Mediterranean Archaeology and Archaeometry, Vol. 11, No. 2, pp. 99-106

THE CHEMICAL COMPOSITION AND MANUFACTURING TECHNOLOGY OF POTTERY TYPES AT UDHRUH, SOUTHERN JORDAN

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Received: 16/11/2009
Accepted: 20/01/2010

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ABSTRACT

This paper presents laboratory analyses of selected pottery sherds from the ancient site of Udhruh in southern Jordan. The site exhibits pottery sherds from Nabataean times up to the late Islamic period. However, in this study the samples were randomly chosen. The analyses were carried out using a scanning electron microscope equipped with specialist software. The paper establishes the historical context of Udhruh, the methodology employed, and the results of the study. The results reveal differences in the chemical composition of samples, and a variety of manufacturing techniques, only some of which appear to have been of local inspiration.

KEYWORDS: Jordan, Manufacturing, Laboratory, Pottery, Udhruh, Ware

1. INTRODUCTION AND OBJECTIVES

Pottery manufacture has been long seen as a reflection of technical and artistic development. In Middle Eastern archaeology, pottery remains a vital dating tool for establishing the relative chronology of cultures. Traditionally, pottery studies focused on typology, form, ware, and surface decoration. New scientific approaches have utilized technological advances that offer results that have hitherto been impossible to obtain with traditional typological studies (Rice, 1987). It is now possible to date ceramics using thermoluminescence, chemical analysis, and microscopy (Rice, 1987). In this study, scientific techniques were used to gain an understanding of ceramic morphology and to see if the variation in appearance is reflected in the chemical composition. The results were also used to determine if the pottery was manufactured locally.

2. HISTORICAL BACKGROUND

Udhruh is referred to in historical sources as early as the second century AD, but there is no mention of it being a military site. Ptolemy, writing at this time, mentioned it only as a town in *Arabia Petraea* (Killick, 1983, 1987a, 1987b, 1986; Gregory, 1995: 383; al-Muqadassi, 1994). The site appears more often in Byzantine and Early Islamic sources and documents, where, for example, the Byzantine tax document known as the Beersheba Edict lists Udhruh among the towns of *Palestina Tertia* as does Stephan of Byzantium (Killick, 1983: 110, Parker, 1986: 95; Mayerson, 1986: 141-148; Abudanh, 2004; 2006). Udhruh is also thought to be the Augustopolis mentioned by George of Cyprus and Hierocles (reported by Killick, 1983: 110; Parker, 1986: 95; Pringle, 200), a view supported by data which has recently been revealed from the Petra Papyri (Graf, 2001: 229). Two bishops from Augustopolis are mentioned attending two church councils in the 5th and 6th centuries AD (Killick, 1983: 110-111, Parker, 1986: 95, Koenen, 1996: 178; Fiema, 2002: 210).

Udhruh was also often mentioned in Early Islamic sources, as the town's inhabitants agreed to pay the poll tax to Prophet Muhammad in A.D 630 (Killick, 1983: 112; Fiema, 2002: 210; Schick, 1994, Walmsley, 2001). The major archaeological feature at Udhruh is the Roman fortress, but there are other significant monuments. Outside the curtain wall of the fortress and about 20m south of the south-western corner tower, a Byzantine church was built to serve a community which appears to have lived within the fortress at the time. An Ottoman fort was later constructed against the northern side of the Roman fortress.

3. IMPORTANCE OF STUDY

This study is the first time that Udhruh pottery has been analysed by scientific techniques rather than by typological criteria. There have been many analyses of pottery from ancient Jordanian sites, including Chalcolithic pottery from Teleilat Ghassul (Edwards & Segnit, 1984), Nabataean pottery from Petra (Amr, 1987), Neolithic pottery from Wadi Shueib (Bataina, 1996), EBI pottery from Jebel Abu-thawwab (Quraan, 1996), Umayyad pottery from Hayyan Al-Mushref site(Ata 1998), Byzantine pottery from Baddiyyah (Al-Syouf, 2000), Islamic Glazed ceramics from Northern Jordan (Al-Saad, 1999), Islamic painted pottery (Tawalbeh, 1996), and Roman pottery from Jerash (Haddad, 2000).

4. MATERIAL AND METHODOLOGY

The results presented in this study were obtained from laboratory analyses conducted with a Scanning Electron Microscope (SEM) at Al-Hussein Bin Talal University (AHU) in Ma'an.

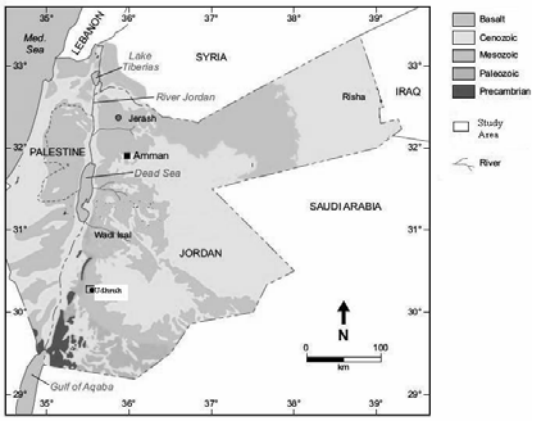

Figure 1: Map of the geology of Jordan. Modified from Bender 1974. Udruh area is highlighted.
Source: Dill et al (2009)

4.1 Pottery Collection

The pottery analyzed in this study was collected from Udhruh (Figure 1) during fieldwork conducted by archaeology students at al-Hussein Bin Talal University. This was a training excavation and Udhruh was chosen due to its long settlement history.

The area of excavation was divided into five systematic grids. Pottery was collected from each level throughout the excavation area, and kept in tagged finds bags. At the end of the fieldwork, all the pottery was washed and counted, which offered the opportunity to examine it in detail, and to identify representative samples for analysis.

4.2 Sample Preparation

Ten samples were chosen reflecting the diversity of the pottery in terms of the ware and the manufacturing quality (Table 1). The samples included pottery that was painted, glazed, hand, and wheel made, and included poorly fired examples. Samples contain grains of particle size in the range of sand – clay.

Table 1: Archaeological description of the studied pottery samples

Sample number	Description
S N 1	Ext. Int. Slip 10B Grey 2 bluish black 2.5/1. Ware: 7.5 YR 2.5/1 black.
S N 2	Slip. Ext.Int 7.5YR 8/4 Pink. Ware: ext. 5YR 7/6 reddish yellow. Core: 10YR 7/3 very pale brown.
S N 3	Ware. ext. int. 5YR 6/8 reddish yellow. Core. 2.5Y 3/7 pale yellow. Paint.7.5 YR 2.5/2 very dark brown. 10 R 6/6 light red 10 YR 8/3 very pale brown.
S N 4	Core: 7.5YR 8/4 Pink. Ext. int. 2.5YR 7/8 light red
S N 5	Slip ext. Int. 2.5Y 8/2 Pale Yellow. Ware: 2.5 YR 6/8 light red
S N 6	Ext. core: 10B. Grey 2 bluish black 2.5/1. int. 7.5YR 5/3 brown.
S N 7	Glazed green. Ware: 5 YR 8/4 Pink
S N 8	Ext. 10YR 8/3 very pale brown. Int.5YR 8/4 Pink. Core %YR 2.5/1 black
S N 9	Ware: 5YR 7/6 reddish yellow.
S N 10	Ext. int. 5Y 8/3 pale yellow. Core: 7.5 YR 8/4 Pink

Polished sections for selected samples were prepared in two ways. First by cutting a few selected samples into small chips using a laboratory scale saw. The aim of this analysis was to study the samples in their original condition and to determine their internal texture, composition, and component relationships. Second, the remaining samples were crushed using a pestle and mortar. Both types were mounted on stubs with conductive carbon tape and then ground, polished and smoothed, and coated with carbon.

4.3. Scanning Electron Microscopy (SEM) Analysis

To characterize the pottery samples, SEM analysis was carried out at the electron microscopy laboratory at AHU. Analysis was performed using JEOL JSM-6060LV scanning electron microscope operating at 20 kV. The SEM is equipped with IXRF System, and EDS (Energy Dispersive X-ray Spectrometer). All pottery samples were observed with the SEM, with elemental compositions being analyzed by EDS. The EDS technique identifies and quantifies the constituent elements of the sample and possesses the ability to analyze particles with a diameter of three micrometers and larger. Accordingly, the concentration of particular elements, such as Si and Al, were determined.

The EDS spectrum of elements detected in each sample was obtained in both 'spot' and 'beam' modes. Sum spectrums of selected sample surfaces were taken. Like many other scien-

tific analytical tools, only some elements are detected by the EDS, so compounds and mineralogy were inferred from the abundance and distribution patterns of these elements with the help of the SEM images obtained.

5. RESULTS AND DISCUSSION

A simplified SEM petrographical analysis of the selected pottery samples is shown in Table 2, and SEM micrographs obtained by SEM are illustrated in Figure 2.

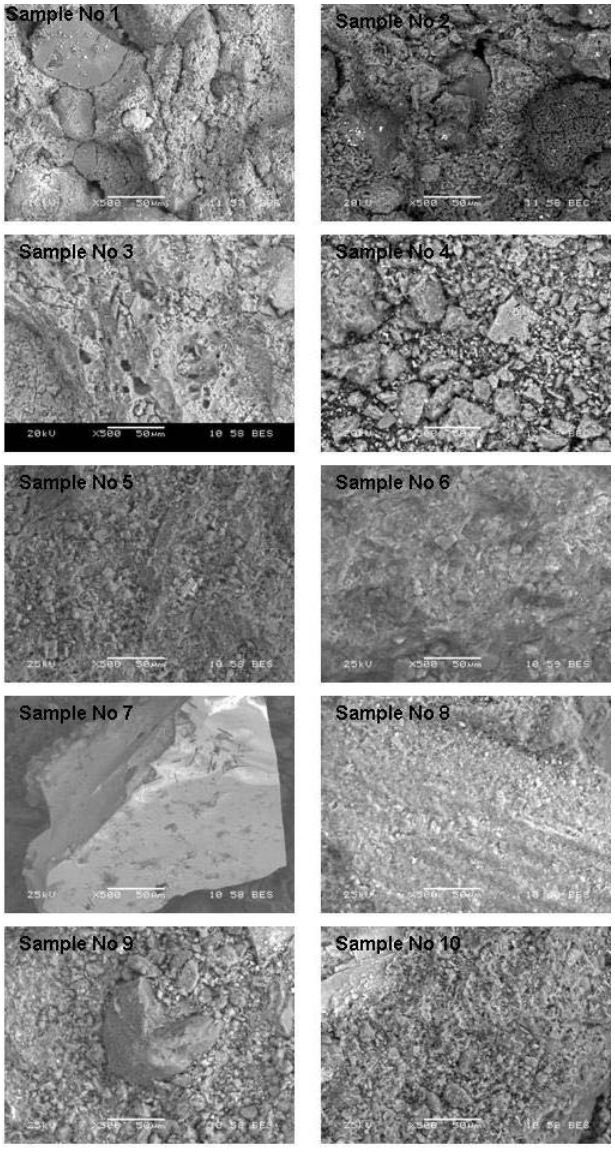

Figure 2: SEM micrographs of selected pottery samples from Udhruh

The petrographical analysis clearly shows that similar techniques were utilised to manufacture all the investigated pottery samples. Different materials have been used in the ware of all samples and the presence of these materials clearly reflects a deliberate inclusion in order to produce durable objects for daily use. The practice of adding other materials to the clay is known from prehistoric times and appears to have continued for many millennia (Rice, 1987).

Figure 3 illustrates the Si distribution. Si is related either to quartz fraction or clay fraction. However, the abundance of silicon (Si) and oxygen (O) in the spectrum of analyzed coarse particles in SEM images may indicate that the Si is mainly related to the quartz fraction. Both petrography and chemistry indicate that more than 20% of the coarse mineral fraction of the selected samples is quartz. Different distribution parents of Si and Al (Figure 3 and Figure 4) indicates different mineral fractions (i.e. quartz and clay). Quartz grains have almost sharp edges indicating that they were most likely crushed and added to the clay during the manufacturing process. Crushed quartz is typically used to consolidate the ware. Quartz pebbles, which may be brought from local valleys, normally have rounded shapes, due to the fact that have been eroded and carried considerable distances by floods, and have to be crushed before being added to clay.

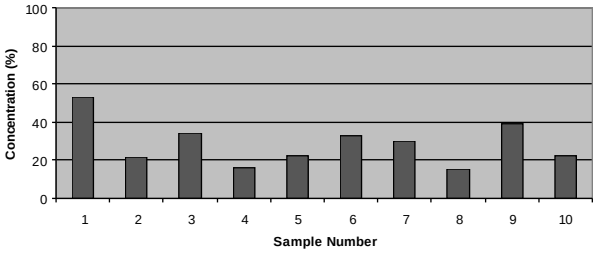

Figure 3: Relative abundance of Si (%) in the studied pottery samples

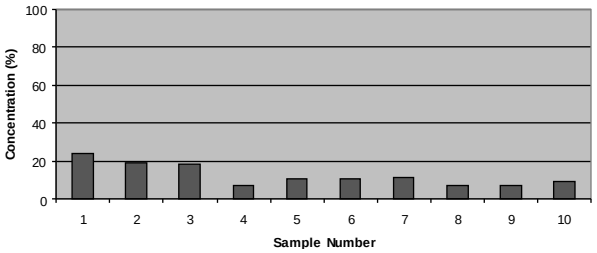

Figure 4: Relative abundance of Al (%) in the studied pottery samples

Despite the fact that samples show different physical appearances in terms of the ware, colour, thickness and touch, the analysis indicated some features common to all. These include clay, silt particles, and sand grains. Clay is the

basic component of all samples and the remaining materials are embedded within it. The variation in colour is due to different percentages of minerals or as a result of the use for cooking which has given the external surface a black appearance.

Table 2: Petrographical description of the studied pottery samples

Sample number	Group number	Description
S N 1	Group I (Intact)	Pottery ware is made of quartz/silt grains embedded in a fine clay matrix (See Fig.2). Coarse grains are in the range of 50-100 microns in size. They appear to be poorly compacted and not very well cemented. The percentage of grains to fine cake is in the range of 1:4. Grains have clear morphology.
S N 2		Slightly different from that of sample SN 1. Cake contains a fragment of clay and sand grains all embedded within fine mud. Clay and quartz are the dominant mineral phases. Abundance of the coarse grains is less than that of sample SN 1. Sample may be affected by firing.
S N 3		The ware of this pottery sample is totally different from that of sample 1&2. Cake contains more silica than that of sample 01& 02. Sand particles are found within a siliceous groundmass and the few clay particles are distributed not homogeneously. Grains are well cemented and compacted.
S N 4	Group II (Crushed)	Contains sand and clay particles probably embedded with lime groundmass. Quite similar to sample SN 3.
S N 5		Cake contains very distinctive sand particles which are embedded within the clay matrix. Grains and cement appear to be coherent. The sample has a homogeneous texture. The percentage of coarse grains is quite low.
S N 6		Cake is made of silt size particles within fine clay. Quite homogenous in texture. Grains appear to have sharp edges.
S N 7		Sample composed of sand/silt size particle within fine clay. Not very well coherent. Fragments from the coating material have distinctive morphology (See Fig. 2). Traces of calcite grains.
S N 8		Sample SN 8, 9 and 10 Almost have identical mineralogy with minor variations. Sample consists of silt size particles with sharp edges embedded in very fine clay matrix.
S N 9		Sample contains coarse quartz particles embedded with very fine clay and silt matrix. The percentage of these coarse particles is quite low.
S N 10		Sample consists of silt particles and fine clay matrix. The texture of this sample is quite different from all the analysed samples. It is quite porous, and contains thin flakes of quartz with sharp edges. Coarse quartz particles are quite abundant.

However, the presence of certain materials, such as quartz grains, in the morphology of the pottery samples might be explained in two ways. The first is that the pottery was manufactured locally at the potter's home or workshop. Here, the pottery may have been prepared without giving much attention to the materials that might be accidently mixed with the clay, especially sand grains. The second possibility is that the potter did not carefully prepare the clay, sieving the raw material and consequently throwing out unnecessary materials. This suggestion seems to support the assumption that the pottery was of local manufacture.

The analysis clearly shows that some samples are well made and their components

are homogeneous, suggesting that some samples were manufactured in well controlled workshops (e.g. samples SN 3, 4 and 5). This same conclusion can be also drawn from the results of the the SEM analysis which shows the sand content to be variable (See Figure 3).

This variation is most likely due to the different techniques that the potter may have used during the manufacturing process. It may also reflect the time period during which pottery was made since it is well known that the production of pottery experienced periods of development and retrenchment since its invention (Rice, 1987). In the study area, Nabataean ware is undoubtedly the best quality, while from later periods ceramics are noticeably inferior (Amr, 1992).

6. CONCLUSION

Udhruh pottery shows various physical appearances in terms of the ware colour, thickness and texture. It also shows some variation in composition. The variation in colour is due either to different percentages of minerals or as a result of the utilization of the object for cooking. Pottery samples are mainly made from silt and clay particles. Some were fired. Overall they have a distinct morphology. The petrographical analysis clearly shows that similar techniques were utilized to manufacture the pottery, the sharp edges of the quartz grains may strongly suggest that it was brought from local valleys.

The presence of certain materials in the morphology of the pottery samples might indicate either that the pottery was manufactured locally or that the potter did not carefully prepare the clay, sieving the raw material and consequently throwing out the unnecessary materials. This suggestion seems to support the view that the ware was locally manufactured. This study provides useful information concerning the provenance of this pottery, the inclusions used by the potters, and the tempering material.

Finally, this study offers scientific information regarding provenance, and identifies tempering materials, manufacturing techniques, and conditions of the pottery.

ACKNOWLEDGEMENTS

The authors would like to thank Dr. Nicholas John Saunders, Department of Archaeology and Anthropology at the University of Bristol, for editing the first and second drafts of this paper. Dr. Saad Twaissi is thanked for his excellent work on pottery.

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