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ARCHAEOMETRIC CHARACTERIZATION OF THE BYZANTINE AND UMAYYAD POTTERY AT BARSINIA, NORTH JORDAN

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ABSTRACT

Byzantine, Late Byzantine-Early Umayyad, and Umayyad Pottery from Barsinia, north Jordan, was investigated in order to examine the effects of the political transition on pottery production traditions. WD-XRF, AAS and SEM-EDX were used for bulk and matrix compositional analysis, while petrography, XRD, and refiring test were used for mineralogical investigation. The results show that, although there was obvious changes in the typology of pottery, there were no considerable differences in pottery production traditions and the raw materials selection in the rural communities during the periods of interest in north Jordan. This verifies use of same local source and potter to produce different styles.

KEYWORDS: Barsinia, Byzantine pottery, Umayyad pottery, Late-Byzantine/Early Umayyad pottery, raw materials, manufacturing technology

INTRODUCTION

Throughout the ancient history different nations yielded different cultures. These differences can be recognized in the archaeological remains. Pottery is one of the most important artifacts that provide archaeologists with information on many aspects of the past. Typological, chronological and scientific studies that are usually focusing on pottery types, their main characters and clay components, are very helpful in identifying the production techniques, the raw materials that were used in production, and consequently, the differences between the pottery types.

In some archaeological sites of northern Jordan there was a conflict of unspecific or inaccurate dating of similar pottery objects that derived from two consecutive periods; the late Byzantine and the Umayyad (mid 6th – mid 8th centuries A.D.). Many pottery objects that were uncovered in archaeological sites, which were settled in those both periods, were considered as "late Byzantine-early Umayyad pottery". In some archaeological sites the historical context the transition phase between the Byzantine and the Umayyad periods is not always clear. It is accordingly uncertain if there is a specific limit between those periods especially in term of pottery production.

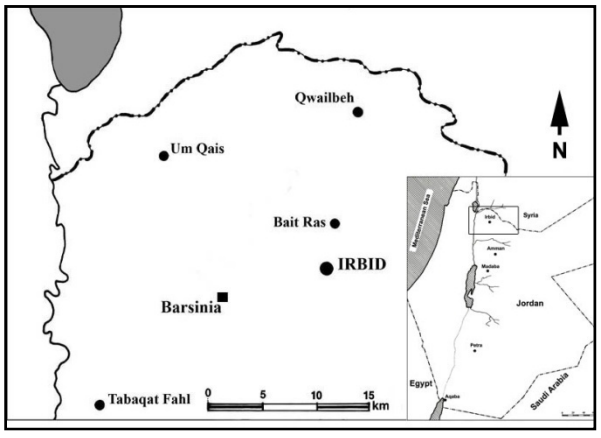


Figure 1. Location of Brasinia and the surrounding urban centers (Umm Qais (Gadara), Bait Ras (Capitolias) and Tabaqat Fahl (Pella)

The main objective of this study is to determine the possibility of giving a proper date to the "late Byzantine-early Umayyad" pottery, through characterization of the raw materials and manufacturing technology and to explain if this group can be assigned to either groups of pottery.

Barsinia is one of the prominent rural sites, which has been flourished during the Hellenistic, Roman, Byzantine and Umayyad periods in the region of northwest Jordan (Fig. 1). For more information about the historical periods and occupation phases at the site please refer to the Excavational report (El-Khouri 2012). During the first season of excavation at the site, a large number of Byzantine and Umayyad pottery were collected (El-Khouri 2009; 2012; forthcoming). Fifteen pottery sherds of different types of objects were chosen to be analyzed for the purpose of this research (Fig. 2). According to the archaeological stratigraphy of the excavated area as well as the parallel examples from other sites, these pottery sherds were all dated to the Byzantine, Umayyad or Late Byzantine-Early Umayyad periods.

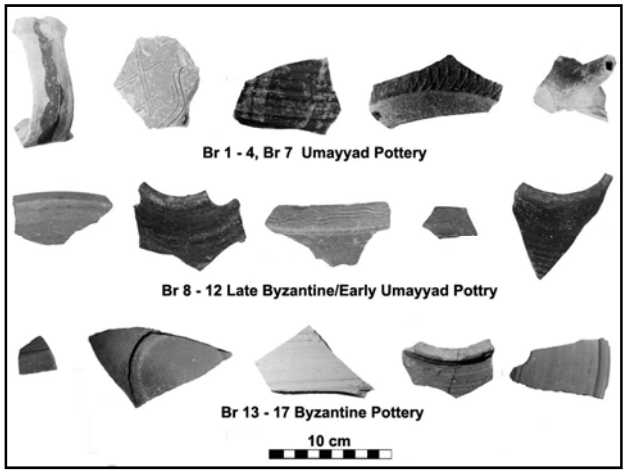


Figure 2. pottery studied samples: Byzantine: Br 13-17, Late Byzantine/Early Umayyad: Br 8-12, Umayy\ad: Br 1-4 and 7.

BYZANTINE AND UMAYYAD POTTERY

Results of many archaeological excavations and surveys revealed that the few decades that followed the Islamic expansion to Belad esh-Sham were an extension to the prior Byzantine period, since this expansion left neither destructive nor violent evidences in most of the region (Walmsley, 2007: 21; 1997). Examples showing this cultural continuity are numerous. They can be considered through the continuation of the Byzantine mosaic tradition that is seen in a number of Umayyad palaces, such as the pal-

aces of Khirbet Al-Mafjar, Al-Qastal, and Al-Hallabat (Piccirillo, 1994: 343-353). The Byzantine cultural affects are also clearly recognized at Ayla in southern Jordan, where the Umayyad architectural elements and the city plan were built according to the Byzantine forms (Parker, 2003: 329; Whitcomb, 1995: 281).

In general, archaeological excavations in the region of northern Jordan revealed that many pottery types that were produced in the Byzantine and the Umayyad periods are similar. It displays a continuation in producing similar pottery forms by using the same techniques. In spite of these sorts of similarities many distinctive developments appeared in the Umayyad period (Walmsely, 2007: 51-54; Schick, 1998: 88-90; Whitcomb, 1995: 278; Smith et al. 1989: 9, 114; Smith et al., 1973: 217-220, 235). This was obvious through the appearance of new pottery types such as the "red on cream" vessels (Br. 1) that are characterized by the red, purple or brown painted motifs on the outside surface of the vessel. The painted decorations included red on white floral designs, wavy lines, simple linear bands, geometrical patterns of vertical and horizontal lines. Other new pottery types of the Umayyad period are the "cut ware bowls" (Br. 4) that were made by using sharp equipment such as a knife (Hendrix et al. 1997: 237-265), and the large hand-made Umayyad grey basins with incisions on the outside surface (Br. 2) (Brown 1991: 227; Sauer 1982: 332).

DESCRIPTION OF OBJECTS

Our selected groups of pottery contain five different categories; jars, bowls, basins, cooking pots and a jug, made of different fabrics.

Jars

The study includes two Umayyad jars (Br. 1, Br. 3), one Byzantine jar (Br. 15), and two jars dated to the transition period (Br. 9, Br. 12). (Br. 1) is a small jar, made of pink ware, with white slip on outer surface and red paint on handle and other body parts. This type of jars is called red on cream, made usually of fine buff to light pinkish brown well-levigated ware, painted usually with red geometric designs (Smith et al. 1973: 234). Different examples of this popular type were found in many sites such as Pella, Heshbon, Amman, and Khirbet Al-Karak (Smith et al. 1973: 234; Smith et al. 1989: 113; Sauer 1973: 42; Harding 1951; Saller 1957: 214; Delougaz and Haines 1960). (Br. 3) is a fragment of a water "bag-shaped" jar made of grey well-fired fabric, with dirty white painted stripes on the outside surface of the ribbing body. It is a very common type at many Umayyad sites, such as Pella (McNicoll et al. 1982, Pl. 146-3,), Heshbon (Sauer 1973: 43), Amman Citadel, Jericho, Nebo, Al-Mefjer, and Khirbet Al-Karak (Sauer 1973: 43). The transition period group of pottery contains two jars (Br. 9 and Br. 12). (Br. 9) is a water jar fragment, made of reddish well-fired grey fabric, and has a ribbing body. Parallels to this type were found at Pella (McNicoll et al. 1982, Pl. 139-5). (Br. 12) is a large "bag-shaped" jar fragment, made of reddish brown well-fired fabric, with two loop handles and ribbing body. Parallels to this type are also numerous; examples could be seen in Jerash (Uscatescu 2001, Fig 3, No.1, P. 68), and Pella (Watson 1986, Fig. 5, No. 19, p. 179). (Br. 15) is a body sherd of a large Byzantine jar, with ribbings on the outside body surface. It was made of very fine light red ware, beij fabric from outside, well levigated, and well fired. This is a type of "bag-shaped Jar", very common during the Late Roman and throughout the Byzantine periods 3rd – 5th century AD (Magness 1993, 223-224; Hendrix et al. 1997: 237-265, Khouri, forthcoming).

Bowls

Four bowls are included in the study. Three Byzantine (Br. 13, Br. 14, Br. 17), and one is dated to the transition period (Br. 8). (Br. 13) is a fragment of a bowl made of red fabric. A similar piece was found at Pella (Smith et al., 1973, Pl. 43-1304). (Br. 14) is a bowl fragment, made of a well-fired red fabric. Similar fabric was found at Pella (Smith et al., 1973: 224-226). (Br. 17) is a bowl with vertical rim, made of red coarse fabric, well-levigated, and well-fired. Similar pieces were found at Pella (Smith et al., 1973: Pl. 28:1135), and Gadara (Kerner 1997, Fig. 14, No. 5, P. 294). (Br. 8) is a shallow bowl, made of light red fine fabric, well-fired. It resembles some imported red-slip ware in Pella (McNicoll et al. 1982, Pl. 139-11). It is perhaps a local version of some "African Red Slip" types.

Basins

Three basins are included in the study. Two are Umayyad (Br. 2, Br. 4), and one is dated to the transition period (Br. 10). Basins were produced in both Byzantine and Umayyad periods, but they are more common in the Umayyad period. Umayyad basins are often decorated with wavy incised and thumb impressed on the body, rounded lips, thickened rims, straight sidewalls, and simple flat bases (Hendrix et al. 1997: 237-265). (Br. 2) is a fragment of a large basin, made of hard-baked pinkish grey fabric, decorated with incised band-combing on the outside surface. This type of basins is very common at Pella (McNicoll et al. 1982, Pl. 140-9), and Heshbon (Sauer 1973: 43). (Br. 4) is also a fragment of a wide flat-based basin, made of grey well fired fabric, this type is characterized by its knife-cut decorations on the outside surface, known as "cut ware", it is common at Pella and other Umayyad sites (McNicoll et al. 1982, Pl. 149-2; Sauer 1973: 43). (Br. 10) is a large basin, made of pinkish grey fabric, with comb incisions on the upper surface of the rim. This type occurred in both the Byzantine and the Umayyad periods, parallels are seen at Pella (McNicoll et al. 1982: 158, Pl. 139) and Heshbon (Sauer 1973: 38).

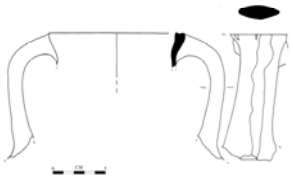
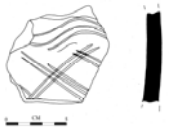
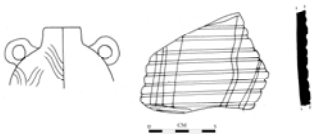
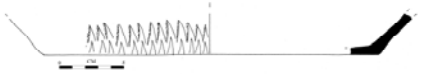
Cooking pots

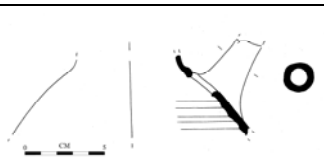
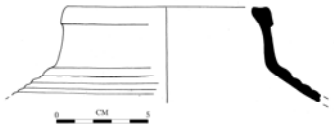
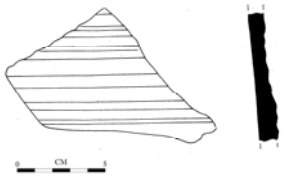
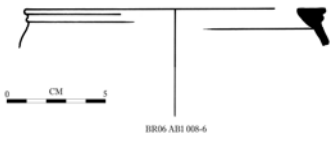
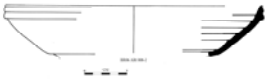
Two cooking pots are included in the study. One is dated to the Byzantine period (Br. 16), and one to the transition period (Br. 11). (Br. 16) is a closed cooking pot with a flat everted rim, made of light red coarse well-fired fabric, with slight ribbing on the exterior surface. Parallels to this type were found at Beth Shean (Johnson 2006, Nos. 227-228) and Pella (McNicoll et al. 1982, Pl. 138:6). (Br. 11) is also a closed cooking pot with short neck, made of reddish brown coarse well-fired fabric. Parallels were found at Humayma (Oleson et al. 1995: pl. 19. Fig. 102-6).

Jugs

Only one jug is included in the study, dated to the Umayyad period (Br. 7). It is a fragment of body and spout, made of pink fabric with slight-ribbing on the inside surface and irregular spout opening on the jug's body. This is a very common type in the Umayyad period at Pella (McNicoll et al. 1982, Pl. 142-1 and Walmsley 1995, Fig. 7.1).

Table 1. Description and dates of the studied samples

Sample no.	Form	Description	Drawings
Br. 1	Jar	Complete handle and part of a rim. White slip on the outer surface (5YR,8/1), red paint with brush on the handle (5YR,4/6). Pink fabric occurred on the inside surface. Section is pink fabric (5YR,8/4). Well levigated. Rim diam. 12 cm.	
Br. 2	Basin	Body fragment of a large basin, hard baked fabric, pinkish grey outside (7.5YR,6/2) and grey inside (7.5YR,N6), light grey section. Decorated with incised band-combing. Well fired.	
Br. 3	Jar	Body fragment of a water (bag-shaped) jar made of grey fabric, grey inside (7.5YR,N6), dark brown outside (7.5YR,4/2) grey section, well fired, hard baked fabric. Dirty white (7.5YR,N8) painted stripes on the outside surface. Ribbing body.	
Br.4	Basin	Fragment of a wide flat base large basin, made of grey fabric (7.5YR,N6), well fired, knife cut decoration on the lower part of the body, so called (cut ware) rocker decoration. Base diam. 25 cm.	

Br. 7	Jug	Fragment of body and spout of a jug, pink fabric outside (7.5YR,7/4), pink inside (5YR,8/4) and slight-ribbing on the inside surface. Irregular spout opening on jug's body.	
Br. 8	Bowl	Shallow bowl, made of light red fabric (2.5YR,6/6) inside surface, outside surface and section. Well fired. Very fine ware. Rim diam. 28 cm.	
Br. 9	Jar	Fragment of rim and neck and part of body of a water jar. Reddish grey fabric (5YR,5/2) inside and outside surface. Grey section (5YR,5/1). Well fired. Ribbing outside, hard baked fabric. Rim diam. 11 cm.	
Br. 10	Basin	Large basin, made of pinkish grey fabric (5YR,6/2) inside and outside. Incised rim with comb incisions. Rim diam. Rim diam. 36 cm.	
Br. 11	Cooking pot	Fragment of a rim and a neck of a cooking pot, short neck, made of reddish brown coarse fabric (2.5YR,5/2). Black line in section, not well fired. Rim diam. 13 cm.	
Br. 12	Jar	Fragment of a handle and a body of a large bag-shaped jar. Ribbing on the outside surface, loop handle on shoulders. Reddish brown fabric outside (2.5YR,5/2), light red fabric inside and section (2.5YR,6/8). Fine ware, well levigated. Rim diam. 13 cm.	
Br. 13	Bowl	Fragment of a rim and a body of a bowl, made of red fabric (2.5YR,5/6) inside and outside surface, not well fired, grey section. Rim diam. 14 cm.	
Br. 14	Bowl	Part of a base and a body of a bowl, made of red fabric (2.5YR,5/8), well fired. Traces of fire on surface, three lines of horizontal ribbings along the inner body surface. Base diam. 10 cm.	
Br. 15	Jar	Body fragment of a large jar, made of light red fabric from inside and section (2,5YR,6/8), beij fabric (maybe slip) from outside (7.5YR,8/4), ribbings on the outside body surface, very fine ware, well levigated, well fired.	
Br. 16	Cooking pot	Closed cooking pot, flat everted rim, light red fabric interior (2.5YR 6/6), dark gray exterior (2.5YR N4), slight ribbing on the exterior surface, coarse ware, well levigated, evenly fired. Rim diam. 14 cm.	
Br. 17	Bowl	Vertical rim above sharp carnation, red coarse fabric (2.5YR 4/8), well levigated, evenly fired. Rim diam. 30 cm.	

MATERIALS AND ANALYTICAL METHODS

To gather information about the raw materials and manufacturing technology, a total of 15 pottery sherds were selected (for their description see Table 1), 5 samples from each period, then subjected to a multi-methodic analyses. Thin sections were prepared and petrographic study was curried out using Leica refracted polarized light microscope. Two samples from

each group were refired at temperatures between 650 °C and 1050 °C with an interval of 100 °C and one hour soaking period at the required temperature. The original samples and the refired ones were prepared as a powder then subjected to XRD (shimadzu XRD-600) in order to confirm the results of petrography and estimate the initial firing temperatures of the investigated pottery sherds. The powders of the original samples were analyzed for their bulk chemical compositions using WD-XRF spectrometer (S4 Pioneer from Bruker) according to ASTM C1271-99. To measure the trace elements concentrations, AAS (NOVA 300 Analytik Jena AG) was used. The results were then statistically investigated using ANOVA test. FEI quanta 200 SEM-EDX was used to measure the chemical compositions of the matrices, i.e. the clay, avoiding the non-plastic inclusions. The average values of 5 point analyses in each sample were counted and then plotted with the ideal clay types compositions on ternary diagram in order to determine the clay type(s) that were used to manufacture the investigated pottery sherds.

RESULTS

Petrography and XRD analysis

Byzantine pottery in Barsinia is characterized by medium fabric and contains moderate amount of non-plastic inclusions (Fig. 3a). Quartz grains are the main dominant non-plastic inclusions. Plagioclase, micrite limestone, and argillaceous materials are less common (Table 2). Sample Br 15 is an exception, which contains larger amount of chalk inclusions than quartz and characterizes by very fine fabric and contains foraminifera (microfossil) in chalky matrix (Fig. 3b).

Late Byzantine/Early Umayyad pottery shows no great differences from the Byzantine one (Table 2); the same type of non-plastic inclusions with lower amounts. However, this pottery is slightly finer in fabric (Fig. 3c). Sample Br 11 is medium to coarse fabric, which is an exception.

Umayyad pottery characterizes by fine to medium fabric (Fig. 3d), same types of non-plastic inclusions with a larger amounts (Table 2). Sample Br 4 contains relatively high amount of coarse grains of argillaceous materials (Fig. 3e).

XRD results (Table 2) confirmed petrography; quartz is the main mineral phase in almost all samples, except sample Br 15 where calcite is the main phase, feldspars (mainly anorthite) exists as minor phase. Iron oxide, calcite, and microcline present as minor or trace phases, sample Br 15 contains apatite as trace phase, which is strong indication for the fish bones and teeth remains in chalk and/or chalky clay that used for its manufacture.

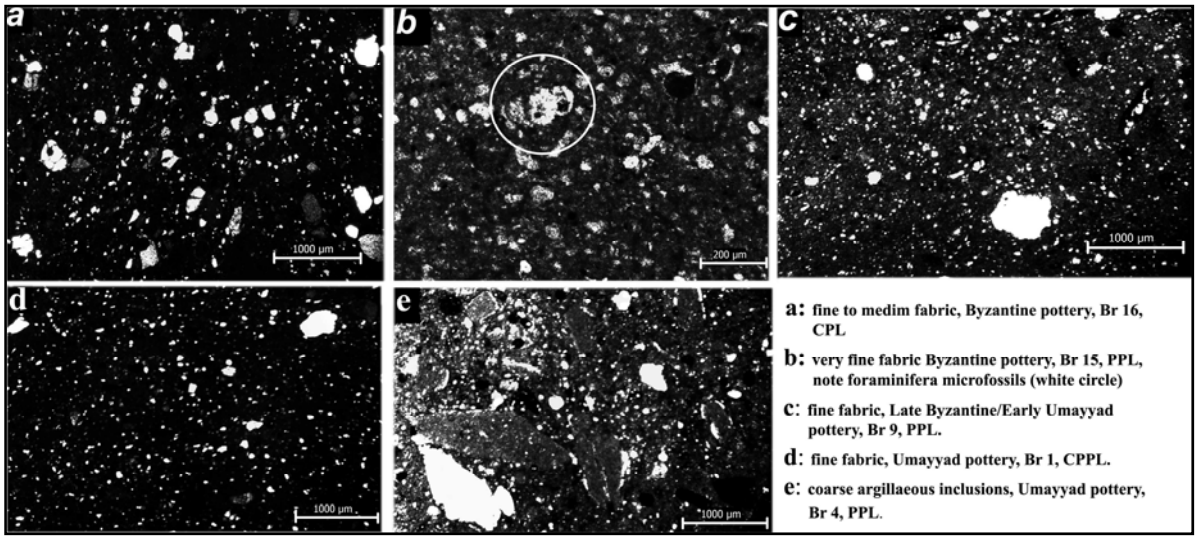


Figure 3. Polarized Microscope images showing the examples of fine fabric dominated in the studied sherds (a, c, and d), chalky matrix including foraminifera (b), argillaceous inclusions (e).

Table 2 Petrographic characterization and XRD results of the studied pottery sherds

Sample No	Non-plastic inclusions	Grain Size**	Grain Shape	Abundant*	Notes	Mineral phases measured by XRD***
Br 1	Quartz	V.fine-medium	Subrounded-angular	x	Fine to medium fabric, contains moderate amount (ca. 35%) of non-plastic inclusions. Highly weathered and wavy extinction quartz. Iron oxide as irregular patches and staining ca. 5%.	Qtz (Ma). An and Gh (Mi). Cal, Di, and Hem (Tr).
	Plagioclase (anorthite)	Fine-medium	Subrounded	++		
	Micritic limestone	Fine-medium	Subrounded	-		
Br 2	Quartz	Fine-medium	Subangular-angular	xx	Medium fabric, contains high amount (ca. 50%) of non-plastic inclusions. Calcareous clay matrix of two mixed types. Quartz is of polycrystalline, wavy extinction type. Few fine grains of pyroxene. Iron oxide ca. 5%.	Qtz (Ma). Gh (Mi). An, Cal, and Di (Tr).
	Micritic limestone	Medium	Rounded	++		
	Plagioclase (anorthite)	Fine-medium	Subrounded-angular	++		
Br 3	Quartz	Fine-medium	Subangular-angular	xx	Fine fabric, contains high amount (ca. 50%) of non-plastic inclusions. Calcareous clay matrix of two mixed types. Quartz is of polycrystalline, wavy extinction type. Few fine grains of pyroxene. Iron oxide ca. 5%. Argillaceous inclusions ca. 3%	Qtz (Ma). An and Spl (Mi). Cal and AnOr (Tr).
	Micritic limestone	Medium	Rounded	++		
	Plagioclase (anorthite)	Fine-medium	Subrounded-angular	++		
Br 4	Argillsceous inclusions	Medium-coarse	Subrounded-rounded	xxx	Coarse fabric, high amount (50%) of non-plastic inclusions. Mixing of two types of clay. Fossiliferrous limestone, foraminifera in chalk patches. Iron oxide staining.	Qtz (Ma). An, Cal, Gh and Di (Tr).
	Quartz	Fine	Subrounded-subangular	++		
Br 7	Quartz	Fine-medium	Subrounded-angular	x	Fine to medium fabric, moderate amount (ca. 35%) of non-plastic inclusions. Wavy extinction, weathered quartz. Few coarse grains of sandstone. Iron oxide as stain ca. 3%.	Qtz (Ma). Fe-Mc, Hem and Di (Tr).
	Plagioclase (anorthite)	Fine-medium	Subangular	++		
	Micritic limestone	Fine-medium	Subrounded	-		
Br 8	Quartz	Fine-medium	Subrounded	++	Fine fabric, contains moderate amounts (ca. 30%) of non-	Qtz (Ma). Mc (Mi). Fe-Di and Hem (Tr).
	Plagioclase	Fine	Subangular	++		

	(anorthite)				plastic inclusions. Highly weathered wavy extinction quartz. Secondary calcite invaded fissures.	
Br 9	Quartz	Fine	Subrounded-subangular	++	Fine fabric, contains low amounts (ca. 15%) of non-plastic inclusions. Calcareous and argillaceous clays matrix not well mixed. Remains of burnt organic matter (straw). Iron oxide patches.	Qtz and An (Ma). Cal, Mc, Di and Dol (Tr).
	Plagioclase (anorthite)	Fine	Subrounded	-		
Br 10	Quartz	Fine-medium	Subangular-angular	++	Fine to medium fabric, contains moderate amounts (ca. 35%) of non-plastic inclusions. Wavy extinction quartz. Iron oxide patches ca. 3%	Qtz (Ma). Cal and An (Mi). Mc, Di and Gh (Tr).
	Micritic limestone	Fine-coarse	Rounded-subrounded	++		
	Plagioclase (anorthite)	Fine-medium	Subangular	+		
Br 11	Quartz	Medium-coarse	Subrounded-angular	x	Medium to coarse fabric, high amounts (40%) of non-plastic inclusions. Iron oxide exists. Highly weathered feldspar and quartz.	Qtz (Ma). An and Hem (Mi). Di and Cal (Tr).
	Plagioclase (anorthite)	Fine-medium	Subrounded-subangular	++		
	Micritic limestone	Fine-coarse	subrounded	+		
Br 12	Quartz	Fine	Subangular	++	Fine to medium fabric, low amounts (ca. 10%) of non-plastic inclusions. Not well mixed tow types of clays, one of them is chalk. Wavy extinction, weathered quartz. Iron oxide as stain. Feldspar exists.	Qtz (Ma). Hem (Mi). Cal, Mc, and Gh (Tr).
	Argillaceous inclusions	Medium	Subrounded	++		
Br 13	Quartz	Fine-medium	Subangular	x	Medium fabric contains high amounts (ca. 50%) of non-plastic inclusions. Highly weathered feldspar. Iron oxide as irregular patches and staining.	Qtz (Ma). Cal, Mc, Gh, Di, and Hem (Tr).
	Plagioclase (anorthite)	Fine-medium	Subrounded-subangular	++		
	Micritic limestone	Fine-coarse	Subrounded	++		
Br 14	Quartz	Fine-coarse	Subrounded-angular	xx	Medium fabric contains high amounts (ca. 60%) of highly weathered non-plastic inclusions. Wavy extinction quartz. Iron oxide exists.	Qtz (Ma). An and Hem (Mi). Di (Tr).
	Plagioclase (anorthite)	Fine-coarse	Subangular	x		
Br 15	Chalk	Fine	Rounded	++	Very fine fabric contains low amounts (ca. 15%) of non-plastic inclusions.	Cal (Ma). Gh and Qtz (Mi). An and Ap (Tr).
	Quartz	Fine	Rounded	++		

					Calcareous clay matrix (chalk) with high content of foraminifera microfossils. Iron oxide exits.	
Br 16	Quartz	Fine-coarse	Subangular-angular	x	Medium fabric, high amounts (50%) of non-plastic inclusions. Wavy extinction, weathered quartz. Iron oxide staining. Secondary calcite on boundaries	Qtz (Ma). Di (Mi). An, Gh, Spl, and Hem (Tr).
	Plagioclase (anorthite)	Fine-medium	Subangular-angular	++		
	Argillaceous inclusions	Fine	Rounded	+		
Br 17	Quartz	Fine-medium	Subangular	x	Fine to medium fabric, moderate amount (ca. 40%) of non-plastic inclusions. Wavy extinction, weathered quartz. Iron oxide.	Qtz (Ma). An (Mi). Di and Hem (Tr).
	Plagioclase (anorthite)	Fine-medium	Subangular	++		

* xxx: very high > 40%. xx: high (30-40%). x: moderate (15-30%). ++: low (5-15%). +: scarce (3-5%). -: rare < 3%.
** v.fine: < 63μ, fine: 63μ-0.5mm, medium: 0.5-1mm, coarse: 1-2mm, v.coarse: > 2mm
*** Qtz: Quartz, Cal: Calcite, Mc: Microcline, Gh: Gehlenite, Di: Diopside, Hem: Hematite, An: Anorthite, Dol: Dolomite, Spl: Spinel, Ap: Apatite, AnOr: Anorthoclase. (Ma): Major, (Mi): Minor, (Tr): Trace

Chalk and chalky clay rocks are exposed around Barsinia in the Upper Cretaceous Belqa Group (Moh'd, 2000).

In addition to that the high temperature calcium aluminum silicate (gehlenite) and calcium silicate (diopside) phases exist in almost all samples (Table 2).

In fact the clay and the non-plastic inclusions that were used in the pottery manufacture are available in the area falling within the geological group and age formation.

Chemical analysis

Bulk chemical analysis indicates that Byzantine pottery were manufactured using non-calcareous clay (CaO < 5 %), sample Br 15 contains 30.3 % CaO and 3.06 % P_2O_5 which is a good sign for fish bone and teeth remains previously mentioned.

Calcareous and non-calcareous clays (CaO ranges between 2.3 and 11.9 %) were used in the manufacture of Late Byzantine/Early Umayyad pottery (Table 3).

Note that P_2O_5 / CaO in bone is 1:1.2, and in any case microfossils do not have the composition of bones. Though the 1:1.2 ratio is in bone here we talk about bulk chemistry for calcareous clay pottery sherd that contains few fragments of fish bone that were leached out from a geological formation called Al-Hisa phosphorite Formation that contains phosphate rocks on the top of the hills nearby.

All samples contains relatively high amounts of iron oxide (FeO ranges between 3.01 and 8.25%), note that Umayyad pottery contain lower amount than others (Table 3).

In comparing elemental concentration between SEM with XRF and other techniques one should bear in mind the calibration protocole followed (grain size, mean atomic number etc, see, Liritzis et al., 2011).

Here SEM-EDX was run on ware matrix (clay) and XRF on the whole ware (bulk).

The results of ANOVA test for the bulk chemical oxides indicate that no statistical differences among the three groups (Table 4).

When the results of the matrices (clay) chemical analysis plotted on the ternary diagram of SiO_2 – Al_2O_3 + TiO_2 – alkalis + alkali earths the result showed that all pottery sherds from all groups were manufactured using illite and illite/smectite clays (Fig. 4).

Table 3. Bulk and matrices chemical composition of the studied samples by XRF/ AAS and SEM respectively

Sample No	***	Na_2O*	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	K_2O	CaO	TiO_2	FeO	LOI**	Sr	Cr	Mn	Co	Ni	Cu	Zn	Pb	Cd
Br 1	Bulk	0.23	0.81	17.00	60.00	0.16	0.05	1.42	11.90	1.43	3.01	3.50	86.50	928.46	385.00	839.20	3291.57	176.70	491.22	22.30	15.00
	Matrix	0.95	1.48	21.33	54.95			2.08	13.80	1.04	3.94										
Br 2	Bulk	0.02	1.29	12.70	63.60	0.28	0.05	1.23	9.10	1.50	4.18	5.50	7.00	837.75	87.50	2832.50	2195.70	173.60	489.40	164.10	30.90
	Matrix	1.01	2.43	19.63	60.56			2.48	7.64	1.51	5.57										
Br 3	Bulk	0.01	1.17	25.80	53.50	0.33	0.04	2.05	5.73	2.18	7.12	1.20	45.00	1137.43	743.24	2296.42	2282.50	112.60	714.01	3.00	46.40
	Matrix	1.24	2.82	24.24	57.30			2.80	2.79	1.36	6.70										
Br 4	Bulk	0.01	1.35	16.70	63.40	0.14	0.03	2.08	3.67	1.41	4.90	5.80	63.10	851.75	227.10	593.20	2565.96	151.10	485.68	13.80	22.30
	Matrix	0.98	1.82	21.26	59.64			2.85	3.95	2.19	6.57										
Br 7	Bulk	0.01	1.14	19.90	66.50	0.18	0.06	1.82	2.30	1.60	4.63	1.40	75.00	898.22	324.20	3077.00	2710.76	157.40	562.18	72.40	26.50
	Matrix	1.06	2.43	26.94	57.70			2.33	2.52	1.04	5.37										
Br 8	Bulk	0.01	0.86	19.70	65.60	0.16	0.03	2.01	2.40	1.57	5.38	1.60	68.60	763.70	474.30	2421.57	2679.21	176.00	522.04	121.20	27.60
	Matrix	0.90	1.79	23.47	59.19			3.51	2.09	1.64	6.67										
Br 9	Bulk	0.02	1.69	23.50	53.70	0.25	0.03	1.98	7.30	1.84	7.72	1.20	17.70	1058.21	11.20	218.10	2751.43	144.50	601.68	108.10	27.60
	Matrix	0.85	2.45	23.96	52.19			1.84	9.14	1.42	7.27										
Br 10	Bulk	0.03	1.55	15.20	62.50	0.20	0.06	1.91	7.96	1.27	4.71	4.10	1.00	951.06	689.22	1387.50	2325.12	161.70	476.68	76.00	42.70
	Matrix	0.72	2.87	22.09	55.85			3.42	4.97	1.17	8.02										
Br 11	Bulk	0.03	1.67	16.70	64.10	0.17	0.07	0.84	3.58	1.57	8.28	1.90	9.40	1062.51	942.88	958.60	2511.53	201.90	713.74	13.00	30.40
	Matrix	1.36	2.95	21.55	55.93			1.14	2.66	2.07	11.11										
Br 12	Bulk	0.02	1.36	27.60	51.20	0.33	0.04	1.67	5.80	1.85	7.35	2.00	31.80	802.25	356.30	18.70	3201.60	161.90	781.05	115.80	30.20
	Matrix	1.22	2.34	29.72	48.09			2.61	3.14	2.50	9.33										
Br 13	Bulk	0.00	1.44	16.30	63.80	0.15	0.00	1.08	4.57	1.61	7.99	2.00	10.20	795.40	1532.10	736.30	2398.97	192.50	765.29	58.60	32.30
	Matrix	0.77	2.94	21.33	55.61			1.59	2.49	1.93	12.00										
Br 14	Bulk	0.38	1.29	16.00	60.20	0.16	0.04	1.85	1.26	0.97	5.52	2.60	16.10	826.46	631.27	1337.40	2447.05	143.90	529.21	81.20	28.80
	Matrix	1.36	3.11	25.03	53.91			2.92	2.07	1.31	9.27										
Br 15	Bulk	0.00	0.83	11.80	32.00	3.06	0.04	0.81	30.30	0.55	3.86	16.20	49.40	812.97	326.10	1105.80	2455.60	182.60	653.20	136.90	31.00
	Matrix	0.76	1.46	16.13	45.03			2.58	24.08	0.68	7.47										
Br 16	Bulk	0.01	1.32	21.00	62.50	0.18	0.03	1.41	3.74	2.18	5.18	1.80	14.70	725.00	15.30	3126.10	2418.60	155.90	506.05	215.70	35.70
	Matrix	1.06	2.39	27.18	55.61			2.26	2.64	2.17	6.03										

Sample No	***	Na_2O	MgO	Al_2O_3	SiO_2*	P_2O_5	SO_3	K_2O	CaO	TiO_2	FeO	LOI**	Sr	Cr	Mn	Co	Ni	Cu	Zn	Pb	Cd
Br 17	Bulk	0.02	1.13	15.40	64.80	0.15	0.05	1.07	2.73	1.53	7.60	4.40	41.20	934.85	906.09	1509.33	2424.41	172.70	549.28	43.50	35.70
	Matrix	0.94	2.38	18.97	60.25			1.28	2.74	1.45	10.80										

* Oxides are in wt% measured using XRF, while elements are in ppm and measured using AAS

** LOI : loss on Ignition / in house method

*** Matrices compositions are in % measured using SEM-EDX, average of 5 point analysis

Table 4. ANOVA test results

	Na_2O	MgO	Al_2O_3	SiO_2	K_2O	CaO	TiO_2	FeO	Sr	Cr	Mn	Co	Ni	Cu	Zn	Pb	Cd
F	0.363	1.474	1.233	0.115	1.929	0.218	0.584	1.863	2.167	1.519	0.786	1.057	0.924	0.756	0.535	0.908	0.445
P. value	0.703	0.268	0.326	0.892	0.188	0.807	0.573	0.197	0.157	0.258	0.478	0.378	0.423	0.491	0.599	0.429	0.651

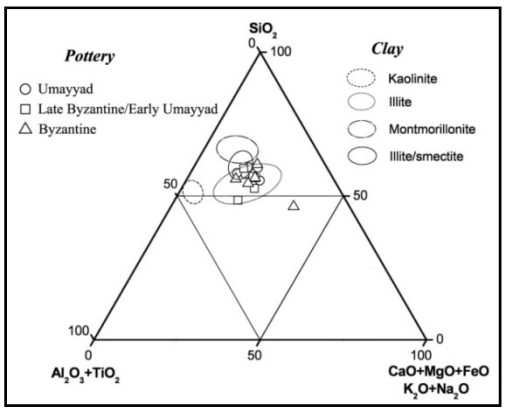


Figure 4. Ternary diagram showing the major element compositions of Byzantine, Late Byzantine/Early Umayyad and Umayyad pottery matrices and the typical clay compositions. Calcareous and non-calcareous illite and illite/smectite clays were used in the manufacture of these sherds. (Data are after Weaver, 1989; Newman and Brown, 1987; Srodon et al. 1986, and Gaudette, et al., 1966).

Refiring test

The refiring test for Byzantine sherds indicated that at 750 °C firing temperature calcite completely disappeared from sample Br 15 as XR diffractograph shows (Fig. 5a), while at 850 °C gehlenite content sharply increased. At 850 °C firing temperature plagioclase (anorthite) formed in sample Br 17, this phase did not exist in the original sample. Late Byzantine/Early Umayyad and Umayyad refired pottery sherds showed the same behavior as in Byzantine one. Samples Br 10 and Br 2 showed the same results as Br 15 (Fig. 5b). While the few remains of calcite disappeared at firing temperature of 750 °C in samples Br 12 and Br 1 they are also originally contain small amounts of gehlenite and diopside, which increased at firing temperature of 850 °C (Fig. 5c).

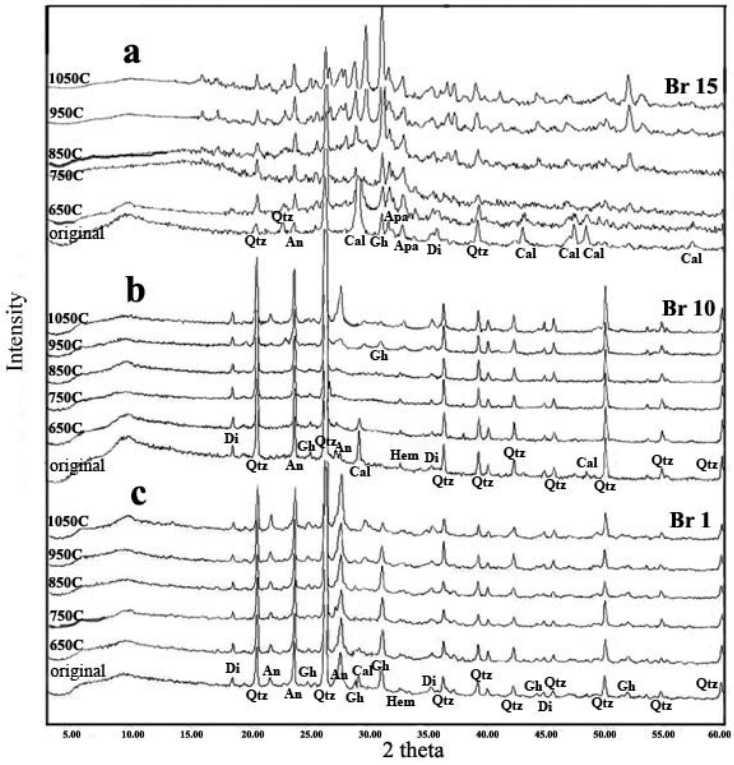


Figure 5. Difractographs showing the minerals phases in the refired pottery sherds. a: Byzantine, Br 15, note calcite disappeared at 750˚C. b: Late Byzantine/Early Umayyad, Br 10, same as a. c: Umayyad, Br 1, note at 750˚C calcite disappeared and the original sample contains gehlenite and diopside are already exist. (An: anorthite, Ap: apatite, Cal: calcite, Di: diopside, Gh: gehlenite, Hem: hematite, Qtz: quartz)

DISCUSSION

Typology

Many local types of Byzantine and Umayyad pottery objects of northern Jordan revealed a kind of similarity in shapes, clay components and production techniques. Most Byzantine and Umayyad objects are wheel made except storage jars and basins (Hendrix et al. 1997: 237-265). Some objects evidenced that several pottery forms remained unchanged for several decades in the Byzantine and early Islamic periods (Smith et al., 1973: 217, 223), such as the cooking pots form with horizontal handles, the large flat-bottom basins, and the storage jars (Smith et al., 1973: 224-226).

Many techniques were used in both periods in surface treatment, such as slipping, burnishing, painting, ribbing, combing and finger pressing (Hendrix et al. 1997: 237-265; Sauer 1982: 330).

Raw materials

The results of mineralogical, chemical and statistical analysis indicate that pottery in Barsinia during Byzantine throughout Umayyad periods was made using both calcareous and non-calcareous clays. Moreover, illite and illite/smectite mixed with the available non-plastic inclusions; such as quartz, micrite limestone, argillaceous materials and chalk (Moh'd, 2000), thus, pottery in Barsinia during these periods was locally made.

However, the same raw materials, i.e. same sources, were continued to be used. This is in harmony with the situation in southern Jordan, where local pottery production (raw materials and technology) were continued in the transitional period (Holmqvist and Martinon-Torres, 2011; Holmqvist, 2007). As a rural site it seems that the change to use new materials was very slow, maybe because the locally available materials were sufficient to fulfill the manufacturing and production needs.

Manufacturing technology

Almost all the refired pottery sherds contain calcite either as minor or trace mineral, this mineral decomposed from the samples between 650 and 900 °C (Noll, 1991). This depends on the duration time and atmosphere of firing (Rice, 1987: 98). Moreover, the decomposition temperature of calcite depends also on its amount and grain size (Shoval et al., 1993; Rice, 1987:93-94). In addition, almost all the investigated pottery sherds contain high temperature calcium aluminum silicate and/or calcium silicate mineral phases such as gehlenite and diopside (table 2), these minerals formed in calcareous illite clay at temperature above 850 C (Riccardi et al., 1999; Maggetti et al., 1991; Noll, 1991; Maggetti, 1982).

Thus, potters at Barsina fired their products in temperatures ranging between 750 and 850 °C during Byzantine, Late Byzantine/Early Umayyad, and Umayyad periods, which mean that manufacturing technology relatively continued or changed very slowly.

This leads to conclude that the traditions of pottery production and the use of the raw materials sources were continued during these periods. No real innovations in pottery production in the urban areas in north Jordan have been achieved until the middle 8th century A.D. when Abbasid tin- opcified glazed ware started to appear at Basra (Mason, 1995).

Pottery from same periods and major sites in north Jordan, for example the Decapolis cities, needs to be investigated to see if the very slow change, if there is at all, in pottery production traditions the same as in urban areas or the change was, as a result of political and religious issues, very dramatic

CONCLUSIONS

Raw materials and manufacturing technology of pottery characterization using archaeometrical investigation provide information about the differences of pottery production traditions.

However, although there was obvious change in the style and form of pottery i.e. typology, there were no large differences in pottery production traditions and the raw materials selection in the rural site of Barsinia during the periods of interest. This implies, use of same source and potter to produce different styles.

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REFERENCES

Brown, R. M., (1991) Ceramics from the Kerak Plateau. In J. M. Miller (ed.) *Archaeological Survey of the Kerak Plateau*. Atlanta: Scholar Press, American Schools of Oriental Research., 169-279.

Delougaz, P. and Haines, R. (1960) *A Byzantine Church at Khirbat Al-Karak*. University of Chicago Press.

El-Khouri, L., (2009) Barsinia: a Newly-Excavated Archaeological Site in North-Western Jordan. *Studies in The History and Archaeology of Jordan* (SHAJ) 10, 61-66.

El-Khouri, L., 2012 Architectural Remains at Barsinia, Results of Two Seasons of Excavations (2006 and 2007). *ADAJ* 55: 467-488.

El-Khouri, L. (forthcoming) Byzantine and Umayyad Period Pottery at Barsinia (2006 Season of Excavation). *PEQ*

Gaudette, H.; Eades, J. and Grim, R. (1966) The nature of illite. *13th National Conference on Clay and Clay Minerals*. Oxford, London, Pergamon: 33 – 49.

Harding, L., (1951) Excavations on the Citadel, Amman. *ADAJ*, Vol. 1. P. 7-16.

Hendrix, R., Drey, P., and Storfjell, J., (1997) *Ancient Pottery of Transjordan.* Institute of Archaeology, Horn Archaeological Museum, Andrews University. Berrien Springs, MI. USA.

Holmqvist, V. (2007) Ceramic production traditions in the Late Byzantine-Early Islamic transition: A comparative analytical study of ceramic from Palaestina Tertia. In: *EMAC 07, 9th European Meeting on Ancient Ceramics*, Biro, K.; Szilagyi, V. and Kreiter, A. (eds): 91 – 95.

Holmqvist, V. and Martinon-Torres, M. (2011) Many potters – one style: Pottery production and distribution in transitional Late Byzantine-Early Islamic Palaestina Tertia. In: *Proceedings of the 37th international symposium on archaeometry*, Turbanti-Memmi, I (ed). Springer-Verlag Berlin Heidelberg: 71 – 76.

Johnson, B. (2006) The Hellenistic to Early Islamic Period Pottery. In A. Mazar, *Excavations at Tell Beth-Shean 1989-1996. Vol. I From the Late Bronze Age IIB to the Medieval Period*. The Israel Exploration Society. The Institute of Archaeology, The Hebrew University of Jerusalem. Jerusalem, 523-589.

Kerner, S. (1997) Umm Qays-Gadara: A preliminary report 1993-1995. *ADAJ* XLI: 283-301

Liritzis, I., Mavrikis, D., Zacharias, N., Sakalis, A., Tsirliganis, N. and Polymeris, G.S. (2011) Potassium determinations using SEM, FAAS and XRF: some experimental notes. *Mediterranean Archaeology and Archaeometry*, Vol. 11, No. 2, 169-179

Maggetti, M. (1982) "Phase Analysis and its Significance for Technology and Origin". In J. Olin, and A. Franklin (eds) *Archaeological Ceramics*. Smithsonian Institution Press, Washington D.C., 121-135.

Maggetti, M.; Baumgartner, D. and Galetti, G. (1991) Mineralogical and chemical studies on Swiss Neolithic crucibles. In: *Archaeometry'90*, Pernieka, E. and Wagner, A. (eds): 95-104.

Magness, J. (1993) Jerusalem Ceramic Chronology, circa 200-800 CE. Sheffield

Mason, R. (1995) New looks at old pots: results of recent multidisciplinary studies of glazed ceramics from the Islamic world. *Muqarnas: Annual on Islamic Art and Architecture* 12: 1 – 10.

McNicoll, A., Smith, R., Hennessy, B. (1982) *Pella in Jordan 1*. Australian National Gallery. Canberra.

Moh'd, B. (2000) "The Geology of Irbid and Ash Shuna Ash Shamaliyya (Waqass) map sheet No. 3154-II and 3154-III". *Natural Resources Authority reports*, Amman. Jordan. Bulletin 46.

Newman, A. and Brown, G. (1987) The chemical constitution of clays. In: *Chemistry of clays and clay minerals, Mineralogical Society Monograph 6*, Newman, A. (ed). John-Wiley & Sons, New York: 1-129.

Noll, W. (1991) *Alte Keramiken und ihre Pigmente: Studien zu Material und Technologie*. E. Schweizerbart'sche Verlagsbuchhandlun, Stuttgart.

Oleson, J. P., Amr, Kh., Foote, R. and Schick, R. (1995) Preliminary report of the Humayma excavation project, 1993. ADAJ 39: 317-354.

Parker, S.T. (2003) The Roman 'Aqaba Project: the 2002 campaign. *ADAJ* 47: 321-333.

Piccirillo, M. (1994) *The mosaics of Jordan*. Amman: ACOR.

Riccardi, M. P., Messiga, B and Duminuco, P. (1999) An approach to the dynamics of clay firing. *Applied Clay Science* 15: 393-409.

Rice, M. (1987) *Pottery analysis: A sourcebook*. The University of Chicago Press/Chicago and London.

Saller, S. J. (1957) *Excavations at Bethany* 1949-1953. Franciscan Press

Sauer, J. (1973) *Heshbon Pottery 1971*. Andrews University Press. Berrien Springs, Michigan.

Sauer, J. (1982) The Pottery of Jordan in the Early Islamic Periods. In *Studies in the History and Archaeology of Jordan*, ed. A. Hadidi. Amman: Department of Antiquities of Jordan,.329-37

Schick, R (1998) Palestine in the early Islamic period: luxuriant legacy. *Near Eastern Archaeology* 61 (2):74–108

Shoval, S.; Gaft, M., Beck, P and Kirsh, Y. (1993). Thermal behaviour of limestone and monocrystalline calcite tempers during firing and their use in ancient vessels. *Journal of Thermal Analysis* 40 (1): 263 – 273.

Smith, R. et al. (1973) *Pella of the Decapolis, Vol. I*. The College of Wooster. William Clowes & Sons. London.

Smith, R. et al. (1989) *Pella of the Decapolis 2*. Final report on the College of Wooster excavations in area IX, the civic complex, 1979-1986. Wooster.

Srodon, J.; Morgan, D.; Eslinger, E.; Eberl, D. and Karlinger, M. (1986) Chemistry of illite/smectite and end-member illite. *Clay and clay minerals* 34 (4): 368 –378.

Uscatescu, A. (2001) L'apport des fouilles du macellum (Jérash, Jordanie) à la connaissance des céramiques byzantines tardives de Gerasa. In E. Villeneuve and P. Watson (eds.) *La céramique Byzantine et proto-islamique en Syrie-Jordanie (IVe-VIIIe siècle apr. J. C.)*, actes du colloque tenu à Amman les 3-5 décembre 1994. BAH 159.

Walmsley, A. (1995) Tradition, innovation, and imitation in the material culture of Islamic Jordan: the first four centuries. SHAJ 5: 657 – 68. Amman. Department of Antiquities.

Walmsley, A. (1997). Ceramic and the social history of Early Islamic Jordan: the example o Pella (Tabaqat Fahl). Al-'USUR AL-WUSTA. *The Bulletin of Middle East Medievalists*. Vol. 9(1): 1-4.

Walmsley, A. (2007). *Early Islamic Syria: an archaeological assessment*. Duckworth. London

Watson, P. (1986) A Byzantine House. In F. Zayadine (ed.) *Jerash Archaeological Project*. Vol. 1. Amman, Department of Antiquities.

Weaver, C. (1989) *Clays, Muds, and Shales*. Developments in Sedimentology 44. ELSEVIER. Netherlands.

Whitcomb, D. (1995) The Misr of Ayla: new evidence for the early Islamic city. Studies in History and Archaeology of Jordan (SHAJ) 5: 277-288.