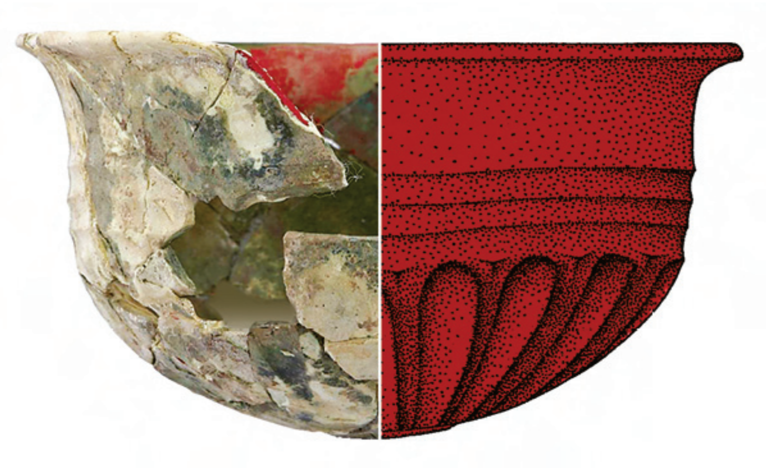
ANNALES



Thessaloniki 2009

du 18e CONGRÈS

de l'ASSOCIATION INTERNATIONALE
pour l'HISTOIRE du VERRE

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Editors
Despina Ignatiadou, Anastassios Antonaras

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Couverture / Cover illustration

The *haematinon* bowl from Pydna. Height 5.5 cm.
© 27th Ephorate of Prehistoric and Classical Antiquities, Greece.
The bowl (skyphos) is discussed in the paper by Despina Ignatiadou 'A *haematinon* bowl from Pydna', p. 69.

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MYCENAEAN BEADS FROM KAZANAKI, VOLOS: A FURTHER NODE IN THE LBA GLASS NETWORK

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Introduction

Mycenaean glass has not been studied as extensively as Egyptian or Mesopotamian glass, mostly because glass does not preserve well under the more humid soils of mainland Greece and the Aegean, and the material is not as widely available for research analysis. Only in the last few years, a more systematic and comprehensive investigation of the Mycenaean vitreous materials has been undertaken and has increased our understanding of the Mycenaean glass and faience making[1].

It is now accepted that the technology, of not only glass working, but the production of vitreous materials in general has been brought to the Aegean from the Near East, and in particular Egypt. From around 1500 BC glass starts to appear first in Crete and then in mainland Greece. The first glass objects have been identified as imported Egyptian and Mesopotamian products[2], however shortly after glass emerges in the Aegean we encounter glass objects worked locally[3].

After the initial import of glass beads from Egypt and Mesopotamia, during the flourishing of the Mycenaean palaces from the late 15th century BC on, local production of glass working into ornaments emerged. Remains of jewellery workshops, including moulds used for the production of these glass objects, have been found throughout the various Mycenaean centres[4]. Glass waste has been found together with finished objects at the Mycenaean citadel of Tiryns, identifying a local glass workshop within the Tiryns palatial centre[5].

Up to today no archaeological finds pointing to a primary glass production have been identified anywhere in the region of the Mycenaean centres. However, with the recent analytical work by Walton *et al.* (2009) and Jackson and Nicholson (2010), and the well-known Uluburun shipwreck with 175 glass ingots and thousands of glass beads on board[6], there is increasing evidence of glass trading in the Eastern Mediterranean.

The present paper examines glass finds from the Mycenaean tholos tomb of Kazanaki in Eastern Thessaly. Comparing our samples with LBA glass from the literature, especially with the extensive data provided by Shortland *et al.* (2007), Walton *et al.* (2009) and Degryse *et al.* (2010), enables us to place this glass within the broader compositional patterns of LBA glasses.

The Site

In 2004 an intact Mycenaean tholos tomb (Fig. 1) near the ring-road of Volos was investigated, providing valuable information concerning the burial customs of this period[7]. Among other finds, the tholos tomb contained significant numbers of Mycenaean glass jewellery, which are discussed in this paper.

The tholos tomb was found intact and belongs to the category of the medium scale tholos tombs. The entrance of the tomb preserves *in situ,* intact, its stone barrier (1.50 m thick).

Inside the tholos four shaft graves were investigated which had been dug into the floor. Bones of seven dead were found inside the tholos tomb[8], those of an adult woman in her 40s, of three men aged between 25 and 30, of a second adult woman aged 18 and of two children of about 8 years old.

The bones of the seven dead, along with their funeral gifts, were exposed to a fire of no more than 300 °C. After that, the remains of the pyre, that is the

1. Panagiotaki 2008; Tite *et al.* 2005; Walton *et al.* 2009; Nikita and Henderson 2006.
2. e.g., Walton *et al.* 2009.
3. Panagiotaki 2008, 45.
4. Dickinson 1999, 187.
5. Panagiotaki *et al.* 2005.
6. Pulak 2008.
7. Adrymi-Sismani 2005.
8. Papanastasiou 2009.

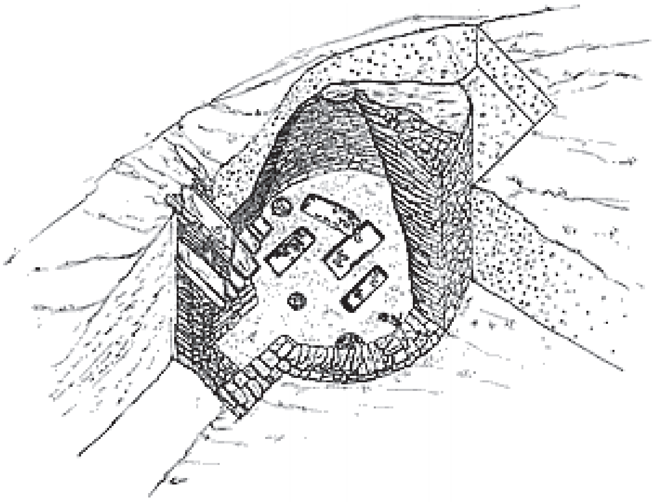

Fig. 1: Drawing of the tholos tomb at the Iolkos Mycenaean centre in the area of Kazanaki.

Fig. 2: Some of the relief beads that were found in the tholos tomb of Kazanaki.

semi-burnt bones and the semi-carbonized wood of the stretchers along with the grave gifts were placed without discrimination inside the three shaft graves, covered with stone slabs, and sealed with clay. During its transfer to the shaft graves, part of this material was scattered all over the tholos' floor. Consequently, the association of the grave gifts with specific deceased individuals is impossible. However, based on Papanastasiou (2009), we know that the seven dead were exposed to the fire at the same time.

The funeral gifts accompanying the dead consist of 42 decorated and plain vases that date the tomb to the LH III A2 period. We think that the plain vases that were found next to the fire, some of which bearing visible traces of burnt materials, had probably been used in second-phase funeral customs that took place during the simultaneous exposure of all seven dead in the fire, which –according to the pottery evidence– dates to the end of the LH III B2 period. The seven dead were given especially rich funeral gifts, including more than one thousand necklace beads made of gold, glass and faience, gold finger rings, gold and glass plaques, bronze daggers, clay figurines and seal stones with relief representations in semi-precious hard stones, as well as golden disks that were decorating the shrouds, and ivory rosettes and small plaques decorating their wooden stretchers.

The impressive assemblage from this tomb and its position in the inlet of the Pagasetic Gulf link this monument to the important Mycenaean centre of Iolkos[9]. The large amount of Mycenaean glass jewellery found in the tholos tomb in Kazanaki testifies to the high quality of the glass manufacturing techniques that were available to this big palatial centre.

The Samples

All the samples were found at the Kazanaki tholos tomb during the 2004 excavations and are associated with finds dated from 1400 to 1300 BC, broadly contemporary to the Amarna period in Egypt. Most of the beads and plaques were moulded, ornamental or part of necklaces, and are all stylistically identified as typical Mycenaean (Fig. 2).

The exact number of glass beads from the site is difficult to determine due to their fragmentary status; around 50 individual relief beads and plaques were analysed by air path XRF at the museum of Volos; fifteen of these were selected for further analysis. The preservation condition of the glass was one of the major criteria for identifying the objects to be selected for further examination, focussing on those with un-corroded areas of glass visible at the surface. This resulted in the selection of only blue glass beads, while those of different colours, including white and possibly yellow, were too corroded to merit sampling.

The majority of the beads where glass is still visible are blue in colour. The XRF analysis showed that all the beads and plaques are made of a soda-lime-silica glass with high contents of magnesia attributed to plant ash. Most of them had been coloured by cobalt, some by copper, and there was also a number of beads that were multiple striped. The colorants identified were lead-antimonate for yellow, calcium-antimonate for white, and copper or cobalt for the blue stripes.

Out of the fifteen beads that were selected for more detailed examination, only eleven had adequate glass for further analysis.

Methodology

The selected samples were analysed using laser ablation inductively coupled plasma mass spectrome-

9. Adrymi-Sismani and Alexandrou 2009.

try (LA-HR-ICP-MS) for major, minor and trace elements. The technique was selected because: (i) of its quasi-non-destructive nature, as the samples remain visually intact after the analysis. The laser removes a cylinder of glass of about 80 µm in diameter and 200 µm in depth, (ii) the low detection limit in the range of a few parts per million (ppm) or even lower makes it an ideal technique to measure trace elements in glass, allowing us to discriminate between regional production centres and possibly identifying sources of raw materials, and (iii) it is a rapid technique for the direct and quantitative determination of the chemical composition of glass.

The ablation system used is located at the National Centre of Scientific Research (CNRS) in Orléans, France. It consists of a Neodyme:YAG laser coupled with the Thermo Finnigan ELEMENT XR mass spectrometer. There was no special sample preparation for the samples that were analysed using LA-HR-ICP-MS.

The system was operated at its full energy at approximately 4 mJ with a laser beam diameter of 80 µm, and a frequency of 7 Hz. A pre-ablation time ranging from 15 s to 25 s was set up to eliminate the transient part of the signal and also to eliminate any possible surface contamination or corrosion affecting the results of the analysis. Two ablation passes were performed and the average was calculated. The National Institute of Standards and Technology (NIST) standard reference materials 610 and 612 along with Corning glass A were used for external standardization. Concentrations were calculated according to Gratuze (1999). Using the analytical protocol defined by Gratuze (1999), the detection limits range from 0.01 % to 0.1 % for the major elements, and between 20 and 500 ppb for all the other elements. The accuracy of the results is between 5 % and 10 % relative of the given standard values[10].

Chemical Composition

All eleven beads have a very similar composition. They are soda-lime-silica glasses, and their elevated concentrations of magnesia suggest that they were made using plant ash as the alkali source (Table 1). They all have very consistent compositions typical to other LBA glass. The silica content ranges from 64 % to 68 %, the soda levels range from 18 % to 21 %, the magnesia content is between 2.2 % and 3.5 %, and the lime content is from 4.5 % to 6.8 %.

	SiO_2	Na_2O	CaO	K_2O	MgO	Al_2O_3
K34649	64.3	21.3	5.54	1.66	2.49	2.06
K44033 23	65.0	20.4	5.57	1.35	3.47	1.92
K44039	65.2	19.2	6.53	1.12	3.39	2.10
K44141	65.1	20.0	5.88	1.34	3.12	1.92
K44141 bis	65.4	19.7	6.00	1.27	3.10	1.95
K44040 002	63.9	19.1	7.42	1.17	3.64	2.19
K35372	67.2	20.3	4.52	1.54	1.81	1.63
K35722	64.4	19.7	6.74	1.17	3.41	2.09
kaz t1	67.1	20.0	4.93	1.55	2.28	1.67
kaz t2	67.9	17.7	5.31	0.80	2.14	3.78
kaz t5	64.9	18.3	6.84	1.91	3.30	2.08
CorngA Measured	66.7	14.6	5.06	2.97	2.73	0.86
CorngA Given	66.9	14.3	5.03	2.87	2.66	1.00

	FeO	TiO_2	MnO	CuO	CoO	Cl
K34649	0.71	0.10	0.23	0.20	0.06	0.93
K44033 23	0.75	0.10	0.14	0.04	0.05	0.82
K44039	0.69	0.10	0.20	0.13	0.08	0.78
K44141	0.72	0.09	0.20	0.15	0.08	0.84
K44141 bis	0.69	0.09	0.17	0.15	0.08	0.87
K44040 002	0.68	0.10	0.16	0.14	0.08	0.83
K35372	0.62	0.07	0.12	1.08	0.09	0.61
K35722	0.66	0.09	0.22	0.14	0.08	0.84
kaz t1	0.67	0.09	0.13	0.18	0.07	0.83
kaz t2	0.65	0.09	0.19	0.02	0.05	0.99
kaz t5	0.82	0.09	0.14	0.27	0.08	0.74
CorngA Measured	1.07	0.79	0.96	1.29	0.13	N/A
CorngA Given	1.09	0.79	1.00	1.17	0.17	N/A

Table 1: Main and minor oxide concentrations of the samples from the tholos tomb at Kazanaki (wt %).

They are all coloured by cobalt with contents between 500 and 800 ppm. Only one has also significant amounts of copper oxide (1.1 %) potentially pointing to a deliberate addition rather than contamination from the cobalt colorant. As typical of cobalt-blue LBA glasses, all the beads show elevated contents of NiO, MnO, and ZnO; these elements are highly correlated with cobalt showing that they are contaminations associated with the source of the colorant.

Also, as most cobalt blue glasses from Egypt where the cobalt source has been linked to the alum ore of the Kharga oasis of the Western deserts in Egypt[11], all samples have elevated alumina levels of more than 1.5 %. Furthermore, all samples show low contents of potash of less than 2.0 %, again a typical indicator of the LBA cobalt blue glasses found in Egypt.

10. Smirniou 2012.

11. Kaczmarczyk 1986; Tite and Shortland 2003.

Trace Elements

Although on major elemental level LBA glass might seem quite homogeneous with small variations throughout the various regions, recent trace elemental analysis[12] has identified regionally diagnostic markers that enable us to differentiate between Mesopotamian and Egyptian-made glass. As has been noted first by Shortland (2005), there are a number of elements that most probably are associated with the raw materials, not with any colorant, and are distinct enough to chemically discriminate between glass from Mesopotamia and Egypt. Glass from Mesopotamia is often associated with levels of Cr of more than 10 ppm, while Egyptian glass is most frequently linked to elevated contents of La, Ti, and Zr, reflecting their elevated levels in the Nile silt[13], or possibly resulting from the use of stone tools for grinding the quartz pebbles[14].

Looking at the plot of La versus Cr (Fig. 3), we see that two distinct groupings are forming; one low La high Cr group that all Mesopotamian and most non-cobalt blue Mycenaean glass belongs to, and the other high La low Cr group comprising all the cobalt-blue (both Mycenaean and Egyptian), and the non-cobalt Egyptian samples. The ratio Cr/La is between 1.5-2.4 for all Egyptian and cobalt-blue Mycenaean glass, and between 7.1-7.3 for all Mesopotamian and non-cobalt Mycenaean samples, in line with the geographical grouping first suggested by Shortland (2005). The eleven samples from Kazanaki (Table 2) clearly plot close to the Egyptian samples with a ratio between 1.5 and 2.6, with the only exception of K35372 that has slightly elevated levels of Cr, around 16 ppm, and a Cr/La ratio of 4.5.

Similarly, all Mesopotamian and some non-cobalt Mycenaean glass has less than 20 ppm Zr (Fig. 4), while the Egyptian glass shows higher levels, reaching up to almost 80 ppm. The Kazanaki samples again match the Egyptian glass with a range between 40 and 60 ppm.

Titanium levels (Fig. 4) are quite low for Mesopotamian glass, around 160 ppm on average; all other groups, both Egyptian and the samples from Kazanaki have more than 400 ppm. Interestingly, the cobalt-blue glass shows even higher contents of an average of almost 800 ppm for the Egyptian samples, and around 600 for the Kazanaki ones.

12. Shortland *et al.* 2007; Walton *et al.* 2009.
13. Shortland 2005.
14. Rehren and Pusch 2008.

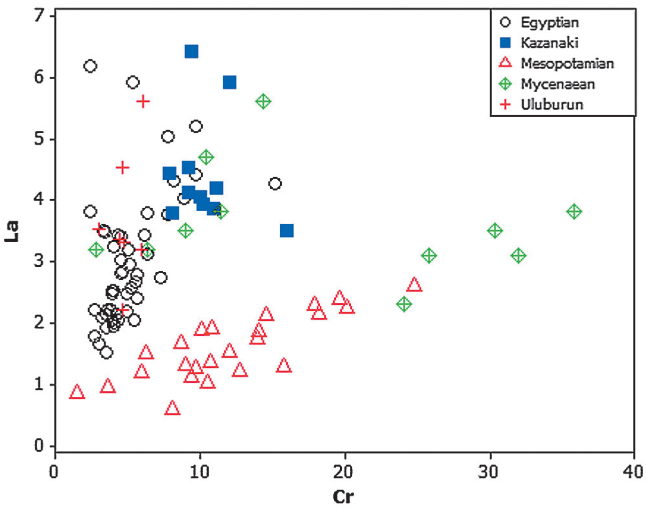

Fig. 3: La versus Cr contents of the Kazanaki samples in comparison with other cobalt-blue and non-cobalt glass samples from Egypt and Mesopotamia (Shortland *et al.* 2007), the Uluburun shipwreck (Jackson and Nicholson 2010; Rehren unpublished) and the Mycenaean centres (Walton *et al.* 2009). We observe two distinct groupings, where the Kazanaki samples clearly have levels of La and Cr similar to the Egyptian samples.

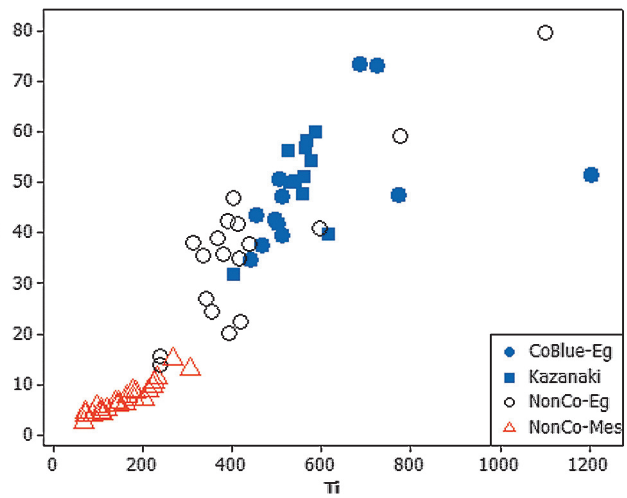

Fig. 4: Zr versus Ti plot of the Kazanaki samples in comparison with other cobalt-blue and non-cobalt glass samples (Shortland *et al.* 2007) from Egypt and Mesopotamia.

Discussion

Looking at the silica and soda levels, there are no distinct differences among glass from the various regions: Mesopotamia, Egypt, and the Mycenaean centres. However, most of the non cobalt blue Egyptian and Mycenaean samples show somewhat elevated levels of alumina and a tendency to slightly lower potash levels compared to the Mesopotamian glass (Fig. 5). As expected, most of the samples that are coloured

	P	Ti	V	Cr	Ni	Zn	As	Rb	Sr	Y	Zr	Nb	Ag
K34649	648	577	12.22	10.27	319	560	5.15	10.37	493	9.71	54.42	1.74	0.49
K44033 23	724	615	12.38	8.06	288	373	1.80	6.24	444	15.06	39.70	1.76	
K44039	616	569	10.40	7.86	470	766	3.98	6.03	608	13.28	58.34	1.80	0.11
K44141	670	541	10.84	9.18	489	989	4.97	7.44	529	11.00	50.17	1.74	0.14
K44141 bis	647	529	10.60	10.00	451	921	4.88	6.75	544	11.05	50.04	1.77	0.15
K44040 002	720	585	10.07	11.13	451	798	4.45	6.18	662	13.73	60.00	1.77	7.42
K35372	752	404	12.92	15.98	527	1179	6.85	11.34	263	5.92	31.82	1.35	0.21
K35722	671	563	10.72	9.26	486	784	4.29	6.34	597	12.80	56.79	1.80	0.12
kaz t1	641	558	9.93	10.97	231	721	4.77	13.59	447	6.70	47.73	1.79	0.72
kaz t2	552	526	9.07	9.43	258	454	10.41	4.77	403	8.70	56.20	1.71	0.67
kaz t5	688	560	12.32	12.07	347	844	6.80	12.67	502	11.14	51.04	1.89	1.51

	Sn	Sb	Ba	La	Ce	Pr	Nd	Tm	Yb	Lu	Hf	Ta	Au
K34649	31	124	64.09	3.94	8.63	1.11	5.15	0.11	0.70	0.10	1.32	0.10	0.10
K44033 23	10	10	62.84	3.78	8.55	1.11	5.41	0.12	0.79	0.11	0.92	0.10	1.57
K44039	21	315	47.21	4.43	9.90	1.28	6.33	0.13	0.85	0.13	1.34	0.10	0.05
K44141	24	359	49.46	4.52	10.71	1.27	5.67	0.10	0.68	0.10	1.19	0.09	0.06
K44141 bis	25	389	53.45	4.05	9.83	1.18	5.42	0.10	0.67	0.10	1.19	0.10	0.06
K44040 002	28	488	49.70	4.20	8.94	1.20	6.02	0.13	0.94	0.14	1.46	0.11	0.63
K35372	14	111	70.10	3.50	7.89	1.13	5.44	0.06	0.42	0.06	0.79	0.09	0.80
K35722	25	369	46.27	4.12	9.35	1.27	5.91	0.12	0.79	0.13	1.35	0.10	0.06
kaz t1	54	230	47.25	3.86	8.34	0.96	4.29	0.07	0.46	0.07	1.12	0.10	27.79
kaz t2	28	72	60.23	6.41	6.65	0.88	4.20	0.09	0.60	0.08	1.56	0.14	0.38
kaz t5	150	211	51.05	5.92	11.44	1.36	6.58	0.11	0.66	0.10	1.14	0.10	0.53

	Sm	Eu	Gd	Tb	Dy	Ho	Er	Pb	Bi	Th	U
K34649	1.21	0.34	1.29	0.25	1.35	0.29	0.85	4.57	0.09	1.01	0.62
K44033 23	1.26	0.43	1.28	0.37	1.85	0.38	1.05	0.51	0.05	0.81	0.45
K44039	1.42	0.42	1.37	0.32	1.65	0.37	1.07	5.12	0.09	1.05	0.52
K44141	1.27	0.37	1.09	0.28	1.48	0.30	0.85	10.21	0.11	1.01	0.59
K44141 bis	1.24	0.37	1.11	0.27	1.40	0.31	0.87	12.35	0.11	0.96	0.56
K44040 002	1.45	0.45	1.49	0.35	1.73	0.39	1.08	9.03	0.09	1.11	0.46
K35372	1.46	0.43	1.09	0.26	1.12	0.21	0.56	17.94	0.03	0.89	0.96
K35722	1.37	0.41	1.37	0.32	1.60	0.34	1.02	4.29	0.10	1.04	0.53
kaz t1	0.94	0.24	0.86	0.20	1.00	0.27	0.58	32.80	0.08	0.90	0.53
kaz t2	1.05	0.28	1.01	0.20	1.14	0.22	0.69	16.73	0.07	0.74	0.48
kaz t5	1.61	0.43	1.45	0.34	1.55	0.32	0.89	27.35	0.05	1.00	0.51

Table 2: Trace elements (ppm) of samples from the Kazanaki tholos tomb.

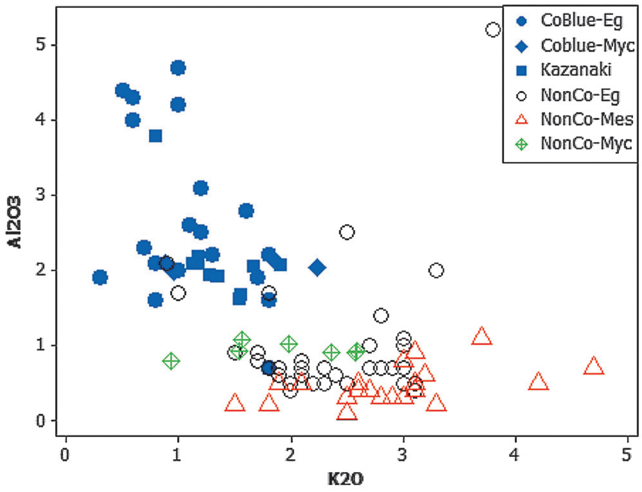

Fig. 5: Alumina and potash contents of the Kazanaki samples in comparison with other cobalt-blue and non-cobalt glass samples from Egypt, Mesopotamia, and the Mycenaean centres (Shortland *et al.* 2007; Walton *et al.* 2009).

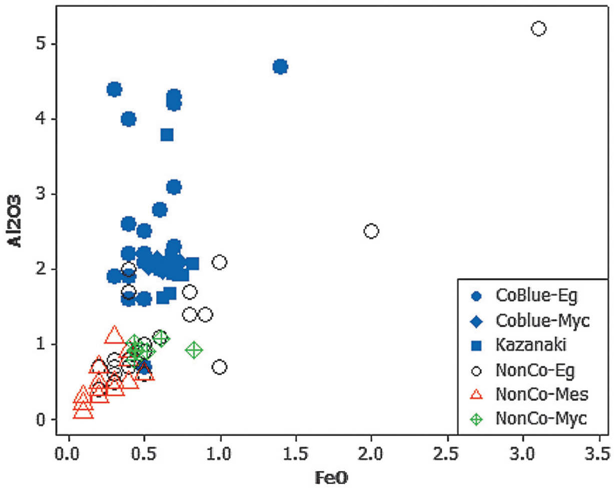

Fig. 6: Alumina and iron oxide contents of the Kazanaki samples in comparison with other cobalt-blue and non-cobalt glass samples from Egypt, Mesopotamia, and the Mycenaean centres (Shortland *et al.* 2007; Walton *et al.* 2009).

by cobalt, whether Mycenaean, Egyptian, or from the Uluburun shipwreck, show low levels of potash (lower than 2.0 %) and high levels of alumina (more than 1.5 %) (Fig. 5). The samples from Kazanaki, which all are cobalt blue glasses, clearly belong to this typical Egyptian cobalt-blue group.

All cobalt-blue glass that has been found on the Uluburun shipwreck, in Egypt or the Mycenaean centres, show elevated levels of iron oxide and titanium (Fig. 6). In comparison, the non-cobalt glasses from Mesopotamia and the Mycaenean centres have significantly lower contents of the two oxides, less than one-third the content of the cobalt-blue glasses. Again, the Kazanaki samples all fall within the range of known cobalt-blue glasses, further suggesting their common, most likely Egyptian origin. However, we have to take into account that our sample base is biased: only cobalt-blue beads were well enough preserved to be further analysed, probably due to their elevated alumina content acting as a stabiliser. We were unable to obtain quantitative chemical data from those more corroded beads that had initially white or yellow glass, as identified by their antimony and lead-antimony signatures detected qualitatively by XRF.

From the chemical composition, we see three groupings of glass: one from Mesopotamia that also includes most non-cobalt blue Mycenaean glass; another grouping with all the Egyptian non-cobalt glasses; and a third one that includes the Egyptian cobalt-blue glass, the Uluburun samples and the cobalt blue Mycenaean samples (Fig. 5). This latter group includes the eleven analysed samples from the site of Kazanaki. Interestingly, the Mesopotamian glasses have very well defined Cr/La and Ti/Zr ratios, while the Egyptian and Uluburun samples, and the cobalt blue Mycenaean ones, are more varied, possibly forming sub-groupings. However, none of these possible sub-groups appears to be typical for glass found at the Mycenaean centres, but rather point to possibly more than one centre within New Kingdom Egypt producing glass[15].

Conclusion

The eleven well-preserved glass samples from the Kazanaki tholos tomb at the Mycenaean palatial centre of Iolkos are all consistent in their major, minor and trace element content with known Egyptian cobalt-blue glass, despite some of them having a rather light colour. In contrast, they do not match the compositional profile of Mesopotamian glasses for a number of diagnostic trace elements. Glass of some other colours was identified qualitatively, especially white and yellow, but its bad preservation status prevented quantitative analysis, and no assignation to a possible region of origin for those samples was possible. Some yellow glass found in Egypt has been linked to a Mesopotamian origin[16], and the only known LBA source of antimony, crucial for both white and yellow glass, is in modern-day Georgia. Whether the occurrence of

15. Smirniou 2012.
16. Brill 1999; Shortland 2006.

these glass colours among the beads from the tomb at Kazanaki, colours typically rather rare in Mycenaean contexts, is significant for the wider interpretation of Iolkos and its international relations has to remain uncertain at this time.

In summary, there is no evidence from the examination undertaken that the glass analysed here was of local Mycenaean production, but more likely that it was imported from Egypt, probably as ingots similar to those found at the Uluburun wreck. Clearly, stylistically the glass was worked in the typical Mycenaean fashion, most probably in a Mycenaean glass workshop. This is a new strong indication of glass trade between the Mycenaean world and Egypt, from a site much further north than has been previously suggested[17].

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