

4.1 – A PRELIMINARY STUDY OF THE POTTERY FROM A WELL SHAFT IN AYASULUK/EPHESOS¹

Introduction

The research of the medieval pottery of the temple of Artemis (Artemision) in Ephesos was conducted under the auspices of Professor F. KRINZINGER and Dr. Ş. PFEIFFER-TAŞ of the Austrian Archaeological Institute². The study of identification and classification was carried out by J. VROOM, in order to bring light into the discussions of provenance. In addition, laboratory examinations of petrologic thin sections and heavy mineral analysis were performed by R. SAUER and Y. WAKSMAN. Based on the mineralogical and chemical compositions, the samples were classified into 6 fabric types (type a, b, b1, b2, c and d). As a continuation of this study, a compositional analysis was carried out for a total of 14 monoglazed (green, cream, green and brown) and undecorated ceramics (Fig. 1), which were excavated in Hamam III/Schachtbrunnen/Ayasuluk/Ephesos. Preliminary results of the compositional data are given in this report. The sampling was done by Ş. PFEIFFER-TAŞ. Resemblance with previously uncovered pottery from the medieval period was traced as far as the existing organizational conditions permitted. The aim of this study was to identify these selected samples, group them according to their compositional differences and to compare them with reference groups manufactured in Iznik³ and the Artemision findings in Ephesos.



Fig. 1: A group of analysed sherds

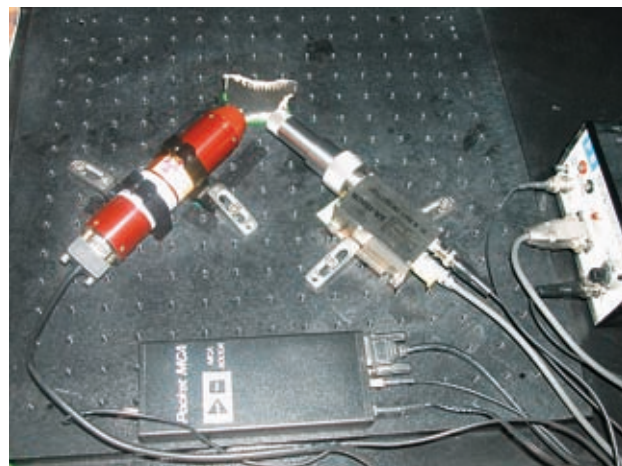


Fig. 2: The portable XRF setup composed of Eclipse III X-ray tube and a Si-PIN detector.

¹ The author is grateful to Şule PFEIFFER-TAŞ for providing the samples in this study and would like to thank Mustafa DOĞAN for his assistance during the pxf analysis and Cem BERK for the SEM-EDS analysis.

² Parts of the results have been published in KRINZINGER 2005.

³ The context of the Iznik reference group in this study is red ware which was uncovered in 1968 and 1991 at the Iznik Kiln excavation site. The first excavations and the pioneer work for the identification and classification of Iznik ceramics was done by O. ASLANAPA, and the archaeometric analyses of excavation materials was conducted by the author; cf. OKYAR 1995.

Experiments

In this study, X-ray fluorescence spectrometry and scanning electron microscopy analysis (SEM EDS) techniques were performed in order to identify selected samples from a well shaft of the Ayasuluk/Ephesos excavation site. A portable xrf equipment⁴ composed of the following parts was used for the first measurements (Fig. 2).

- An X-ray tube ›Eclipse III‹ by Oxford-Amptek [6] consisting of a 30-kV, 100-µA, Ag-anode;
- A Si-PIN detector by Amptek, having an energy resolution of about 200 eV at 5.9 keV, the entrance of the detector is collimated with a 1 cm long brass cylinder and with an internal collimator hole of 2 mm diameter.

Complementarily, a SEM-EDS analysis was carried out with a scanning electron microscope type JSM-6335F of Jeol on the fresh cut sections after coating the surface with Au for conductivity. The bulk analysis was taken with a counting time of 100s, at the magnification of x100 to x150, depending on the area of the analyzed samples.

Samples

The samples from the year 2005, which were selected by the excavation team, are presented in Table 1. Among the examined samples were unglazed red body fragments and blue, green and yellow monoglazed ceramics. The major elements that were detected with the PXRF device are depicted in Table 1. The chemical composition of the samples in weight percentage (%w), according to the SEM-EDS results, is given in Table 2.

Table 1. List of the samples and the major elements detected by PXRF

Sample code	Description	Analysis Area	Detected elements
K2	<i>dark green glazed, no slip, red body</i>	<i>glaze body</i>	Pb>Cu>Fe>K Fe>Pb>K>Ti
K3	<i>orange-brown glazed, no slip, red body</i>	<i>glaze body</i>	Pb>Fe>Cu>K>Cl Fe>Pb>Ca>Ti
K10	<i>Dark coloured, over-fired, glazed</i>	<i>glaze body</i>	Pb>Fe>Cu>K Fe>K
K31	<i>Red body fragment, no glaze</i>	<i>glaze body</i>	– Fe>Ti>K>Ca
K17	<i>Red body fragment, no glaze</i>	<i>glaze body</i>	– Fe>Ti>K>Ca
K18	<i>Red body fragment, no glaze</i>	<i>glaze body</i>	– Fe>K>Ti>Ca>Cr
K22	<i>Red body fragment, no glaze</i>	<i>glaze body</i>	– Fe>Ti>K>Ca
K52	<i>Red body fragment, no glaze</i>	<i>body glaze</i>	Fe>Ti>K>Ca –
K20	<i>Yellowish red body fragment, no slip, no glaze</i>	<i>body</i>	Fe>Ti>K>Ca
K11	<i>dark coloured, over-fired, red body</i>	<i>glaze body</i>	Pb>Fe>Cu>K Fe>Pb>Ti>Ca>K

⁴ The portable XRF equipment which was used is very useful for the analysis of archaeological materials, because the analysis is non-destructive, multi-elemental, simple and relatively inexpensive. However, light elements up to Si could not be detected due to the strong absorption in the Be window and in the air (1–2 cm) between the specimen and the detector.

Sample code	Description	Analysis Area	Detected elements
K54	Red body fragment, no slip, over fired	glaze/front glaze/back body	Fe>K>Ti>Ca Fe>Ti>Ca>K Fe>Ti>K
K48	cream green glazed, weathered, beige slip, red body	glaze body	Pb>Fe>Cu>Ca>K Fe>Pb>Ti>K
K1	cream green glazed, weathered, beige slip, red body	glaze slip	Pb>Cu>Fe>K Fe>Pb>Ti>Zn>Ca
K56	Red body fragment, no slip, over-fired	glaze body	Fe>Ti>K Fe>Ti>K>Ca

Results

According to the results, the glaze of the ceramics was characterized as lead glaze; the amount of lead oxide has differing values because of the alterations on the surface, though. The major elements that were detected were Si, Fe, Al, Pb, the minor ones Na, Mg, K, Ca, Ti, Cu. Variations could mostly be seen in the amount of iron, calcium, lead and magnesium, and were traced for clustering.

Table 2. Composition of ceramics according to the SEM analysis results (elements are in the weight % oxide form)

Sample code	Area	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	K ₂ O	CaO	TiO ₂	FeO	CuO	PbO
K56	body	1.07	3.15	18.97	55.98	2.88	0.64	1.1	16.21	nd	nd
K22	body	1.83	2.84	20.38	54.01	3.86	0.89	1.41	14.78	nd	nd
K54	body	1.74	2.68	20.88	56.41	2.98	0.96	1.12	13.23	nd	nd
K17	body	0.89	2.6	22.66	54.51	3.5	1.25	1.15	13.44	nd	nd
K52	body	1.84	3.11	19.29	57.87	2.48	1.38	1.15	12.89	nd	nd
K10	body	0.67	3.93	23.6	54.54	3.88	1.01	1.1	11.28	nd	nd
K11	body	1.1	4.43	22.76	51.19	4.25	1.47	0.95	13.85	nd	nd
K31	body	1.07	3.01	21.69	52.84	3.92	1.59	1.05	14.83	nd	nd
K18	body	0.71	2.82	19.88	53.14	4.7	3.26	nd	15.49	nd	nd
K3	body	0.77	4.11	19.63	51.43	4.75	5.67	0.71	12.93	nd	nd
K2	body	1.29	4.9	19.6	52.72	4.44	6.45	0.67	9.93	nd	nd
K1	body	n.d.	3.62	17.32	53.5	3.8	10.53	0	11.2	nd	nd
K20	body	1.3	4.07	17.01	48.15	3.3	10.57	0.87	14.72	nd	nd
K3	glaze	0.71	0.55	3.36	42.87	2.3	0.98	0.55	6.45	0	42.22
K2	glaze	1.49	0.47	5.33	53.73	5.42	1.8	0	2.18	4.86	23.62
K1	glaze	n.d.	1.73	10.74	68.34	4.64	2.37	0	1.82	0	10.36
K48	glaze	1.22	1.4	12.05	74.5	5.43	3.26	0	0.88	0	1.27

* nd-not detected

The x-ray spectrum of the samples compared with the others is shown in Figs. 3–5, in which fluorescence peaks are visible from left to right, due to the K, Ca, Fe, Cu and Pb elements. Fig. 3 shows the typical x-ray spectrum of the analyzed clay bodies. In Fig. 4 the XRF spectra of glazes from the potsherds are given, showing the presence of K, Ca, Fe, Cu and Pb elements. The presence of Cu is obvious due to the green colour pigment. In Fig. 5 a comparison of visible differences of the fluorescence peaks, due to the CaO content among the bodies, is shown. A kind of fingerprint and elemental profiles given by XRF spectra are also confirmed by the SEM-EDS analysis. From the compositional data in Table 2, one can see that the bodies are characterized by a soda content (0.7–1.9% Na₂O), which is lower than the potassium content (2.5–4.8% K₂O), and alumina (17–23%). They are highly rich in iron oxide (>11%) as well. Iron oxide was detected in the

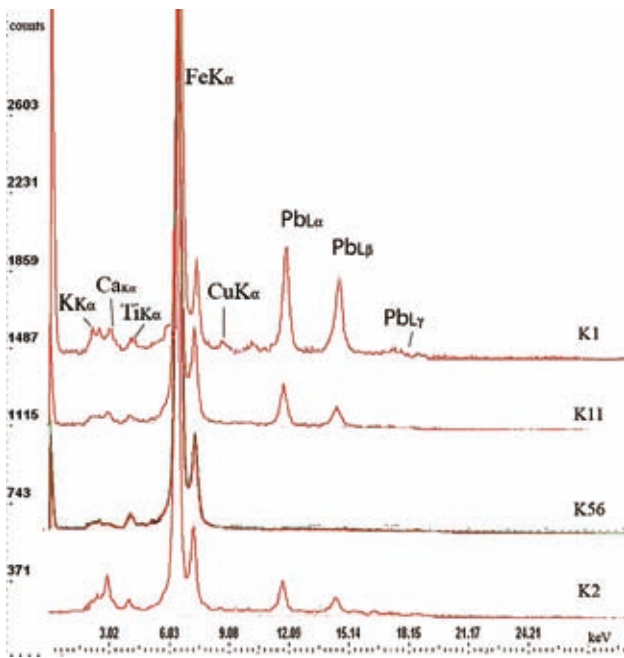


Fig. 3: The recorded body spectra of K1, K2, K11, K56. X-ray peaks of K, Ca, Ti, Pb and Fe

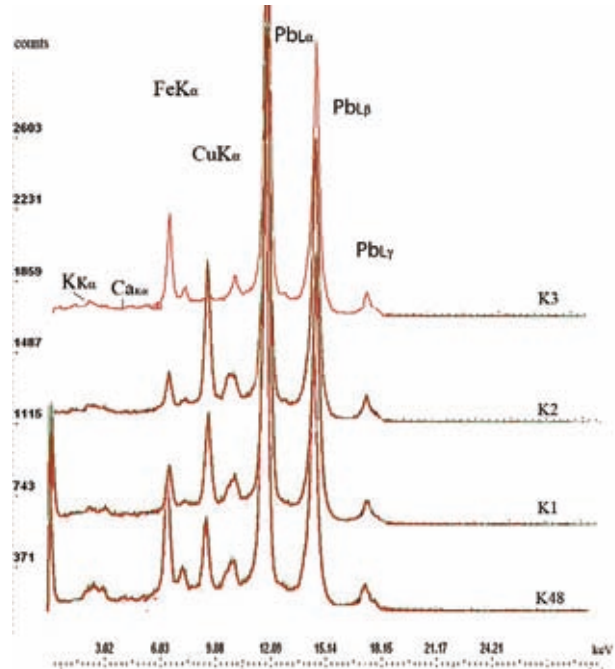


Fig. 4: The recorded glaze spectra of samples K1, K2, K3, K48. X-ray peaks of K, Ca, Fe, Cu and Pb

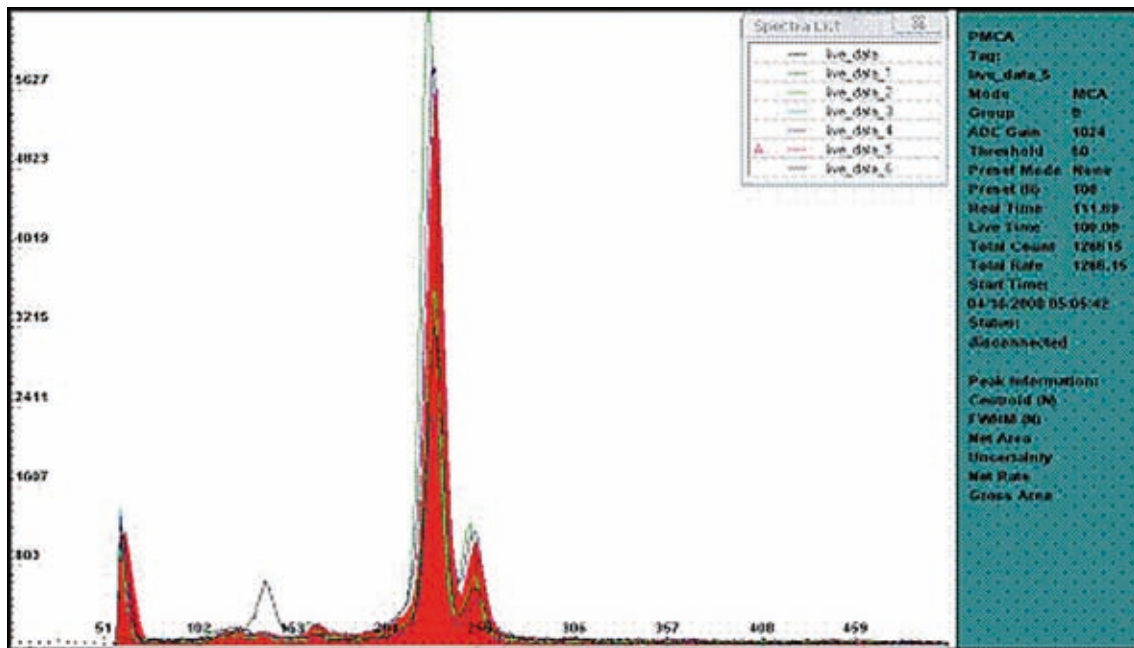


Fig. 5: Comparison of body spectra recorded by PXRF for various samples (code K31, K17, K18, K22, K52 and K20).

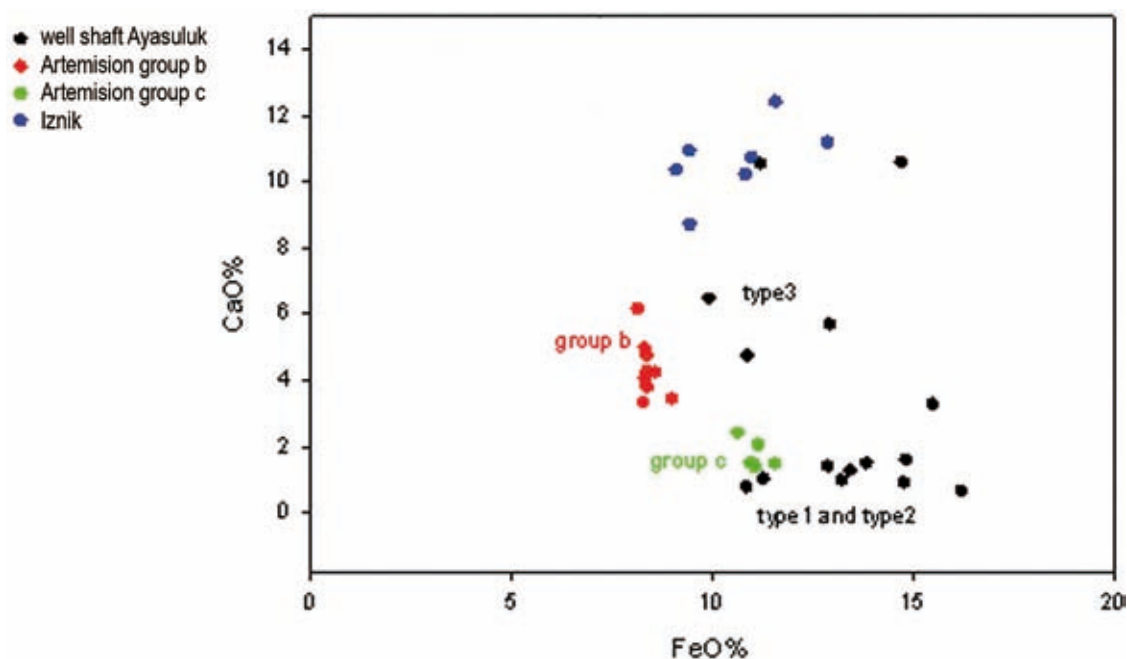


Fig. 6: The plot on the left is the scattergram of analysed pottery bodies from the well shaft showing the groups according to their CaO and FeO contents and their relation with the reference groups from the Artemision and early Iznik ceramics.

bodies of all the samples; it is highly rich, showing that either some highly rich ferruginous clays were used, or hematite and micaceous inclusions exist⁵. Titanium oxide was detected in many areas, depending on the amount of the iron oxide content.

The clay used for the body is calcareous for the samples K1, K20, K2, K3, K18 and non-calcareous for the rest. It has been noted that the glazes were all transparent, with an orange brown colour because of the small amounts of iron oxide or a green colour because of the copper oxide present.

In Fig. 6 a scattergram shows the iron and calcium oxide content of the analyzed bodies, in order to make comparisons with reference groups from Artemision and Iznik. Data for group b and group c of the Artemision is drawn from SAUER–WAKSMAN⁶. The Iznik data is taken from the author's results⁷. However, these classification results are preliminary and it should be noted that more data is needed for a better understanding.

Conclusions

The bodies of the analyzed sherds differ mainly in regard to the iron and calcium oxide content. Among the studied samples, only K1 and K20 have a high CaO content (10.5%w) and the samples K3 and K2 have a moderate level of CaO of about 5–6%w. We can say that both of these were made from calcareous clays, whereas the others were produced from non-calcareous clays for a general classification showing the CaO content below 5%.

Based on the chemical composition, samples can be grouped into 3 main types of body fabric (Table 2). Sherds in a given group are expected to be made locally from the same raw material.

⁵ The micas are complex hydrous potassium-aluminum silicate minerals. Muscovite: $K_2Al_4Si_6Al_2O_{20}(OH,F)_4$ Biotite: $K_2(Mg,Fe)_6-5AlO_3-1(Si_6-5Al_2-3)O_{20}(OH,F)_4$.

⁶ cf. SAUER – WAKSMAN 2005.

⁷ cf. OKYAR 1995.

Type1 This group is carbonate free, it includes samples K56, K22, K54. Their composition resembles ›group c‹ in the report of the Artemision ceramics, which was securely identified as locally produced.

Type2 This group includes samples K17, K52, K10, K11 and K31. It differs mainly from *type1* by a slightly higher content of calcium and also shows similarities with ›group c‹ in the report of the Artemision ceramics.

Type3 The samples K18, K3, K2, K1, K20 and K48 are united in the calcareous group, whereas K1 and K20 are higher calcareous than the rest, showing a chemical resemblance with the features of ‘*ERSW-B ware*’⁸. They were also probably made locally, though⁹. The composition of group *type3*, apart from K1 and K20, seems to have resemblance with ›group b‹ of the Artemision ceramics.

Based on the comparison with already studied pottery, all groups show a high iron content, which differentiates them from the Artemision ceramics. The soda, potassium and magnesia contents are similar with the ›group b, c, d‹ ceramics of the Artemision, though. On the other hand, there was no siliceous artificial *stone paste* among the studied samples, similar to the resembling ›group a‹ in the Artemision. Furthermore, the burned or overfired artefacts such as K11, K54, K56 and the defected waste products such as K10 and K2 were also identified as locally produced⁴ by Ş. PFEIFFER-TAŞ. As for the glazes, the monochrome green glaze contains copper and iron as the major colouring elements. The amount of lead oxide in the glazes varies abruptly between 1-42% and silica changes from 43% to 75% because of weathered surfaces. The low content of lead oxide for the samples K1 and K48 could hint to us that these samples belonged to an earlier transition period set between the alkaline and the lead glazes.

This work stands at the beginning of the identifying of groups of compositions within the general descriptive categories. Further research is surely needed in order to make the characteristics of these chemical groupings more obvious.

⁸ Unclassified, including a high content of CaO, ~10.60%w; cf. LADSTÄTTER – SAUER 2005, 167 Fig. 9.

⁹ cf. PFEIFFER-TAŞ ch. 4.