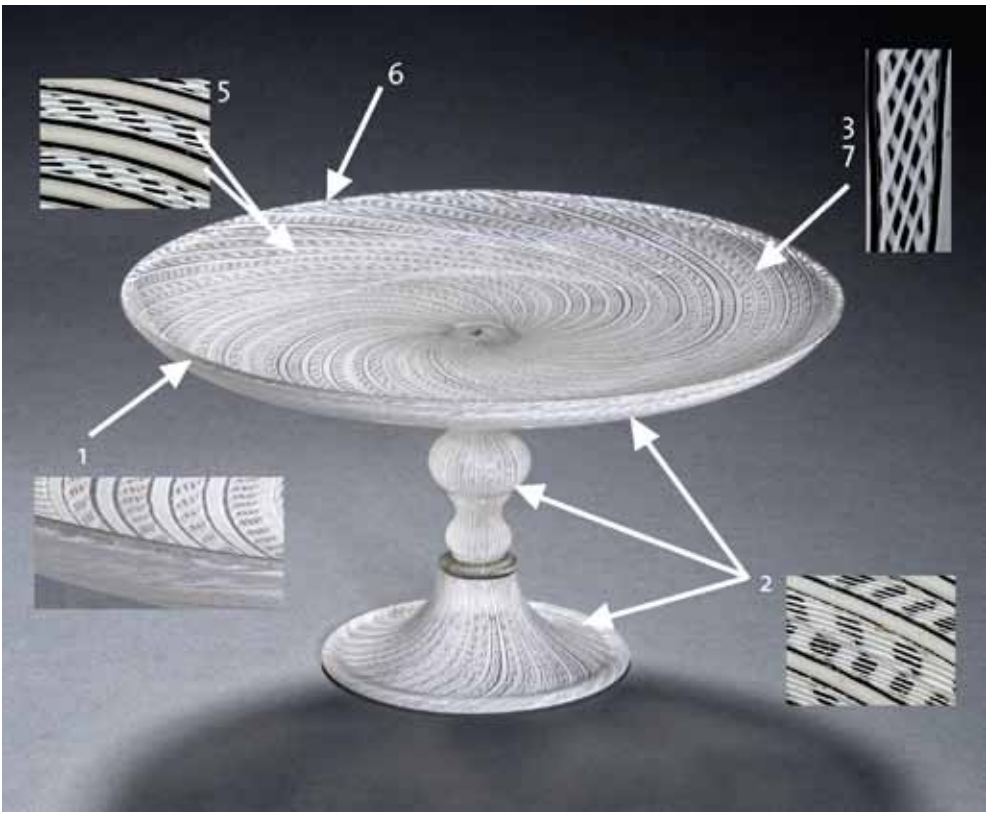

Fig. 1 - Early filigrana glass: wineglass (alzata), Venice or façon de Venise, late sixteenth century. Height: 10,3 cm, diameter bowl: 18,8 cm, diameter foot: 8,1 cm.

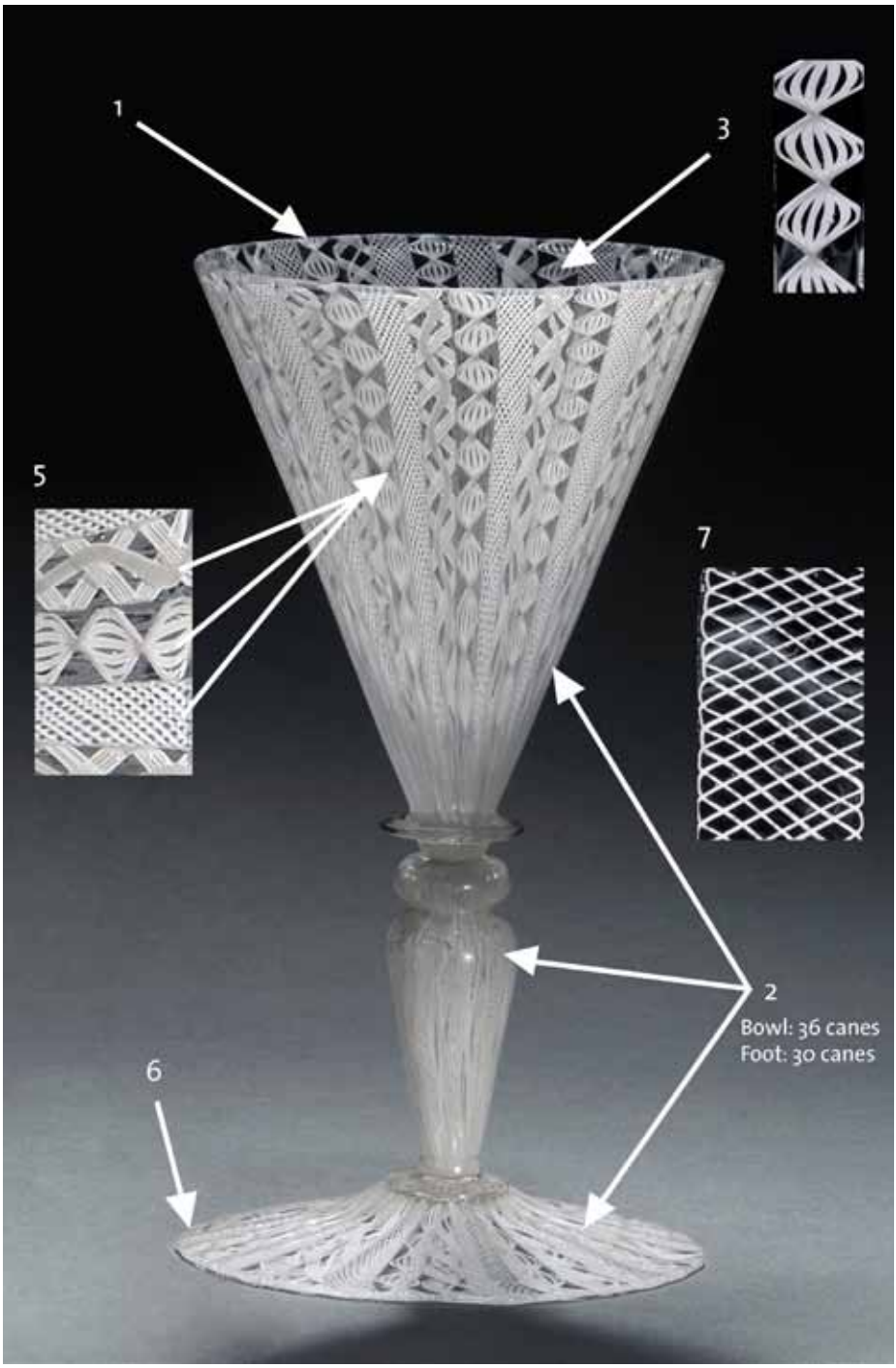

Fig. 2 - Rosenborg castle glass: wineglass, Venice, around 1700. Height: 16,9 cm, diameter bowl: 8,9 cm, diameter foot: 8,8 cm.

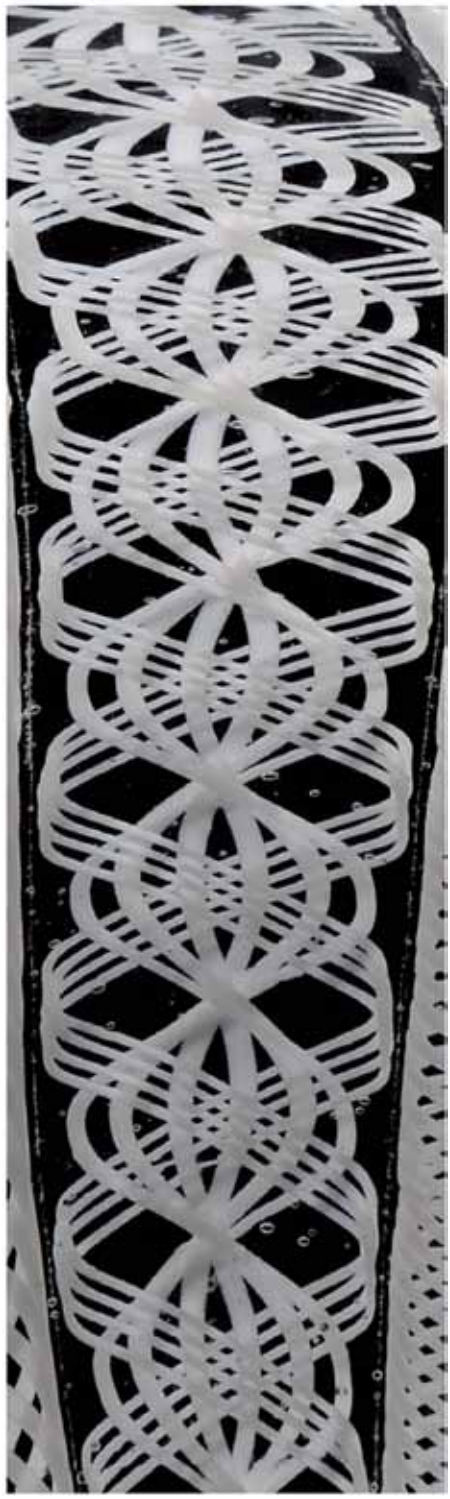

Fig. 3 - Canne miste B.