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Investigating the origins of two main types of Middle and Late Byzantine amphorae

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ABSTRACT

Unlike Late Roman/Early Byzantine amphorae, Middle and Late Byzantine amphorae have been little studied and their origins and contents are still largely unknown. Out of the four main types distinguished by Günsenin, two were investigated in the present research: types Günsenin II (10th–11th century AD) and Günsenin III (12th–13th century AD). Samples taken from various excavations and find spots in central Greece, located in Thebes, Chalcis, and the countryside of Euboea were investigated for their provenance by chemical analysis. Thanks to previously established reference groups, samples of amphorae Günsenin III, of part of amphorae Günsenin II and of transitional types could be attributed to Chalcis, whose harbor played a major role in the Aegean at the medieval period.

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1. Introduction

Although transport amphorae have been the subject of numerous archaeometric studies, the origins of the Middle and Late Byzantine types which circulated on a large scale in the Mediterranean had hardly been investigated so far. We are referring here especially to the so-called Günsenin I to Günsenin IV types found in the Mediterranean and the Black sea from the 10th to the mid-15th century AD and usually related to the Byzantine Empire (Günsenin, 1990; Bulgakov, 2000).¹ Only for type Günsenin I have workshops been identified in the region of Tekirdağ (Turkey, on the shores of the Sea of Marmara) (Günsenin, 1993). It is now known as “Ganos amphora”, even though other workshops may have existed as well (Todorova, 2012, 58).

In this paper we present typology and provenance studies of amphorae of types Günsenin II and Günsenin III, carried out in the framework of the POMEDOR project “People, Pottery and Food in the medieval

Eastern Mediterranean”.² Various origins had been proposed for type III, including the north coast of Asia Minor (Sanders, 1993, 283), the area of Tanagra in Boeotia where an overfired sherd of this type has been found (Vionis, 2008, 38, 40 Fig. 17b), and locations where Late Roman 2 amphorae had previously been manufactured (Piéri, 2005, 91). Other authors suggested workshops in the Crimea, the Black sea coast area (Yacobson, 1950, 104–105) and the lower Danube area, where they would have followed Constantinopolitan prototypes (Barnea and Ștefanescu, 1971, 267).

Thebes, in Boeotia, and Chalcis, the harbor of Byzantine Thebes and later on a Venetian hub under the name of Negroponte (Kontogiannis, 2012), were of particular interest to us. Historical sources and archaeological data confirm that there was a substantial agricultural production, especially wine and oil (Kontogiannis et al., forthcoming), which ought to have been transported in locally made containers. Furthermore, Chalcis was recently shown to be the origin of an important production of tablewares contemporary with the Günsenin III amphorae, the main “Middle Byzantine Production” (Waksman et al., 2014; see also Waksman et al., in this volume).

Samples were taken from excavations in different sites in central Greece (Chalcis and other sites in the Euboea, Thebes), the majority of

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¹ These types are also known as follows: Günsenin I, Saraçhane 54, Bakirtzis II; Günsenin II, Saraçhane 60, Bakirtzis IV; Günsenin III, Saraçhane 61, Bakirtzis V; Günsenin IV, Bakirtzis VI (see Bakirtzis, 1989; Hayes, 1992; Vroom, 2005, 94–101).

² www.pomedor.mom.fr.

the samples coming from rescue excavations in Chalcis. Amphorae samples were studied for both their typology and their archaeometric features, in order to define the corresponding productions from both viewpoints, combining archaeological and archaeometric information (see e.g. Waksman, 2016). Among the array of available archaeometric approaches to ceramics (Hunt, 2016), chemical analysis was chosen because it enabled us to make use of a large body of comparative data, including chemical reference groups we had previously defined in the database of Lyon laboratory. In Chalcis and Thebes, these reference groups were built using evidence of pottery production (kiln furniture and pottery wasters) found in archaeological layers dated back to the medieval or post-medieval periods (Waksman et al., 2014). They are not related to the same category of pottery - tablewares in one case, amphorae in the other, and potters commonly use different clayey material to manufacture different categories which have to meet different functional requirements. However, in the present case these amphorae have a fairly fine fabric, suggesting that potters could have used the same material for both. In this case, reference groups established using samples of tablewares could potentially be appropriate for amphorae as well.

2. Archaeological sites, contexts and sampling

2.1. Sites and contexts

The amphorae included in the present research (45 samples, Table 1 and Annex A) come from various excavations and find spots, located in Thebes, Chalcis, and the countryside of Euboea. Their selection was dictated either by their recognizable form or their recovery from dated layers of the Middle and Late Byzantine period. Among the amphorae from Thebes, an almost complete example (BZN204; cat.1) was found in the excavations conducted in the framework of the Thebes Ismenion Hill Synergasia Project, by the Bucknell University team. Research at the slopes of the Ismenion hill over a number of years located an extensive Byzantine neighborhood that developed outside the medieval fortified nucleus of the Kadmeia from the 11th until the early 14th century. The amphora was unearthed from the closed context of a cesspit dated to the 12th–13th century.³ Other sections of this neighborhood, including the parochial church and an area potentially used for workshops of unknown nature so far, were excavated in nearby plots (Koikalou, 2001–2004, 21, 36–38; 2005, 436–437; 2006, 513–515, 522–523). A group of six amphorae body sherds (BZY816–821; cat.2–7) were collected from the material of a 2001–2002 rescue excavation within the Kadmeia hill (*Vourdoumba 38 Str.*, (*Konsta plot*)), which uncovered a housing complex with its earliest occupation phase being attributed to the Byzantine period. Most of the material was dated to the 12th and 13th century (Koikalou, 2001–2004, 38–39). The Chalcis pieces come from salvage work in various locations, both within and outside the perimeter of the urban enclosure. Most identifiable specimens (BZY804–807, BZY811–812, BZY815, BZN310–312, BZN315–317, BZN319–320; cat.8–13, 14–16, 18–20, 26–28) were unearthed in six plots distributed throughout the Byzantine/medieval city (*Angeli Goviou & Favierou Str.* (*Matsa plot*)), *Isaiou & Trapezountiou Str.* (*Domi plot*)), *Erotokritou-Olynthou-Skalkota Str.* (*Toulitsi plot*)) and along the course of its walls (*Agia Varvara square (IKA plot)*), *Mardochoiou Frizi Str.* (*KTEL plot*)), *Eleftheriou Venizelou 53 Str.* (*Xidi plot*)). They were found either in Middle to Late Byzantine house complexes (mainly 10th/11th to 13th century), or within built pithoi that had been turned into cesspits with well dated context (Georgopoulou-Meladini, 1972, 367–368; Georgopoulou-Meladini, 1973, 314; Georgopoulou-Meladini, 1973–1974, 499–507, 509–510; Papadakis, 1975, 277–279, 290–293; Vaxevanis, 2009, 477–479). The same is true for thirteen body sherds (BZY783–795; cat.22–25, 29–37) from the *Erotokritou-Olynthou-*

Table 1

Samples analyzed, with indication of the catalogue and laboratory numbers, site of discovery, dating of the context, type and chemical group.

Cat. nb.	Lyon lab. nb.	Site of discovery	Dating of the context	Type	Chemical group
1	BZN204	Thebes	12th–13th	Günseinen III	Chalcis
2	BZY816	Thebes	Mixed, 13th–16th	Günseinen III	Chalcis
3	BZY817	Thebes	13th–14th	Günseinen III	Chalcis
4	BZY818	Thebes	12th–13th	Günseinen III	Chalcis
5	BZY819	Thebes	Mixed, 12th–16th/17th	Günseinen III	Chalcis
6	BZY820	Thebes	Mixed, 12th–16th/17th	Günseinen III	Chalcis
7	BZY821	Thebes	Mixed, mainly 16th/17th	Günseinen III	Chalcis
8	BZY811	Chalcis	10th–11th	Günseinen II	Chalcis
9	BZN310	Chalcis	10th–11th	Günseinen II	Chalcis
10	BZN311	Chalcis	10th–11th	Günseinen II	Chalcis
11	BZN312	Chalcis	10th–11th	Günseinen II	Chalcis
12	BZN315	Chalcis	10th–11th	Günseinen II	Chalcis
13	BZN316	Chalcis	10th–11th	Günseinen II	Chalcis
14	BZY812	Chalcis	10th–11th	Günseinen II	Minor group
15	BZY815	Chalcis	10th–11th	Günseinen II	Marginal to minor group
16	BZY807	Chalcis		Günseinen II	Chalcis
17	BZY800	Chalcis	13th–early 14th	Günseinen II	Chalcis
18	BZY805	Chalcis		Transitional	Chalcis
19	BZY804	Chalcis		Transitional	Chalcis
20	BZN317	Chalcis		Transitional	Minor group
21	BZY798	Chalcis	13th–early 14th	Transitional	Chalcis
22	BZY783	Chalcis	10th–11th	Transitional	Chalcis
23	BZY784	Chalcis	10th–11th	Transitional	Chalcis
24	BZY785	Chalcis	10th–11th	Transitional	Chalcis
25	BZY786	Chalcis	10th–13th	Transitional	Chalcis
26	BZN319	Chalcis		Günseinen III	Chalcis
27	BZN320	Chalcis		Günseinen III	Chalcis
28	BZY806	Chalcis		Günseinen III	Chalcis
29	BZY787	Chalcis	10th–13th	Günseinen III	Chalcis
30	BZY788	Chalcis	10th–13th	Günseinen III	Chalcis
31	BZY789	Chalcis	10th–13th	Günseinen III	Chalcis
32	BZY790	Chalcis	10th–13th	Günseinen III	Chalcis
33	BZY791	Chalcis	Mixed, Late Byzantine and Post-Byzantine	Günseinen III	Chalcis
34	BZY792	Chalcis	Mixed, Late Byzantine and Post-Byzantine	Günseinen III	Chalcis
35	BZY793	Chalcis	12th–13th	Günseinen III	Chalcis
36	BZY794	Chalcis	10th/11th–13th	Günseinen III	Chalcis
37	BZY795	Chalcis	10th/11th–13th	Günseinen III	Chalcis
38	BZY796	Chalcis	12th–14th	Günseinen III	Chalcis
39	BZY799	Chalcis	13th–early 14th	Günseinen III	Chalcis
40	BZY801	Dokos		Transitional	Minor group
41	BZY802	Dokos		Transitional	Chalcis
42	BZN321	Dokos		Günseinen III	Chalcis
43	BZN322	Dokos		Günseinen III	Chalcis
44	BZY803	Dokos		Günseinen III	Chalcis
45	BZY797	Karystos		Günseinen III	Chalcis

Skalkota Str. (*Toulitsi plot*). Few identifiable pieces (BZY798, BZY800; cat.17, 21) and body sherds (BZY796, BZY799; cat.38–39) come from two neighboring plots in an area outside the walls, lying at a short distance to the northeast of the city enclosure (*Mitropoleos Str.* (*ATTON plot*)), *Balaleon 33 Str.* (*Chanos plot*)). This obviously represented an extension of the urban structure outside the walls (Kontogiannis, 2012, 45, 55). In both cases, the sparse built remains were corroborated by large cesspits, whose content proved both well dated and extremely diverse. Their main period of use covered the 13th–14th century AD (Bedermacher-Geroussi, 2012, 74; Skartsis et al., forthcoming). A large group of amphorae (BZY801–803, BZN321–322; cat.40–44), many of which almost complete, were altogether located in what must have been the storeroom or warehouse of a rural installation. It was excavated in the 1990s in the area of the modern village of Dokos (*Aggelou plot*), at ca. 10 km to the east of Chalcis. A further sample of an amphorae body sherd (BZY797; cat.45) comes from the southern part of the island. It was unearthed in Karystos, during trial pits at the Church of Transfiguration, in the village of Palaiochora, which is identified with the site of the Byzantine settlement in the area (Helen Tsiompikou, pers. comm.).

³ We would like to thank the excavators, Profs. Kevin Daly and Stephanie Larson, for sharing the information and giving us permission to sample and publish this significant find.

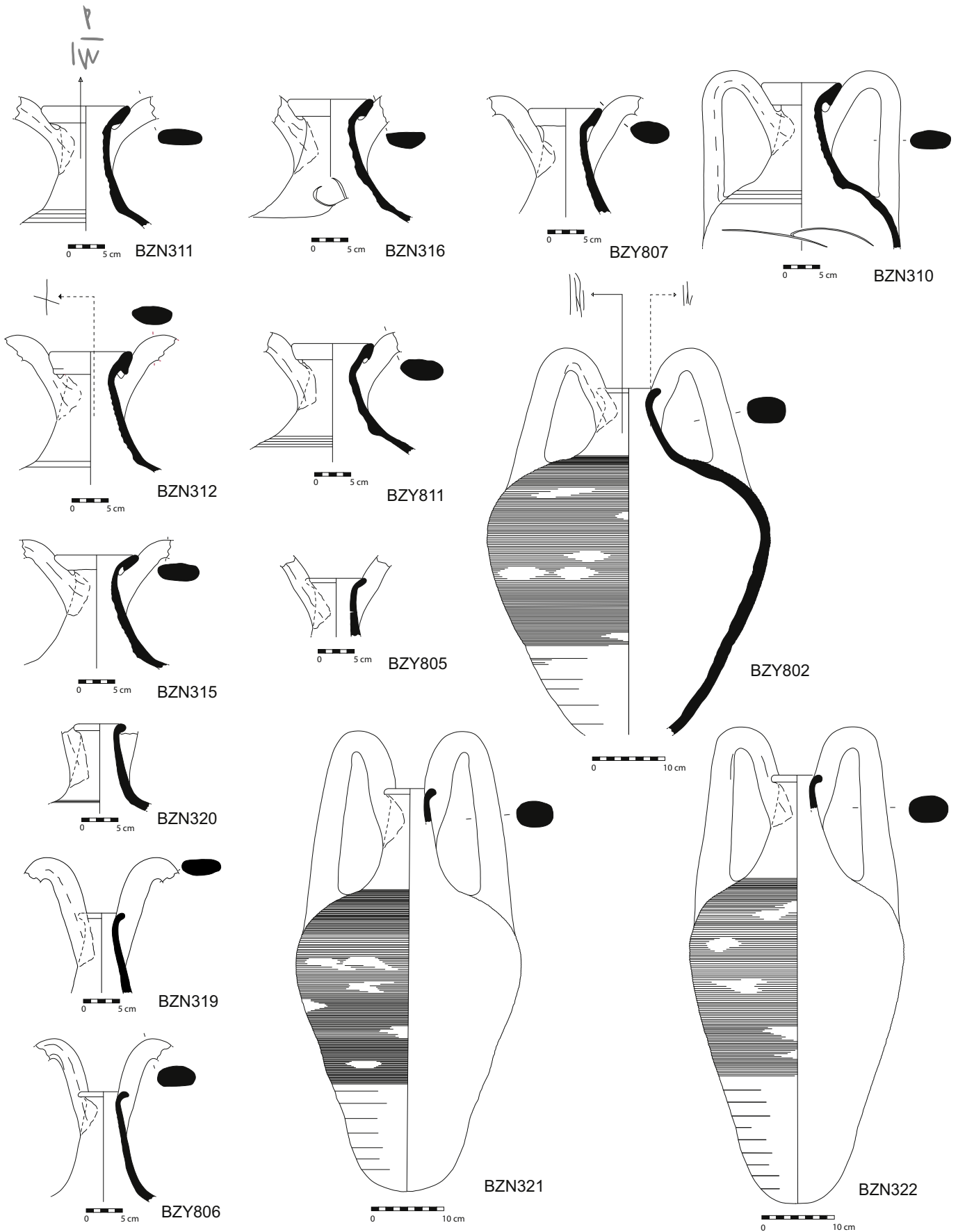


Fig. 1. Amphorae of types Günsenin II (BZY807, BZY811, BZN310–312, BZN315–316), Günsenin III (BZY806, BZN319–322) and of transitional type (BZY802, BZY805) attributed to Chalcis production (E. Todorova).

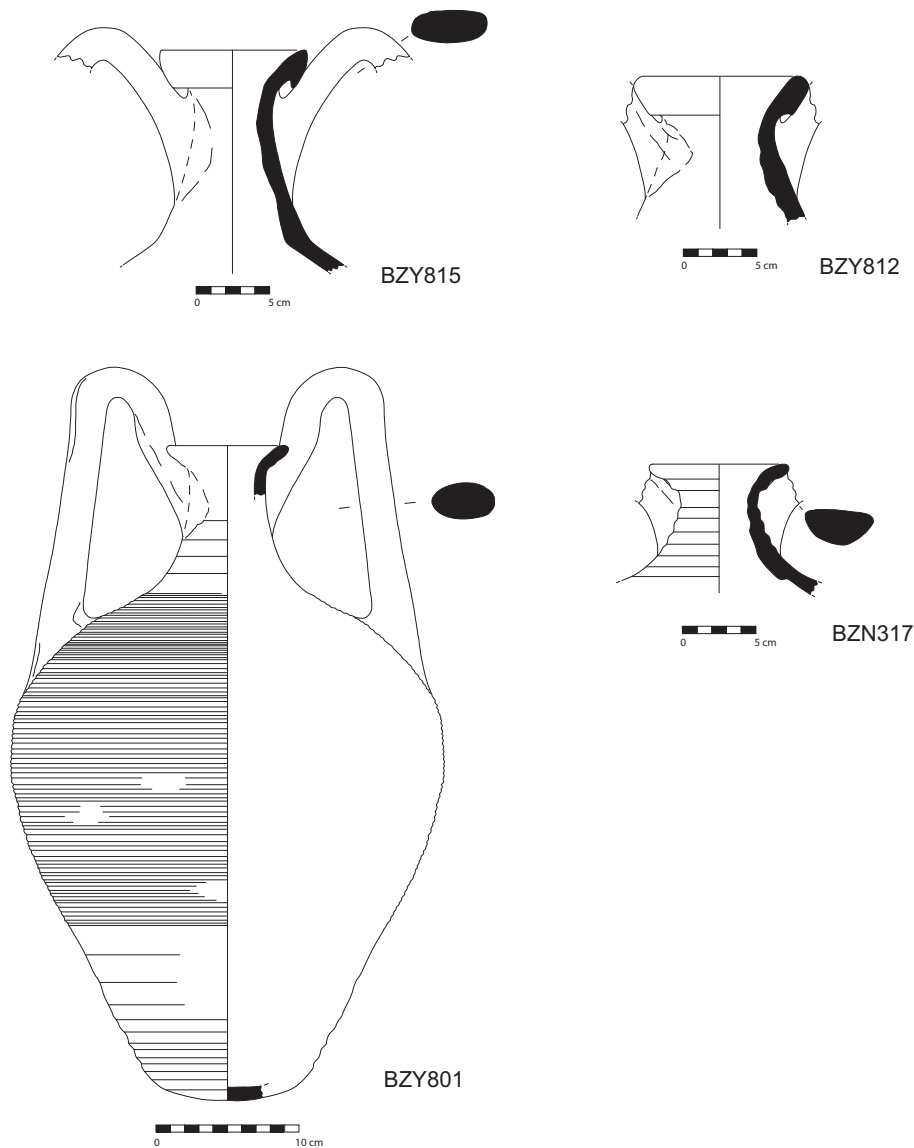


Fig. 2. Amphorae of types Günsenin II (BZY812, BZY815) and of transitional type (BZY801, BZN317) belonging to another, as yet unlocated, production (E. Todorova).

2.2. Typology of the sampling

Out of the 45 samples, 21 had significant typological features. They are described below (Figs. 1–2), and in further details in the catalogue (see Annex A). The others were body sherds taken randomly, with the aim of having a more representative sample of the existing quantities and the provenance ratio of Günsenin II or Günsenin III encountered in our material.

From a morphological point of view the amphorae can be divided into three different types.

Nine amphorae (BZY807, BZY811–812, BZY815, BZN310–312, BZN315–316; cat.8–13, 14–16) and one handle (BZY800; cat.17) belong to the Günsenin II type, and more specifically to the subtype a (Günsenin, 1990, 26–27, Pl. XXXIII–XXXV). They have broad piriform body, bulging belly and rounded bottom. The high conical neck ends with a wide-splayed overhanging rim, slightly deformed by the handles.⁴ The strap-like handles are attached to the neck under the rim. They rise above the rim level and taper down to the belly. There are several shallow horizontal grooves on the shoulders.

⁴ This difference in rim shaping should not be considered as sign of different production centers, but has rather resulted of the work of individual potters.

The fabric of the Günsenin II amphorae is hard, mixed with considerable amount of single small-sized (1–2 mm) and large-sized (4–5 mm) lime particles (Fig. 3). The color after firing had turned mainly to yellowish red or reddish-yellow, but also pink to light reddish brown. Only the outer surface of BZY800 (cat.17) and BZY811 (cat.8) is lighter in color in comparison with the rest of the fabric, possibly due to the use of salt water in the manufacturing process (Peacock, 1984).⁵ There are traces of organics (probably straw) in the fabric of the handles of some of the specimen (BZY807, BZY811, BZN311, BZN315; cat.8, 10, 12, 16) and in the entire fabric of BZY812 (cat.14). No slip on the outer surface of the vessels is observed. Some of the amphorae were decorated with arch-like incised lines on the belly (BZN310; cat.9), while others have graffiti (BZN312; cat.11) and dipinti (BZN311; cat.10) on the necks. A circular mark made before the firing of the vessel is attested on the neck of BZN316 (cat.13).

The Günsenin II amphorae date back to the 10th–11th century AD and were largely distributed all over the Mediterranean and the Black sea areas reaching as far as Southern Sweden (Todorova, 2012, 63–68 and the respective literature quoted).

⁵ A similar effect is observed for some transitional and Günsenin III types below.

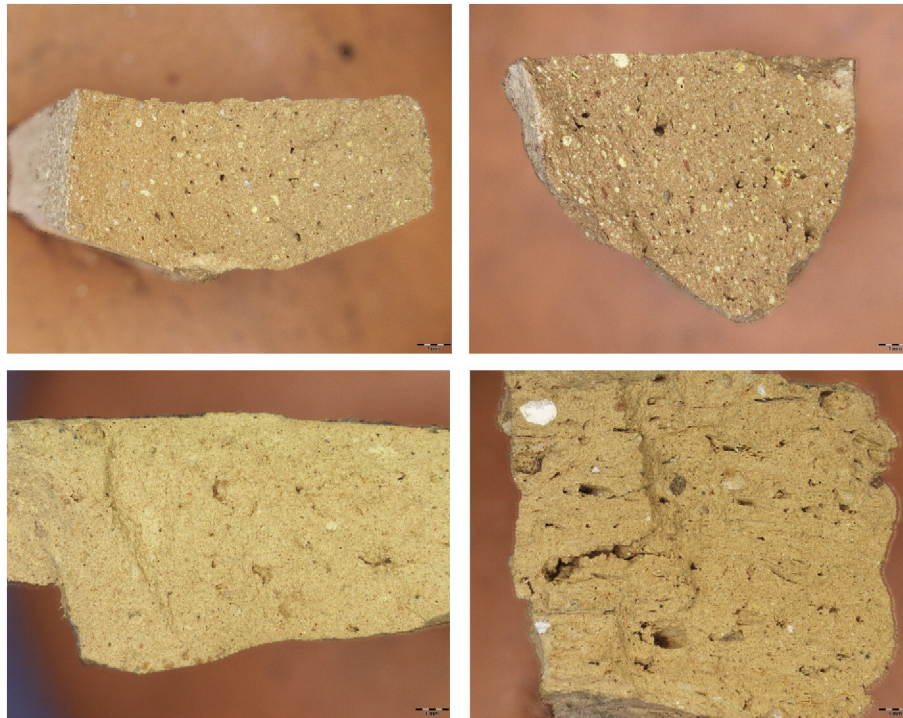


Fig. 3. Examples of fabrics: top row Chalcis' production, left BZN312 (type Günsenin II), right BZN320 (type Günsenin III); bottom row other production, left BZY801 (transitional type), right BZY812 (type Günsenin II) (photos J. Burlot).

Six amphorae (BZY806, BZN204, BZN319–322; cat.1, 26–28, 42–43), seventeen body sherds (BZY787–796, BZY799, BZY816–821; cat.2–7, 29–39) and a handle (BZY803; cat.44) belong to the Günsenin III type (Günsenin, 1990, 28–30, Pl. XXXIX–LII). They are high-bellied piriform containers with slender body and rounded bottom. The long narrow conical neck ends in a slightly curved to the outside rounded rim, mostly splayed by handles. Long heavy handles with ovoid cross-section rise

steep above the rim level and curve down abruptly towards the belly. The body is covered by very close-set horizontal fine grooves, partly obscured by small smears and turning into shallow, spaced wide ribs towards the rounded bottom.

The fabric is hard, mixed with many single small-sized (1–2 mm) and large-sized (4–5 mm) lime particles (Fig. 3). There is a large amount of organics (straw) in the fabric of the handles. The color after firing has

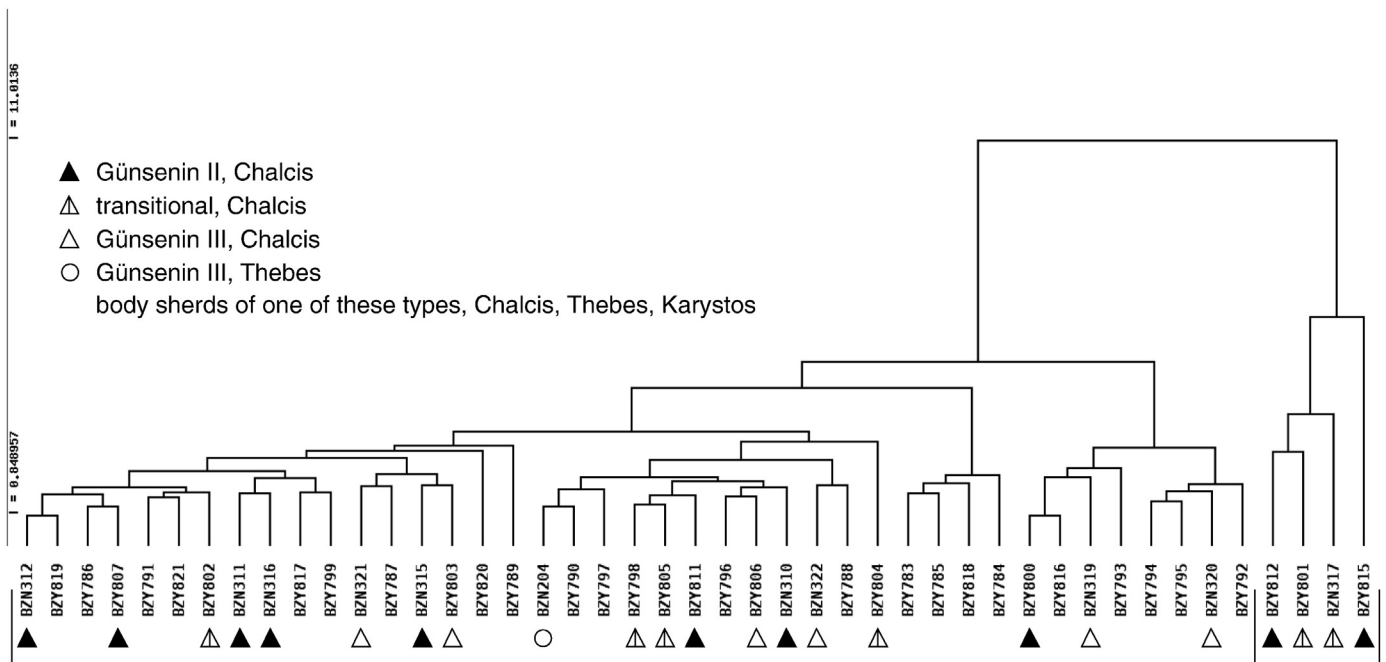


Fig. 4. Classification according to chemical compositions of samples of Byzantine amphorae. Symbols indicate where the amphorae were found, as well as their type for the best-preserved examples. The chemical groups are underlined (S.Y. Waksman).

Table 2
Chemical compositions of samples of Byzantine amphorae, and reference groups of Chalcis and Thebes. Amphorae are ranked as in the dendrogram Fig. 4. Major and minor elements are given in oxides weight %, trace elements in ppm; m: mean, σ : standard deviation, n: number of samples, ld: limit of detection; elements between brackets were not used in the classification.

Lab id.	CaO	Fe ₂ O ₃	TiO ₂	K ₂ O	SiO ₂	Al ₂ O ₃	MgO	MnO	(Na ₂ O)	(P ₂ O ₅)	Zr	Sr	Rb	Zn	Cr	Ni	(La)	Ba	V	Ce
Main group																				
BZN312	5.02	7.09	0.863	3.80	59.00	19.92	2.44	0.1161	1.41	0.17	174	107	149	106	144	98	39	614	122	86
BZY819	4.92	7.28	0.859	3.87	59.27	19.49	2.39	0.1163	1.42	0.20	170	105	147	104	143	103	35	619	119	88
BZY786	5.23	7.27	0.887	3.67	59.05	19.61	2.33	0.1183	1.47	0.18	188	119	149	104	146	96	34	609	123	81
BZY807	4.86	7.29	0.882	3.80	59.23	19.59	2.35	0.1172	1.52	0.20	185	106	149	104	147	97	39	606	129	84
BZY791	4.82	7.24	0.854	3.63	59.82	19.20	2.44	0.1172	1.52	0.17	176	102	145	104	149	107	50	606	132	88
BZY821	3.96	7.25	0.874	3.66	60.72	19.32	2.26	0.1177	1.49	0.18	185	96	146	101	149	100	44	615	126	83
BZY802	5.15	7.17	0.863	3.61	59.65	19.14	2.39	0.1188	1.59	0.15	188	102	145	104	145	100	40	626	122	91
BZN311	4.30	7.05	0.874	3.77	60.59	19.18	2.22	0.1134	1.51	0.22	195	107	143	99	151	97	40	632	126	86
BZN316	4.48	7.01	0.868	3.69	60.53	19.06	2.24	0.1115	1.54	0.30	190	115	143	101	143	96	40	606	132	92
BZY817	4.87	7.10	0.871	3.54	60.35	18.94	2.32	0.1174	1.53	0.18	191	102	139	97	159	115	43	590	122	85
BZY799	5.16	6.95	0.872	3.65	60.09	18.88	2.32	0.1148	1.63	0.17	187	113	143	92	141	100	45	594	127	89
BZN321	4.76	6.97	0.857	3.70	60.06	18.97	2.46	0.1184	1.75	0.17	191	119	146	102	156	104	40	678	125	80
BZY787	4.44	7.09	0.885	3.86	60.23	19.09	2.19	0.1142	1.57	0.35	182	118	149	104	150	102	33	650	120	82
BZN315	4.02	7.06	0.881	3.94	59.48	20.47	2.37	0.1181	1.31	0.18	174	102	150	107	142	98	37	638	128	80
BZY803	4.89	7.32	0.856	3.74	59.34	19.54	2.36	0.1180	1.50	0.16	167	104	147	106	145	99	33	650	120	78
BZY820	4.63	6.99	0.846	3.95	60.62	18.71	2.10	0.1128	1.62	0.25	175	94	145	98	160	108	46	636	110	83
BZY789	5.56	7.36	0.843	3.63	58.52	19.40	2.62	0.1216	1.54	0.23	164	118	135	110	149	108	34	612	122	81
BZN204	4.55	7.82	0.858	3.81	58.37	20.14	2.47	0.1244	1.52	0.15	164	98	155	108	151	107	35	650	132	87
BZY790	5.46	7.76	0.864	3.82	57.36	20.36	2.58	0.1241	1.33	0.16	163	109	155	112	150	107	33	646	133	84
BZY797	4.86	7.51	0.868	3.68	58.86	19.87	2.45	0.1252	1.40	0.19	174	99	152	110	146	104	35	642	123	84
BZY798	5.60	7.77	0.879	4.00	56.58	20.56	2.81	0.1215	1.32	0.17	162	118	158	112	168	119	32	650	130	82
BZY805	4.77	7.77	0.880	3.99	57.73	20.40	2.58	0.1206	1.36	0.21	168	109	158	107	170	114	43	656	131	84
BZY811	5.30	7.51	0.873	3.92	57.87	20.01	2.59	0.1203	1.40	0.21	175	113	154	110	191	114	50	648	126	85
BZY796	5.46	7.65	0.860	4.07	57.39	19.96	2.61	0.1239	1.50	0.20	163	110	157	110	152	113	37	617	127	91
BZY806	5.07	7.63	0.857	4.01	57.89	19.92	2.57	0.1219	1.59	0.18	163	105	153	110	168	111	36	611	132	84
BZN310	4.35	7.64	0.867	3.94	58.82	20.14	2.40	0.1190	1.37	0.18	167	102	152	108	176	111	41	632	126	90
BZN322	5.64	7.31	0.837	3.69	57.88	19.58	2.80	0.1212	1.79	0.17	166	139	150	102	163	118	41	660	134	84
BZY788	4.74	7.55	0.870	3.86	58.45	19.87	2.43	0.1214	1.56	0.36	172	124	153	103	154	109	39	648	140	81
BZY804	4.46	7.40	0.874	4.29	59.01	19.73	2.29	0.1180	1.43	0.21	178	103	152	100	148	103	43	636	126	80
BZY783	5.48	8.13	0.895	4.02	56.02	21.28	2.53	0.1261	1.17	0.16	159	104	162	116	160	110	38	673	138	83
BZY785	4.96	8.23	0.883	4.12	56.07	21.43	2.58	0.1259	1.24	0.16	152	106	167	115	167	116	41	690	145	89
BZY818	4.20	8.06	0.889	4.19	57.30	21.25	2.56	0.1276	1.06	0.16	158	95	163	115	157	117	42	682	129	85
BZY784	4.61	8.00	0.889	4.07	57.12	21.20	2.40	0.1214	1.19	0.19	164	109	163	108	152	108	34	704	139	83
BZY800	4.83	6.44	0.850	3.46	62.48	17.59	2.26	0.1092	1.63	0.19	202	110	129	91	139	94	38	569	110	79
BZY816	5.26	6.55	0.847	3.40	62.03	17.76	2.16	0.1107	1.52	0.20	206	101	131	94	142	96	33	565	108	80
BZN319	4.50	6.58	0.853	3.48	62.01	17.90	2.35	0.1116	1.88	0.16	214	113	131	103	151	101	32	563	108	85
BZY793	5.55	6.32	0.842	3.23	62.42	17.14	2.33	0.1100	1.71	0.18	229	113	124	90	142	94	38	548	106	85
BZY794	5.44	6.71	0.860	3.40	60.90	18.33	2.26	0.1133	1.65	0.16	195	105	137	97	140	94	45	599	114	83
BZY795	5.20	6.94	0.849	3.48	60.34	18.42	2.53	0.1151	1.79	0.15	189	106	138	101	150	99	38	603	113	79
BZN320	5.27	6.88	0.842	3.58	60.30	18.40	2.47	0.1129	1.61	0.36	189	116	134	101	175	113	41	596	117	84
BZY792	5.26	6.65	0.845	3.45	60.83	18.12	2.63	0.1142	1.73	0.19	208	119	136	97	142	99	40	614	118	76
Minor group																				
BZY812	12.74	6.76	0.618	3.39	53.38	16.27	5.09	0.1051	1.13	0.31	110	210	120	94	267	367	27	680	105	59
BZY801	11.77	6.94	0.644	3.45	52.49	17.08	5.95	0.1077	1.20	0.15	112	205	130	87	277	413	36	677	89	60
BZN317	11.76	7.10	0.654	3.34	53.08	16.54	5.99	0.1059	1.00	0.20	113	173	126	101	293	439	28	635	109	72
BZY815	7.85	6.45	0.674	3.78	57.67	17.83	4.07	0.1081	1.22	0.16	132	149	144	78	244	227	30	658	103	64
Chalcis reference group, local production (n = 56, Waksman et al., 2014)																				
m	5.17	7.38	0.848	3.70	58.68	19.68	2.52	0.1190	1.40	0.19	174	105	152	103	153	108	42	625	134	80
σ	0.62	0.42	0.014	0.21	1.90	0.98	0.18	0.0062	0.17	0.05	17	6	10	7	13	9	7	34	12	10
Thebes reference group, local production (n = 17, Waksman et al., 2014)																				
m	9.54	7.26	0.724	2.03	60.17	12.36	6.70	0.1076	0.47	0.23	138	139	84	89	530	552	<ld	272	118	53
σ	0.60	0.19	0.021	0.10	0.87	0.46	0.46	0.0055	0.08	0.04	6	6	4	5	32	48		15	7	8

turned to yellowish red, reddish-yellow (mainly), light red, and light reddish-brown to pink. No traces of slip have been detected on the outer surface. Still, the outer surface of BZN319–320 (cat.26–27) and BZY803 (cat.44) has a lighter, creamish color.

The Günsenin III amphorae are dated to the 12th–13th century AD and similarly to the Günsenin II type they were distributed all over the Eastern Mediterranean and the Black sea area (Todorova, 2012, 79–83 and the respective literature quoted).

Four amphorae (BZY801–802, BZY805, BZN317; cat.18, 20, 40–41), two handles (BZY798, BZY804; cat.19, 21), and four body sherds (BZY783–786; cat.22–25) can be attributed to a transitional type where characteristic signs of both Günsenin II and Günsenin III

amphorae can be observed.⁶ No amphorae belonging to the other Günsenin II–III transitional type (Günsenin, 1990, 27–28, Pl. XXXVIII/1a,b, 2, LXXXIV/1) have been identified so far. Although the amphorae are not identical they have large broad body and bulging belly. The conical neck ends with a slightly thickened and curved outwards rounded rim splayed by the handles. The handles are either strap-like or with ovoid cross-section and are attached to the neck under the rim. They rise above the rim level and taper down to the belly. The belly and body are covered with close-set horizontal fine grooves more spaced

⁶ This type was defined by N. Günsenin as her transitional type I–III (Günsenin, 1990, 24–25, Pl. XXX, XXXI, XXXII, LXXXIII/1).

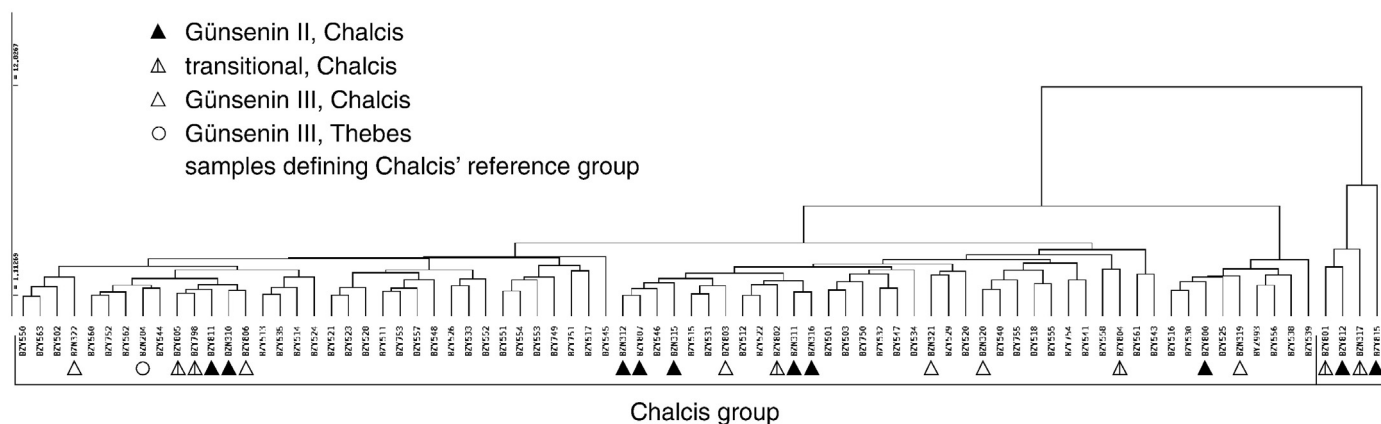


Fig. 5. Classification according to chemical compositions of samples of Byzantine amphorae, together with the reference group of Chalcis. Symbols indicate where the amphorae were found, as well as their type for the best-preserved examples. The chemical groups are underlined (S.Y. Waksman).

towards the bottom. The neck of BZN317 (cat.20) is also covered with shallow grooves.

The fabric of BZY801–802, BZY805 (cat.18, 40–41) is hard, mixed with many single small-sized (1–2 mm) and large-sized (4–10 mm) lime particles (Fig. 3). The color after firing has turned mainly to reddish-yellow, but also pink to light reddish-brown. There is a large amount of organics (probably straw) in the fabric of the handles (BZY802, BZY805; cat.18, 41). No traces of slip have been detected, but BZY798, BZY802 and BZY804–805 (cat.18–19, 21, 41) have a lighter color of the outer surface. BZN317 (cat.20) differs from the other amphorae not only from morphological point of view, but also as fabric. The fabric is relatively hard, but soapy. It is mixed with large amount of organics, grog particles (2–3 mm) and single molluscs. The color after firing has turned to reddish-yellow. No slip is detected on the outer surface.

So far these containers are hard to date since there are only few parallels, most of which with uncertain chronology (Barnea, 1959, 907, Fig. 2; Florescu and Florescu, 1959, 626, Pl. V₈; Pletneva, 1959, Fig. 31₁; Günsenin, 1990, 24–25, Pl. XXX, XXXI, XXXII, LXXXIII/1; Garver, 1993, 105–110, Ill. 37, Ill. 39, Plate 42; Todorova, 2012, 63, Pl. XXXII_{192–196}, XCII_{192–XCIII196}; Morozova et al., forthcoming). Considering the fact that they appear to be a transition between the Günsenin II and Günsenin III amphorae, one should put them at the end of the 11th–early 12th century AD.

3. Materials and methods

3.1. Chemical analysis of ceramic bodies

WD-XRF analyses were carried out in Lyon (CNRS UMR 5138) using a Bruker S8 Tiger X-ray spectrometer. Samples are cut out with a diamond-coated saw, and an external layer, whose chemical composition is more liable to be altered by the burial environment, is removed. After heating at 950 °C (removal of water, volatile elements, organics), cooling and grinding, 800 mg of ceramic powder is mixed with 3200 mg of flux (lithium metaborate and tetraborate). The mix is heated to liquid state in a gold and platinum crucible, then cast into a bead. Analyses are carried out on these homogeneous beads, of fixed geometry, which correspond to a mean chemical composition representative of the initial material. Twenty-four elements are quantified, after calibration of the set-up using 40 geological standards (CRPG, USGS, NIST, British Chemical Standards, etc.). The calibration is regularly checked using 3 in-house pottery standards.

3.2. Cluster analysis

Out of the 24 elements quantified, 17 are taken as active variables in multivariate statistical treatments used to classify samples into groups

of similar chemical composition. These include major and minor elements in ceramics (MgO, Al₂O₃, SiO₂, K₂O, CaO, TiO₂, MnO, Fe₂O₃) and trace elements having various geochemical behaviour (V, Cr, Ni, Zn, Rb, Sr, Zr, Ba, Ce). Classifications are carried out by hierarchical cluster analysis, applied to standardized data, using euclidian distance and average linkage (e.g. Picon, 1984). Interpretation however requires further examination of the initial individual chemical compositions, taking into account various geochemical, technological and analytical factors (e.g. Waksman, 2016).

4. Results of chemical analysis

The classification of the amphorae samples according to their chemical composition shows a large, main group and a small, minor one (Fig. 4). The main group includes 41 out of the 45 samples considered in this study.

Samples in the minor group (BZY812, BZY801, BZN317, BZY815) are distinguished by higher magnesium, chromium and nickel contents, which point to ultrabasic components (Table 2). One of them (BZY815) is marginal, due to lower Mg, Ni, Ca, Sr and higher Si, K, Rb concentrations. Its aspect suggests that part of it was reduced and overfired during firing. Alterations of a glassy phase due to overfiring could induce chemical differences (Picon, 1991). This would however not explain those observed in our case, as we would then rather expect a loss in K. In any case, the group is too small to be well defined, and to decide if these differences are significant.

The classification shown in Fig. 5 compares our sampling of amphorae to the reference group of Chalcis, which was established for its production of tablewares, both contemporary and posterior to the amphorae (Waksman et al., 2014). It shows that all the amphorae belonging to the main group are included in it (see also Table 2). In this case, the clayey material used by Chalcis potters for tablewares and for amphorae is similar, and the reference group previously defined could be used to identify the origin of these amphorae.

The other group was compared to the reference group we had defined for Thebes, also for tablewares (Waksman et al., 2014) (Fig. 6, Table 2). The binary plot in Fig. 6 shows that although these samples and Thebes' reference group share high chromium and nickel contents as a common chemical feature, they do not correspond to the same range of values. They do not seem to present a common co-variation either, although there are not enough amphorae samples to be certain. The criterium of a common correlation may be significant especially in the case of ultrabasic materials, in which the absolute values of chromium and nickel may be globally high, but very variable (Waksman and Tréglia, 2007). In this case, we cannot show a connexion between our reference group of Thebes and the group of amphorae. This does not

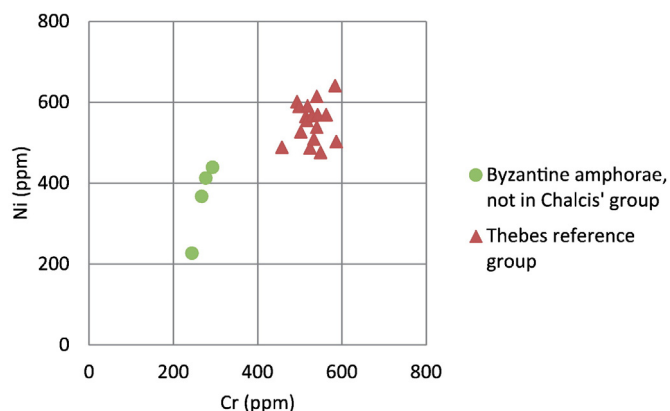


Fig. 6. Binary plot chromium–nickel, showing different trends in two high Cr–Ni groups, one including Byzantine amphorae and the other corresponding to Thebes reference group (S.Y. Waksman).

rule out Thebes altogether as a potential origin, though, as different raw materials may have been used for the two categories of wares.

To sum up, chemical analysis pointed out a main group which may be attributed to the production of Chalcis, and at least another production whose origin could not be identified.

The main group, corresponding to Chalcis production, includes samples of both Günsenin II and Günsenin III types, as well as some transitional forms between Günsenin II and III (Fig. 1, Fig. 4). The other group does not include samples of type Günsenin III, but is also heterogeneous from the typological viewpoint, as it includes two examples of Günsenin II (BZY812, and BZY815 which is marginal to the group), and two transitional forms (BZY801, BZN317) (Fig. 2, Fig. 4). It is too small to be well defined, and would request further research on both its archaeological and archaeometric characteristics.

5. Concluding remarks

Our results show that most of the amphorae we considered may be attributed to the production of Chalcis. The latter includes types Günsenin II and III, which implies that this production lasted for several centuries, from the 10th to the 13th century. The two types should now be reconsidered in their general typo-chronological framework: on the one hand to study the evolution of Chalcis production from one type to the other, through the recognition of locally fabricated transitional forms. On the other hand, chemical analysis pointed out that Chalcis was not the only production site, at least for type Günsenin II and some transitional forms; our results suggest multiple workshops whose location cannot be identified at the present stage of research. Besides, it is noticeable that, based on the sampled material, we have so far no evidence of Günsenin III production other than Chalcis.

The latter represents the vast majority of the samples considered in the present study. This may be a sampling bias, as our sampling mainly comes from Chalcis itself, and the close relationships between Thebes and Chalcis may explain that a “random” sampling from Thebes is shown to be of Chalcis origin only. However, ongoing archaeometric studies of amphorae of types Günsenin II and III, found in the Novy Svet shipwrecks off the Crimea (Zelenko, 1999, 2009) and in Turkey (Günsenin, 1990), show that Chalcis production was also exported (Morozova et al., forthcoming). Shipwrecks finds in the Aegean indicate that Günsenin III amphorae were traded on a large scale (Koutsouflakis, forthcoming), as were the tablewares manufactured in Chalcis (Waksman et al., 2014, in this volume).

Our results emphasize the role of the harbor of Chalcis as the maritime gateway of agricultural products of Central Greece, which may have been exported along with other more elusive products such as

the famous silk textiles of Thebes (Jacoby, 1991–1992; Kontogiannis et al., forthcoming). Residues analysis carried out on some of the Günsenin III presented in this paper are expected to provide further insight into the nature of this trade, through the identification of their contents (Pecci et al., forthcoming). How this trade was impacted by the fourth Crusade, when Chalcis changed hands from Byzantine to Frankish rule at the beginning of the 13th century, would also deserve further research.

Acknowledgements

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Appendix A. Catalogue of the samples investigated

Boeotia - Thebes

Günsenin III

- [BZN204] Amphora. Preserved height: 0.48 m. Max. diameter of belly: 0.28 m. Rim and most part of handles missing. Pear-shaped body with rounded bottom. Small part of high handles attached on the shoulder. Fine horizontal grooves on body. Fabric⁷: light red (2.5 YR 6/6 to 7/6), with some small-to-medium voids and white inclusions. Ismenion Hill, Bucknell University excavations 2014, pit 6 (12th–13th century). Chalcis production

Body sherds.

- [BZY816] Vourdoumba 38 Str. (Konsta plot), trench II, pit 1 (find-group 11: mixed, 13th–16th century). Chalcis production
- [BZY817] Vourdoumba 38 Str. (Konsta plot), trench V (find-group 61: 13th–14th century). Chalcis production
- [BZY818] Vourdoumba 38 Str. (Konsta plot), trench I, pit 2 (find-group 50: 12th–13th century). Chalcis production
- [BZY819] Vourdoumba 38 Str. (Konsta plot), balk 2/near wall 2 (find-group: 32: mixed, 12th–16th/17th century). Chalcis production
- [BZY820] Vourdoumba 38 Str. (Konsta plot), balk 2/near wall 2, (find-group: 32 mixed, 12th–16th/17th century). Chalcis production
- [BZY821] Vourdoumba 38 Str. (Konsta plot), trench IV, near wall 2 (find-group 25: mixed, mainly 16th/17th century). Chalcis production

Euboea - Chalcis

Günsenin II

- [BZY811] Amphora, upper part. Preserved height: 0.16 m. Preserved width: 0.21 m. Diameter of rim: 0.115 m. Conical neck with folded rim. Part of strap handles starting from the middle of the neck and rising above rim. Fabric: yellowish red to reddish yellow (5YR 5/6 to 6/6), with some small-to-medium voids and white inclusions. Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5

⁷ Fabric color is described here according to the *Munsell Soil Color Charts* (1998 edition).

- (find-group 159: 10th–11th century).
Chalcis production
9. [BZN310] Amphora, upper part. Preserved height: 0.242 m. Preserved width: 0.265 m. Diameter of rim: 0.108 m. Conical neck with folded rim. Strap handles starting from the middle of the neck, rising above rim and ending on the shoulder. Shallow horizontal grooves on the shoulder and incised decoration with curved lines on upper body. Fabric: light red to reddish yellow (2.5YR 6/6 to 5YR 6/6), with some small voids and some small-to-medium white inclusions.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 169: 10th–11th century).
Chalcis production
10. [BZN311] Amphora, upper part. Preserved height: 0.18 m. Preserved width: 0.185 m. Diameter of rim: 0.12 m. High conical neck with folded rim. Part of strap handles starting from the middle of the neck and rising above the rim. Shallow horizontal grooves on the neck. Fabric: reddish yellow (5YR 6/6 to 7/6), with some small voids and a few small-to-medium white inclusions. Red *dipinti* on the neck.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 169: 10th–11th century).
Chalcis production
11. [BZN312] Amphora, upper part. Preserved height: 0.175 m. Preserved width: 0.172 m. Diameter of rim: 0.12 m. High conical neck with folded rim. Part of strap handles starting from the middle of the neck and rising above the rim. Shallow horizontal grooves on the shoulder. Fabric: pink to light reddish brown (5YR 6/4 to 7/4), with a few small voids and white inclusions. Incised *graffito* (cross) on the neck.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 169: 10th–11th century).
Chalcis production
12. [BZN315] Amphora, upper part. Preserved height: 0.183 m. Preserved width: 0.185 m. Diameter of rim: 0.12 m. High conical neck with folded rim. Part of handles starting from the middle of the neck and rising above the rim. Fabric: reddish yellow (5YR 7/6), with a few small voids and a few small-to-medium white inclusions.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century).
Chalcis production
13. [BZN316] Amphora, upper part. Preserved height: 0.16 m. Preserved width: 0.17 m. Diameter of rim: 0.115 m. High conical neck with folded rim. Part of strap handles starting from the middle of the neck and rising above the rim. Fabric: reddish yellow (5YR 6/6 to 7/6), with a few small voids and a few small-to-medium white inclusions. Circular mark on the neck.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century).
Chalcis production
14. [BZY812] Amphora, upper part. Preserved height: 0.16 m. Preserved width: 0.21 m. Diameter of rim: 0.115 m. Small part of neck with folded rim preserved. Part of strap handle starting from the middle of the neck and rising above the rim. Fabric: yellowish red to reddish yellow (5YR 5/6 to 6/6), with some small-to-medium voids and white inclusions.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century).
Unknown production
15. [BZY815] Amphora, neck and handle fragment. Preserved height: 0.17 m. Preserved width: 0.12 m. Estimated diameter of rim: 0.12 m. About half of high conical neck, small part of folded rim and part of a strap handle rising above the rim level. Fabric: reddish yellow (5YR 7/6), with many small-to-large voids and white inclusions.
Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 170: 10th–11th century).
Unknown production
16. [BZY807] Amphora, upper part. Preserved height: 0.19 m. Preserved width: 0.20 m. Diameter of rim: 0.105 m. High conical neck, folded rim. Part of strap handles starting from the middle of the neck and rising above the rim level. Fabric: reddish yellow (5YR 6/6), with a few small voids and occasional small white inclusions.
Aggeli Goviou & Favierou Str. (Matsa plot).
Chalcis production
17. [BZY800] Amphora, handle fragment. Preserved height: 0.16 m. Preserved width: 0.7 m. Part of strap handle and very small part of body preserved. Fabric: reddish yellow to yellowish red (5YR 5/8 to 6/8), with some small-to-medium voids and white inclusions.
Mitropoleos Str. (ATTON plot), trench D, pit 6 (find-group 69: 13th–early 14th century).
Chalcis production
- Transitional*
18. [BZY805] Amphora, upper part. Preserved height: 0.105 m. Preserved width: 0.115 m. Diameter of rim: 0.08 m. Narrow neck with thickened rim. Part of handles starting from the middle of the neck and rising above the rim. Fabric: reddish yellow (5YR 6/6 to 6/8), with some small-to-large voids and white inclusions.
Agia Varvara square (IKA plot).
Chalcis production
19. [BZY804] Amphora, handle fragment. Preserved height: 0.233 m. Two mended pieces preserve almost complete high heavy handle. Fabric: reddish yellow (5YR 6/6 to 6/8), with some small-to-large voids and white inclusions.
Agia Varvara square (IKA plot).
Chalcis production
20. [BZN317] Amphora, upper part. Preserved height: 0.062 m. Preserved width: 0.095 m. Diameter of rim: 0.12 m. Shallow horizontal grooves on the neck. Tapering rim. Part of handles starting from the middle of the neck and rising above the rim. Fabric: reddish yellow (5YR 7/6), with many small to large voids and rare small white inclusions.
Agia Varvara square (IKA plot).
Unknown production
21. [BZY798] Amphora, handle fragment. Preserved dimensions: 0.09 m × 0.08 m. Lower handle attachment and very small part of shoulder preserved. Fabric: reddish yellow (5YR 6/6), with

some small-to-medium voids and white inclusions. Fine horizontal grooves.

Mitropoleos Str. (ATTON plot), trench D, pit 6 (find-group 70: 13th–early 14th century).

Chalcis production

Body sherds.

22. [BZY783] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century). Chalcis production
23. [BZY784] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century). Chalcis production
24. [BZY785] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench D, pit 5 (find-group 159: 10th–11th century). Chalcis production
25. [BZY786] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 186: 10th–13th century). Chalcis production

Günsenin III

26. [BZN319] Amphora, upper part. Preserved height: 0.188 m. Preserved width: 0.21 m. Diameter of rim: 0.065 m. Upper part of narrow neck with everted thickened rim and part of high heavy handles starting from the neck. Fabric: light reddish brown to pink (5YR 6/4 to 7/4), with many small-to-large voids and many small white inclusions.

Isaiou & Trapezountiou Str (Domi plot), pit II.

Chalcis production

27. [BZN320] Amphora, upper part. Preserved height: 0.123 m. Preserved width: 0.15 m. Diameter of rim: 0.078 m. Narrow neck, thickened rim, conical shoulder. Part of high heavy handles starting from the shoulder preserved. Fabric: light reddish brown to pink (5YR 6/4 to 7/4), with many small-to-medium-voids and white inclusions.

Mardochoiou Frizi Str (KTEL plot).

Chalcis production

28. [BZY806] Amphora, upper part. Preserved height: 0.225 m. Preserved width: 0.135 m. Estimated diameter of rim: 0.065 m. Long, narrow conical neck with everted rim and part of high handles starting from the neck. Fabric: reddish yellow (5YR 6/6), with some small voids and many small-to-medium white inclusions.

Eleftheriou Venizelou 53 Str. (Xidi plot).

Chalcis production

Body sherds.

29. [BZY787] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 186: 10th–13th century). Chalcis production
30. [BZY788] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 186: 10th–13th century). Chalcis production
31. [BZY789] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 186: 10th–13th century). Chalcis production
32. [BZY790] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 186: 10th–13th century). Chalcis production
33. [BZY791] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 178: mixed, Late Byzantine and Post-Byzantine). Chalcis production

34. [BZY792] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 178: mixed, Late Byzantine and Post-Byzantine). Chalcis production

35. [BZY793] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 189: 12th–13th century). Chalcis production

36. [BZY794] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 195: 10th/11th–13th century). Chalcis production

37. [BZY795] Erotokritou-Olynthou-Skalkota Str (Toulitsi plot), trench E (find-group 195: 10th/11th–13th century). Chalcis production

38. [BZY796] Balaleon 33 Str. (Chanos plot), wall 1 (find-group 36: 12th–14th century). Chalcis production

39. [BZY799] Mitropoleos Str. (ATTON plot), trench D, pit 6 (find-group 70: 13th–early 14th century). Chalcis production

Euboea Countryside

Transitional

40. [BZY801] Amphora. Height: 0.50 m. Max. diameter of belly: 0.27 m. Pear-shaped body with fine horizontal grooves, rounded bottom. Conical neck, everted rim, high handles starting below the rim and ending on the shoulder. Fabric: reddish yellow (7.5YR 7/6), with rare small voids and a few small white inclusions.

Dokos (Aggelou plot).

Unknown production

41. [BZY802] Amphora. Height: 0.46 m. Preserved diameter of belly: 0.26 m. Estimated diameter of rim: 0.085 m. Complete profile (two mended pieces). One handle and large part of body missing. Pear-shaped body with rounded base. Short neck, everted rim. Handles starting from the neck, rising above the rim and ending on the shoulder. Fabric: pink to light reddish brown (5YR 7/4 to 6/4), with some small to large voids and a few small to large white inclusions.

Dokos (Aggelou plot).

Chalcis production

Günsenin III

42. [BZN321] Amphora. Height: 0.625 m. Estimated diameter of rim: 0.035 m. Max. diameter of belly: 0.305 m. Almost complete (part of one handle missing). Tall pear-shaped body with rounded bottom. Narrow neck with everted rim. High handles attached on the rim and shoulder. Fabric: yellowish red to reddish yellow (5YR 5/6 to 6/6), with a few voids and some medium-to-large white inclusions.

Dokos (Aggelou plot).

Chalcis production

43. [BZN322] Amphora. Height: 0.655 m. Diameter of rim: 0.07 m. Max. diameter of belly: 0.295 m. Almost complete (one handle missing). Tall pear-shaped body with rounded bottom. Narrow neck with everted rim. High handles attached on the rim and shoulder. Fabric: reddish yellow (5YR 6/8), with a few voids and some small white inclusions.

Dokos (Aggelou plot).

Chalcis production

44. [BZY803] Amphora, handle and body fragment. Preserved height: 0.215 m. Preserved width: 0.17 m. Small part of rounded upper body and part of a high handle attached on the shoulder. Fabric: pink to reddish yellow (5YR 7/4 to 7/4), with a few small-to-

medium voids and some medium-to-large white inclusions.
Dokos (Aggelou plot).
Chalcis production

Body sherds.

45. [BZY797] Karystos, Palaiochora, Church of Transfiguration. Chalcis production

Appendix B. Supplementary data

3D model: Example of amphora of type Günsenin III (sample BZN322), shown to belong to Chalcis production (Ephorate of Byzantine Antiquities of Chalkida, Greece; 3D model S. Shabo). Supplementary data associated with this article can be found in the online version, at <http://dx.doi.org/10.1016/j.jasrep.2016.12.008>.

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