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What's in the Pot? An Investigation Into the Use of a Byzantine Ceramic Vessel[1]

Meggan King
McCrone Research Institute*

KEYWORDS

Ceramic, pottery, water vessel, Amorium, Turkey, Byzantine, archaeology, polarized light microscopy (PLM), scanning electron microscopy (SEM), microchemistry

ABSTRACT

During the 2007 excavation season at the Byzantine city of Amorium, a shard of ceramic with an associated residue, which was believed to have been in the interior of this piece of ceramic vessel, was collected and submitted to the author for analysis. The study was divided into two parts: analysis of the residue and analysis of the ceramic shard. Identification of the residue revealed that the ceramic may have been used as a water vessel in the past. Characterization of the ceramic shard could yield information regarding the source material and manufacturing process of the vessel.

INTRODUCTION

Amorium is a medieval city of the Byzantine Empire located in central western Turkey. A brief history of Amorium has been published previously in *The Microscope* (1), and additional information about the excavation is available from the Amorium Excavation Project (2).

In this study, a ceramic shard and its associated lining (residue) was collected from area AM-07, A-20, Area 13 during the 2007 excavation season at the Amorium excavation site and submitted to the author for analysis (Figures 1 and 2).

MATERIALS AND METHODS

Analysis was performed on objects after they were cleaned to eliminate interference. The supernatant liquid that was used for washing, along with any debris that was removed from the pieces were retained.

Residue

The residue was first examined using a stereomicroscope. A small piece of the residue was submerged in distilled water and observed under the polarized light microscope (PLM) to determine whether the residue was water soluble. A small fragment of the residue (approximately 0.5 cm x 0.5 cm) was washed by placing it into a microcenterfuge tube with distilled water and a small amount of ethyl alcohol.

The tube was then held in an ultrasonic bath for several minutes and any debris was allowed to settle. The fragment was then removed and allowed to dry. All of the supernatant liquid was retained. After drying, a piece of the clean fragment was prepared for examination using PLM by crushing and mounting the resulting particles in n=1.66 refractive index liquid.

A portion of the clean residue was also mounted on a carbon-tape stub and examined using scanning electron microscopy coupled with energy dispersive spectroscopy (SEM/EDS).

[1] Presented at Inter/Micro 2008.

* 2820 S. Michigan Avenue, Chicago, IL 60616

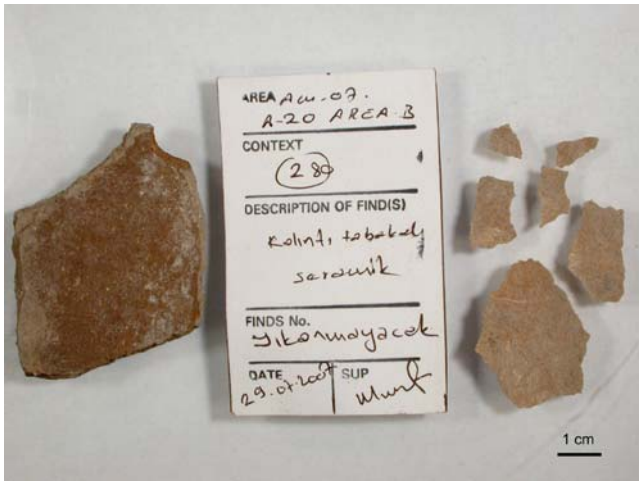

Figure 1. Concave surface of Byzantine ceramic shard (left) and associated residue (right).

Figure 2. Convex surface of Byzantine ceramic shard (left) and associated residue (right).

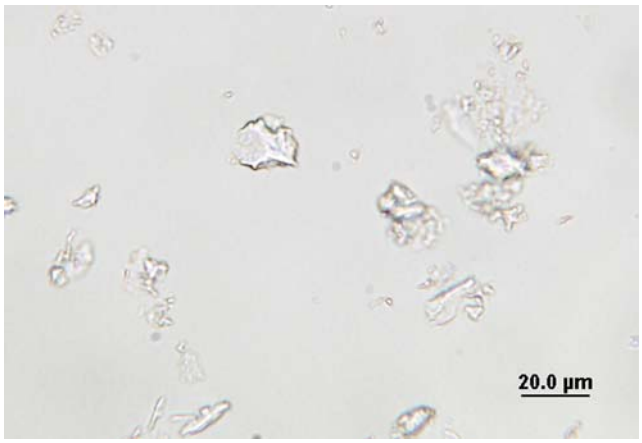

Figure 3. Plane-polarized light photomicrograph of a suspected calcium carbonate particle mounted in n=1.66, polarizer oriented N-S.

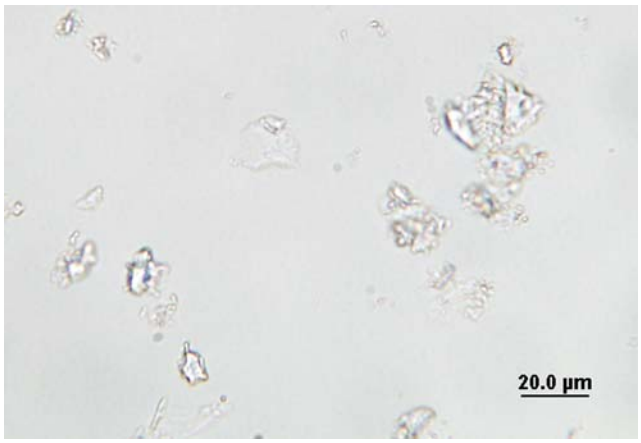

Figure 4. Plane-polarized light photomicrograph of a suspected calcium carbonate particle mounted in n=1.66, polarizer oriented E-W. Notice the large contrast change when the polarizer is oriented E-W as opposed to N-S.

Ceramic Shard

The ceramic shard was first examined macroscopically and then by stereomicroscopy. A small fragment (approximately 1 cm x 0.5 cm) was removed from the original ceramic shard. This piece was then washed and allowed to dry using the same technique that was used for the residue. The fresh fractured surfaces were examined in order to assess the ceramic fabric and attempt to determine the forming method of the vessel.

A portion of the fragment was also crushed, using a mortar and pestle, to examine the mineral composition by PLM and reflected light microscopy. To prepare the crushed material for microscopical analysis, it was first separated by size fraction. The crushed material was placed in a 50 mL beaker along with a few drops of ethanol and 5-7 mL of distilled water. The beaker was swirled and then placed in an ultrasonic bath for 1 minute. The supernatant liquid containing the fine silt and clay fraction was decanted into a new clean beaker and retained.

This process was repeated multiple times until the supernatant liquid remained clear after sonication, leaving behind the coarse mineral fraction. The coarse mineral fraction was allowed to dry and was then separated by density using bromoform (density = 2.9 g/mL). Bromoform separations allow "light" minerals

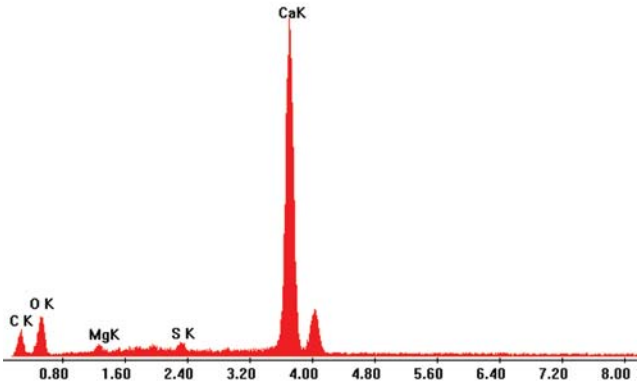

Figure 5. EDS spectrum of the concave surface of the residue. Major elements detected include calcium, carbon and oxygen.

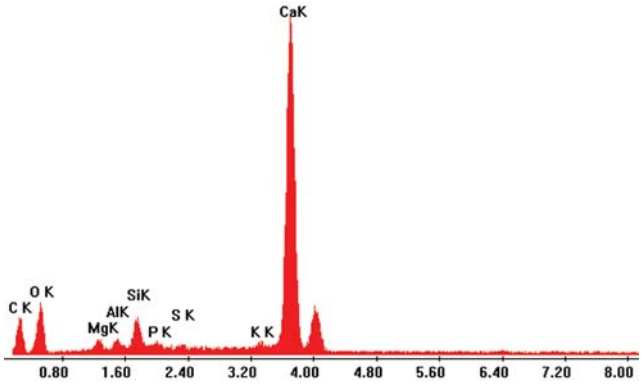

Figure 6. EDS spectrum of the convex surface of the residue. Major elements detected include calcium, carbon and oxygen.

Figure 7. Arrow shows direction of "rilling" on concave ceramic surface, characteristic of wheel-thrown pieces.

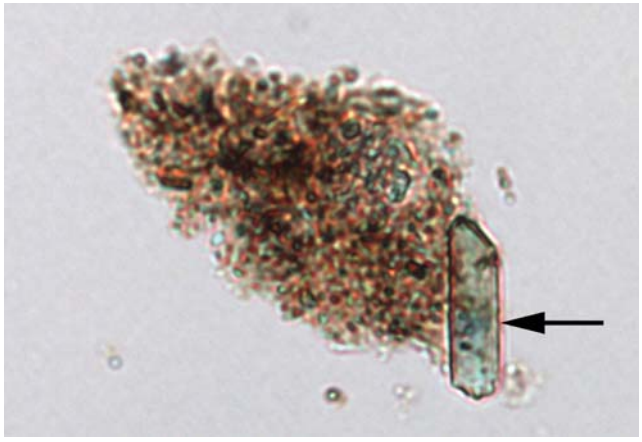

Figure 8. Tourmaline (shown with arrow) in light fraction mounted in n=1.66, plane polarized light.

to be separated from "heavy" minerals. Light minerals will float on the surface of the bromoform and can be removed with a pipette while heavy minerals will sink to the bottom of the microcenterfuge tube. The light mineral fraction was prepared by mounting particles in n=1.540 refractive index liquid and the heavy mineral fraction was prepared by mounting particles in n=1.660 refractive index liquid. Optical properties determined by PLM were used to identify the minerals present.

RESULTS AND DISCUSSION

Residue

Stereomicroscopy was used for initial observations and it was noted that the material is approximately 300 μm thick, pitted, porous and brittle. It was also determined that this residue is not readily water soluble. Under the PLM, the residue appears to be composed almost entirely of calcium carbonate due to the high birefringence and large contrast change observed in the n=1.660 liquid mounting medium when the polarizing filter or stage is rotated (Figures 3 and 4).

Carbonates were also detected by submersing a portion of crushed residue in dilute hydrochloric acid and observing the effervescence of CO_2. The resulting spectra from SEM/EDS analysis are shown in Figures 5 and 6. The major elements present in the residue are calcium, carbon and oxygen. Minor amounts of magnesium, aluminum, silicon, phosphorus, sulfur and potassium were also present.

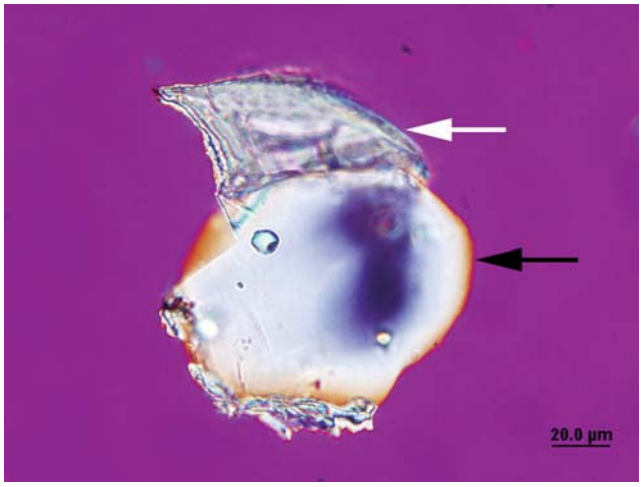

Figure 9. Quartz grain (black arrow) with diagenetic calcite (white arrow), crossed polars with Red I plate.

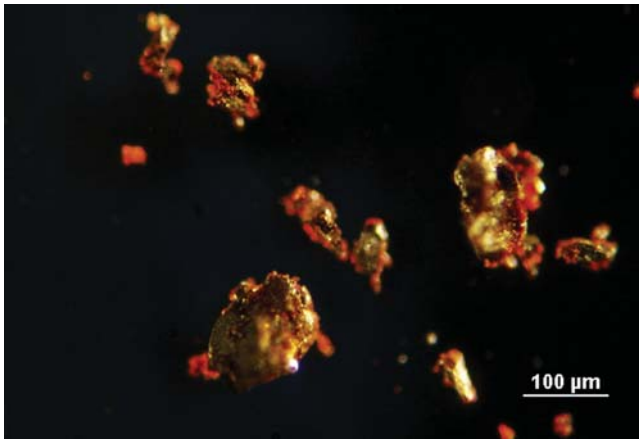

Figure 10. Iron oxide, reflected light.

Ceramic shard

The ceramic shard has a thickness ranging from 3.4 mm to 4.9 mm. The concave surface of the ceramic piece has a red-orange color (Figure 1); the convex surface of the ceramic piece has a dark brown-black colored surface (Figure 2). The interior surface (Figure 7) exhibits "rilling" — undulating ridges and striations on the wall surface (3).

The light fraction is composed mainly of quartz and calcite with small amounts of alkali feldspar and tourmaline (Figure 8). The quartz and calcite are often intimately associated (Figure 9). Many quartz and feldspar grains are cemented together with diagenetic calcite (4).

The heavy fraction is mainly composed of iron oxides many of which are magnetic and likely magnetite; the non-magnetic iron oxides are likely hematite (Figure 10). Some carbonates and biotite mica are also present.

CONCLUSIONS

Due to the relative uniform thickness of the shard, presence of parallel striations (rilling) on the interior surface, and the cultural context of the piece, it is most likely that the vessel was formed using a wheel-throwing technique.

The residue is composed almost entirely of calcium carbonate, with small amounts of other trace elements as seen by SEM/EDS.

The ceramic piece has a mineral composition consisting primarily of calcite, quartz and iron-oxide based minerals. The intimate association of the quartz and calcite found in the light mineral fraction indicates that some of the ceramic source material is most likely from sedimentary rocks.

Assuming that the ceramic piece was once part of a vessel and that the residue was at one time attached to the ceramic piece, the analysis performed by PLM and SEM/EDS support the conclusion that the residue is a calcium carbonate scale. This would be expected, if the vessel was used to store or boil water.

ACKNOWLEDGEMENTS

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