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Source: *The Journal of Egyptian Archaeology*, Vol. 83 (1997), pp. 143-153

Published by: Egypt Exploration Society

Stable URL: <http://www.jstor.org/stable/3822462>

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THE ULU BURUN GLASS INGOTS, CYLINDRICAL VESSELS AND EGYPTIAN GLASS

By PAUL T. NICHOLSON, CAROLINE M. JACKSON *and* KATHARINE M. TROTT

This paper examines a possible Egyptian origin for the glass ingots discovered in the Ulu Burun shipwreck off the Turkish coast and seeks to relate them to cylindrical vessels believed to be ingot moulds from Tell el-Amarna. A preliminary distinction between types of Ulu Burun ingot is also suggested and a comparison made between the ingot moulds from Amarna and those from Qantir.

IN their valuable article on 'New Kingdom Glass-melting Crucibles from Qantir-Piramesses' Drs Th. Rehren and E. B. Pusch raise several points of similarity with the well-known cylindrical vessels from Tell el-Amarna.¹ The purpose of this paper is to expand on some of these points, particularly in relation to the idea that there might have been an export trade in glass from Egypt, perhaps as early as the late Eighteenth Dynasty.

Petrie² took the view that glass was actually manufactured at Amarna, and on the evidence available, many believed glass to have been an Egyptian invention. This view prevailed into the 1950s, although some scholars such as Harden were already wondering whether soil conditions were responsible for the apparent lack of still earlier glass vessels from Mesopotamia.³ By the 1960s an Asiatic origin for glass had become established⁴ and with it came a change in the way Egyptologists thought of glass. It seems to have become accepted that the glass industry was introduced into Egypt from abroad,⁵ perhaps as a result of the bringing back of captive glass-workers following the campaigns of Tuthmosis III. This seems highly plausible in view of the apparent appearance of glassmaking as a fully fledged industry in Egypt at around 1500 BC.

To say that foreign workers established the industry in Egypt is not the same as saying that Egypt was subsequently dependent upon foreign sources—such as imported glass ingots—for her raw material. This, however, has become a commonly held view, and there seems considerable reluctance in some quarters to accept that the Egyptians might have been able to manufacture their own glass from its basic constituents, at least by the time Amarna was flourishing as the capital city.⁶

¹*JEA* 83 (1997), 127–41. We are grateful to the authors for providing us with a pre-print of their article, and for their comments on an earlier draft of this paper.

²W. M. F. Petrie, *Tell El Amarna* (London, 1894).

³D. B. Harden, 'Glass and glazes', in C. Singer et al. (eds), *A History of Technology*, II (Oxford, 1956), 318–19; P. R. S. Moorey, *Ancient Mesopotamian Materials and Industries* (Oxford, 1994), 190.

⁴D. B. Harden, 'Ancient glass I, Pre-Roman', *The Archaeological Journal* 125 (1968), 46–72.

⁵A. L. Oppenheim, 'Towards a history of glass in the ancient Near East', *JAS* 93 (1973), 259–66.

⁶The absence of any suggestion that the Egyptians made their own glass is evident in publications dating after c. 1960. R. Newton and S. Davison, *Conservation of Glass* (London, 1989) 107, are more specific: 'There seems to have been no production of glass from its raw materials in ancient Egypt before the fifteenth century BC, and

This is not the place to detail the evidence for glass production at Amarna, either from Petrie's work⁷ or that currently taking place on behalf of the EES.⁸ Suffice it to say that there are numerous finds which suggest that *glassmaking*, as distinct from *glassworking*,⁹ was taking place at the site.

Cylindrical vessels

Rehren and Pusch note the similarity between cylindrical vessels ('crucibles') from Qantir and those from Amarna (Table 1). The vessels at both sites have a similar external base diameter and are made from Nile clay thrown on the potter's wheel and lined with a white parting layer. At both sites the vessels appear to be connected with the production of glass, and the discovery by Rehren and Pusch that a discoloured red glass ingot now in the Cairo Museum,¹⁰ fits almost exactly cylindrical vessels from Qantir tends to confirm the view, already suggested by Nicholson,¹¹ that such vessels may be regarded as ingot moulds. There also seem to be differences between the vessels at the two sites, and these may actually be reinforced by the ingot itself. It will be noted that the ingot has a rounded profile, and that it is some 10 cm in thickness. Whilst it fits the mould with complete profile from Qantir, it would stand proud of either of the complete profiles so far discovered at Amarna. Its diameter is also smaller, as examination of the selection of vessels illustrated by Weatherhead and Buckley¹² makes clear. Whilst the two complete profiles of Amarna vessels (Table 1, Cat. 1 and 3) both have a total height of 11.0 cm or less, the complete example from Qantir (FZN 84/0088) is 13 cm tall and two of the incomplete vessels are themselves 12 cm tall. None of the Amarna vessels so far examined approaches this height. The external base diameter is comparable at both sites, as is the rim diameter.

A series of these cylindrical vessels from Amarna is currently being examined, and preliminary investigation suggests that there may be two or three variants. These range from vessels which are virtually true cylinders with quite sharp angles between the walls and base on the interior (type A) to those which are more curved (type B). An intermediate group has also been distinguished (type A/B). The impression gained from examining several of the Qantir specimens in photographs, and as presented at lectures, is that a higher proportion of them have the rounded profile, although we appreciate that examples with more angular walls also exist.

it is generally considered that the Egyptians had failed to learn the secret of glass-making (and this is borne out by the finds at Tell el-Amarna), despite the fact that they were skilled makers of glass articles (i.e. glassmelters) from glass cullet which had been imported from Upper Syria.' See also E. M. Stern and B. Schlick-Nolte, *Early Glass of the Ancient World 1600 B.C.–A.D. 50* (Ostfildern, 1974), 25.

⁷Petrie, *Tell El Amarna*, 16–28.

⁸P. T. Nicholson, 'Glassmaking and glassworking at Amarna: some new work', *Journal of Glass Studies* 37 (1995), 11–19; id., 'Recent excavations at an ancient Egyptian glassworks: Tell el-Amarna 1993', *Glass Technology* 36/4 (1995), 125–8; id., 'New evidence for glass and glazing at Tell el-Amarna (Egypt)', *Annales du 13^e Congrès de l'Association pour l'Histoire du Verre* (Amsterdam, 1996) 11–19.

⁹In glassmaking, glass is formed from its raw materials (silica, alkali and lime) whilst in glassworking it is re-melted from ingots or cullet.

¹⁰Cairo JE 64296. See Rehren and Pusch, *JEA* 83, 135.

¹¹*Journal of Glass Studies* 37, 17–18; *Glass Technology* 36/4 (1995), 128.

¹²F. Weatherhead and A. Buckley, 'Artist's pigments from Amarna', in B. J. Kemp (ed.), *Amarna Reports*, V (EES Occasional Publications 9; London, 1989) 202–40.

A number of the Amarna vessels contain traces of cobalt blue glass on the interior, as well as drips of glass on the exterior. Although other colours are known, including turquoise blue and green, the cobalt blue seems to be the predominant colour. In some cases glass has caused the rim of one cylindrical vessel to adhere to the base of another, suggesting that they might have been stacked. It has also been found that a slight chamfer around the base of some vessels would allow them to have been fitted into one another in a stack. So far as we are aware, these features have not yet been observed at Qantir.

TABLE 1. *Summary Measurements of Cylindrical Vessels from Amarna*

Catalogue number	External base diameter (cm)	Percentage preserved	Height preserved (cm)	Rim diameter (cm)	Percentage preserved	Type	Context
1.	16.0	38.0	9.2 (complete)	18.0	10.0	A	Surface. S. Palace Dumps
2.	14.0	38.0	9.7+	—	—	A	Surface. King's House
3.	16.5	27.0	11.0 (complete)	18.0	6.0	A	Surface. Main City
4.	14.0	14.0	6.5+	—	—	A/B	Surface. S. Palace Dumps
5.	20.0	20.0	8.9+	—	—	A	Surface. S. Palace Dumps
6.	20.0	18.0	4.4+	—	—	B	Surface. Main City
7.	14.0	15.0	5.7+	—	—	B	Surface. O45.1
8.	18.0	21.0	3.1+	—	—	A	Surface. S. Palace Dumps
9.	14.0	40.0	4.7+	—	—	A/B	Surface. S. Palace Dumps
10.	14.0	25.0	6.0+	—	—	B	Surface
11.	16.0	13.0	5.5+	—	—	A	Surface. Main City
12.	18.0	29.0	6.1+	—	—	B	Surface. S. Palace Dumps
13.	18.0	15.0	5.5+	—	—	A	Surface. S. Palace Dumps
14.	14.0	13.0	5.6+	—	—	A	Surface. SW of Q44.1
15.	Fragment only—no useful measurements preserved						Surface. EES dig house
16.	Fragment only—no useful measurements preserved						Surface. W. of M50.14
17.	18.0	4.0	—	—	—	A	Surface. S. Palace Dumps
18.	—	—	—	18.0	8.0		Surface. Central City
19.	—	—	—	17.0	9.0		Surface. S. Palace Dumps
20.	—	—	—	16.0	8.0		Surface. S. Palace Dumps
21.	—	—	—	16.0	10.0		Surface. nr. O45.1
22.	16.0	12.0	4.2+	—	—	A/B	Surface. nr. M50.14
23.	16.0	15.0	—	—	—	A?	Surface. nr. M50.14
24.	18.0	14.0	4.5+	—	—	A	Surface. nr. M50.14
25.	18.0	18.0	4.2+	—	—	A	Surface. nr. M50.14
26.	18.0	12.0	3.7+	—	—		O45.1 K80 [7998]
27.	17.0	32.0	3.4+	—	—	A	O45.1 K80 [7998]
28.	16.0	30.0	4.5+	—	—	A	O45.1 L75 [9026]
29.	17.0	28.0	5.0+	—	—	A	Surface. Q75
30.	—	—	—	18.0	8.0		O45.1 K80 [7966]
31.	Fragment only—no useful measurements preserved						O45.1 L80 [7974]
32.	Fragment only—no useful measurements preserved						O45.1 M75 [8979] Obj.30655
33.	Fragment only—no useful measurements preserved						O45.1 M75 [8981] Obj.30656
34.	Fragment only—no useful measurements preserved						O45.1 L75 [8979]
35.	Fragment only—no useful measurements preserved						O45.1 L75 [8979]
36.	16.0	5.0	3.2+	—	—	A	O45.1 K85 [7962]
37.	Fragment only—no useful measurements preserved						O45.1 M75 [8979] Obj.30550
38.	Fragment only—no useful measurements preserved						O45.1 M75 [8981] Obj.30591

(Approximate measurements of the type collection of cylindrical vessels currently held at Amarna.)

The presence of 'hot spots' on the vessel walls noted by Rehren and Pusch may well be significant at Amarna too. There are certainly areas of such overfiring on some of the vessels, but examination of those fragments held in the type collection at Amarna, and observed on the palace dumps, has failed to reveal any regular pattern consistent with the three 'hot spots' recognised in the Qantir examples. This may be due in part to the different type of glass being produced. Red glass, which predominates at Qantir, demands extremely careful regulation of furnace conditions, whilst the blue glass most commonly produced at Amarna is less demanding.

Craft integration and the use of cobalt

At present there is no evidence from site O45.1 (that currently under investigation) at Amarna for metalworking but, as both we and Rehren and Pusch¹³ note, the Amarna finds made by Petrie may instead have been associated with the production of faience and of pigment, and this is borne out in the new work. In addition to glass manufacture, the current excavations have also yielded very clear evidence for the production of pottery, in the form of a clay preparation area, unfired sherds and a pottery kiln. This grouping may suggest a crafts quarter based around ceramics and pigments. Such a grouping might be particularly advantageous if the well-known Amarna blue painted pottery was being manufactured in such an area. As yet there is no firm evidence for the manufacture of blue painted pottery at site O45.1. However, the colouring material used for this pottery is known to have been cobalt,¹⁴ and there is extensive evidence for the use of cobalt colorant in the making of glass, blue pigment and possibly faience at the site.

Until recently it was not widely accepted that cobalt occurred in workable deposits in Egypt. However, work by Kaczmarczyk¹⁵ has shown that an exploitable source of cobaltiferous alum was available, and has countered arguments by Dayton¹⁶ that the source of cobalt was European. Several industries (pottery production, glassmaking, pigment manufacture and faience production) may have been located together since they shared similar technologies and used cobalt as a colorant.

If we accept an Egyptian origin for cobalt, and accept the argument put forward some time ago for the Amarna cylindrical vessels as ingot moulds¹⁷ along with that convincingly stated by Rehren and Pusch for the Qantir 'crucibles', then one must reconsider whether or not the Egyptians could actually *make* glass, that is, produce it from its raw materi-

¹³*JEA* 83, 139–41.

¹⁴J. Riederer, 'Recently identified Egyptian pigments', *Archaeometry* 16 (1974), 103–9.

¹⁵A. Kaczmarczyk, 'The source of cobalt in ancient Egyptian pigments', in J. S. Olin and M. J. Blackman (eds), *Proceedings of the 24th International Archaeometry Symposium* (Washington D.C., 1986) 369–76; id., 'The identity of *wšbt* alum', *JEA* 77 (1991), 195.

¹⁶J. E. Dayton, 'Cobalt, silver and nickel in Late Bronze Age glazes, pigments and bronzes, and the identification of silver sources from the Aegean and the Near East', in M. J. Hughes (ed.) *Scientific Studies in Ancient Ceramics* (London, 1981), 129–42; id., 'Geological evidence for the discovery of cobalt blue glass in Mycenaean times as a by-product of silver smelting in the Schneeberg area of the Bohemian Erzgebirge', *Revue d'Archeometrie (Supplement)* 3 (1981), 57–61.

¹⁷See n. 8 above. See also W. E. S. Turner, 'Studies of ancient glass and glass-making processes. Part I. Crucibles and melting temperatures employed in ancient Egypt at about 1370 B.C.', *Journal of the Society of Glass Technology* 38 (1954), 436–44T.

als.¹⁸ It could be that raw glass was imported into Egypt and simply re-melted when it had the cobalt colorant added to it, in which case the crucibles/ingot moulds would simply be convenient vessels in which to carry out this process. The finished ingot would then be sent to other workshops in the city of Amarna, or, indeed, elsewhere in Egypt. However, recent work suggests that the situation might be more complicated.

The current programme of excavation at Amarna is being accompanied by experimental archaeology and scientific analyses and, combined with the apparent scale of the operation at Amarna, suggests that glass could actually have been made at the site. That being so, the ingots may not have been destined only for local use.

The Ulu Burun ingots

The blue glass ingots discovered in the Ulu Burun shipwreck off the Turkish coast, and now undergoing conservation at the Museum of Underwater Archaeology in Bodrum, offer considerable insights into this question of trade. A cast of one of the cobalt blue ingots was made available to us¹⁹ and in March 1996 was taken to Amarna where it was found to fit as perfectly as possible²⁰ into several of the more complete cylindrical vessels from Amarna (fig. 1 and pl. XVII, 2). Comparison of 1:1 scale drawings of the Qantir ingot with three²¹ of those of cobalt blue ingots from Ulu Burun also shows some differences. The three Ulu Burun ingots are all of greater diameter than that from Qantir, by up to 2 cm. On the other hand, the Qantir ingot is considerably deeper from top to bottom, by up to 3 cm. The impression gleaned from these drawings was borne out in the preliminary examination of several of the actual Ulu Burun ingots (fig. 2 and Table 2).

In July 1996 Trott and Nicholson were able to visit the Museum of Underwater Archaeology at Bodrum and to measure a selection of the ingots.²² Of the 24 ingots measured, only five had an upper diameter smaller than that of the 13 cm example from Qantir; all the rest were larger. These five clearly came from moulds smaller than those so far known from Amarna. In all cases the maximum thickness of the Ulu Burun ingots was less than the 10 cm of the Qantir example. It will be obvious from this that none of the Ulu Burun ingots examined in any way resembled that known from Qantir.

There is also a further distinction to be made among the Ulu Burun pieces themselves. Although the measurements were taken rapidly and no attempt was made to select ingots randomly, there does seem to be a division by size and colour (fig. 1). Where the ingots are believed to be coloured using cobalt,²³ they are generally larger, typically having an

¹⁸The difference between a 'crucible' and an 'ingot mould' is largely semantic. If the ingot is set in its crucible, then the crucible has become an ingot mould, whereas if it were melted in such a vessel and the melt removed into some other vessel, it would be simply a crucible.

¹⁹P. T. Nicholson is most grateful to Professors Bass and Pulak for providing him with drawings of several of the Ulu Burun ingots. He is similarly indebted to them, and to their colleagues Jane Pannell and Claire Peachey, for making a cast of ingot KW4.

²⁰Obviously any given ingot will only match precisely the actual mould in which it was produced.

²¹These are ingots KW3, KW4, and KW34.

²²They are grateful to Prof. Pulak for permitting this visit and allowing the publication of these provisional results, as well as to C. Peachey for facilitating access to the material.

²³At present it is not possible for the excavators to say with certainty what the precise number of ingots is (since many are fragmentary) nor what their original colours were (as many are completely hydrolysed and have lost their original colour). Most of the ingots are currently undergoing conservation. We are indebted to Prof. Pulak for a provisional estimate that there are approximately 170 ingots in total and that the predominant colour is cobalt blue. There are, however, 21 certain examples of turquoise blue and one purple ingot.

upper surface diameter exceeding 13 cm. The maximum thickness is also distinctive, with the cobalt ingots generally having thicknesses above 3.5 cm, and usually above 5.0 cm, while those coloured with copper are typically 3.5 cm in thickness. The upper-surface diameter for the ingots believed to be coloured with copper is usually below

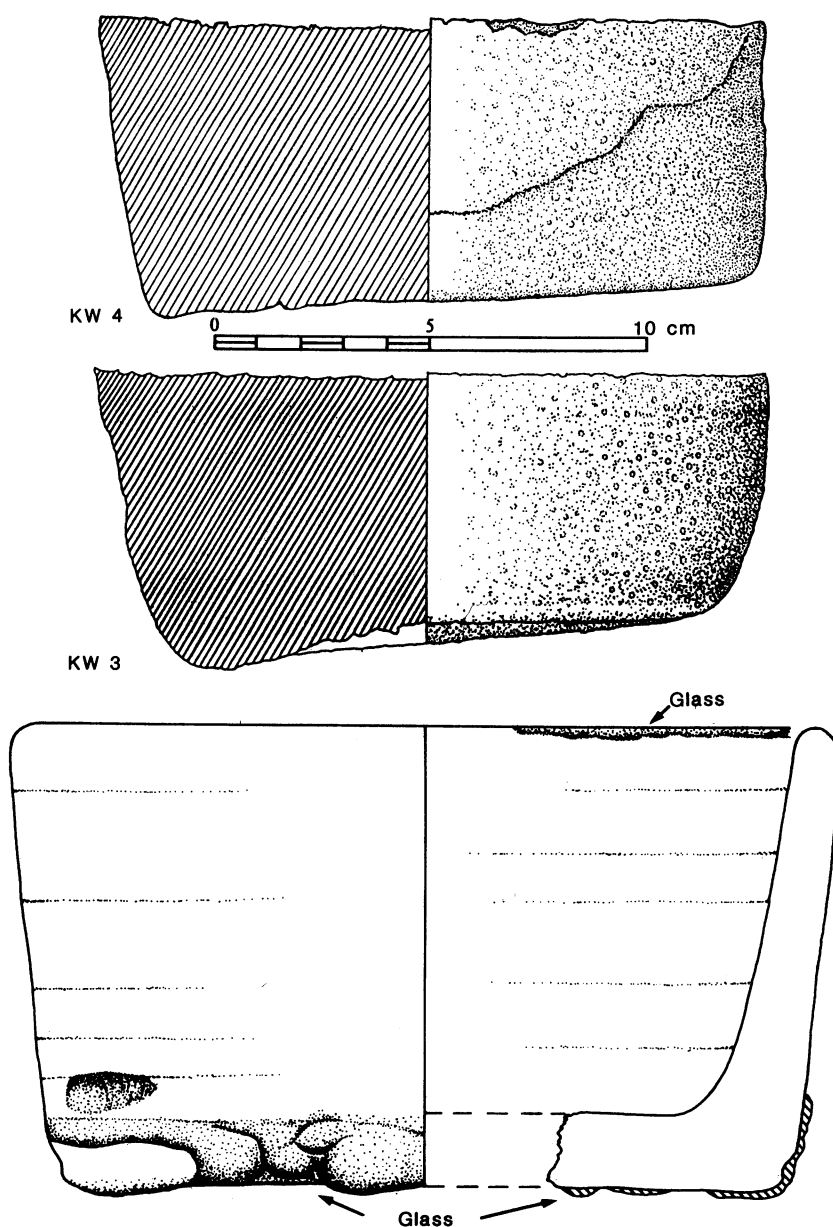


FIG. 1. An Amarna cylindrical mould (Surface find Main City No.3) shown with Ulu Burun ingots KW3 and KW4, which match its profile well. Like any traditional wheel-thrown vessel, the mould is not truly circular; the diameter of this one is approximately 18.0 cm. (Ingot drawings courtesy of Profs G. Bass and C. Pulak, drawing by Ian Dennis.)

13 cm, and the maximum recorded is 13.5 cm. For the ingots coloured with cobalt the upper-surface diameter can be up to about 15.5 cm.²⁴ Whilst this evidence alone might suggest that the ingots would fit moulds from either Amarna or Qantir, other considerations suggest that moulds of the Amarna type might be more likely.

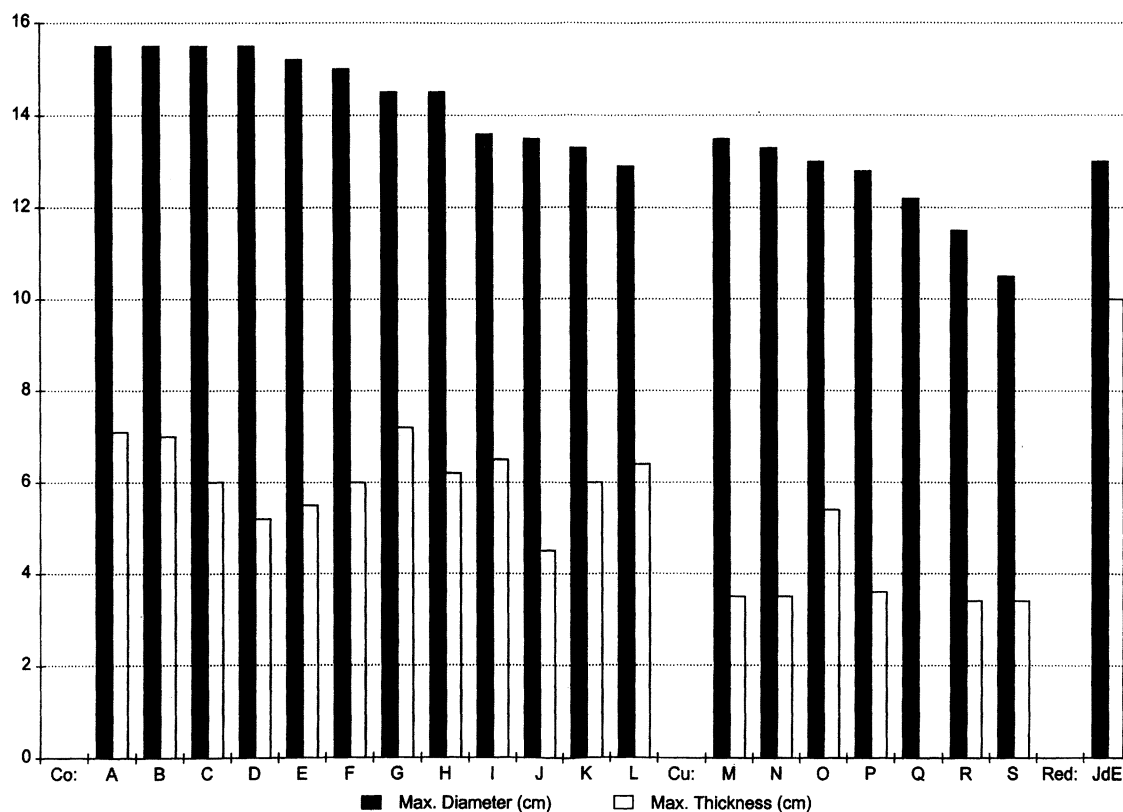


FIG. 2. Bar chart showing the differences in maximum diameter (solid black bar) and maximum thickness (shaded bar) for those Ulu Burun ingots provisionally thought to be coloured by cobalt and by copper respectively compared to the discoloured red glass ingot from Qantir. Those coloured by copper tend to be smaller and thinner than those coloured by cobalt. The proportions of the Qantir ingot are markedly different from any from Ulu Burun. (Figure prepared by Walter Gneisinger.)

Co = presumed cobalt colorant Cu = presumed copper colorant

A = KW3 (measured from drawing only)
 B = KW4
 C = KW3086
 D = KW4758
 E = KW2501
 F = KW3189
 G = KW3132
 H = KW3685
 I = KW34 (measured from drawing only)
 J = KW10120

K = KW3485
 L = KW3214
 M = KW4532
 N = KW4425
 O = KW4218 (may be coloured with Co)
 P = KW2923
 Q = KW3034
 R = KW762
 S = KW1896
 JdE = JE 64296 from Qantir

²⁴It should be stressed that the measurements are provisional and a fuller study must await the completion of conservation.

The profile of the Ulu Burun ingots is generally smooth and their vertical walls are not badly chipped, as on that from Qantir, suggesting that they parted more easily from their moulds.²⁵ They also show profiles like those of Amarna mould types A and B. Another notable difference is that the upper surface of the Qantir ingot is almost flat,

TABLE 2. *Comparison of Ingot Measurements (cm) from Ulu Burun and Qantir*

<i>Probably coloured by cobalt</i>		<i>Probably coloured by copper</i>	
KW3 (measured from drawing)		KW4532	
Max. diam.	15.5	Max. diam.	13.5
Max. th.	7.1	Max. th.	3.5
KW4		KW4425	
Max. diam.	15.5	Max. diam.	13.3
Max. th.	7.0	Max. th.	3.5
KW3086		KW4218 (may be coloured with Co)	
Max. diam.	15.5	Max. diam.	13.0
Max. th.	6.0	Max. th.	5.4
KW4758		KW2923	
Max. diam.	15.5	Max. diam.	12.8
Max. th.	5.2	Max. th.	3.6
KW2501		KW3034	
Max. diam.	15.2	Max. diam.	12.2
Max. th.	5.5	Max. th.	not recorded
KW3189		KW762	
Max. diam.	15.0	Max. diam.	11.5
Max. th.	6.0	Max. th.	3.4
KW3132		KW1896	
Max. diam.	14.5	Max. diam.	10.5
Max. th.	7.2	Max. th.	3.4
KW3685		<i>Red (discoloured to green)</i>	
Max. diam.	14.5	<i>ingot from Qantir</i>	
Max. th.	6.2	JE 64296	
KW34 (measured from drawing)		Max. diam.	13.0
Max. diam.	13.6	(as reconstructed by	
Max. th.	6.5	Rehren and Pusch)	
KW10120		Max. th.	10.0
Max. diam.	13.5		
Max. th.	4.5		
KW3485			
Max. diam.	13.3		
Max. th.	6.0		
KW3214			
Max. diam.	12.9		
Max. th.	6.4		

²⁵ It is, of course, possible that the Qantir ingot has suffered greater secondary damage prior to burial, and as a single example, little weight can be put on this.

whereas those from Ulu Burun are often vesicular and uneven. The underside of the Ulu Burun ingots is slightly concave, reflecting the convex interior of the moulds, and again suggesting that they parted easily from these, and several examples show the casts of the potter's finger marks so noticeable on the interior of the moulds from Amarna.

The Amarna vessels tend to be found in quite large pieces, perhaps indicating that the ingot they contained could usually be separated from them with ease, a view which may be supported by the fact that comparatively few of them contain extensive traces of glass. This relatively clean profile accords well with the profile of the Ulu Burun ingots themselves, and begs the question of whether the ingots came from Amarna. This is certainly not to argue that the Qantir and Amarna vessels had a different function, but rather to note the similarity of the Amarna vessels to the Ulu Burun ingots (fig. 2). Rehren and Pusch²⁶ have drawn our attention to the fact that some of the Qantir moulds have similar rim diameters to the Amarna examples, and if filled to the average depth of the Ulu Burun ingots, they would produce ingots of a similar diameter. However, the apparent depth of the Qantir moulds along with the evidence of the surviving ingot and the predominance of red, rather than (cobalt) blue, glass at that site tend to argue against Qantir as a source for the Ulu Burun ingots.

Possible origin and date of the Ulu Burun ingots

Rehren and Pusch state that, 'Certainly Egypt was on the consumer side of the [copper] oxide trade. Bearing this in mind, it seems reasonable to discuss a non-Egyptian origin also for the glass ingots found off the Turkish coast. The similarity in chemical composition between cobalt blue glass from Egypt and from the Ulu Burun wreck points to a common, but not necessarily an Egyptian, origin.'²⁷ So far as we are aware, full details of the chemical analyses of the Ulu Burun ingots have not yet been published, although a note by Bass²⁸ states that Dr R. H. Brill of the Corning Museum found the ingot he examined 'identical in content to blue glass in Egyptian bottles and Mycenaean medallions dating from the same period as the shipwreck'.²⁹ If we accept that the cobalt source used at this time was Egyptian and not European, then it is not unlikely that the source of the ingots was Egypt.³⁰ Whether or not it was Amarna is a much more difficult question, although recent dating evidence might make such a link more likely.

Weinstein³¹ discusses the dates of the Egyptian finds from the Ulu Burun wreck at some length. Among the finds are several Amarna pieces, including a gold scarab of Nefertiti. There are, however, other Egyptian objects dating to the Second Intermediate Period, and Weinstein makes a case for many of the Egyptian items being old at the time of their deposition, probably on their way to be melted down. He dates the wreck to the late fourteenth or early thirteenth century BC 'to the late 18th Dynasty or at latest the

²⁶ Personal communication.

²⁷ *JEA* 83, 141, n. 28.

²⁸ G. F. Bass, 'Oldest known shipwreck reveals splendors of the Bronze Age', *National Geographic* 172 (1987), 692–733.

²⁹ *Ibid.* 718.

³⁰ The source of the ingots need not be the same as that of the base glass from which they were made, but experimental work (below) lends weight to the view that they may indeed be Egyptian.

³¹ G. F. Bass, C. Pulak, D. Collon and J. Weinstein, 'The Bronze Age Shipwreck at Ulu Burun: 1986 campaign', *AJA* 93 (1989), 1–29.

very beginning of the 19th'.³² Recent dendrochronological evidence puts the wreck at 1316 BC, a date roughly midway between Amarna and the date of the Qantir cylindrical vessels. However, there is no Ramesside material from the Ulu Burun wreck, and a date of 1316 BC would also indicate an Eighteenth Dynasty date³³ according to most chronologies. This would tend to suggest that the Ulu Burun ingots predate the glassworking evidence so far known from Qantir.

Conclusions

To sum up, there is a predominance of red glass at Qantir, whereas the cylindrical vessels from Amarna are mainly associated with cobalt blue glass. Cobalt blue is the predominant colour of the ingots recovered from Ulu Burun. On present evidence, the cylindrical vessels from Qantir seem to be taller than those from Amarna, and the preserved ingot is similarly tall. The ingots measured from Ulu Burun are several centimetres shorter. Finally, the new dating of the Ulu Burun wreck suggests a date in the late Eighteenth Dynasty, something already suggested by the lack of Ramesside material recovered from it.

In the absence of published analyses, it cannot categorically be demonstrated that the Ulu Burun ingots came from Amarna.³⁴ However, the evidence must seriously lead us to consider the possibility that the ingots are to be dated to a period in the late Eighteenth Dynasty, when moulds of the Amarna type were in use, and that they might even have come from that site. We would in any case suggest that even during the lifetime of Amarna some of the ingots made at that city were destined for minor workshops elsewhere in the settlement and at other sites in Egypt. It is equally possible that, following the abandonment of the site, the glassmakers of Amarna were moved to other royal centres such as Thebes or Memphis, and that that was where the ingots were cast.

If this view is correct, and the ingots are both Egyptian and to be dated to the late Eighteenth Dynasty, then we must reconsider the position of Egypt in terms of the history of glass and of Mediterranean trade at this time. We feel that it has been assumed for too long that the Egyptians did not make their own glass, let alone export it as raw material.³⁵ This more complicated view of trade accords well with the picture of craft integration suggested by Rehren and Pusch for Qantir and which Nicholson has put forward elsewhere for Amarna.³⁶ It is becoming increasingly clear that ancient crafts were closely integrated and that their practitioners shared many technologies in common.

³²Ibid. 24.

³³Reported at the meeting of the Archaeological Institute of America in December 1995: see J. Eisenberg, 'Archaeological news from San Diego', *Minerva* 7/2 (1996), 49.

³⁴However, only in exceptional circumstances can analyses of glass be used to give a precise source of production.

³⁵Whilst this paper has dealt with the possible export of raw glass from Egypt, the position of the trade in finished glass vessels remains ambiguous: see, for example, E. J. Peltenburg, 'Ramesside Egypt and Cyprus', in V. Karageorgis (ed.), *Acts of the International Archaeological Symposium 'Cyprus Between the Orient and the Occident'* (Nicosia, 1986), 149–79, esp. 153.

³⁶P. T. Nicholson, *Ancient Egyptian glass and its relationship to faience and other manufactures: A 'vitreous materials industry'?* (unpublished dissertation, University of Manchester Dept. of Extra-Mural Studies, 1993). Links between crafts have also been examined by D. Stocks, *Industrial technology at Kahun and Gurob: Experimental manufacture and test of replica and reconstructed tools with indicated uses and effects upon artefact production* (unpublished MPhil thesis, University of Manchester, 1988); id., 'Making stone vessels in ancient Mesopotamia and Egypt', *Antiquity* 67 (1993), 596–603.

Analytical work by Jackson, Nicholson and Gneisinger at the University of Wales, Cardiff,³⁷ and by M. S. Tite and A. Shortland at Oxford is designed to clarify these craft relationships and elucidate the technological stages of glass production. A programme of experimental archaeology is also underway and lends support to this view.³⁸ A full report on the work at Amarna site O45.1, outlining the reconstruction of glass technology at the site, is planned for the near future.

³⁷ Generously supported by the Leverhulme Trust, grant number F407J.

³⁸ Jackson and Nicholson, in preparation.



1. Two ceremonial tails lying on the bottom of the gold coffin, from the pubis to halfway down the shins
(*photograph by H. Burton: GI neg. 793, reproduced by permission of the Griffith Institute, Oxford*)

TUTANKHAMUN'S CARNELIAN SWALLOW WITH SUN DISC (pp. 109–25)



2. Cast of the Ulu Burun ingot KW4 in cylindrical vessel 1, a surface find
from Tell el-Amarna

THE ULU BURUN GLASS INGOTS, CYLINDRICAL VESSELS AND EGYPTIAN GLASS (pp. 143–53)