Journal of Archaeological Science: Reports 19 (2018) 148–154

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

FTIR analysis and 3D restoration of Transylvanian popular pottery from the XVI-XVIII centuries

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ARTICLE INFO

Keywords:
FTIR spectroscopy of ceramics
Transylvanian pottery
Ceramics firing temperature
3D pottery restoration

ABSTRACT

The Fourier transform infrared spectra of Transylvanian pottery fragments from XVI-XVIII centuries and the identification of their vibrational frequencies and curve fitting of the 1400–800 cm^{-1} spectral massif have allowed to determine the chemical and mineralogical composition of the fragments and their firing temperature. A pottery vessel was restored in a virtual environment by using 3D laser scanning and computer aided design software. An additive manufacturing solution was used for 3D printing of the inner pottery support to reassemble the fragments in order to assist classical restoration activities. The digital restoration allows for correct spatial positioning of the ceramic vessel fragments and 3D modelling of the vessel shape using the profile obtained after matching the fragments.

1. Introduction

The popular Romanian pottery originates from the old Cucuteni Culture pottery. Between 1885 and 1910 archaeological investigations in the Cucuteni locality (Moldova region, Romania) revealed ceramic pots dating from 4000 to 3000 - BC. Keeping with tradition, popular craftsmen from XVI-XVIII centuries were manufacturing ceramics by starting with the clay that was portioned, water treated and then left to settle from a few days to several months. After that the clay was cut in pieces (Slătineanu, 1938, 1958; Godea, 1995). These pieces were battered with wooden hammers, wetted and laid on cow skin and further battered with hands or feet for a few hours. This allowed for the removal of stones and other hard objects from the clay. When the clay pieces became soft and elastic they were placed on a wheel and the shaping process started. After the pots were shaped, they were wiped with a wet piece of leather and then left to dry for a few days in the shadow. Next the pots were wetted and covered with varnish (a mixture of clay and water with a specific colour). They were dried again and then fired in kilns built from bricks and woven twigs. The temperature was carefully controlled (850-900 °C) especially during the first firing, which was made using wood, and endured between five and 10 h. Then the pots were left to cool down slowly for roughly 12 h. The glazing consisted in coating the fired pottery with a layer of clay and natural pigments followed by a new firing that took 7 h. The red was obtained from an iron oxide rich earth, the white from limestone and the green from burning copper in the kiln, grinding the obtained dross and mixing it with clay.

There are two types of ceramics based on the firing process: oxidation (red ceramics) or reduction (black ceramics). Black ceramics from Dacian origin can be found in Moldova region and northern Transylvania. Red ceramics has a Roman origin and can be glazed or unglazed. Unglazed pottery comes from the Roman tradition and the glazed one with a vivid colouring follows the Byzantine style (Nicolescu and Petrescu, 1974; Dolea, 1987; Florescu, 1958). From an artistic point of view the first signs of independent ceramic creation emerge towards the end of the XIV century and the beginning of the XV century. The popular Romanian pottery is developed during the XVI-XVIII centuries (Svinţiu, 2008). The studied objects come from an archaeological dig site in the Railway Station Square of Sibiu, Romania. Different fragments of cooking pots, jugs for water and wine keeping and transportation were discovered in this site. It seems that an inn existed in the area based on the large quantities of popular pottery found there. The aim of this paper was to investigate the mineralogical composition and firing temperatures of pottery fragments from a bowl of this site by Fourier transform infrared spectroscopy, FTIR. Their colour, decoration, thickness, shape and spectroscopic analyses are used to establish

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https://doi.org/10.1016/j.jasrep.2018.02.044
Received 31 October 2017; Received in revised form 14 February 2018; Accepted 27 February 2018
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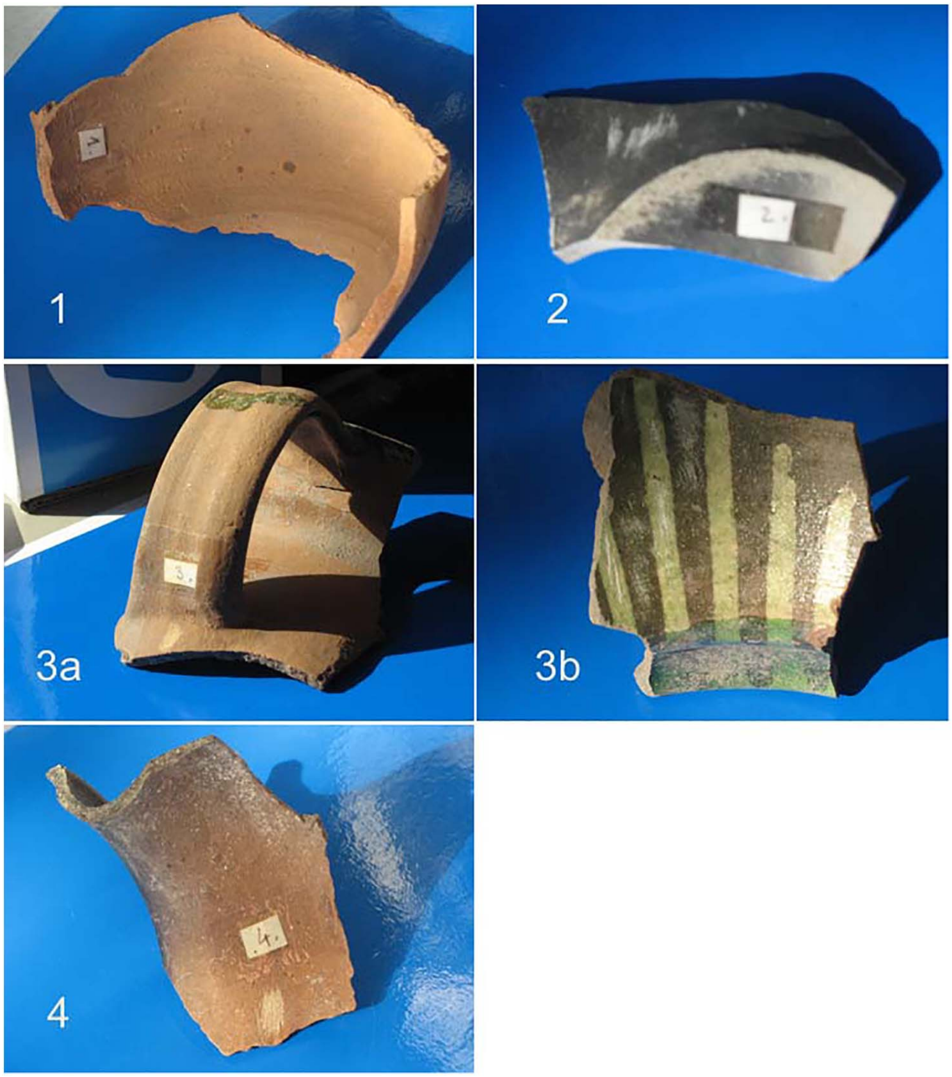

Fig. 1. Photographs of the pottery fragments studied by FTIR spectroscopy. Their labels, 1–4, correspond to the sample numbering. The 3a and 3b photographs are different views of the same fragment.

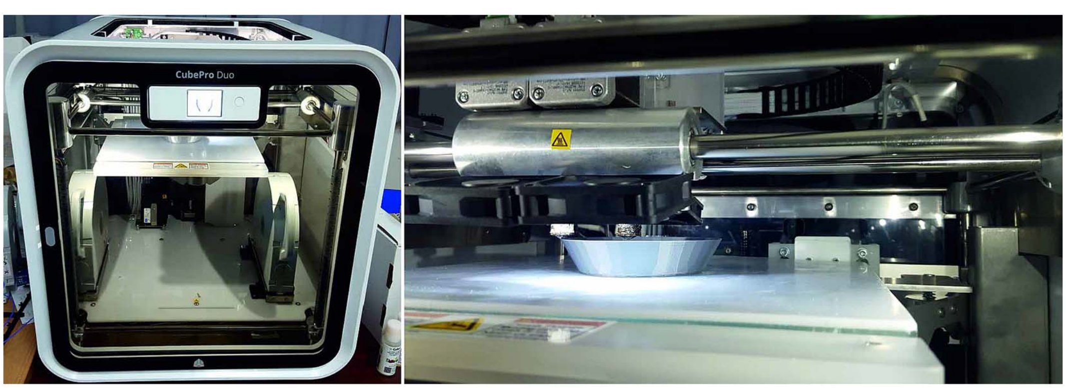

Fig. 2. 3D printing of the reconstructed model of the bowl.

relationships among them and to attempt to restore an original pottery vessel. Scanning, 3D modelling, reconstructions and visualizations are very useful in different archaeological contexts, from representations of complex sites and architectural reconstructions (Pejic et al., 2017; Garstki et al., 2015) to individual objects (Marutoiu et al., 2017; Bratu et al., 2017; Onmek et al., 2017; Carrozzino et al., 2014). Digital reconstruction of ceramic vessels is a topic addressed by many researchers, in an effort for developing an automated system for archaeological classification and reconstruction of ceramics (Kampel and Sablatnig, 2003), using different techniques like surface marking information with anchor points on the fragment borders (Cohen et al., 2013) or colour markings and anchor points on surface breaks (Cohen et al., 2016). Physicochemical analyses provide additional and very useful information for reconstruction tasks (Rahim, 2016). Therefore, a