The manufacturing process and social practice: The story of white paste inlay

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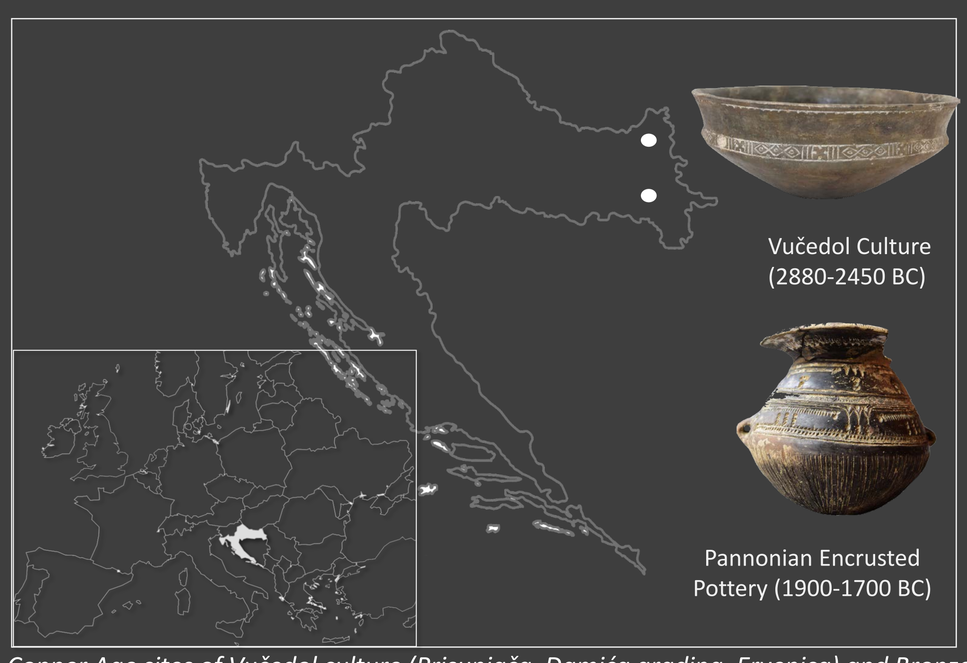
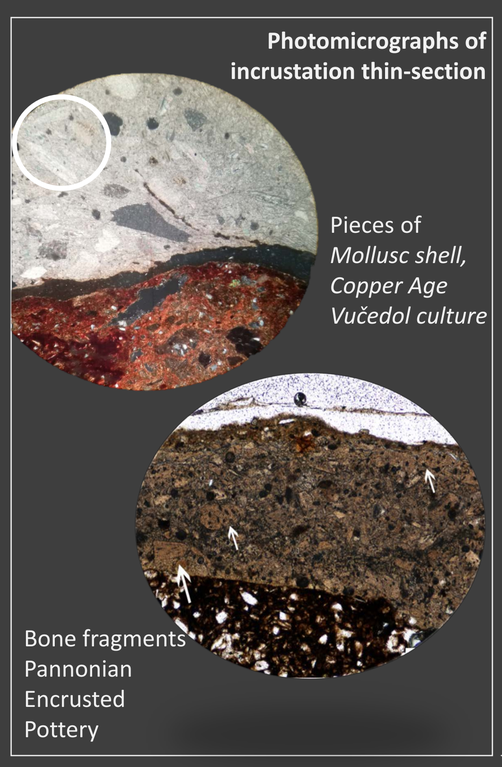
Introduction

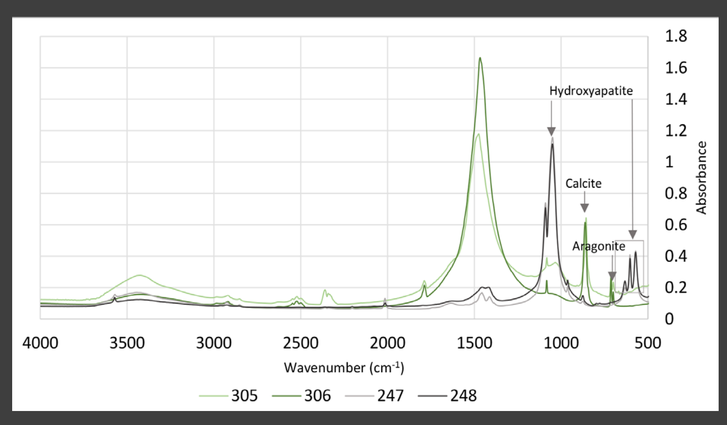
White paste or incrustation is a very characteristic and widespread technique of decorating prehistoric ceramic vessels, especially within the pottery traditions in the Carpathian Valley and the Balkans. It is a technique of applying the paste and filling the grooves created by incising and engraving specific motifs on the vessel surface. The white paste was often used on a dark grey and black surface, making the vessel motif stand out. The results showed that the basic component of various recipes consists of calcite or hydroxyapatite – the bone material, and aragonite – carbonate polymorph, found in bivalves and mollusc shells (Kos et al. 2015; Perišić et al. 2016; Sofaer and Roberts 2016). However, the process of making a paste, especially regarding the binding agents, and the way of fixing the paste is still unknown, and there are no focused studies of this step in the operational sequence of ceramic production.

The paper presents the results of compositional analysis of a white paste inlay used for decorating Copper Age (2880-2470 BC) and Bronze Age (2000-1700 BC; 900 BC) pottery in eastern Croatia, applying optical microscopy and FT-IR spectroscopy analytical methods and archaeological experiments conducted in controlled and real conditions.



Copper Age sites of Vučedol culture (Prisunjača, Damića gradina, Ervenica) and Bronze Age site of Pannonian Encrusted Pottery (Jagodnjak-Krčevine) in eastern Croatia.





FT-IR spectra of archaeological incrustation inlay with characteristic bands of hydroxyapatite (Bronze Age samples 247 and 248) and aragonite (Copper Age samples 305 and 306).

The white paste in the Copper Age was made mostly from crushed shells while in the Bronze Age, the main component of inlay was crushed bones.

Material and methods

The main research method is an archaeological experiment conducted in controlled and real conditions. The raw materials used in the experiment were selected based on the results of the analytical methods applied on samples of Copper and Bronze Age pottery from Croatia.

The hypothesis is based on the results of earlier research, which showed that the basic raw material for incrustation in the Carpathian Basin, but also beyond, was derived from bones and shells. Bones are composed of hydroxyapatite ($Ca_{10}(PO_4)_6(OH)_2$) whereas shells are made of carbonate polymorph, aragonite ($CaCO_3$). Burning shells at 450 °C leads to the thermal decomposition of aragonite to a more stable mineral phase, calcite. This carbonate component in shells, as well as in hydroxyapatite disintegrates at temperatures between 700 to 900 °C and leads to the formation of a quicklime (CaO). By adding water to pieces of quicklime ($CaO+H_2O$) after a while, a pronounced exothermic reaction occurs – slaking of lime ($Ca(OH)_2$). After cooling, such material hardens. The raw materials used in experiments: Mollusc river shells, deer antlers, long animal bone and human long bone.

Additional research questions:

- is it necessary to pulverize the burned material or does it disintegrate due to contact with water and chemical reaction;
- are there any advantages of using a certain type of raw material compared to another during the production process;
- are there any advantages of using a certain type of raw material compared to another during fixing the paste.

Experiments in controlled conditions: *long bones and antler were fired in a laboratory kiln by heating to 900°C for 120 minutes (Step 1). After the material had cooled, it was crushed and pulverized in a mortar (Step 2) and water was added to produce slaked lime (Step 3). After a few minutes of continuous mixing, a very fine thick paste was obtained, which was formed into smaller briquettes.*

Experiment in real conditions: *Mollusc river shells were fired together with pottery on an open fire (Step 1). The firing lasted for an hour and a half, the maximum temperature was around 800°C and the soaking time lasted for about 15 minutes. After the firing, while still hot, the water was slowly added with constant mixing (Step 3). The shells started to decompose and disintegrate (the process of slaking lime happened). After a few hours, the paste was completely dry, achieved hardness and became solid as concrete.*

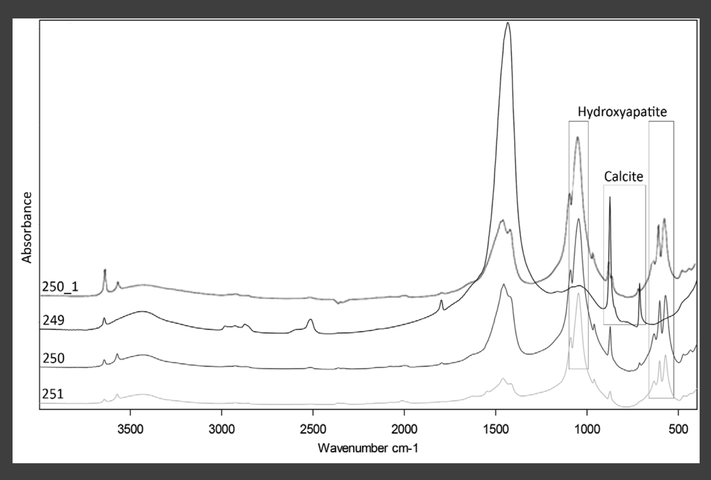
Results

Experiment in real conditions:

- the firing time and the temperature for getting the quick lime out of river shells are much shorter than the time needed to achieve a quick lime out of bones.
- The paste made of Mollusc shells was applied using hands and filling the incisions on previously fired vessels; after a few hours, the paste dried and became white and solid.

Experiments in controlled conditions:

- the experiment was conducted to increase the duration of firing, the soaking time and temperature; these resulted in the complete combustion of bone material (deer antler and long animal bone)
- in the grinding process, ease of grinding, fineness and colour of the powder were recorded.
- antler and human long bones are easily crushed, and a fine and white to light grey powder is obtained;
- long animal bones are much harder, and it is necessary to sift the crushed material several times in order to obtain a fine yellowish powder



FT-IR *spectra of experimental incrustation samples of shells (sample 249), antler (sample 250) and bones (sample 251); sample of quicklime (bones, 251_1).*

Sample number	Type of raw material	Warm-up time (min.)	Soaking time (min.)	Soaking temperature	Colour	Grinding	Seeving needed	Paste
/	Mollusc river shells	45	75	650°C	Burned grayish white	No need	No	Very fine
251	Animal bone - long	45	75	900°C	Burned yellowish white	Heavy	Yes	Fine
250	Animal bone - antler	45	75	900°C	Burned white	Very Easy	No	Very fine
/	Human bone - skull	45	75	900°C	Burned yellowish white	Hard	Yes	Fine
/	Human bone – long bone	45	75	900°C	Burned white	Easy	No	Very fine

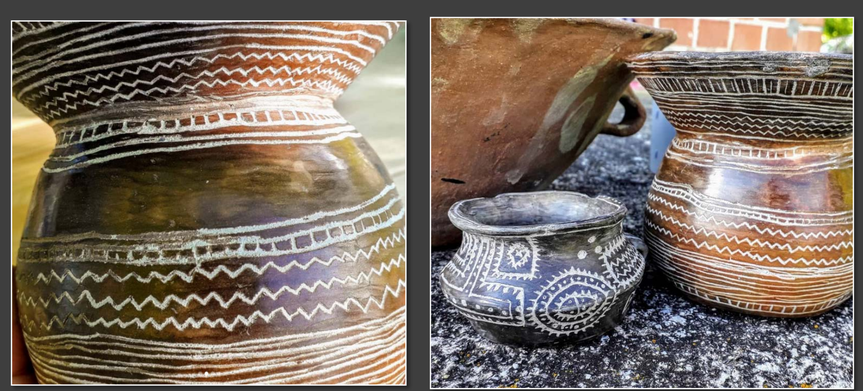
Results of experiments conducted under controlled conditions burned in a laboratory furnace

Discussion and Conclusion

According to the results of the experiments, the differences can be seen in the manufacturing process of the different inlay recipes. While preparing the paste made of shells there is one step less in the operational sequence. It doesn't need crushing and grinding to the powder, only adding water to the fired shells to get a very fine paste. On the other hand, paste with bones will require grinding and probably sieving of the powder before the slaking to get the fine paste. As our experiments have shown, the powder from the antler is much more suitable than animal bones, as some other conducted experiments have shown. Using the Mollusc river shells is a more economical and less time-consuming procedure which requires less working engagement in the manufacturing process.

In the context of the production process, the optimization of time and resources is always of great importance. Therefore, it is assumed that preparing the raw material for the inlay paste (bones or shells) could have been taking place during just a few technological and social activities that necessarily involve reaching high temperatures (between 700 and 900 °C) and these are: the production of metal objects, firing the pottery and burning the dead. Regarding the first two activities, animal bones and shells need to be collected and then intentionally burned. While considering the third activity, the direct use of raw materials (human and/or animal bones) can be assumed.

The research has also indicated that the process of producing white paste inlay is in direct interaction with various social activities that took place within the prehistoric community. In the case of the cross-craft interactions linking these and other activities open up new possibilities for interpretation and understanding of communities from the past. Additional social mark is reflected in different inlay recipes, textures and traditional practices in making encrusted pottery emphasizing also the cultural identity of the white paste inlay.



Experiment in real conditions: pots with the paste made of shells

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References: Kos, K., Posilović, H., Durman,A., Ristić, M. and Krehula; S., 2015. White encrustation produced from deer antler phosphate on prehistoric ceramics from Podunavlje, *Archaeometry* 57, 4 (2015), 636–652. Perišić, N., Marić-Stojanović, M., Andrić, V., Mioč, U.B., and Damjanović, Lj., 2016. Physicochemical characterisation of pottery from the Vinča culture, Serbia, regarding the firing temperature and decoration techniques, *Journal of the Serbian Chemical Society* 81 (12), 1415–1426. Sofaer, J. and Roberts, S., 2016. Technical Innovation and Practice in Eneolithic and Bronze Age Encrusted Ceramics in the Carpathian Basin, Middle and Lower Danube, *Archäologisches Korrespondenzblatt Jahrgang* 46, 2016, Heft 4, Römisch-Germanischen Zentralmuseum Mainz, 479–574.