CHANGES IN BYZANTINE GLAZING TECHNOLOGY FROM THE NINTH TO THIRTEENTH CENTURIES

Pamela ARMSTRONG, Helen HATCHER, Mike TITE

Résumé : Cet article est une partie d'une recherche plus vaste sur les changements qui se produisirent à la fin du XIe siècle dans la production de la céramique byzantine glaçurée. Avant cette époque les céramiques glaçurées étaient peu nombreuses et ne se trouvaient que rarement hors des principales implantations urbaines alors qu'après celle-ci on les rencontre partout en grandes quantités, même sur de petits sites ruraux. Une façon d'aborder la recherche sur les causes et circonstances qui amenèrent la prolifération des céramiques glaçurées à un moment particulier est d'examiner la technique de glaçurage utilisée avant et après cette époque pour voir si les changements dans la méthode de production peuvent avoir joué un rôle dans l'accroissement de cette dernière. Utilisant la microscopie électronique à balayage avec la fluorescence X, nous avons examiné les glaçures de dix céramiques byzantines : Impressed White Ware ; Polychrome White Ware; Green and Brown Painted Ware ; Fine Style Sgraffito, Aegean Ware, Zeuxippus Ware and St. Symeon Ware. Ces groupes ont été sélectionnés pour analyser les développements chronologiques intervenus dans la technique de la glaçure.

Investigation of the glazes applied to Byzantine ceramics arose from a more comprehensive enquiry into the transformation of production and dispersion of Byzantine ceramics which took place during the eleventh century. It forms part of an ongoing multidisciplinary examination of the stimuli that brought about these developments, and their ramifications for Byzantine culture in general. The larger question is being approached in three ways: technological, artistic and economic. This paper is concerned with the first, the technology involved in the production of Byzantine ceramics. The lack of preserved kilns precludes investigation in that area; however investigation of the glazes that survive on various types of vessel provides a convenient keyhole through which to view technological skills. By technology is meant the composition of particular glazes, the deliberate addition of substances to change the quality and properties of the glazes, and the nature of the bodies to which they were meant to adhere, and whether there is any correlation between body and glaze. Any changes that might be detected in the technology may then be related to corresponding changes in the greater evolution of Byzantine ceramics.

What was the "greater evolution" ? In essence it could be described as a transition from centralized to dispersed production of glazed pottery. In the ninth and tenth centuries large quantities of glazed wares were in use in Constantinople (Hayes 1992 : 12-13). Although also found at every major and minor Byzantine site from Otranto to Kiev, at sites other than the capital they occur only in relatively small numbers, and are always a small proportion of the overall pottery from a particular site, compared with the unglazed wares (Armstrong 1996 : fig. 1). Although no glazed-ware-producing kilns of these centuries have been found in Constantinople, the general concensus of opinion agrees that they were produced in that city (Hayes 1992 : 12). They are characterized by their distinctive fabric, from which their generic name, `White Wares', is derived. The white fabric varies from a coarse, gritty grey white, which may fire to shades of pale pink, to an exceptionally fine, pure white fabric. The coarser fabric tended to be used for utilitarian vessels: lamps, candlesticks, chafing dishes, bowls and jugs, while the finer version was used for architectural ceramics, revetement tiles and icons, as well as bowls and cups with very thin walls. The latter group was delicately painted, frequently with Islamic-like designs, and is known as Polychrome White Ware (Talbot Rice 1954).

In the provinces, during the course of the eleventh century, the proportion of glazed to unglazed wares changed dramatically with the advent of red-bodied glazed wares. From that period on "refined" table wares with glazes are found on rural sites in greater quantities than ever glazed White Wares had occurred on the same or similar sites (Armstrong 1989). Analytical work has shown that they were produced at a number of different locations (Megaw and Jones 1981). Therefore there is much greater variation in the fabrics of Red Wares than White Wares. The Red Wares of Thessalonike and Macedonia tend to be orange or brick red, and relatively soft; those of the west coast of Asia Minor are red and hard; while the Red Wares of the eastern Peloponnese can be pale cream, almost white, to pale pink, rather than red. [1] Even so, in Byzantine terminology, vessels with pale-coloured bodies, such as those produced at Corinth and Argos (as 6 here) are "Red Wares", in contrast to "White Wares" which are associated with Constantinople and an earlier period of production. They can be distinguished from each other in that Red Wares, even the whitish versions, have a coating of white slip as part of their decoration, while White Wares were never slipped.

1 These are very generalized descriptions ; obviously there will be regional variations within those areas.

This was probably adopted in order to achieve the appearance of a white body, which seems to have been the potters' ideal type. The coating of slip also played a significant role in the new decorative techniques of Red Wares, either by providing a smooth and light-coloured background for painted motifs, or a strong contrast for patterns etched through it onto the darker body below.

WARES TESTED

The individual sherds investigated here were selected as examples of White Wares (1-4) from the ninth and tenth centuries, Red Wares of the eleventh and twelfth centuries (5-7), and finally Red Wares of the Crusader period (8-10), that is, of the early thirteenth century. All the sherds examined are in the collections of either the Victoria and Albert Museum, London, or the Ashmolean Museum, Oxford.[2] Table 1 indicates the provenance and present location of the individual pieces.

1 and 2 are Impressed White Ware bowls (Hayes 1992 : 18-29).[3] The decoration, often roughly rendered, was either stamped on to the wet vessel, or sometimes the vessel itself was pressed on to a mould.[4] The clay is relatively coarse, particularly for the production of table or fine wares. There is no intervening slip, and the thick coating of glaze, always green or yellow, was applied directly to the body. 1 shows the profile of a bird looking left under a dark green glaze, which extends to the top of the footplate on the outer surface. 2 has a floral motif at the centre of the floor and yellow-green glaze on the inner surface only. While 1 and 2 were found in excavations in the city of Lakedaimon, ancient Sparta, their place of manufacture was almost certainly Constantinople[5].

3 and 4 are Polychrome White Ware bowls (Talbot Rice 1954; Hayes 1992 : 35-37). The fabric is fine and white. The colours employed in their decoration were matt-red, yellow, and black or dark brown. There is a thin, pale green glaze covering all of the exterior. The area of yellow glaze was examined for this study. 3 and 4 were found in Constantinople, where they were probably made.

5 is from a Green and Brown Painted bowl (Morgan 1942 : 72-75). Green and Brown Painted Wares seem to have been the successors of Polychrome Ware in that the colours were often tinted glazes. The red clay body of 5, coarse-textured, porous and micaceous, with small grey grits and quartz inclusions, was coated with a thick white slip, on to which a decoration was painted in a green glaze. There is a thin, clear glaze covering the interior of the vessel, so thin as to be scarcely visible to the naked eye. Both the green and the clear glazes were tested. 5 was a product of Lakedaimon, from where it was excavated[6].

6 is an example of a Fine Style Sgraffito bowl (Morgan 1942 : 120-123). The white slip covering the interior has been carefully scratched with a fine-pointed tool to reveal spiral motifs on the clay body. The fabric is pale-cream, almost flesh coloured, with many small to medium black and dark red angular inclusions. The interior covered with a pale-green glaze glaze, which extends just over the rim. 6 was found on the surface at Zygouries, a low hill near ancient Mycenae, and was probably manufactured at Argos.[7]

7 is an Incised, or Aegean, Ware (Megaw 1975 : 34-45)[8]. It is made by the same technique as 6, but incised with a broad-bladed tool, which reveals more of the clay body so as to create a two-dimensional effect. The motif here is an animal, probably a deer. The fabric is brick red with many medium lime inclusions and small grey grits. A yellow glaze covers both the inner and outer surfaces, even extending under the foot. Agia Marina, the find spot of 7, is a separate site in the region of Zygouries; no place of production is posited.

8 is a particular type of incised ware, known as Zeuxippus Ware (Megaw 1968; Megaw 1989). This example is Zeuxippus class II, because it has added colour, bright green and yellow brown, to enhance the incision. True Zeuxippus Ware is distinguished by its fine, hard, red body and glossy, hard glazes, all of which characterize the piece examined here. The glaze is yellow to pale green. While 8 was found in Lakedaimon, Zeuxippus Ware has been found at a number of late Byzantine and/or Crusader sites throughout the eastern Mediterranean and Black Sea (Megaw 1968; Megaw 1989). Its place of manufacture is unknown and much debated (Calogero and Lazzerini 1983; Lazzerini and Calogero 1989).

9 and 10 are colour-enhanced incised wares found exclusively on Crusader sites of the eastern Mediterranean. (Lane 1937 : 45-53 ; Scott 1981 : 679-696). The colour of the fabric varies from light orange to pale red and is relatively coarse. The multiplicity of types of incised decorations are highlighted with green and either yellow brown or dark brown colours. The covering glaze is pale yellow. Discovery of

	Laboratory No.	Museum No.	Provenance	Present Location
1	CR9550	C36-1921	Lakedaimon	Victoria & Albert
2	CR9551	C11-1921	Lakedaimon	Victoria & Albert
3	CR9560	1993.14	Constantinople	Ashmolean
4	CR9559	1993.19	Constantinople	Ashmolean
5	CR9562	1923.243(5)	Lakedaimon	Ashmolean
6	CR9563	1964-440B	Zygouries	Ashmolean
7	CR9561	1996.570	Agia Marina	Ashmolean
8	CR9564	1923.243(22)	Lakedaimon	Ashmolean
9	CR9548	C303G1937	Al Mina	Victoria & Albert
10	CR9549	C304M1937	Al Mina	Victoria & Albert

Table 1 : Sources of Examined Vessels and Reference Numbers.

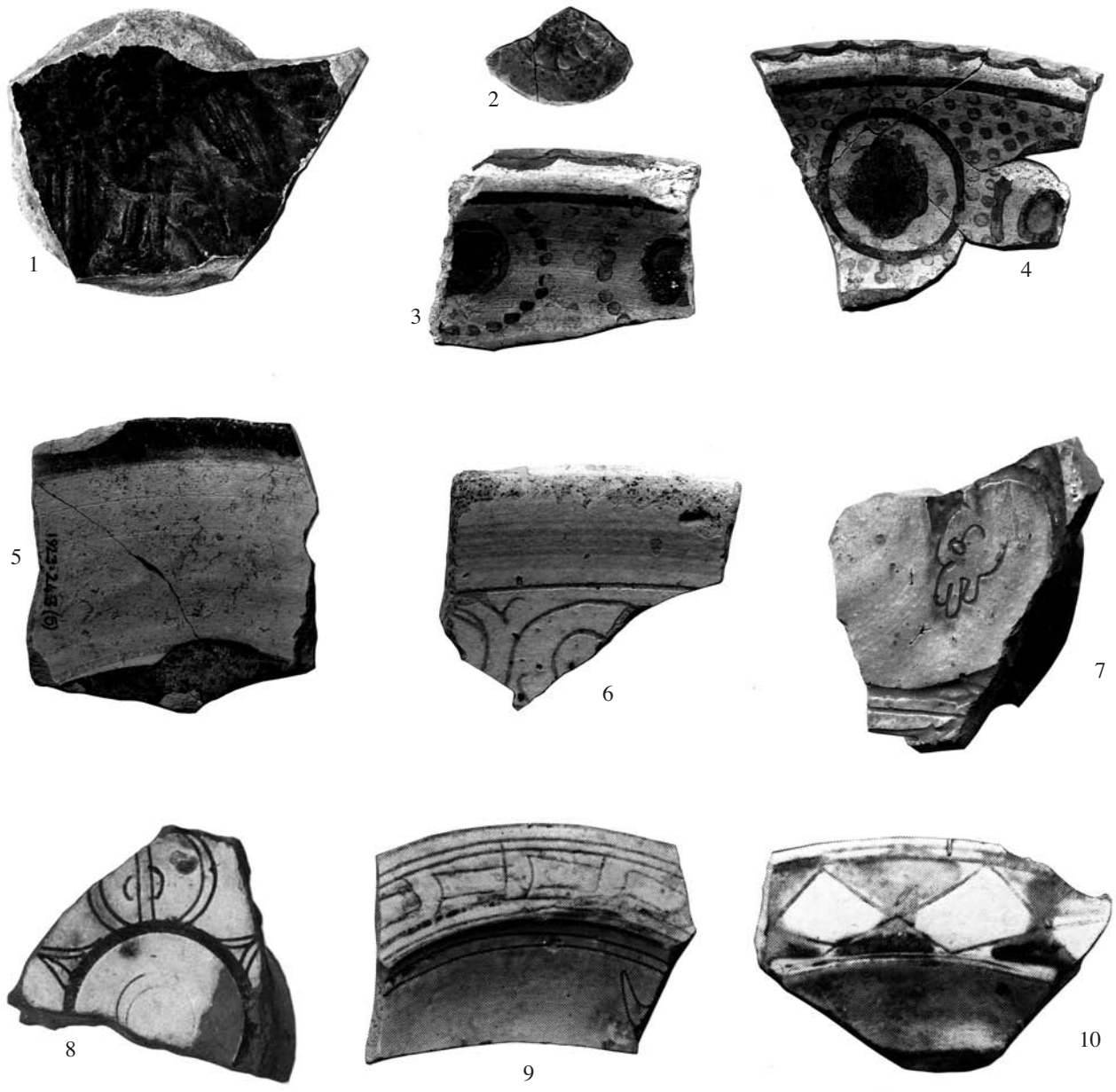

PLATE 1 : Actual sherds whose glazes are examined here. Not to scale.

2 We are grateful to Oliver Watson and Judith Crouch for their help and patience while working at the Victoria and Albert Museum. We were able to examine the pottery from the Ashmolean collections by courtesy of the Visitors of the Ashmolean Museum. The authors would like to thank Dr. Michael Vickers for his patient help while the samples were selected. 1-2 were given to the Victoria and Albert and 5 and 8 to the Ashmolean by the Department of Archaeology of the Ministry of Education of the Greek Republic, through Mr. A. M. Woodward. 6 and 7 were given to the Ashmolean by the Department of Archaeology of the Ministry of Education of the Greek Republic, through Dr. H. W. Catling. 9 and 10 were brought to London by Arthur Lane (Lane 1937 : 78).
3 They form part of his Glazed White Ware II group.
4 Armstrong 1996, 000, discusses the different techniques used to achieve an "impressed" decoration.
5 For reports of the excavations see Dickins 1905-6 : 394-406, esp. 404, and Dawkins, 1908-9 : 3. Other aspects of 1 and 2 have been treated elsewhere: see Armstrong 1996, where no. 14 = 1 here, and 22 = 2 here.
6 That it was a product of that city is the opinion of Armstrong, who is preparing a corpus of Byzantine ceramics from the excavations there for publication.
7 This opinion is based on discussions with Dr. A. Oikonomou, who has much experience of the Byzantine ceramics of Argos. Kilns producing such wares have been located during excavations there.
8 7 is not his low ring base type. See also Armstrong 1991 : 335-347, where 12 is similar to 7 here.

some wasters from its manufacture at the crusader port of St. Symeon (= Al Mina), gave it the name St. Symeon Ware. 9 and 10 were found in excavations at Al Mina. [9]

Experimental procedures

Polished sections through the glazes and into the body were examined in the SEM (Cameca SEMprobe) using the backscattered electron mode by which the phases present could be distinguished on the basis of differences in their atomic number, which are revealed by different shades of grey (eg quartz and other body phases appear darker than the higher atomic number glaze phase). The bulk chemical compositions of the bodies and glazes were determined using, respectively, attached energy-dispersive and wavelength-dispersive X-ray spectrometers (EDS and WDS) operating at 20kV and current of 10nA, areas in the section of up to 1mm and 100μm across respectively being analysed. These data are presented in Tables 2 and 3 respectively.

Results

The White Ware bodies are characterised by high alumina contents (20-27% Al203) and comparatively low iron contents (less than 3% FeO). The Red Ware bodies are characterised by high iron contents (7-10% FeO) but are otherwise more variable in composition. The sherd probably manufactured at Argos (6) and the three Crusader period sherds (8, 9, 10) are all made from calcareous clays but with lime contents ranging from 10-30% CaO. In contrast, the remaining two eleventh/twelfth-century sherds (5, 7) are made from non-calcareous clays. On the basis of the vitrification observed in cross-section in the SEM, both White Wares and Red Wares were probably fired in the temperature range 900-1000•C.

Both the White Ware and the Red Ware glazes are all of the transparent high lead type with a lead oxide content (PbO) typically in the range 60-70%, an alkali content (Na20 + K2O) less than 1% and an alumina content (Al203) in the range 1-7%. The principal difference between the glazes analysed is that the Polychrome White Ware and Crusader period Red Ware glazes contain less alumina (0.9 - 1.4% and 1.4 - 2.3% Al2O3 respectively) than the Impressed White Ware and eleventh/twelfth-century Red Ware glazes (3-7% Al2O3). Copper colorant (1-4% CuO is present in sherds 1, 5 and 9 and iron colorant (1-5% FeO) in sherds 3, 4, 6 and 10. The FeO content of 5 is probably from the body rather than the glaze, and reflects the thinness and poor quality of the covering glaze. Otherwise the glazes contain less than 1% FeO.

A high lead glaze slurry can be prepared directly from a mixture of silica (eg quartz sand or ground flint), a lead com-

%	SiO2	TiO2	Al2O3	FeO	MnO	MgO	CaO	K2O
1	65.8	1.3	27.3	2.7	<0.1	nd	1.6	1.3
2	74.0	1.8	19.5	1.6	<0.1	nd	1.0	2.0
3	75.4	0.4	22.0	0.1	0.1	nd	1.7	0.4
4	69.6	1.2	25.1	1.8	0.3	nd	1.1	1.0
5	67.7	0.6	18.9	7.6	0.6	nd	0.9	3.7
6	47.5	0.8	12.3	7.6	0.2	0.9	27.9	2.8
7	57.6	1.0	23.0	7.7	0.2	0.9	5.2	4.5
8	64.1	0.9	12.6	7.5	0.3	1.5	10.1	3.1
9	56.4	0.8	10.9	7.7	<0.1	2.0	19.2	3.0
10	49.9	1.2	11.5	9.8	0.1	6.3	18.8	2.5

Table 2 : Standardless EDS Analysis of Body Fabric. Results have been normalised to 100%. All sodium results were below detection limit. Magnesium results may be low, and iron results high, by this method.

%	SiO 2	TiO 2	Al2O 3	FeO	Mn O	Mg O	CaO	Na2 O	K2O	PbO	CuO
1	20.4	nd	6.7	0.5	nd	0.4	0.4	nd	0.2	68.5	2.89
2	21.4	0.2	5.8	0.2	nd	0.1	0.1	nd	0.3	71.7	0.08
3	26.5	0.1	0.9	4.6	nd	0.1	0.6	0.7	0.2	65.8	0.28
4	26.5	0.1	1.4	5.3	0.1	0.2	1.4	1.1	0.3	62.5	0.33
5gr	24.9	0.3	5.7	0.9	nd	0.3	1.1	0.2	0.4	61.7	4.43
5cl	23.9	0.2	4.5	2.8	nd	0.4	0.9	0.4	0.4	59.4	2.47
6	34.8	nd	3.2	1.2	0.1	0.7	4.0	0.4	1.6	53.9	0.10
7	29.5	0.1	6.8	0.5	0.1	0.3	0.6	0.4	0.8	60.7	0.21
8	28.0	nd	1.5	0.1	0.1	0.1	0.4	0.1	0.2	69.5	0.08
9	27.6	0.1	1.6	0.8	0.1	0.6	2.7	0.1	0.7	64.4	1.09
10	33.9	nd	2.3	2.3	0.1	0.6	0.7	0.1	0.6	59.3	0.06

Table 3. WDS Analysis of Glazes. Results have been normalised to 100%.

pound (eg litharge or red lead) and clay which is the source of the alumina. The clay component is important in the application of the glaze since it helps to maintain the lead oxide particles in suspension and also gives plasticity to the glaze slurry. Further, the presence of clay facilitates the application of the glaze to a leather hard body since, as a result of its clay content, the shrinkage of the glaze during drying will be similar to that of the body.

High lead glazes have a low maturing temperature, typically in the range 900-1000•C, so that high quality glazes with even coatings over the surfaces of the bodies and the elimination of any pinholes in the surfaces can be produced at comparatively low firing temperatures.

High lead glazes have the further advantage of a significantly lower low thermal expansion as compared to that for alkali glazes. The contraction of such high lead glazes during cooling following firing is therefore comparable to that for typical White Ware and Red Ware bodies and thus cracking or "crazing" of the glaze surface is avoided. The avoidance of `crazing' is further helped by the greater elasticity of high lead glazes as compared to alkali glazes.

Conclusions

The first use of high lead transparent glazes in the West seems to have occurred during the Roman era (Picon 1986; Symonds 1995). Subsequently such glazes continued to be used throughout Europe and the Near East more or less up to the present day (Jones 1950; Hochuli-Gysel 1977; Symonds 1989; Hatcher,1994), including being applied to Islamic pottery contemporary with the Byzantine pottery under investigation.[10] However in the Islamic world types of glazes were varied (Mason 1994), while the Byzantine ones were more uniformly consistent.

The above results show that there are no obvious changes in Byzantine glazing technology from the ninth until the thirteenth centuries, when other aspects of ceramic production underwent radical changes, and, in particular, very similar high lead transparent glazes are used for both the White Wares and the Red Wares. This means that there were no external stimuli from technological sources which might have brought about the great change from centralized to dispersed production of Byzantine glazed ceramics, and other approaches to the problem remain to be examined elsewhere.

Bibliography

Armstrong 1989 : ARMSTRONG (P.).— Some Byzantine and Later Settlements in Eastern Phokis. *Annual of the British School at Athens*, 84, 1989, p. 1-42.

Armstrong 1991 : ARMSTRONG (P.).— A Group of Byzantine Bowls from Skopelos. *Oxford Journal of Archaeology*, 10.3, 1991, p. 335-347.

Armstrong 1996 : ARMSTRONG (P.).— From Constantinople to Lakedaimon: Impressed White Wares. *In :* A Mosaic of Byzantine and Cypriot Studies in Honour of A. H. S. Megaw, Herrin (J.), Mullett (M.E.M.), Otten-Froux (C.) (edd.), London, forthcoming 1996.

Armstrong : ARMSTRONG (P.), HATCHER (H.).— Byzantine and Allied Pottery, Phase II: Past Work on Materials Analysis and Future Prospects. *In :* Materials Analysis of Byzantine and Related Pottery, Dumbarton Oaks Publications, Washington, forthcoming.

Calogero 1983 : CALOGERO (S.), LAZZARINI (L.).— Caratterizzazione chimico-fisica di ceramiche graffite bizantine e veneziane arcaiche trovate nella laguna veneta. *Faenza*, 69, 1983, p. 60-70.

Dawkins 1908-9 : DAWKINS (R.M.).— *Annual of the British School at Athens*, 15, 1908-9, p. 3.

Dickins 1905-6 : DICKINS (G.).— Laconia II. Excavations at Sparta. 1906, *Annual of the British School at Athens*, 12, 1905-6, p. 394-406.

Hatcher 1994 : HATCHER (H.), KACZMARCZYK (A.), SCHERER (A.), SYMONDS (R.P.).— Chemical Classification and Provenance of Some Roman Glazed Ceramics. *American Journal of Archaeology*, 98, 1994, p. 431-56.

Hayes 1992 : HAYES (J.H.).— Excavations at Saraçhane in Istanbul, Vol. 2, *The Pottery*, Princeton, 1992.

Hochuli-Gysel 1977 : HOCHULI-GYSEL (A.).— Kleinasiatische glasierte Reliefkeramik (50 v. Chr. bis 50 n. Chr.) und ihre oberitalischen Nachahmungen, Acta Bernensia, Bern, 1977.

Jones 1950 : JONES (F.F.).— The Pottery. *In :* Excavations at Gözlü Kule, Tarsus I: The Hellenistic and Roman Periods, Princeton, 1950.

Lane 1937 : LANE (A.).— Medieval Finds at Al Mina in North Syria. *Archaeologia*, 87, 1937, p. 19-78.

Lazzarini 1989 : LAZZARINI (L.), CALOGERO (S.).— Early Local and Imported Byzantine Sgraffito Ware in Venice: A Characterization and Provenance Study. *In :* Archaeometry. Proceedings of the 25th International symposium (1989), Maniatis (Y.) (ed.), p. 571-584.

Mason 1994 : MASON (R.).— Islamic Glazed Pottery, *700-1250*, D.Phil. thesis, Faculty of Anthropology and Geography, University of Oxford, 1994.

Megaw 1968 : MEGAW (A.H.S.).— Zeuxippus Ware, *Annual of the British School at Athens*, 63, 1968, p. 67-88.

Megaw 1975 : MEGAW (A.H.S.).— An Early Thirteenth-century Aegean Glazed Ware. In *Studies in Memory of David Talbot Rice*, Robertson (G.), Henderson (G.) (edd.), Edinburgh, 1975, p. 34-45.

Megaw 1981 : MEGAW (A.H.S.), JONES (R.).— Byzantine and Allied Pottery: A Contribution by Chemical Analysis to Problems of Origin and Distribution. *Annual of the British School at Athens*, 78, 1981, p. 235-263.

Megaw 1989 : MEGAW (A.H.S.).— Zeuxippus Ware Again. Recherches sur la Céramique Byzantine, *Bulletin de Correspondance Hellénique*, Supplement 18, DÉROCHE (V.), SPIESER (J.-M.) (edd.), Paris, 1989, p. 259-266.

Morgan 1942 : MORGAN (C.H.).— Corinth XI, The Byzantine Pottery, Cambridge, Mass., 1942.

Picon 1986 : PICON (M.), DESBAT (A.).— Note sur l'origine des céramiques à glaçure plombifère, généralement bicolore, des IIe et IIIe siècles, de Vienne et Saint-Romain-en-Gal. *Figlina*, 7, 1986, p. 125-127.

Scott 1981 : SCOTT (J.A.), KAMILLI (D.C.).— Late Byzantine Glazed Pottery from Sardis. *In* : Actes du XV^{e} Congrès International des Etudes Byzantines (Athenes 1976), II, 1981, Athens, p. 679-696.

Symonds 1989 : SYMONDS (R.P.), HATCHER (H.).— La céramique à glaçure plombifère de l'époque romaine trouvée à Colchester et ailleurs: quelques analyses récentes. *In* : Société française d'étude de la céramique antique en Gaule, Actes du Congrès de Lezoux, 1989, p. 85-92.

Symonds 1995 : SYMONDS (R.P.), WADE (S.M.).— The Roman Pottery from Excavations at Colchester, *1971-85*, Colchester Archaeological Report 10, Colchester, 1995.

Talbot Rice 1954 : TALBOT RICE (D.).— Byzantine Polychrome Pottery, A Survey of Recent Discoveries. *Cahiers Archaéologiques*, 7, 1954, p. 69-77.

Talbot Rice 1965 : TALBOT RICE (D.).— The Pottery of Byzantium and the Islamic World. *In :* Studies in Islamic Art and Architecture in Honour of Professor K. A. C. Cresswell, Cairo, 1965, p. 194-236.

9 For the excavation and detailed pottery report see Lane 1937. He illustrates the two sherds examined here: 9 is on plate XXI.1, top right hand corner, 10 is on plate XXI.2, second row from bottom, third sherd from left.

10 See however Hayes 1992 : 13-15, who disagrees with the concept of a continuous tradition of lead glazing from Roman times onwards in the east.