Provenance studies of Günsenin IV amphorae from the Novy Svet Shipwreck

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Abstract: The origin of Günsenin IV amphorae from the "Novy Svet Late Byzantine shipwreck" (Crimea) was investigated using chemical and petrographic analyses. Besides a main group, several small sub-groups indicate multiple workshops. The former shares similar features with examples of Günsenin I amphorae, including some from the Ganos workshops (Turkey), suggesting that the clayey material they were made of comes from the same geological formations. Petrographic analyses further narrows down the area to parts of the Dardanelles strait and of southern Thrace. These hypotheses are supported by surveys material carried out in the strait, and call for future development of field work in this area.

Keywords: Late Byzantine amphorae, Turkey, Dardanelles strait, Crimea, shipwreck, provenance studies, archaeometry, petrography, chemical analysis

Resumen: El origen de las ánforas Günsenin IV del naufragio bizantino tardío de Novy Svet (Crimea) se investigó a través de análisis químicos y petrográficos. Además de un grupo principal, varios subgrupos pequeños indican múltiples talleres de cerámica. Esas ánforas comparten características similares con ejemplos de ánforas de Günsenin I, incluidas algunas procedentes de los talleres de cerámica de Ganos (Turquía), lo que sugiere que el material arcilloso con el que estaban fabricadas procede de las mismas formaciones geológicas. Los análisis petrográficos reducen aún más el área del origen a partes del estrecho de los Dardanelos y del sur de Tracia. Estas hipótesis están respaldadas por material de encuestas realizadas en el estrecho y exigen un futuro desarrollo de trabajos de campo en esta zona.

Palabras clave: Ánforas bizantinas tardías, Turquía, estrecho de los Dardanelos, Crimea, naufragio, estudios de procedencia, arqueometría, petrografía, análisis químicos

INTRODUCTION

Günsenin IV amphorae (Günsenin, 1990, 2018) are among the latest amphorae widely distributed in the Mediterranean in the 12th to 14th century, before other types of containers such as barrels took over (e.g. Bevan, 2014). Unlike the other main types of Middle and Late Byzantine amphorae (Günsenin I to III), their workshop(s) are identified neither archaeologically, nor on the basis of archaeometric investigations (for Günsenin I: e.g. Günsenin, 1990, 1995, for Günsenin II and III: Waksman *et al.*, 2018). Early observations of samples of Günsenin I and IV amphorae had led M. Picon to notice that their fabrics were fairly similar, and the hypothesis of a common area of origin had been put forward, then nuanced (Günsenin, 2018: 95). The present study intends to investigate this hypothesis further, using chemical and petrographic analyses.

Analyses were carried out on Günsenin IV examples coming from the Novy Svet shipwrecks site, located off the south-eastern coast of the Crimean peninsula, and excavated from 1999 to 2014 by a team of the Taras Shev-

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Figure 1. Map showing the location of the Novy Svet shipwrecks and of other sites and areas mentioned (A. Shapiro).

chenko National University of Kiev directed by S. Zelenko (Fig.1) (e.g. Zelenko, 1999; Zelenko and Morozova, 2010). They follow previous archaeometric investigations of other types of amphorae and of various table wares from the two shipwrecks found at the site (Waksman *et al*., 2009; Waksman and Teslenko, 2010; Morozova *et al*., 2020), including residues analyses of some of the Günsenin IV examples (Pecci *et al*., 2020). The comparative data considered include analyses of Günsenin IV amphorae from the Çamaltı Burnu I shipwreck excavated in the sea of Marmara (Günsenin, 2001, forthcoming), and of Günsenin I amphorae from the Ganos/Gaziköy workshops (Günsenin, 1990, 1995). The study develops previous archaeometric research on the Çamaltı Burnu I material (Waksman, forthcoming), and proposes further insight based on petrographic analysis.

ARCHAEOLOGICAL CONTEXT AND SAMPLES ANALYZED

In the "Novy Svet Late Byzantine shipwreck", Günsenin IV amphorae constitute the dominant majority of the ceramic sherds (Zelenko and Morozova, 2010). The prevalence of this type of amphorae, along with the types of glazed ware and the numismatic material found in the shipwreck, enabled the researchers to date it to the end of the 13th century (Zelenko, 1999). Since 1999, thousands of amphora sherds and several archaeologically complete vessels were raised from the shipwreck. The walls with graffiti, and the upper and lower parts of the vessels, are part of the archaeological collection stored at the Taras Shevchenko National University of Kiev.

Another shipwreck identified in the same zone, the "Novy Svet Byzantine shipwreck", carried two earlier types of amphorae, Günsenin I and II (Zelenko, 2001; Morozova *et al*., 2020). Its layers, dated back to the 10th-11th century, and the 13th century ones overlap over a large portion of the shoreward area, as storms, waves and sediment movements have dispersed elements of each assemblage throughout the other (Morozova *et al*., 2020).

A corpus of 32 samples of Günsenin IV amphorae was taken for chemical analysis in Lyon laboratory (for details of the analytical procedure see e.g. Waksman, 2011). Eleven are rims

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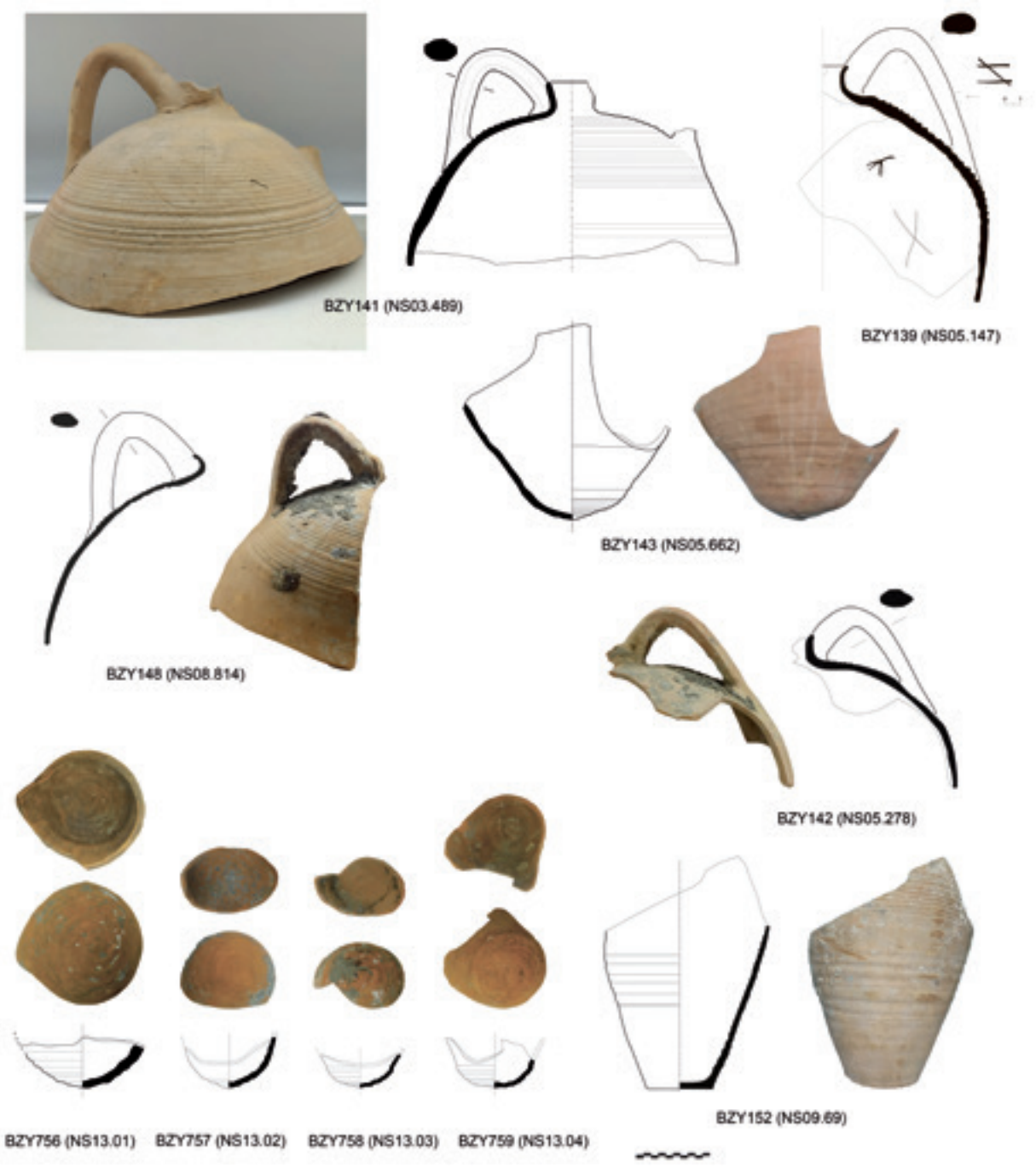

Figure 2. Amphorae from Novy Svet analyzed, belonging to the main chemical group (except for BZY757): upper parts of Günsenin IV, bases of Günsenin IV or Günsenin I, base of Günsenin XXI or XXII (BZY152) (CUA, Tarass Chevchenko National University of Kiev).

with handles or bases (Figs.2, 3), the others are body sherds. Some of the bases and body sherds may alternatively be identified as fragments of Günsenin I amphorae; they will be indicated in the following sections.[1]

A sub-sample of 6 examples was further selected for petrographic analysis, carried out in the IAA laboratory. They were chosen within the main group defined by the results of chemical analysis.

1 The sampling was carried out by Y. Mozorova at an initial stage of the typological study. One of the sample (BZY152, Fig.2) is now identified as a Günsenin type XXI or XXII (Günsenin, 1990: 44).

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Figure 3. Amphorae from Novy Svet analyzed, not belonging to the main chemical group: Günsenin IV amphorae (CUA, Tarass Chevchenko National University of Kiev).

RESULTS OF CHEMICAL ANALYSES

The classification according to their chemical composition[2] of the Novy Svet samples shows a main chemical group and a number of unclassified, isolated samples, except for two of them which have a similar composition (BZY147, BZY769), and possibly two others (BZY149, BZY150) (Figs.4a, 5 and Figs.2, 3). These unclassified sherds indicate that several Günsenin IV amphorae in the Novy Svet cargo came from other production sites. However, when the sampling is representative, most of the cargo would correspond to a single workshop or groups of workshop. The subsequent parts of the archaeometric study focus on the latter.

Figure 4b shows the classification of the Novy Svet samples together with examples

2 Hierarchical clustering analysis based on the concentrations of 15 elements, including the major and minor elements in ceramics (MgO, Al_2O_3, SiO_2, K_2O, CaO, TiO_2, MnO, Fe_2O_3) and trace elements (V, Cr, Ni, Zn, Rb, Zr, Ce), using standardised data, Euclidean distances and average linkage. For details of the classification procedure see e.g.: Picon, 1984; Waksman, 2011.

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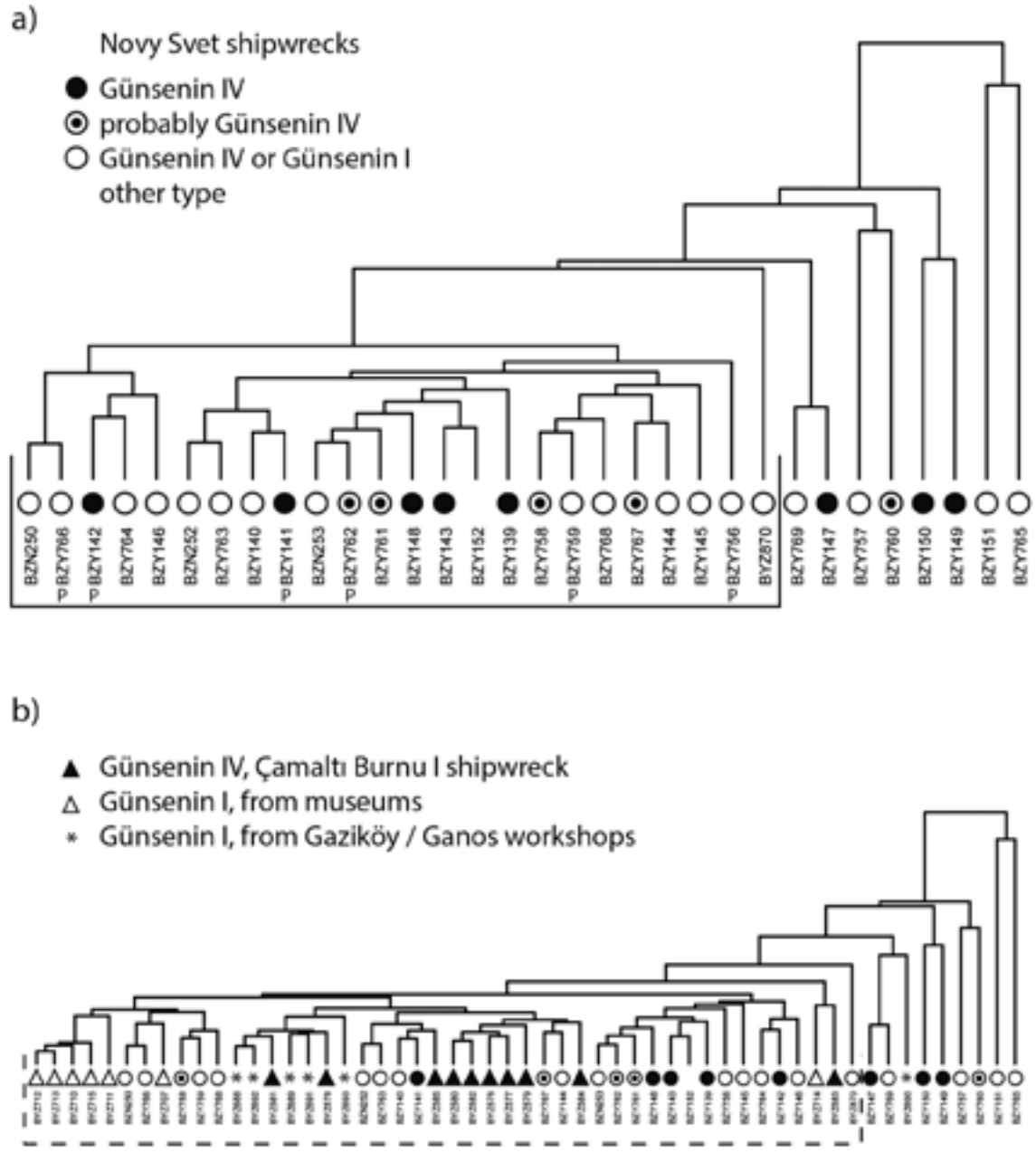

Figure 4. a: Classification according to their chemical composition of the Novy Svet samples. Symbols are related to their typology, «P» indicates those with petrographic analyses, the main chemical group is underlined (S.Y. Waksman). b: Classification according to their chemical composition of the Novy Svet samples, together with comparative material from the Çamaltı Burnu I shipwreck (Günsenin IV amphorae), from Ganos and from Turkish museums (Günsenin I amphorae) (after Waksman, forthcoming). Symbols are related to typology and sites (S.Y. Waksman).

of Günsenin IV amphorae from the Çamaltı Burnu I shipwreck, and with material from Günsenin's PhD. study[3]: samples collected in the village of Gaziköy (ancient Ganos), where kilns and wasters of Günsenin I amphorae were found, and Günsenin I amphorae from Turkish museums (Günsenin, 1990, 1993, forthcoming; Waksman, forthcoming).

A noticeable result is the chemical similarity between the Günsenin IV amphorae from both the Novy Svet and the Çamaltı Burnu shipwrecks and examples of Günsenin I amphorae,

3 We would like to thank N. Günsenin for making these samples available to us.

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Id.	CaO	Fe_2O_3	TiO_2	K_2O	SiO_2	Al_2O_3	MgO	MnO	(Na_2O)	(P_2O_5)	Zr	(Sr)	Rb	Zn	Cr	Ni	(Ba)	V	Ce
Novy Svet, main group																			
BZN250	6.88	7.22	0.803	2.91	59.06	16.17	4.44	0.1020	2.07	0.16	184	193	119	94	249	200	443	124	70
BZY766	6.53	7.29	0.809	2.93	59.40	16.16	4.37	0.0990	2.08	0.15	178	182	123	94	246	194	447	132	70
BZY142	5.16	8.03	0.868	3.14	58.75	17.31	4.33	0.1168	1.94	0.16	179	164	140	104	278	221	481	146	62
BZY764	4.59	7.60	0.838	3.02	59.95	17.04	4.61	0.0942	1.95	0.12	185	198	136	99	268	195	455	138	62
BZY146	5.98	8.50	0.870	2.95	57.60	16.56	4.82	0.0938	2.26	0.16	182	199	128	97	296	233	568	133	55
BZN252	5.32	8.10	0.892	3.22	56.76	18.61	5.06	0.1255	1.56	0.15	163	149	148	123	281	235	491	147	74
BZY763	5.31	7.96	0.893	3.26	56.95	18.69	5.00	0.1229	1.47	0.14	159	149	154	119	262	223	512	153	73
BZY140	6.40	7.90	0.882	3.23	56.78	17.81	5.00	0.1329	1.52	0.15	167	165	148	114	264	212	478	141	76
BZY141	5.22	8.02	0.876	3.20	57.33	17.77	5.33	0.1226	1.77	0.16	164	167	143	118	263	208	526	134	79
BZN253	6.89	8.25	0.864	2.94	56.05	17.56	5.16	0.1146	1.82	0.16	165	186	127	105	265	227	426	146	74
BZY762	7.59	8.24	0.856	2.87	55.67	17.18	5.25	0.1153	1.89	0.15	157	199	127	103	263	226	433	143	69
BZY761	6.53	8.48	0.898	2.86	56.80	17.27	4.77	0.1228	1.90	0.17	177	197	130	106	271	223	542	147	71
BZY148	6.28	9.41	0.872	3.01	55.56	17.28	5.21	0.1070	1.89	0.18	174	186	126	104	285	242	535	148	74
BZY143	4.79	8.41	0.847	3.00	58.67	17.41	4.82	0.0907	1.65	0.12	169	164	142	105	279	227	448	151	72
BZY152	5.37	8.67	0.868	3.03	57.02	17.70	5.01	0.0817	1.88	0.16	169	187	135	111	276	237	514	146	76
BZY139	5.75	9.12	0.895	3.15	55.87	18.07	5.16	0.1060	1.51	0.16	167	164	151	114	279	250	470	157	70
BZY758	5.42	7.58	0.814	2.95	59.34	16.64	4.53	0.1006	2.29	0.14	163	189	126	98	256	197	449	137	82
BZY759	6.37	7.66	0.826	2.86	58.65	17.07	4.42	0.0945	1.71	0.16	160	187	129	104	265	223	479	143	85
BZY768	7.02	7.52	0.817	3.05	57.14	16.88	5.08	0.1017	2.05	0.15	171	195	136	98	258	192	488	143	82
BZY767	6.35	8.74	0.858	3.10	56.28	17.43	5.02	0.1082	1.75	0.17	158	179	140	104	268	237	473	137	86
BZY144	6.34	8.48	0.867	3.14	56.80	16.99	5.22	0.1173	1.70	0.15	179	180	139	107	274	216	471	135	81
BZY145	6.58	7.90	0.870	2.91	57.56	16.72	5.18	0.1003	1.82	0.16	167	203	126	95	331	268	436	135	76
BZY756	5.60	8.41	0.849	2.93	56.14	17.38	6.32	0.1063	1.92	0.15	157	191	124	101	271	214	449	160	84
m	**6.01**	**8.15**	**0.858**	**3.03**	**57.40**	**17.29**	**4.96**	**0.1077**	**1.84**	**0.15**	**169**	**181**	**135**	**105**	**272**	**222**	**479**	**142**	**74**
σ	**0.78**	**0.55**	**0.028**	**0.13**	**1.30**	**0.65**	**0.43**	**0.0129**	**0.22**	**0.01**	**9**	**16**	**10**	**8**	**17**	**19**	**38**	**9**	**8**
marginal to the main group																			
BYZ870	5.43	7.25	0.874	2.70	60.58	17.17	3.64	**0.1476**	1.82	0.20	202	210	134	102	260	196	508	112	97
sub-group of outliers																			
BZY769	6.37	7.13	0.816	2.63	61.64	16.48	2.88	0.0623	1.72	0.11	151	252	122	89	136	81	378	137	74
BZY147	8.06	6.87	0.796	2.64	60.86	15.66	2.89	0.0661	1.88	0.12	168	263	118	92	146	73	371	133	65
other outliers																			
BZY757	1.69	6.85	0.908	3.21	62.60	20.78	2.27	0.0599	1.32	0.15	219	119	156	109	135	64	362	147	88
BZY760	0.78	8.53	1.188	2.55	63.23	18.00	3.18	0.0996	2.13	0.16	207	105	98	98	167	94	405	166	69
BZY150	12.23	7.36	0.732	2.20	52.98	14.28	7.86	0.1820	1.83	0.15	165	332	85	89	259	206	461	130	79
BZY149	9.88	7.47	0.750	2.42	59.36	14.07	3.62	0.2154	1.90	0.13	189	198	98	81	249	193	529	116	59
BZY151	2.64	6.59	0.727	1.54	60.90	23.65	1.76	0.0657	1.81	0.05	226	1023	78	78	47	19	808	131	80
BZY765	0.17	3.79	1.479	1.88	70.57	20.25	1.14	0.0333	0.49	0.02	255	41	106	128	117	65	451	151	67
comparative data																			
Günsenin I amphorae, including Ganos reference samples (n=12, Waksman forthcoming)																			
m	**6.74**	**7.28**	**0.826**	**3.37**	**57.71**	**17.22**	**4.66**	**0.1156**	**1.71**	**0.17**	**182**	**169**	**137**	**105**	**239**	**209**	**496**	**133**	**80**
σ	**0.88**	**0.20**	**0.011**	**0.21**	**1.10**	**0.36**	**0.34**	**0.0114**	**0.09**	**0.02**	**7**	**8**	**5**	**6**	**6**	**8**	**17**	**9**	**7**

Figure 5. Chemical compositions of samples from Novy Svet, ranked as in the classification figure 4a, and comparative data (major and minor elements in oxide weight %, trace elements in ppm; m: mean, σ: standard deviation, n: number of samples; elements between brackets were not used in the classifications) (S.Y. Waksman).

including those from Ganos (Figs.4b, 5). It does not imply that Günsenin IV amphorae were produced in Ganos, as some differences may be noticed (Waksman, forthcoming), and no archaeological evidence that they were manufactured there was found (Günsenin, 2018: 95). But it supports that clays from similar geological formations were exploited to manufacture them. Picon suggested that the clay material used in Ganos workshops corresponds to the coastal Miocene formations of the northern shore of the Sea of Marmara (Günsenin, 1990: 54-56, 2018: 94-95). The presence of localised outcrops of serpentinite in the area may explain the fairly high concentrations in nickel, and to a lesser extent in chromium, in Ganos samples (Fig.5). These formations continue to the south-west, and are present on both sides of the Dardanelles strait. However, previous research does not provide evidence that Günsenin IV workshops were located on the asiatic side of the strait (Waksman, forthcoming). Further clues regarding their location were looked for using petrographic analysis, which could rely on recent and detailed geological studies.

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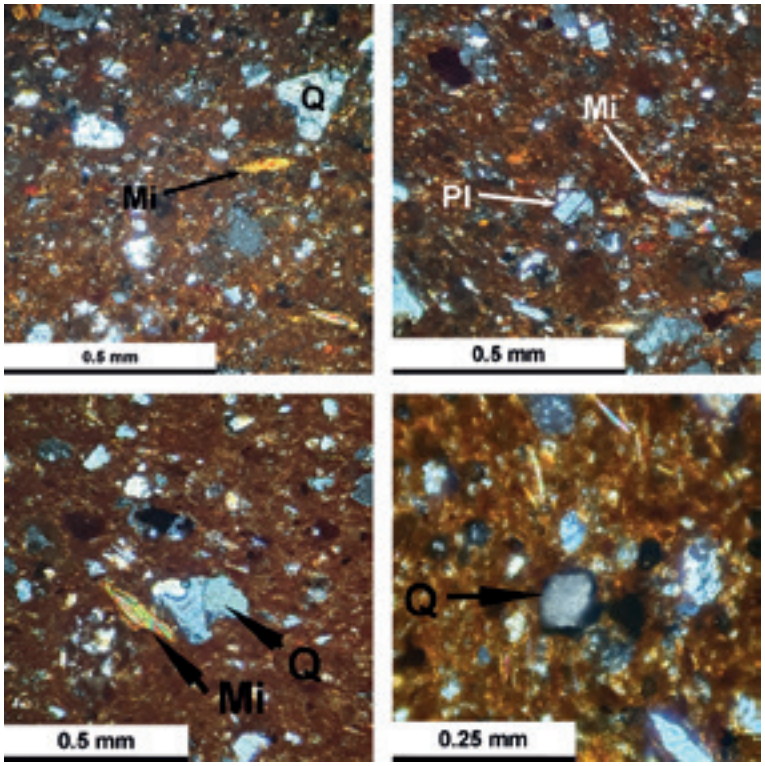

Figure 6. Microphotographs under the polarizing microscope, cross-polarized light: Günsenin IV amphora (above: BZY142), coated quartz in a Günsenin I or IV amphora (below right: BZY766), Novy Svet shipwreck; Günsenin I amphora from Ganos (below left: BYZ692) (A. Shapiro).

RESULTS OF PETROGRAPHIC ANALYSES

The samples examined under the polarizing microscope[4] (marked "P" in Fig.3a) form one petrographic group by both matrix and non-plastic inclusions. They have a slightly ferruginous matrix, containing ca. 10–20% of mica laths, mostly oriented parallel to the surfaces of the vessels, about 5-10% of silty quartz, numerous very dark brown opaque specks of iron oxide (maybe limonite), some K-feldspar, and rare plagioclase and olivine. The sand-size non-plastic inclusions compose ca. 1-3% of the volume of the sherds and their sizes range between 0.05 and 0.4 mm, with few larger grains. The inclusions comprise grains of mosaic and mature quartz, many of which have an undulose extinction, K-feldspar, plagioclase, mica schist, mica laths, hardly eroded basalt, chert, calcareous material, and nodules of ferruginous and/or argillaceous clay (Fig.6, above: BZY142). Some of the silt- and sand-size mineral grains have a black coating, opaque in transmitting light (Fig.6, below right: coated quartz in BZY766), which is present up to the core of the sherds. It probably corresponds to the penetration of the resin used to coat the amphorae, exceptionally preserved in the Black Sea environment as seen from residues analysis (Pecci *et al.*, 2020). The firing temperatures were estimated to ca. 700-750°C for samples BZY142, BZY756, and BZY766, ca. 750-800°C for samples BZY141 and BZY762, and ca. 800-850°C for sample BZY759.

When compared to Günsenin I amphorae from Gaziköy/Ganos (Fig.6, below left: BYZ692), their lithology suggests the same geological environments for both types, with the source of raw materials in clayey formation which originated within or close to ophiolitic series, and allows to propose that these amphorae were manufactured in the same geographic area. The workshops of Günsenin I amphorae identified archaeologically or through geophysical surveys are scattered along the north-western coastal line of the Sea of Marmara, between Hoşköy and Gaziköy/Ganos (Günsenin 1995). The only geologic sequence in the area comprising micas is olistoliths of the upper Eocene Çengelli formations, to the south of Ganos;

4 A previous examination of their microstructures with a magnifying glass showed the following features: light red to yellowish red sherds with very pale brown exterior and grayish brown core in thick cross-sections. The sherds contain plenty of mica laths and rare quartz, chert, and white, apparently calcareous, grits. Numerous rounded and elongated voids represent the negatives of organic matter which disappeared during firing.

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however, micas are also present in phyllites near Mecidiye, in southern Thrace (Okay *et al.* 2010: 10-14). These two areas (indicated by ellipses in Fig.1) are potential sources for the clayey material used to manufacture Günsenin IV amphorae.

CONCLUDING REMARKS

Chemical and petrographic analyses of Günsenin IV amphorae from the "Novy Svet Late Byzantine shipwreck" propose that some of their workshops were located in the region of the Dardanelles strait and/or of southern Thrace. From the typological viewpoint, this hypothesis would be consistent with an evolution from Günsenin I to Günsenin IV amphorae inscribed in the same morphological tradition. Workshops of Günsenin I are attested archaeologically around Ganos/Gaziköy, and it would not be surprising to find those of Günsenin VI in the same area *lato sensu*, extending to the gulf of Saros in southern Thrace. For the same reasons as for the Günsenin I amphorae, this location favours their use for maritime trade along the routes connecting the Aegean, and further on the Mediterranean, to the Byzantine capital and to the Black Sea, as testified by the Çamaltı Burnu I shipwreck. Archaeological clues also support our results, through the numerous fragments of Günsenin IV amphorae as well as the Byzantine structures related to wine production found during excavations and surveys in the region of the strait (e.g. Türker, 2012; Koçyiğit, 2017). Hopefully such field work will develop in the area, and find archaeological evidence of Günsenin IV amphorae workshops.

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