LRCW3
Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean

Archaeology and archaeometry

Comparison between western and eastern Mediterranean

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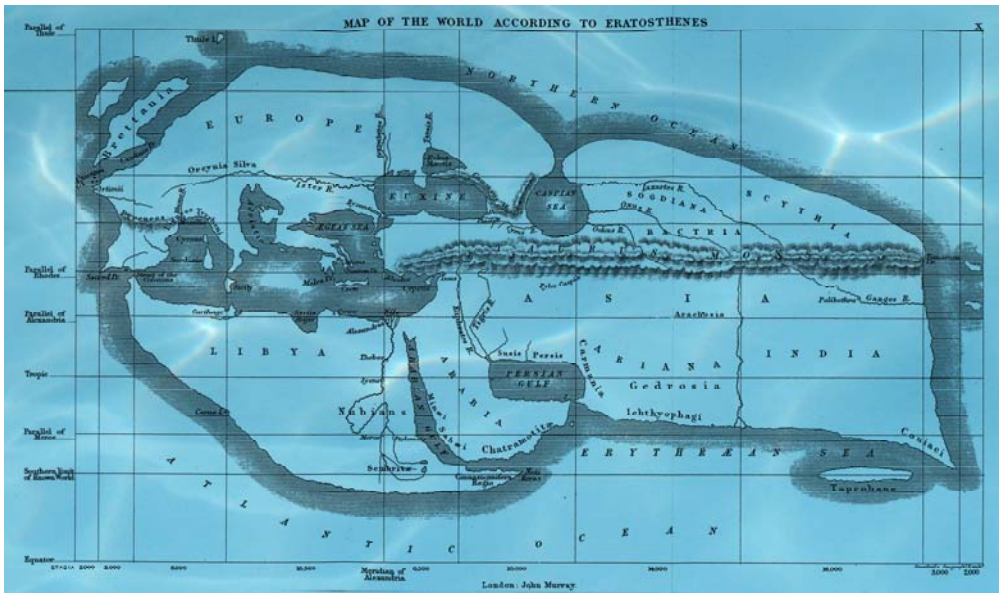

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COMPOSITION, TECHNOLOGY AND FUNCTION OF LATE ANTIQUE-BYZANTINE POTTERY FROM HIERAPOLIS (TURKEY)

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The paper illustrates results of archaeometric analyses performed on samples of Late Antique kitchenwares and plain basins from excavations carried out in insula 104 at Hierapolis (Turkey). Laboratory post-excavation work was part of the activities undertaken under the aegis of the Italian Archaeological Mission at Hierapolis (MAIER) directed by F. D'Andria. The aim of analytical research was to implement the morphological study of the retrieved ceramics combining traditional approaches with applied sciences and techniques. Altogether fifty-six ceramic samples underwent a series of archaeometric analyses (MGR, WD-XRF and thin section analysis) and laboratory tests (water permeability, thermal shock resistance) in order to acquire information on pottery composition, provenience, as well as on clays functional properties.

KEYWORDS: BYZANTINE POTTERY, WATER PERMEABILITY, THERMAL SHOCK RESISTANCE.

INTRODUCTION

Interdisciplinary research was recently undertaken on Late Antique and Byzantine ceramics from Hierapolis (Phrygia) aiming to investigate their composition, technology and function. The project was part of research activities conducted in 2006-2007 by the Italian Archaeological Mission at Hierapolis (MAIER), directed by F. D'Andria. Preliminary results of fieldwork and laboratory analysis are presented in this volume in two separate complementary papers. Each of them explores different aspects in pottery study, combining applied sciences and traditional approaches in the effort to acquire an increasing amount of micro and macro information from the studied ceramic assemblages. The final goal is to achieve a deeper understanding of change and continuity in pottery manufacture, function and technology from Late Antiquity to the Mid-Byzantine period. Data so far collected, will represent a starting platform for future research on pottery circulation, production technology, diet and dining habits at Hierapolis.

The present contribution focuses on results of archaeometric analysis carried out on archaeological ceramics from *insula* 104, while other papers discuss data on raw clay characterisation (cfr. Daszkiewicz et al. in this volume) and pottery residue analysis (cfr. Cottica and Notarstefano forthcoming).
56 ceramic fragments were selected by D. Cottica for laboratory analysis (finewares, kitchenwares, plain basins and a reference collection of over-fired common wares). These sherds underwent a comprehensive series of laboratory tests aimed at establishing the composition of the ceramic body from which they were made, identifying the technology used in their manufacture and determining the vessels' functional properties. The following analytical procedures were employed: MGR-analysis (Daszkiewicz & Schneider 2001), chemical analysis by WD-XRF, thin-section studies, measurement of ceramic properties and analysis of water permeability and thermal shock resistance. MGR-analysis was carried out for all samples. Subsequently, having been classified according to the thermal behaviour of the ceramic matrix and categorised into clastic material groups, a number of samples were chosen for chemical analysis and thin-section studies. This article presents only the results of analyses carried out on kitchenware and basins; the results of all analyses will be published in a monograph currently in preparation (Cottica forthcoming).

THE ARCHAEOLOGICAL CONTEXT

Excavations in *insula* 104 started in 1990 under the direction of A. Zaccaria Ruggiu (University of Venice Ca' Foscari); the primary aim of the research project is the analysis and study of private architecture at Hierapolis. The *insula* is sited immediately north-west of the Roman theatre and lies very close to the site of the sanctuary of Apollo. In Late Antiquity at least three houses occupied the area: one stretched from north to south, across the eastern terrace (the so-called "House of the Doric Court"), a peristyle house extended north-southwards across the central terrace ("House of the Ionic Capitals") and a third building, currently under investigation, was located on the western lower terrace (cfr. D'Andria *et al.* 2008, 121-122, Fig. 119 and Foglio 34). This latter building was named "House of the Painted Inscription" after the discovery in 2004 of a painted inscribed text on the walls of one of its rooms. The discovery and study of this inscription, reporting the text of the "Prayer of Salomon" known from the Apocrypha, provide crucial information on the history and spread of Christianity in Hierapolis and western Anatolia (cfr. D'Andria *et al.* 2006).

Although some of the still standing walls can be dated to the reigns of Domitian and Hadrian, excavations have brought to light only the final period of occupation of the complex, its abandonment and collapse, spanning the period from the fifth to the seventh century AD (cfr. Zaccaria Ruggiu & Cottica 2009). Archaeological evidence indicates that by the early seventh century, the houses had entered a period of change and contraction: spatial reorganisation had took place with the walling off of several rooms and partial abandonment of some others. Finds and ceramic assemblage composition suggest that by the early seventh century several rooms had been abandoned and used as dumping areas, while some others had changed their original function. Buildings in this *insula* eventually collapsed because of an earthquake that occurred sometime in the seventh century AD. The latest coins retrieved from the

collapsed debris on floor levels are issues of the Emperor Heraclius, while the latest (diagnostic) ceramics sealed by the collapsed debris are imitations of ARSW Form 106 and PRSW Form Hayes 10, dating to the seventh century AD. After the collapse of the Late Antique town houses, only a small space in the area of the former "House of the Painted Inscription" was temporarily reused for storing hay, or straw, sometime in the late VII-VIII centuries AD (Cottica 2006). From the time of the destruction of the Late Antique houses, the site was left in abandonment, exposed to robbing and spoliation.

Around the late IX - early X century AD, the debris of the Late Antique houses was levelled to form an even surface suitable for further building activities. New dwellings appeared in the area, together with new morphological (and functional) ceramic types (cfr. Cottica 2007b). The dwellings were organized around an open central space, more-or-less located in the area of the former peristyle of the "House of the Ionic Capitals". Functional structures, such as paddocks and hay-lofts, were scattered in the open spaces amidst the dwellings. Therefore by the X century AD, the "ruralization" of the urban landscape of Hierapolis had been completed and a proper Byzantine settlement had replaced the former classical and early Christian town.

[D.C.]

THE ANALYSED COOKING/KITCHEN AND COARSE WARES: MORPHOLOGY AND CHRONOLOGY

Most of the pots of everyday use in Late Antique Hierapolis (including cooking pots, storage jars, basins, tableware and amphorae) are regional morphological types (Cottica 2005, 2007a). Although the majority of the ceramics from sites in the Lykos valley are still unpublished, preliminary studies (such as Gelichi & Negrelli 2000, 2004; Şimşek 2007, 356-365) and observation by the author suggest that a large number of these regional ceramic types had a significant distribution among the cities of the Lykos valley, such as Tripolis, Laodicea, Colossae and Hierapolis. At the same time, in the present state of knowledge, they find little direct *comparanda* outside the Lykos valley.

A selection of morphological types common in Late Antique contexts at *insula* 104, as elsewhere in Hierapolis, was chosen for archaeometric analysis in order to define their composition (and eventually provenance) and explore their functional and technological properties. Sampled vessels included VI - early VII century AD cooking pots featuring a distinctive globular body with a short collar and sagging base (Fig. 1 nn. 1-2). Two versions were in contemporary use: with and without handles. When present the latter had a distinctive ear-shape. From a macroscopic point of view, Late Antique kitchenwares are usually characterised by an iron-rich clay matrix with metamorphic inclusions of fairly standard size and frequency (cfr. Cottica 2005, Fig. 1 A-B), while coarse wares display a calcareous matrix with metamorphic inclusions (cfr. Cottica 2005, Fig. 1 F-H). Well visible traces of scorching on the bottom of several of these pots suggest that they were mainly used for cooking, although they could also have been used for storage.

For comparative purposes a number of Mid-Byzantine cooking pots, common in X century contexts at Hierapolis, were analysed: these are characterised by a red, highly micaceous fabric, flat base (Fig. 1 nn. 7-8), rounded and often ribbed body (Fig. 1 n. 5). Versions with strap handles attached to an out-flaring rim were also in use (cfr. Cottica 2007b, Fig. 11 nn. 1-3). Scorched areas are frequently present on the lower body and bottom of these vessels.

Finally, analyses concentrated on a very distinctive group of basins in light buff plain ware, which are very common in Late Antique contexts at Hierapolis: their original function is not certain but, on the basis of their overall morphology and size, they were probably used for holding liquids and washing. Indeed, archaeological evidence suggests that broken basins were frequently reused as building material (together with amphorae body sherds). The most common types in use in Late Antique Hierapolis have straight and ribbed body walls, thickened vertical rim with a short listel on the exterior (Fig. 1 n. 3); misfired basins of this latter type are present among the debris of kilns dating from around the V century AD, found in the *agora* area (Fig. 1 n. 4). Basins with a thickened and hooked flanged rim are also widespread in Late Antique contexts (cfr. Cottica 2000, Fig. 5 n. 38).

[D.C.]

ARCHAEOMETRIC ANALYSIS

Analysis was carried out on four fragments of plain basins and 12 samples taken from seven different kitchenware vessels. One sample was taken from each of three kitchenware vessels, two samples being removed from various parts of a further three vessels and another three samples being taken from various parts of one vessel. Several sherds from a single vessel were analysed in order to assess whether there was any variation in the distribution of grains of temper and to see whether there was any noticeable temperature gradient associated with the vessel's original firing or usage.

MGR-analysis revealed that kitchenware vessels were made from a variety of non-calcareous iron-rich clays. On refiring at 1200°C two samples (Fig. 2a, vessel no.5) became slightly over-melted (i.e. over-melting of the sample surface was observed, but there was no change in shape, and the edges remained sharp) and fired to a greyish-brown colour. The remaining samples after refiring at 1200°C were only sintered (i.e. the sherd is well compacted, it may or may not become smaller in size in comparison to the original sample, whilst its edges remain sharp) and fired to a reddish-brown colour, or else fired to various shades of brown-red. Seven MGR-groups were identified equating to individual vessels (the same MGR-group indicates the same matrix type, and hence that the pottery sherds in question were made from a ceramic body prepared from the same plastic raw material). This demonstrates that the vessels selected for analysis represent seven different raw material groups. Taking into account the results of chemical analysis these seven MGR-groups can be combined into three groups of similar chemical composition (Fig. 2a, Tab. 1). Vessel No. 5 differs significantly from the rest, both in terms of its distinctive thermal behaviour and chemical composition (chemical group 3; low Ti, Cr, Ni, Zr). Groups 2 and 3 feature four Middle Byzantine vessels, whilst group 1 comprises two Late Antique vessels and one Middle Byzantine vessel. A greater number of kitchenware sherds would have to be analysed to determine whether or not groups 2 and 3 are associated solely with the Middle Byzantine period.

MGR-analysis did not reveal any differences in original firing temperature in individual vessels. Similarly, no significant differences were noted in the distribution of non-plastic components. Figure 3 shows two samples removed from the same vessel (No. 4); in both cases changes in colour are visible after refiring at 900°C, indicating that the original firing temperature has been exceeded. Thus, the equivalent original firing temperature of this vessel falls within a range of 800-900°C. Observation of the non-plastic particles in all 20 specimens reveals that the grains within the temper were not evenly mixed (Fig. 3). Analysis of thin-sections shows that

these grains consist of metamorphic quartz (quartz which turns out light in a wavy manner), and metamorphic rock fragments (quartz + muscovite) (Fig. 4).

The same types of non-plastic particles are visible in all of the kitchenware sherds, individual samples differing only in the size of grain present. Two Late Antique vessels differ from the Middle Byzantine vessels in having a smaller content of coarse grains. In contrast to Middle Byzantine kitchenwares, Late Antique kitchenwares feature a predominance of grains in fractions of up to 0.5 mm and only isolated grains of *c*. 1 mm in diameter (Fig. 4, samples 72, MD3636 and 38, MD3639).

Samples taken from Late Antique basins were made from different raw materials than the kitchenware sherds. Two fragments were made of calcareous clay; after refiring at 1200°C they are olive-green in colour and have a flowed matrix type (i.e. the sample flows into a thin layer) (Fig.2b; samples 83, MD3641 and 91). Two further plain basin samples were made from non-calcareous, calcium-rich clays. One of them has an over-fired matrix type (i.e. the sample changes in shape, though bloating does not occur, nor does the surface of the sample become over-melted) and fires brown at 1200°C (Fig. 2b; sample 74, MD3640); after refiring, the second sample has a slightly over-melted matrix type and becomes dark brown in colour (Fig. 2b; sample 191, MD3660). In sample 191, MD3660 carbonate concentrations are visible macroscopically after refiring (first emerging after refiring at 800°C, Fig. 3); these concentrations are particularly noticeable within elongated pores.

The chemical composition of basins corresponds to MGR-groups (Tab. 1). However, basins made of non-calcareous, calcium-rich clays do not differ sufficiently in chemical composition to exclude the possibility that after examining a larger number of samples the differences between them may prove to stem solely from the variation in chemical composition inherent within one raw material source and from the effect on chemical composition of the secondary carbonates visible within the pores. The twofold difference in the ratio of CaO to strontium (a correlate of calcium) may result from the secondary deposition in the sherd of carbonates of a markedly different provenance. The similar provenance of two basins is further attested by the results of thin-section studies; in both instances a non-calcareous matrix with an abundance of fine micas (0.15 mm) and elongated cryptocrystalline aggregates is observed. Grains of quartz, cryptocrystalline carbonates, and few grains of coarse crystalline carbonates and fine micas are visible in the thin-section of the basin made of calcareous clay (Fig. 4).

Gauging ceramic properties by hydrostatic weighing reveals little differentiation between kitchenware vessels and basins, the latter yielding marginally poorer results. It would be worth verifying this tendency by carrying out tests on a much larger number of samples. The assessments carried out thus far evince that basins have a greater open porosity (22-28%), greater water absorption (12-16%) and a lower apparent density (1.77-1.84 g/cm^3) than vessels of the kitchenware variety, which have an open porosity of 18-24%, water absorption values of 8-13% and an apparent density of 1.9-2.11 g/cm^3. These two types of pottery vessel do not only differ in terms of their ceramic properties; their functional properties are also notably different. Functional properties were estimated by gauging water permeability. Three measurements were carried out for each sample, the first reading being taken following the mechanical removal of impurities from the pores of each sample, which was effected by boiling in distilled water. The second reading was taken after heating at 400°C (to remove any possible trace of organic treatment from the pores), the third reading being taken after tenfold thermal shock with ΔT 400°C. Each assessment was carried out over 24 hours in controlled conditions. Figure 5 shows water permeability curves plotted against time for kitchenware vessel No. 1 (Fig. 5, sample 58, MD3638) and for a basin made of non-calcareous clay (Fig. 5, sample 191, MD3660).

The three curves of the kitchenware vessel overlie one another and, with the exception of the value recorded in the first minute of the reading, water permeability is almost equal to zero. This means that the vessel's inner surface was made in such a fashion that it is impermeable to water, and that the vessel was made using raw materials appropriate for kitchenware. The curves also reveal that this vessel is very resistant to thermal shock. The readings obtained for basins are entirely different. The first curve does not match those of the subsequent readings, which in turn do not match one another. In contrast to the kitchenware vessel, the basin's water permeability does not amount to zero. These results indicate that the inner surface of the basin had already been breached by a small amount of water during the first reading (though in this instance the water did not permeate through the outer surface), that an organic substance was deposited within its open pores (resulting from the vessel's use?) and that, unlike the kitchenwares, this basin was not resistant to thermal shock. Water permeated through the outer surface of one of the basins after 400 minutes had elapsed. This shows that it could only have been used for holding liquids over a limited period of time.

[M.D.; E.B.; G.S.]

CONCLUSIONS

All of the kitchenware vessels analysed were made from various non-calcareous clays with a temper comprising metamorphic rock fragments and grains of metamorphic quartz. Kitchenware dated to the Late Antique period differs slightly from that of the Middle Byzantine period in the grain size of the ceramic temper. Basins were made of calcareous clay and micaceous non-calcareous clay.

All of the analysed kitchenware vessels are impermeable and resistant to thermal shock; basins are not resistant to thermal shock and some are permeable after the elapse of 400 minutes. Analysis results show that raw materials were specifically chosen to be appropriate to the vessel's intended use.

To-date no clay deposits have been found in the Hierapolis region which might represent the raw materials used for making kitchenware (for a preliminary report on analysis of local raw materials see Daszkiewicz et al. in this volume); however, there are locally available mineral-rock sources which correspond to the non-plastic particles noted in kitchenware vessel sherds. Two basin fragments recovered from excavations at *insula* 104 (cfr. Fig. 2b nn. 83 and 91) were made from a raw material with a similar chemical composition to the kiln waste samples for which a local clay source has been identified (cfr. Daszkiewicz et al. in this volume Fig. 4 samples MD3644 and MD3649 and clay sample MD3963).

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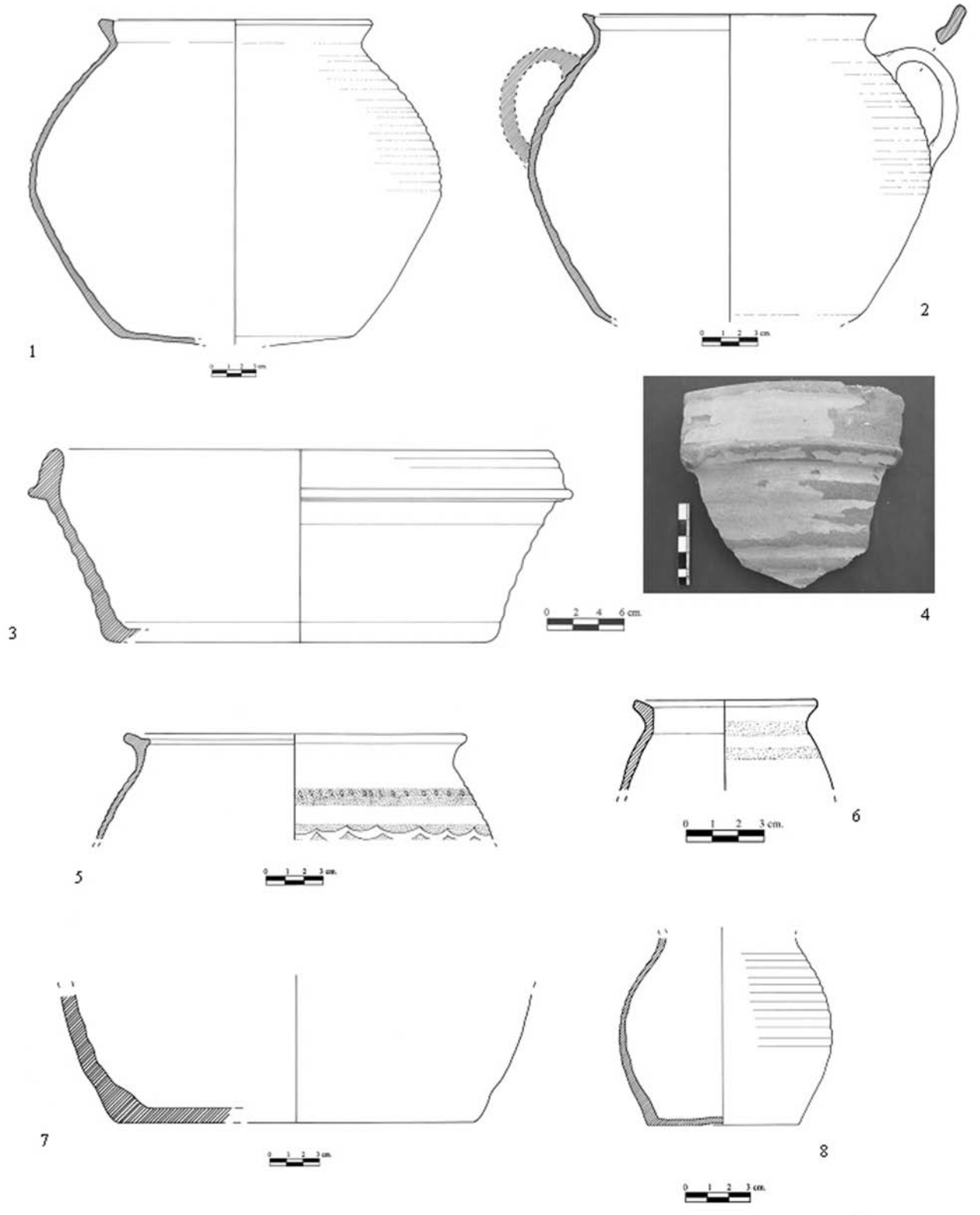

Fig. 1. Morphology of analysed cooking/kitchenwares and plain basins. Nn. 1-2 (samples 72 and 75 in Table 1): Late Antique cooking pots/jars (VI to early VII century A.D.); n. 3 (sample 83 in Table 1) typical Late Antique basin from Hierapolis; n. 4 misfired basin from the *agorà* of Hierapolis; n. 5 (sample 43 in Table 1) upper portion of Mid-Byzantine cooking pot/jar with painted and incised decoration; n. 6 (sample 58 in Table 1) Mid-Byzantine miniature jar with painted decoration; n. 7 (sample 38 in Table 1) lower body of Mid-Byzantine cooking pot/jar; n. 8 (sample 46 in Table 1) fragmentary Mid-Byzantine small jar.

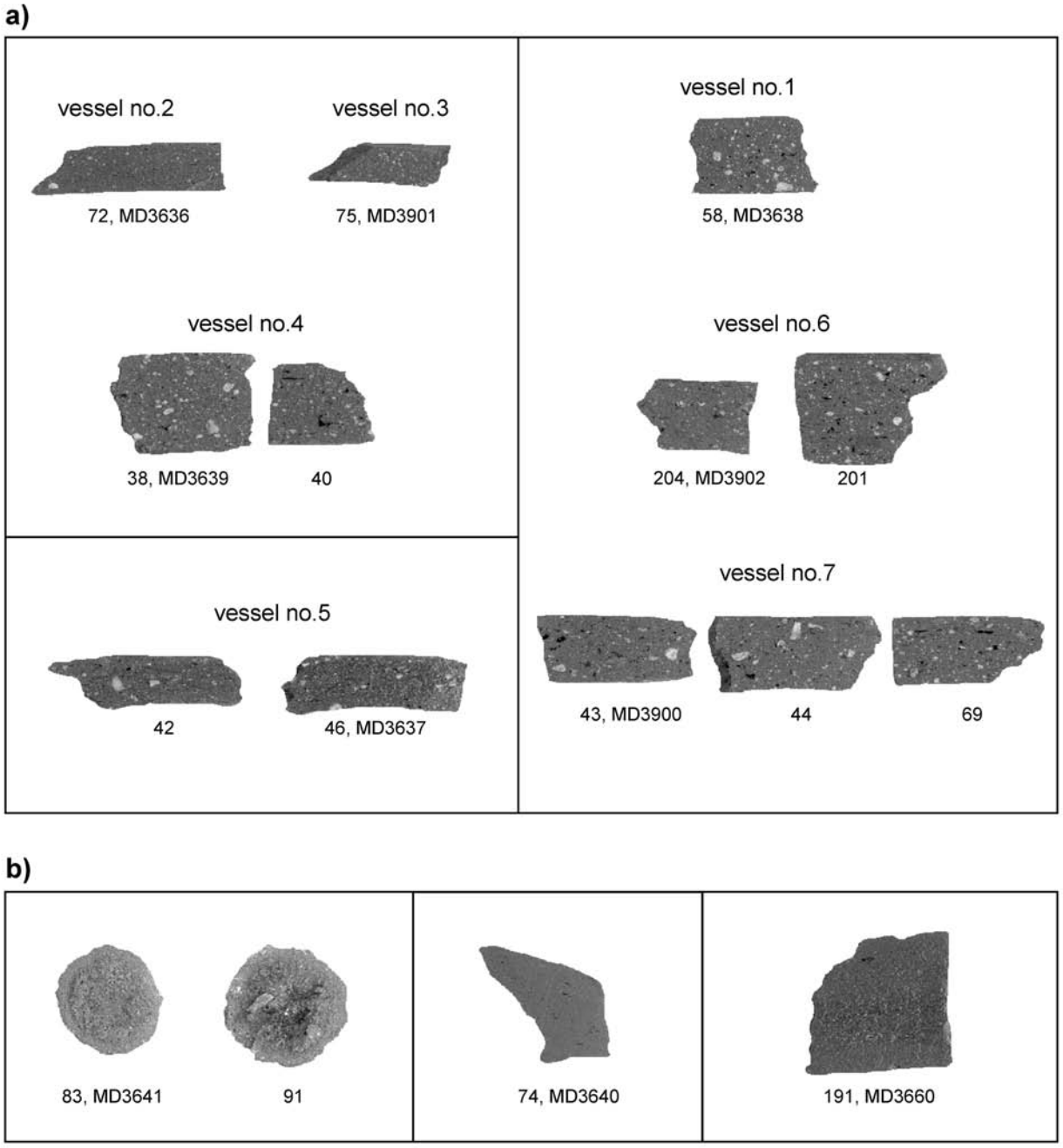

Fig. 2 (a = kitchenwares, b = basins). Fragments after refiring at 1200°C. Refiring was carried out in an electric laboratory chamber furnace, each one at a different temperature, in air, static, with a heating rate of 200°C/h and a soaking time of 1h at the peak temperature. The MD numbers which appear next to some sample numbers are laboratory numbers which indicate that chemical analysis was carried out for a particular sherd.

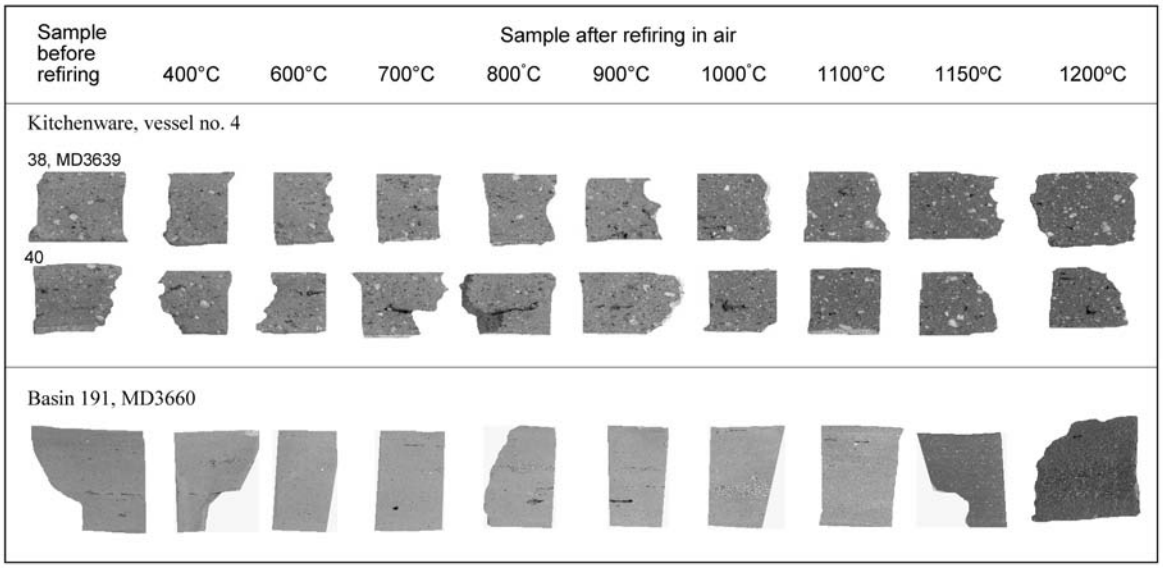

Fig. 3. Samples 38, MD3639 and 40 = samples taken from two different parts of vessel No. 4, this vessel was originally fired at a temperature of over 800°C, but less than 900°C. Sample 191, MD3660 = basin. Samples before and after refiring at different temperatures, in air, static, with a heating rate of 200°C/h and a soaking time of 1h at the peak temperature.

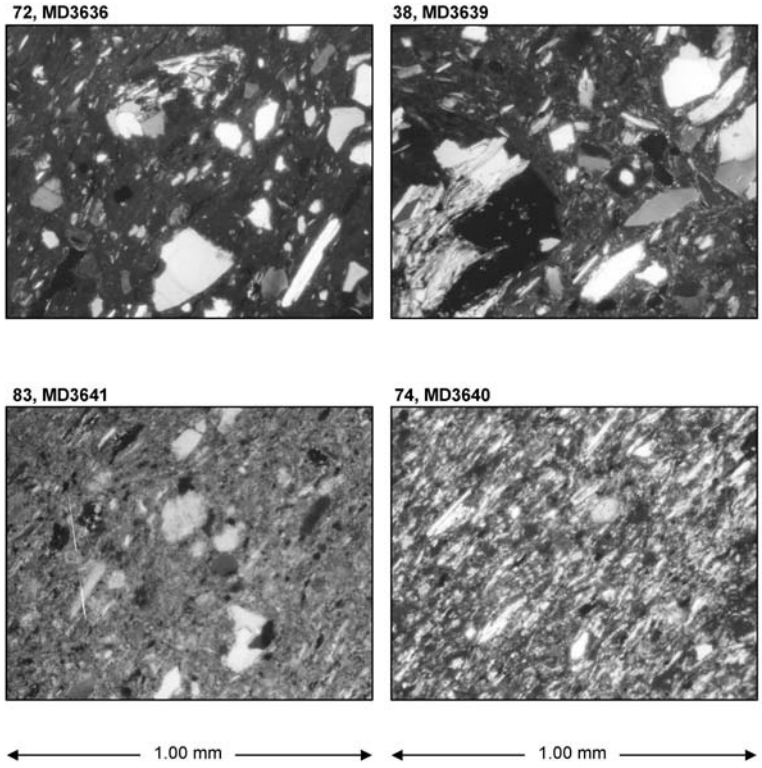

Fig. 4. Sample 72, MD3636 = Late Antique kitchenware, vessel No. 2, matrix coloured by iron compounds, metamorphic rock fragment (quartz and muscovite), grains of quartz, mica. Sample 38, MD3639 = Middle Byzantine kitchenware, vessel No. 4, matrix coloured by iron compounds, large aggregate visible in lower left corner is strongly coloured by iron compounds from metamorphic rock fragment (quartz and muscovite), also visible are grains of metamorphic quartz. Sample 83, MD3641 = basin, low fired calcareous matrix, quartz, cryptocrystalline carbonates, few coarse crystalline carbonates, fine micas. Sample 74, MD3640 = basin, non-calcareous matrix with abundant fine micas (0.15 mm) and cryptocrystalline aggregates after decomposition of carbonates. Photomicrographs of thin-sections, XPL, width of field = 1.0 mm.

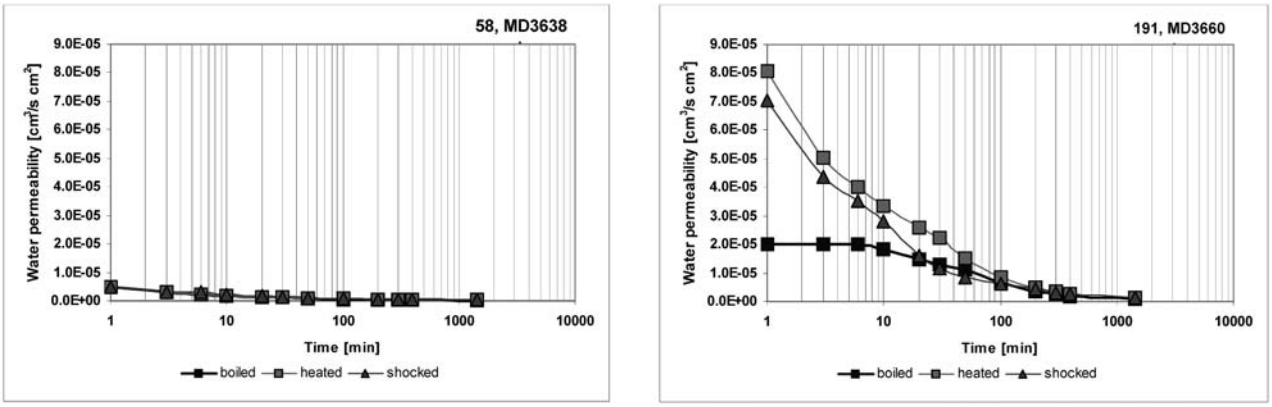

Fig. 5. Water permeability versus time in logarithmic scale.
Sample 58, MD3638 = kitchenware, sample 191, MD3660 = basin.

Sample No. Lab. No.	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	V	Cr	Ni	(Cu)	Zn	Rb	Sr	Y	Zr	(Nb)	Ba	(La	Ce	Pb	Th)	LOI	TOTAL
	% by weight										ppm															%	%
Kitchenwares																											
Group 1																											
38, MD 3639	65,49	1,42	18,08	9,11	0,103	1,29	0,79	0,87	2,73	0,12	165	202	100	32	109	102	140	45	340	26	394	50	105	53	25	1,06	99,48
72, MD 3636	64,33	1,06	20,43	9,27	0,102	1,05	0,82	0,42	2,40	0,11	154	210	123	30	99	126	125	47	338	27	420	51	120	30	20	0,87	100,10
75, MD 3901	64,44	1,00	19,79	9,29	0,098	0,96	0,74	0,65	2,94	0,10	147	196	106	13	89	104	158	40	305	22	372	47	118	29	29	2,32	100,32
Group 2																											
43, MD 3900	61,03	1,14	22,47	10,08	0,112	0,98	0,50	0,49	3,06	0,15	183	163	93	20	79	147	100	46	350	24	530	55	157	19	30	0,52	100,46
58, MD 3638	66,49	1,01	18,73	8,17	0,049	0,81	1,43	0,53	2,70	0,09	135	162	74	18	65	108	208	32	311	22	518	42	119	23	21	3,35	99,12
204, MD 3902	63,74	1,04	20,23	8,79	0,058	1,00	0,43	0,82	3,73	0,15	183	163	88	19	81	130	139	43	300	21	467	66	141	21	25	2,73	99,77
Group 3																											
46, MD 3637	65,56	0,82	18,04	6,40	0,028	2,09	2,28	1,96	2,76	0,07	106	112	49	27	84	118	204	36	194	15	707	30	95	22	19	1,87	99,29
Basins																											
83, MD 3641	49,39	0,75	15,00	7,01	0,080	2,86	21,00	0,79	2,93	0,19	107	381	412	31	79	79	376	26	190	22	316	22	71	31	19	15,38	100,14
74, MD 3640	55,10	1,07	23,49	8,90	0,075	2,13	4,87	0,79	3,41	0,16	143	285	240	34	107	134	313	34	227	30	488	43	104	37	22	2,25	100,59
191, MD 3660	56,54	0,96	19,16	7,96	0,073	2,64	8,59	0,81	3,12	0,16	129	382	324	42	84	110	285	34	229	25	363	45	77	16	20	4,28	99,02

Table 1. Results of chemical analysis. Wavelength-dispersive X-ray fluorescence analysis (Philips PW1400) was used to determine the content of major elements, including phosphorus and a rough estimation of sulphur and chlorine. It was also used to determine a series of fifteen trace elements. Total iron was calculated as Fe_2O_3. All samples were prepared by pulverising fragments weighing 1.5g (sample size was determined by the number and size of the non-plastic components) having first removed their surfaces, including slips, and cleaned the remaining fragments with distilled water in an ultrasonic device. The powders were ignited at 880°C (heating rate 200°C/h, soaking time 1h), melted with a lithium-borate mixture (Merck Spectromelt A12) and cast into small discs for measurement. This data is therefore valid for ignited samples but, with the ignition losses (LOI) given, may be recalculated to a dry basis. For easier comparison the major elements are normalised to a constant sum of 100%. The precision for major elements is about 1%, for trace elements this rises up to 20% depending on the concentrations. Trace elements given in brackets are determined with lower precision: Cu, Nb, La, Ce, Pb and Th. Accuracy was tested by analysing international reference samples and by exchanging samples with other laboratories. For major elements and the most important trace elements it is between 5 and 10%. Values for S and Cl have not been included in Table 1 as they amounted to less than 0.01% in all samples.