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The 4th-Century-BC Mazotos Shipwreck, Cyprus: a preliminary report

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Since November 2007 an underwater project has been carried out by the Archaeological Research Unit of the University of Cyprus, in collaboration with the Department of Antiquities, at a shipwreck on the south coast, 14 miles south-west of Larnaca. Its cargo consists mainly of Chian amphoras and has been provisionally dated to the 3rd quarter of the 4th century BC. The good state of preservation of the site gives an opportunity for studying amphora stowage and the wreck-formation process. Moreover, it can shed new light on sea-routes and trade between Cyprus and the Aegean during the late Classical period.

Key words: Cyprus, shipwreck, Chian amphora, 4th century BC, seaborne trade, underwater survey.

Underwater archaeology has already completed almost half a century of systematic fieldwork around the Mediterranean. Since 1960, our knowledge of ancient trade, sea-routes, navigation and shipbuilding has been enriched significantly, thanks primarily to the excavation of wrecks dated to different periods. Despite this considerable progress, however, and for various reasons which are beyond the scope of this report, the number of underwater archaeological projects carried out every year in the Mediterranean is still quite limited. As a result, many of the insights into maritime activity during different periods in antiquity remain obscure or only partially understood, although 30 years have passed since Muckelroy (1978: 127) discussed 'the unrealized potential of maritime archaeology'.

For Cyprus, as for any island, connections with other islands or mainlands presuppose maritime activity. Many discoveries, whether on land or under water, have already demonstrated the intensity of seaborne trade in which Cyprus was involved throughout its history. Beyond this fundamental but general assumption, it is obvious that more material evidence is needed in order to document and study the mechanisms of Cypriot maritime trade. This remains the case despite the fact that five shipwrecks connected with Cypriot seaborne trade have already been excavated: Cape Gelidonya (Bass, 1967), Kyrenia (Katzev, 1972; Swiny and Katzev, 1973), Uluburun (Pulak, 1998), Cape Iria (Lolos, 1999) and Ma'agan Mikhael (Linder and Kahanov, 2003; Kahanov and Linder, 2004). Additional wreck-sites have been located during various surveys conducted in Cyprus, but most have been found in shallow waters, were heavily looted, and none was systematically excavated. At least three late Roman wrecks have been located at Cape Zevgari, Akrotiri, at Avdimou Bay and at Cape Andreas (Green, 1973: 161; Leidwanger, 2005; Leidwanger, 2007); a Hellenistic wreck was found at Xerolimni, Peyia (Giangrande *et al*., 1987: 192); and a Classical wreck with roof-tiles was surveyed at Cape Andreas (Green, 1973: 150–53). Because these fragmented data do not offer much potential for satisfactory comparisons between them, a coherent synthesis is difficult. Moreover, no systematic underwater survey has ever been conducted around Cyprus.

Nonetheless, a tentative assessment of these wrecks shows that most of them fall into two historical periods, the Late Bronze Age and the Late Roman period; the rest are represented by one or no wrecks, within or beyond Cypriot waters. The systematic excavation and study of the three Late Bronze Age wrecks has resulted in much fruitful discussion and, accordingly, the evidence for seaborne trade in the eastern Mediterranean is now more tangible for this period than for later ones (see for example, Wachsmann, 1998; Phelps *et al*., 1999; Pulak, 2001; Lolos, 2003; Monroe, 2009). Indeed, only from the Kyrenia wreck can we detect any elements for the mechanisms of Cypriot trade with the Aegean during the Hellenistic period, when Cyprus held a particularly important position on exchange routes among the Hellenistic kingdoms. For the Classical era, the evidence again remains limited, as the only excavated wreck with Cypriot goods is the heavily looted Ma'agan Mikhael, found in the Levant.

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Given all the above, systematic research into a wreck with Aegean cargo from the 4th century BC in Cypriot waters should significantly enhance our understanding of many aspects of trade between Cyprus and the Aegean during the late Classical period, before the dramatic political and economic changes which took place in the eastern Mediterranean during the Hellenistic period. Moreover, the material from the wreck which I discuss in this paper gives valuable information about amphora typologies and provides evidence for other, equally relevant, issues such as sea-routes and ship-lading, about which our knowledge is at best fragmented.

The discovery of the Mazotos shipwreck

In 2006 a shipwreck was found accidentally by divers along the south coast of Cyprus; the nearest village is Mazotos. The site was virtually undisturbed, so its archaeological importance, as well as the immediate need for its protection, triggered the organization of the first Cypriot underwater project. The University of Cyprus, after an agreement with the Department of Antiquities of Cyprus, undertook the task of mapping the site, which was the first priority after the declaration of the wreck to the authorities.[1] Since November 2007 four field-seasons have been carried out at the site (17–24 November 2007, 19–31 May 2008, 16 October-1 November 2008, 27 March-5 April 2009) and the preliminary mapping of the wreck has been completed.

The site

The wreck lies at a depth of –44 m, some 14 nautical miles south-west of Larnaca, off Mazotos village, 1.5 nm from the shore (Fig. 1). The main visible feature of the site is a concentration of amphoras on a sandy, almost flat sea-bed. Its maximum vertical relief measures 1 m and its maximum dimensions are 17.5 × 8 m. The concentration is oblong, almost in the form of a ship, and has a north-south orientation. The assemblage consists of at least 500 amphoras partly or totally visible. In its central area, three layers of amphoras can be distinguished above the sea-bottom. The upper layer is the most disturbed and is jumbled in many areas: most of the amphoras have fallen on their side, so their initial loading position cannot be deduced with any certainty. The amphoras of the next layer are fully exposed but in most cases stand upright, like the ones in the third layer beneath them. Those of the third layer, however, are half-buried in the sand. In some parts of the assemblage, a fourth layer of amphoras can be distinguished, almost entirely buried in the sand, with only the mouths of the amphoras still visible.

Mapping the site

The initial objective of the project was to create a detailed map of the site. In order to document the exact position of each amphora, a photogrammetric survey was used alongside conventional tape-measure triangulation. Special attention was given to the creation of a high-resolution photomosaic, so that a detailed study of

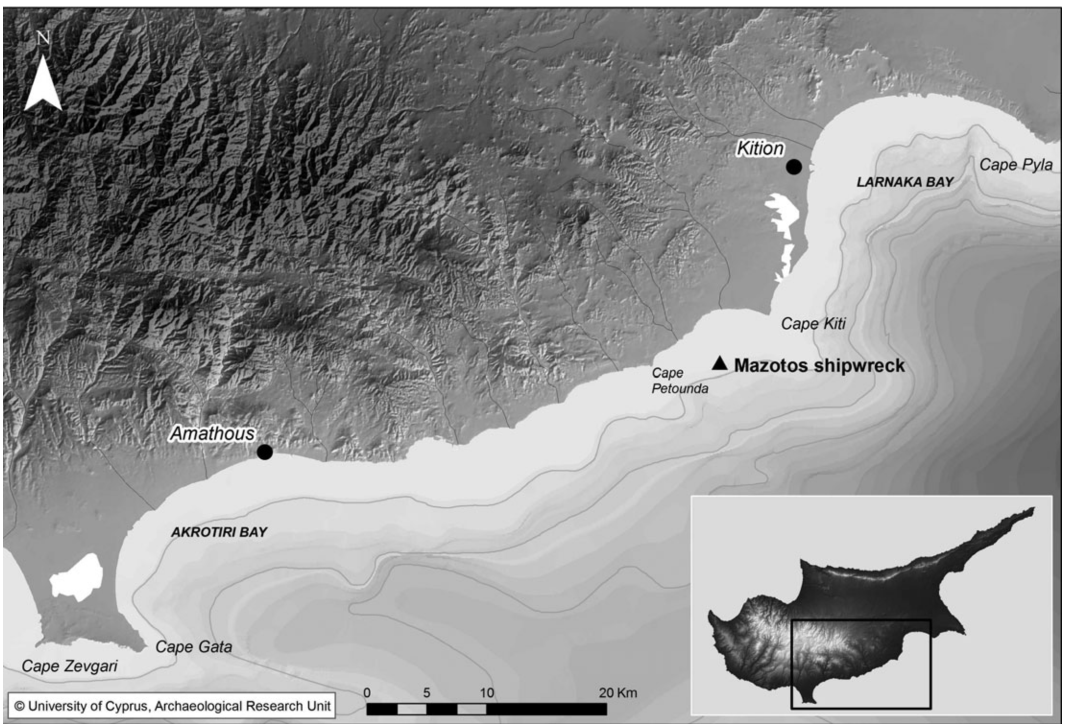

Figure 1. Map of Cyprus. (A. Agapiou, © University of Cyprus, Archaeological Research Unit (ARU). Data compiled from the Geological Survey of Cyprus)

the assemblage could be undertaken on the surface (Fig. 2) (see Appendix 1). Fixed points had to be placed on the sea-bed, as there were no rocks in the area to use as reference-points. These points were custom-made with no metal parts so that they would not contaminate any future inspections with magnetometer or metal-detector. Apart from the simple mapping, our aim was to produce a 3-D model of the site, which could be changed dynamically (see Appendix 2).

Further inspection was also applied around the concentration, using a 1-m metal probe, which demonstrated that the site extends at least 2 m all along each side, and remains are buried under at least 1 m of sand. In addition, during the most recent field-season (2009), a geophysical survey was conducted, in order to detect better the geological stratigraphy of the wreck area as well as the extent of the buried part of the site. For that purpose an intensive survey was carried out in the immediate vicinity of the visible part of the wreck, using a proton magnetometer. Preliminary results indicate that a significant part of the wreck extends beyond the southern end of the amphora assemblage.[2]

In order to investigate the depth and stratigraphy of the sedimentation, a trial-trench was opened on the north-east side of the wreck during the third field-season (October 2008) (Fig. 3). This area, at the edge of the visible cargo, seemed to be a logical spot to conduct the trial: a few amphoras were lying flat on the sea-bed and the exposed mouths or necks of the rest of the visible but half-buried amphoras were indicative of their upright position. During this trial excavation, another layer of amphoras was uncovered, and this seems to be the bottom layer of the cargo, at least at that edge of the concentration; beneath this layer, at a depth of 1.2 m., traces of bedrock were revealed (Fig. 4). Moreover, at the south-east corner of the trench, a series of amphoras were found, lying in a row, one above the other. Most probably they come from the upper layers of the assemblage and had fallen out when the hull deteriorated. Further evidence of hull deterioration is some very small pieces of wood retrieved from above the bedrock during the excavation.

Amphora types

Only six amphoras have been lifted so far. This is a representative sample of the different types that were distinguished during the pre-disturbance survey. Although all the finds are still undergoing conservation, some preliminary results can be presented at this very early stage of the study. On the photomosaic we could count *c*.500 amphoras. The majority come from the island of Chios in the north Aegean. Chios had a long period of amphora production in antiquity, from the 6th to the 2nd century BC. The basic typological phases and chronologies of Chian amphoras were established in the early 1950s and have been further documented ever since, so that today these amphoras are securely identified by most excavators (Anderson, 1954: 168–70; Grace and Savvatianou-Pétropoulakou, 1970: 359–63; Grace, 1979: figs 44–7; Monachov and Rogov, 1990: 138). More specifically, much attention has been focused on their distribution and morphological changes during the 6th and 5th centuries BC, during the initial phases of expansion in their production and the formation of their basic variations (Lawall, 1998a; 2000). Thus it is well documented that the most typical form of the series in the 5th century BC has a bulging neck, a shape that changed dramatically when the straight-neck type was introduced (Lawall, 2000: 66, figs 14–15).

Although the exact date of this change in form remains problematic, it seems that after about 425 BC, 'the straight-neck type was the only form of Chian amphora' (Lawall, 1998a: 80–81; see also Grace and Savvatianou-Pétropoulakou, 1970: 259–60; Mattingly, 1981: 78–9; Barron, 1986: 98–100). The first series of straight-necked types, dated to the late-5th to early-4th centuries BC, can be distinguished from the later forms, which have a slender long neck with a simple rounded rim, a sharp-edged shoulder and a conical toe. The toe in particular, cylindrical and hollowed in the earlier versions, becomes gradually solid and appears in a 'dunce's-cap' form by the end of the 4th century BC (Anderson, 1954: 170; for the use of Chian amphora toes as dating indicators see Lawall, 2005: 45). It seems, too, that short and hollowed 'dunce's-cap' toes should be dated no later than *c*.330 BC but we still lack detailed chronologies for that period (Lawall, 2002: 202). The Chians had stamped their amphoras since 450–425 BC, but name-stamps appear only from the 3rd century onwards, a fact that makes the identification and chronologies of the 4th-century types more difficult (Garlan, 2000: 151; Lawall, 2005: 32–3, n. 11; concerning the 'shortcomings' in studies on unstamped amphoras, see Lawall, 1998b: 77).

In the Mazotos cargo, two different sizes of Chian amphoras have been distinguished so far, represented by amphoras NM1 and NM2 (Table 1) (Figs 5a–b). Both amphoras have a tall straight neck, sharp shoulders and a conical body, which ends in a hollowed toecap (Anderson, 1954: 181, figs 9j, 19a). The dimensions of the upper part (neck and rim) of both amphoras are similar but their body and toe height differs significantly. The differences in the shape and size of Chian amphora toes, as mentioned above, are considered to be indicators for dating. The fact that such differences have been noticed on amphoras from the same wreck, presumably therefore of the same date, is of particular interest. More amphora measurements are certainly necessary before further conclusions can be drawn. The volumes of the two Chian amphoras were measured by filling them with water to the base of the neck (the joint of the neck with the shoulder is traceable by touching, as it forms a ridge in the inner side) as well as to the mid-height of the neck. The capacity of NM1, the larger amphora, was 21.3 litres to

Figure 2. The photomosaic of the wreck, assembled by Bruce Hartzler (© University of Cyprus, ARU)

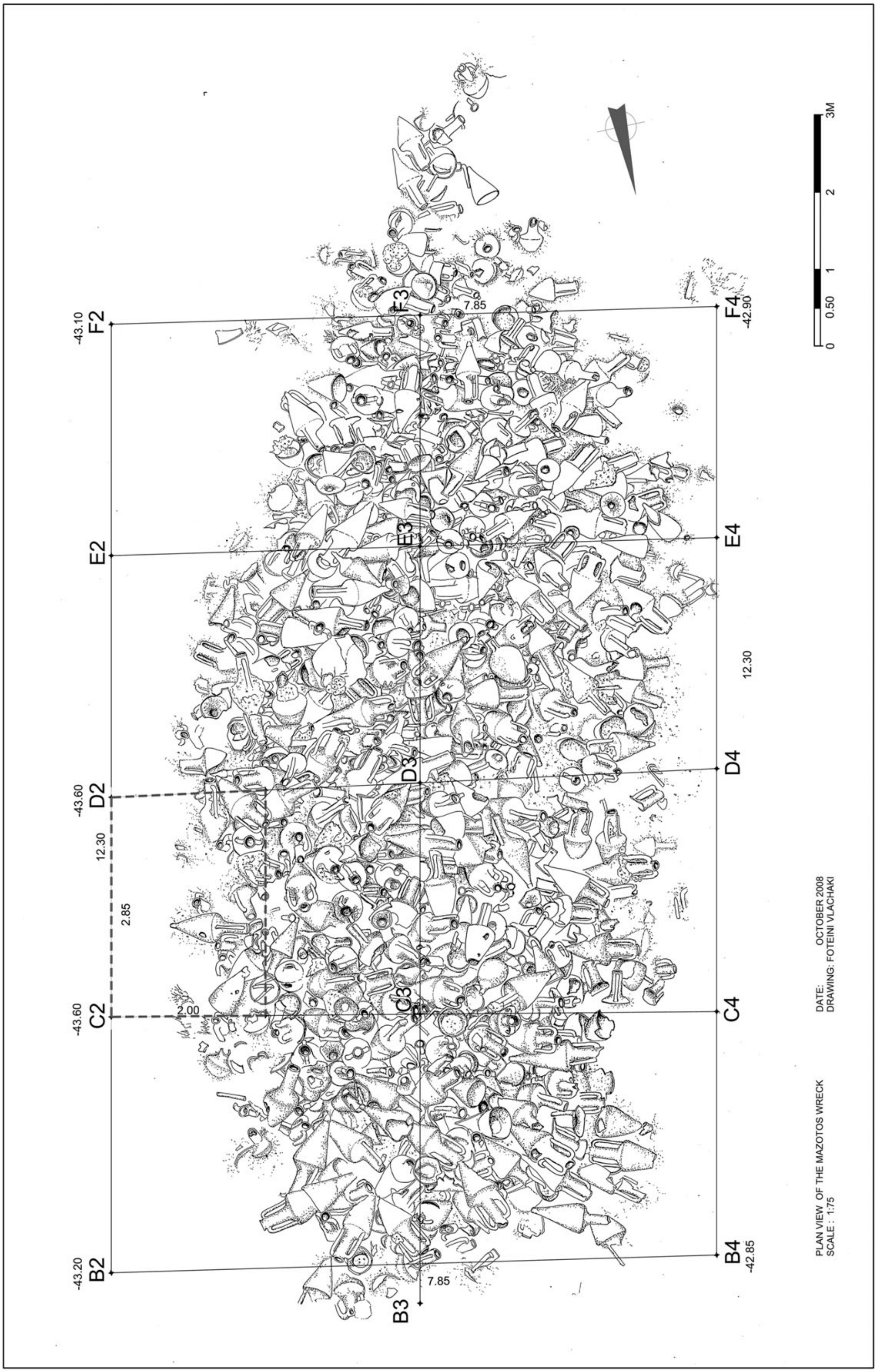

Figure 3. The 2-dimensional site-plan produced manually from the photomosaic. The location of the trial-trench area is marked with a dotted line. (F. Vlachaki, © University of Cyprus, ARU)

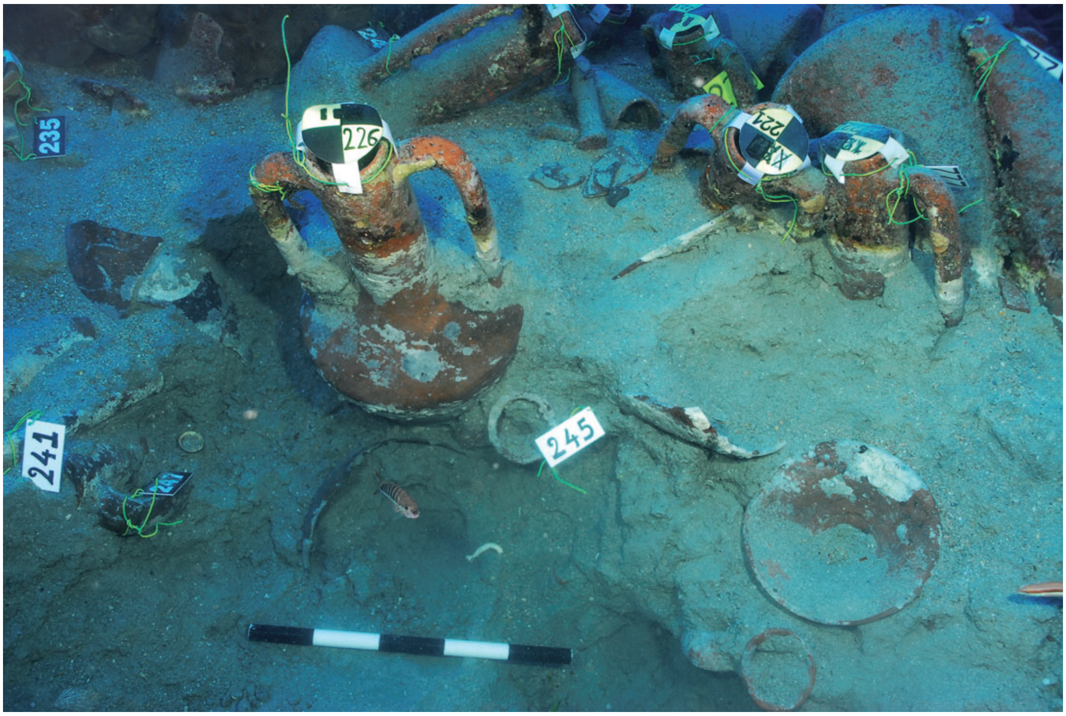

Figure 4. Bottom amphora layer, as revealed during the excavation of the trial-trench. (A. Neofytou, © University of Cyprus)

Table 1. *Catalogue of the finds (NM numbers are inventory numbers of the finds lifted from the wreck and delivered to Larnaca Museum)*

No.	serial no. of tagged finds	Illustration	Amphora condition	Type	Height (mm)	Neck height (mm)	Max diameter (mm)	Rim diameter (mm)	Capacity (ml)
NM1	051	Fig. 5a	Intact	Chian	930	290	353	110 × 95	21300 or 22000 to the mid-neck
NM2	047	Fig. 5b	Intact	Chian (half-size)	750	270	296	100 × 90	9960 or 10730 to mid-neck
NM3	141	Fig. 5c	2 pieces	Samian?	Upper part 460 lower part 260	190	350	external 160, internal 120	
NM4	144	Fig. 5d	Intact	Mushroom rim, knob toe	680	175	407.6	external 155, internal 100	31850 or 32810 to mid-neck
NM5	142	Fig. 5e	Almost intact	Mendaian	620	210	343.9		13855, or 14800 to mid-neck
NM6	145	Fig. 6	Part of rim missing		610	110	337		

the base of the neck and 22 litres to mid-neck, whereas the volume of the smaller NM2 was almost half: 9.96 litres to the base of the neck or 10.73 to its mid-height.

Apart from the Chian examples, four amphoras of a different type were also identified in the cargo assemblage. These belong to the 'mushroom-rim/knob toe' type or *Solokha I*, a type very common in the Aegean from the beginning of the 4th century BC (Mantsevich, 1987; see also the amphora types K, L, M from the El Sec wreck, dated to the first half of that century—Cerda, 1987: 64; for the type see also Lawall, 2005: 33, n. 14). Erythrai and Samos had been proposed initially as their source (Grace, 1971: 112), but their production has also been verified by kiln discoveries in Klazomenai (Doger, 1986), Paros, Ephesos, Knidos, Datca peninsula, Rhodes (Empereur and Tuna, 1989: 289; Garlan, 2000: 73) and Cos (Kantzia, 1994: 335–7). The Coan workshop is dated to the first half of the 4th century BC but production in the south Aegean centres probably continued into the Hel-

Figure 5. **a.** Amphora NM1 (051).
b. Amphora NM2 (047).
c. Amphora NM3 (141).
d. Amphora NM4 (144).
e. Amphora NM5 (142).
(S. Demesticha © University of Cyprus, ARU)

lenistic period (Empereur and Picon, 1986: 112–23). In Cyprus, similar amphoras were found in the Kyrenia wreck (Katzev, 1970: 8) and also at Kourion, where one base was identified in an early Hellenistic deposit (Connelly, 1983: 276). According to Monachov and Rohov's typology (1990: 140, table 6 no. 38), the amphora type found on the Mazotos wreck (NM4), is most probably dated to the third quarter of the 4th century BC (Fig. 5d).

In three different parts of the assemblage, three further types were identified, represented by a single amphora in each case. These are unlikely to have been part of the cargo and their presence amongst the amphora assemblage cannot be interpreted at present. Amphora NM3 was found broken at the southern end of the concentration (Fig. 5c). Although still undergoing conservation (its fabric and profile cannot be examined yet) its morphological features (cornice-shaped rim, low cylindrical neck, knob foot bevelled at its base) allow close comparison with Samian amphoras. Since their first identification by Grace (1971), various amphora-forms have been attributed to production on Samos, but we still lack a synthesis on the evolution of their form during the Classical period. Most probably, simultaneous production centres existed on the island or on the neighbouring lands of Asia Minor, so without kiln evidence, the attribution of amphoras with the above features to specific production centres remains hypothetical (Whitbread, 1995: 129–30). Moreover, many scholars speak about circles of production rather than provenance from a specific centre, due to the similarities attested in the rim or foot formation and body-shape among Aegean amphoras, particularly in the 4th century BC (Monachov, 1999: 170–72; Garlan, 2000: 73; Carlson, 2003: 583–6). Thus the amphora from the Mazotos wreck can be attributed either to the circle of Samos, or to some late evolution of the Samian/Protothasian circle from the northern Aegean, although the archaic syntax of the latter is much better studied than its late Classical descendants (Dupont, 1998: 182).

Amphora NM5 was lying in the middle of the assemblage, very close to NM4 (one of the mushroom-rim amphoras which was lifted (Fig. 5e). NM5 has an everted wedge-shaped rim, quite flat handles with finger-impressions at their lower attachment, a conical neck, broad shoulders and a squat body, which ends in a stem-toe flaring at the end. These features are typical of amphoras from Mende, Chalkidiki. Mendaian amphoras are dated to the second half of the 5th to the late-4th century BC (Grace, 1953: 106–07; Whitbread,

Figure 6. Amphora NM6 (145). (B. Hartzler © University of Cyprus, ARU)

1995: 198–209; Papadopoulos and Paspalas, 1999). Such amphoras formed a significant part of the cargo of the Alonissos wreck, dated to 420–400 BC (Hadjidaki, 1996, 565, 575) and also of the Porticello wreck, dated a few decades later (Eiseman and Ridgway, 1987: 37–42; for the date of the wreck see Lawall, 1998a). Their detailed chronologies throughout the 4th century BC are not yet established, as is the case with most Aegean amphoras of the period. Moreover, very few of them bear stamps.

Papadopoulos and Paspalas (1999: 179) agree that 'the adjective "Mendaian" may have been applied to wine produced in a region more extensive than the chora of Mende itself'. Whitbread (1995: 204–06) showed that there is no standard Mendaian fabric, a fact which makes identification difficult, and Lawall (1997, 114–18) has suggested the existence of a north-Aegean regional style of amphoras with similar morphological characteristics. Moreover, the production of similar amphoras in a Coan workshop of the 4th century BC shows that the production of this group may have extended farther south (Kantzia, 1994, 337–42). Around the middle of the neck of the Mazotos amphora there is a shallow horizontal groove, a feature that is not typical of the type. A stamped amphora (no. A282) found in the Coan workshop also had a groove on the neck but its fabric was not local. Moreover, the base of NM5 does not have a deep hollow, a typical feature of Coan amphoras, so the provenance of the Mazotos amphora should probably be given, for now, simply as north Aegean.

From the northern end of the assemblage came another amphora (NM6) (Fig. 6). Its rim is broken and thus its profile can be reconstructed only from a very small remaining fragment above one of the handles. The shape of the body and the base bears similarities to Khersonesan amphoras (Monachov and Rogov, 1990: table 4 no. 23), dated to the third quarter of the 4th century BC. In this early stage of study, its fragmentary state impedes its identification with certainty.

Date of the wreck

The dating of the wreck can only be based on the amphoras, the only pottery found thus far. From all the above it is clear that we can at least tentatively date the Mazotos wreck to the third quarter of the 4th century BC. A more detailed study of the amphoras, after their conservation has been completed, as well as future excavation, should provide more detailed evidence for dating.

Cargo/amphora stowage

The overall picture of the Mazotos wreck-assemblage enables us to present some preliminary observations on amphora stowage, although these conclusions must remain tentative until further excavations are undertaken. Judging from the upright position of the half-buried amphoras at Mazotos, the cargo of the ship had not been dispersed on the sea-floor, although it is important to note that the amphoras on the western side of the assemblage are inclined outwards (Fig. 7). Thus we can assume, at least tentatively, that the ship landed upright at the time of the wreck, tilted slightly to one side, and was gradually half-buried in sand (for recent work on site-formation processes see Ward *et al.*, 1999; Oleson and Adams, 2004: 31–2).

At the present stage of research, it is not possible to determine whether the cargo throughout its length consisted of four or five layers of amphoras. As noted above, in the central parts of the assemblage, where it is possible to distinguish between the layers, four are visible (Fig. 8). The amphoras in the bottom layers are fully buried except for their mouths. At the edge of the assemblage, where we opened the trial-trench, one layer of amphoras was found entirely buried in the sand. In this area, however, the amphoras from the upper layers were found lying on the sea-bed, probably because they spilled outwards when the ship's hull decayed and collapsed. In other words, the amphoras of the upper layers are not standing in their original position any more, so the number of amphora tiers cannot be determined precisely, although it would seem that there cannot be fewer than three.

Without further excavation it is difficult to relate the stratigraphy to the different areas of the cargo. Parallels from other wrecks do not offer much help, because the known, unlooted, ancient wreck-sites which have undergone slow and gradual changes—due mainly to biodegradation, as is the case with the Mazotos

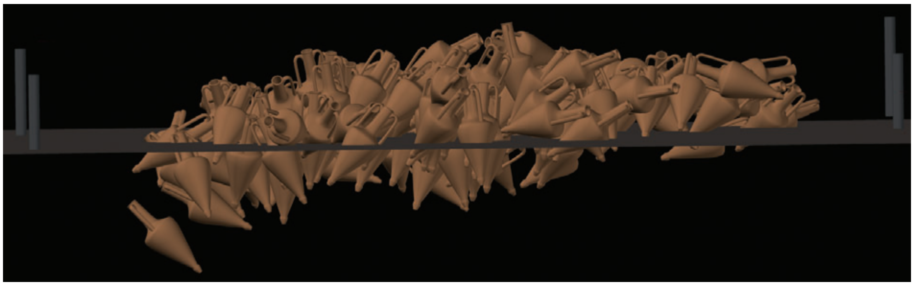

Figure 7. 3D plan of the concentration (north to south). (Foteini Vlachaki and Markos Garras © University of Cyprus, ARU)

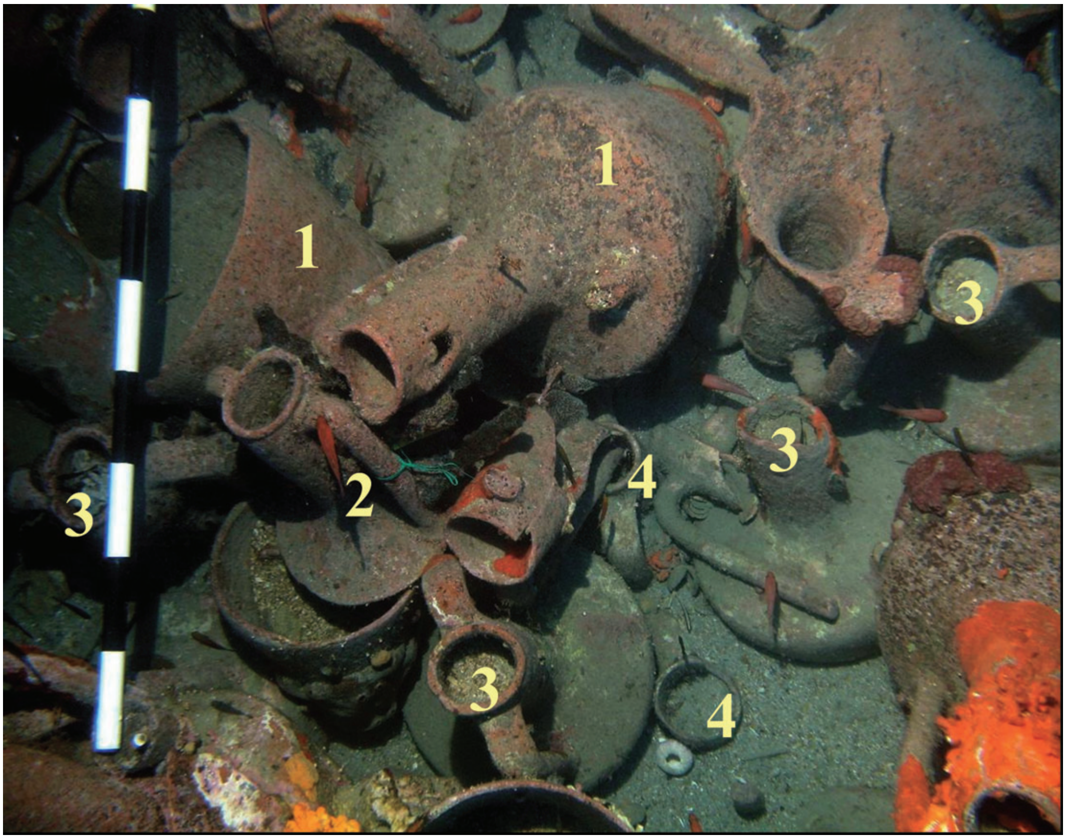

Figure 8. Photo of the possible amphora layers (with numbers). (B. Hartzler © University of Cyprus, ARU)

wreck—seem to be very few. In a general study of ancient wrecks, Parker (1992a: 90) concluded that amphoras could be stowed in from one or two up to at least five layers. More specifically for the Classical period, we have relevant data only from the 5th-century-BC wreck at Alonnesos, which held four layers of amphoras (Hadjidaki, 1996: 574). The preserved cargo of the Tektaş Burnu wreck (dated to 440–425 BC), consisting of 200 amphoras, was dispersed on the sea-bed, whereas the Porticello wreck at Messina, Sicily (dated to *c*.390 BC), was so heavily plundered that we have little idea of the cargo's lading. Even in the case of the Kyrenia wreck, with its good preservation, when the ship split apart the cargo amphoras fell aside and covered the hull, thus protecting the wood but also losing their initial position. Recently, experiments on loading amphoras were made on the *Kyrenia–Liberty*, a replica of the Kyrenia II ship. From these experiments it would seem that three layers of amphoras were loaded, but the position of some of the highest amphoras remains uncertain (Katzev, 2008: 78–9). Another interesting aspect of amphora stowage is the position of the small (half-size) Chian amphoras. Although only four of these small amphoras have been located so far, it is clear that they are found dispersed throughout the assemblage. This may be indicative of their use during the loading of the cargo; perhaps they were used to fill the gaps or secure the stability of the cargo where necessary.

Apart from amphoras, no other pottery types have been recovered so far, as the visible part of the wreck is apparently only its cargo. We expect that other artefacts (such as galley-wares, ship's gear) would have been placed in the bow and the stern areas. At this point, we cannot determine which of the two ends of the site is the stern or the bow, as the ship-like shape of the assemblage is most probably misleading. Nevertheless, the magnetometer survey indicated that significant parts of the wreck are buried beyond the southern end, shaped like a bow.

Amphora content

During the excavation of the trial-trench, one amphora body-piece we found was covered on its inner side with a thick, dark coating, probably a sealant, the particular nature of which (pitch, tar or resin) is still uncertain, as no chemical analyses have yet been carried out. The lined fragment probably belonged to a Chian amphora, which can be assumed by the form and by visual inspection of the fabric. Much attention was given to the fact that neither of the two Chian amphoras which were lifted and emptied of sand (NM1–2) was lined. Moreover, the buried amphoras we found during excavation were neither lifted nor emptied, so their interiors have not yet been inspected.

It is generally accepted that the presence of a resinous sealant indicates that the amphora contained wine, although this assumption should sometimes be considered with caution; lined amphoras may also have contained fish-sauce, fruit or olives (for the lining of amphoras in antiquity see Parker, 1973: 371; Koehler, 1986: 50–51; for analysis of the lining see Heron and Pollard, 1988: 430–43). Nevertheless, in the case of the Chian amphoras, ancient sources leave little doubt about their principle content: Chian wine was famous throughout antiquity, as it was a staple export product of the island from the Classical to the Roman period (Boardman, 1967: 252; Sarikakis, 1986: 122). Especially during Classical times, it would seem that Chian was the most prized of the Greek wines, as plenty of ancient written sources claim.[3]

DNA analyses have been carried out on a Chian amphora, lifted from a wreck at Oinousses, Chios (Hansson and Foley, 2008: 1170–74). The amphora in question is very similar to the Mazotos Chian type and it was not lined with resin. The sample analyzed came from ceramic material (scrapings) collected from the amphora's interior walls. During the analysis, olive and oregano fragments were identified. This discovery led the writers to assume that 'Chian amphoras were not used as wine jars exclusively' and that 'a substantial part of the cargo could have contained olive products, most likely olive oil flavoured with oregano and perhaps additional herbs'.

As already stated (Foley *et al.*, 2009: 294), more samples have to be taken from more sites before final conclusions can be drawn on this matter. What is important to keep in mind, however, is that as long as the sealants used in antiquity, in different periods and geographical areas, are not analyzed adequately, we cannot be sure whether the materials absorbed into wine-amphoras derive from the content of the amphora or the sealant itself. Moreover, the absence of lining on the interior of the unburied amphoras cannot offer a secure indication of the initial existence or absence of pitching. For example, one interesting observation we have already made on lined body-fragments from the Mazotos shipwreck is that the lining material came apart from the walls during the desalination process. The amphora from the Oinousses wreck, as well as the unlined ones lifted from the Mazotos wreck, were taken from the part of the cargo which was exposed on the sea-bed and thus their coating may have come loose and been removed by currents soon after the ship sank.

Trade

Pottery vessels, amphoras in particular, are the main remnants of most shipwrecks located today, although they were not the exclusive cargo of merchantmen in antiquity. Perishable or other commodities (such as metals) played a significant role in the ancient economy, but most archaeological evidence consists of pottery. Thus it has become the main (but not the only) tool for tracing trade-routes and identifying exchange-mechanisms in antiquity. Fine pottery vessels found on land-sites have been identified and studied at great length, so various aspects of their distribution are often used in studies on trade connections and exchange networks (Boardman, 1988). On the one hand, because fine pottery was often used as secondary cargo, it cannot demonstrate adequately the mechanisms of trade (Gill, 1991). Amphoras, on the other hand, due to their particular nature as containers for bulk transport on ships, offer unique potential for further investigations into the 'economic and political changes at a local, regional or inter-regional level' (Lawall, 1998b: 75–7, see also Garlan, 1983).

The Aegean wine trade flourished in the Archaic and especially during the Classical period, when the major wine-producing centres were established. Thasos, Chios, Mende, Lesbos and the Sporades islands were predominant among them. Their geographical position, on the trade-routes of the eastern and western Aegean facilitated their wide distribution around the Mediterranean. In the 4th century BC the number of production-centres in the Aegean increased, but the above-mentioned wine centres remain among the most important, as reported in several ancient written sources (Salviat, 1986).

The vast majority of the visible amphoras on the Mazotos wreck belong to the standard Chian type of the third quarter of the 4th century BC, so Chian wine should be considered as the 'primary cargo' of the ship (Nieto, 1997). As previously noted, Chian wine was particularly praised by Greek writers, and together with Thasian wine was regarded as the best

(Salviat, 1986: 187–92). It was traded widely over the Mediterranean because of its high quality, and also because of the documented sea-power of the island of Chios. Chian amphoras have been found as galley-wares or secondary ladings already during the 6th century BC in the Bon Porté wreck, France (Parker, 1992b: 74) and in the 5th century on the Tektas Burnu wreck near Çeşme, Turkey (Carlson, 2003). The evidence of shipwrecks with Chian amphoras as their main cargo derives mainly from the Aegean. From the 5th century BC, wreck-sites were located in Poros (Stavrolakes and McKernan, 1975), Salamina (Lolos *et al.*, 2007: 36–7) and Rhodes (Kazianes *et al.*, 1990: 231–2), but also in Neseber, Bulgaria (Velkov, 1986: 285; Parker, 1992b: 287). Some wrecks have also been found in Chios itself, dated to both the 5th and 4th centuries BC (Garnett and Boardman, 1961; Touchais, 1985: 831), or Oinousses (Sakellariou *et al.*, 2007: 373; Foley *et al.*, 2009). From the 4th century BC, outside Chios, only one wreck in Knidos (Parker, 1992b: 228) and the Mazotos wreck are known so far, the latter being the only one in the south-eastern Mediterranean.

In the 4th century BC in particular, it seems that Chios was one of the main exporters of wine, especially along the western, northern and southern coasts of Pontus, where Chian amphoras are predominant among the Aegean imports. This trade was probably enhanced by the fact that merchants from the island were involved with the wheat trade from the Pontus to Athens and the Aegean (Sarikakis, 1986: 123–4; Bylkova, 2005: 219–23). Thus the predominance of Chian amphoras in the Black Sea can be indicative of the active role of Chios in the Aegean trade network of the period, which was very closely connected with the Pontus throughout the Classical period, as the archaeological record and written sources reflect (Salviat, 1986; Garlan, 1999; Garlan, 2000: 173–85). The distribution of Chian (and Aegean) amphoras in the eastern Mediterranean during the same period may provide some insight into the nature of trade and economic links between the Aegean and this area, and may help in assessing and interpreting the wreck at Mazotos.

Detailed documentation of the spread of Chian amphoras in the eastern Mediterranean would be quite difficult, as no systematic study has yet been carried out. A great part of the excavated material is still unpublished, and trade with the Aegean during the Classical (or Persian) period has not attracted the attention of many scholars (Waldbaum, 1997: 5). Moreover, most of the existing references are related to finds from the 5th rather than the 4th century BC, for various reasons: the very distinctive amphora-type with bulb-neck was typically Chian and its dating is better established (see above), as this was a peak period for Chian trade. The distribution of Aegean amphoras is better attested for the Hellenistic and later periods, when their import increased and their stamped handles offer more-accurate dating evidence (Sherwin-White, 1978: 238; Finkielsztejn, 2000). These unfavourable research trends, however, may also be indicative of the fact that Aegean amphoras were not abundant either in Egypt or in the Levant during the 5th and 4th centuries BC.

Sporadic references in relevant publications suggest that maritime trade between the Aegean and the eastern Mediterranean might not have been intense, as in the case of the Black Sea, but it was active and continuous. The Ionian ships referred to in an Aramaic text on the Ahiqar Scroll from Elephantine island, dated to 475 BC, are indicative of this practice (Yardeni, 1994). Aegean amphoras are well-attested in the Greek trading-post at Naukratis, and Chian amphoras 'form a large group' among them (Coulson, 1996: 53–4). In the Levant, during the 'rather obscure period of the second half of the 4th century' (Elayi, 1988: 91), Chian amphoras were found during excavations at the harbour of Atlit (Zemer, 1977: 37, no. 30). At Tel Dor, although it is stated that 'the import of Greek wine gradually increased in volume during the period under consideration' (Stern, 2000: 183), it seems that during the 4th century BC trade with the Aegean was in decline, most probably due to the unstable relations of the Greek cities with the Persian empire (Maier, 1994: 326–36; Mook and Coulson, 1995: 99).

The Aegean connections with Cyprus, however, have a particular character, as the island had always played a significant role along the sea-routes of the eastern Mediterranean. The 5th and 4th centuries BC are generally regarded as prosperous for the island, when it enjoyed trade relations with the entire eastern Mediterranean. Cyprus maintained its close trade relations with the Levant, as shown for example by the Ma'agan Mikhael shipwreck (Artzy and Lyon, 2003: 197–8), but in the same period, and during the 4th century BC in particular, Greek or Aegean 'influences' or 'contacts' are obvious (Collombier, 1993; Cayla and Hermary, 2003; Maier, 2007: 26; Petit, 2007; Yon, 2007: 55–6).

Nonetheless, despite the manifold archaeological and historical evidence of Greek influence, reports on imported amphoras remain few, and references to Chian amphoras specifically are quite limited. For example, in most relevant publications, either the 'bobbin-neck' type of the 5th century BC (du Plat Taylor, 1980: 168–71, 176–7; Johnston, 1981: 39–40; Calvet, 2003: 356–7; Jacobsen Winther, 2006: 315), or stamped Hellenistic handles, are singled out (Calvet, 1972: no. 96; Lund, 1993: 122). It would seem—as Johnston (1981: 39) has pointed out—that these reports 'must not be taken as a statistical sample as they have been selected on a largely random basis', and any conclusions drawn from their study should be received with caution. Moreover, no quantitative studies have been carried out, and so it is impossible to compare quantities of Aegean, local or eastern amphoras on Cyprus. Still, as no dramatic increase in Greek amphoras has been reported so far, we may suggest that despite the Greek taste in fine pottery, language or religion, seaborne trade was not intense between the two areas.

The vessel's last voyage

In the present, preliminary phase of research, we can say little with certainty about the last voyage of the Mazotos ship. From Chios, it seems to have reached Cyprus by way of the south Aegean, where it may have loaded the mushroom-rim/knob-toe amphoras. In any case, it is already clear that when it sank it still carried most if not all of its Aegean cargo. From various sources we know that commercial shipping generally avoided navigation in the winter, although it cannot be excluded (Casson, 1959: 39; Rougé, 1981: 15–17; Pryor, 1988: 87–9; Morton, 2001: 255). If we accept that meteorological phenomena have not changed considerably since the Iron Age, we can examine the impact of weather conditions and sea currents on the main trunk-routes during antiquity. As St Paul's journey from Miletus to Tyre shows (*Acts* 21: 1–4), routes from the west or north-west towards Cyprus came together in Rhodes, continued perhaps to Antalya Bay, and finally headed south-east to Cyprus or the Levant. This route is also described in travel accounts from the Byzantine or Crusader periods (Pryor, 1988: 91–5).

As Morton (2001: 158–9) has demonstrated, 'many factors (physical, human, technical) were taken into account before the ancient mariners decided on coastal or open sea sailing'. Sailing along the south coast of Cyprus during the summer depended heavily on the prevailing westerly winds (Murray, 1995: 39). Moreover, in his description of Cyprus in the *Book of Navigation*, the famous Ottoman-Turkish admiral, geographer and cartographer Piri Reis (*c*.1465–1554/5) describes Cape Mozote (Mazotos or Cape Petounda?), noting that the waters are very shallow and any ship should be offshore at least 2 miles (Pavlides, 1993: 314). Between Cape Petounta and Cape Kiti no anchorages or harbours exist and there was no obvious reason for a ship to sail closer to the coast (Leonard, 1995). Thus it seems that the site of the Mazotos wreck today, 1.5 miles offshore, west of Cape Petounda, is most likely situated on a very common east-to-west sea-route along southern Cyprus. If we accept that the ship was heading eastward, then the important Cypriot ports of the 4th century BC, Kition or Salamis, could have been its destination, although the Levant or Egypt cannot be excluded.

Given the limited archaeological horizon, any further interpretation of the Mazotos wreck in this preliminary stage of research would be speculative. It is already obvious, however, that systematic excavation and study of the wreck will contribute significantly to our fragmented knowledge of the trade mechanisms between Cyprus and the Aegean at the end of the Classical period.

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Notes

1. The declaration was made in 2006 to the Department of Antiquities of Cyprus, by Andreas Troullides. According to an agreement with the Department of Antiquities of Cyprus, signed in October 2007, the University of Cyprus undertook the archaeological work on site, under the co-direction of the author and Prof D. Michaelides, Director of the Archaeological Research Unit.
2. The survey was conducted in collaboration with the Laboratory of Marine Geology and Physical Oceanography, Department of Geology, University of Patras, Greece (director: Prof. G. Papatheodorou). A report of the results is in preparation.
3. E.g. Strabo (*Geographica*, XIV I.35): 'ειθ η Αριουσία χώρα τραχεία και αλίμενος, σταδίων όσων τριάκοντα, οίνον άριστον φέρουσα των Ελληνικών' (Then one comes to Ariusia, a rugged and harbourless country, about 30 stadia in extent, which produces the best of the Greek wines). See also Pliny, *Natural History* XIV, viii, ix, and XIV, xvii. 97; Athenaeus, *Deipnosophistae*, I.26,29,32.

Appendix 1: the photomosaic

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This is a description of the technique used to create the colour underwater photomosaic of the Mazotos shipwreck. The primary characteristics of this technique are firstly that it uses free or publicly-available computer software, and secondly that it requires no expensive underwater technology and can be performed using divers and readily-available photographic equipment. Thirdly, it produces timely results of an acceptable quality that can be used during the archaeological process as well as for archaeological publications such as this.

Underwater photography

Three white ropes were placed at 5-m intervals parallel to the wreck's north-south axis. A diver then swam approximately 2 m above the wreck, following these rope guides, and took pictures approximately every metre while looking straight down, striving for at least a 50% overlap between successive images. The first row or strip of images was created by keeping a guide rope on one side of the camera's viewfinder frame, the second strip with the same rope in the centre of the frame, and the third with the rope on the opposite side of the frame (which also guaranteed at least a 50% overlap between the strips). A total of 7 strips (made up of 230 individual images) were created in this fashion, covering the main body of the shipwreck. All photography was performed during a single dive (20 minutes of bottom time) in order to maximize the consistency of exposure across the captured images.

The equipment used to create this mosaic was a simple Canon A620 7.1 megapixel digital camera, an Ikelite underwater housing, and an Ikelite DS-51 strobe. This particular camera has a 28-mm lens at minimal zoom, and all pictures were taken with the camera's focus, aperture, and shutter-speed locked in order to reduce motion-blur and inconsistent exposure. Individual images at a resolution of 3072×2304 pixels resulted in a final mosaic size of approximately $20,000 \times 46,000$ pixels (equivalent to a 1.7×3.8-m poster printed at 300 dpi).

Processing the images

After re-naming the images according to strip and sequence number (01–01.jpg to 07–27.jpg), some initial processing of the images was performed in Adobe Photoshop. The goal was to maximize the uniformity of lighting and colour across all images prior to stitching and blending. Strong underwater blue colour casts were removed using Photoshop's 'Match Color > Neutralize' command. Images were further colour-corrected (if necessary) using the 'Color Balance' command. Finally, images were manually adjusted for exposure and contrast using the 'Levels' and 'Curves' commands.

The images were then loaded into the free, open-source Hugin programme (http://hugin.sourceforge.net/), a program typically used for stitching and blending a series of photographs into a 360° panoramic image but which can also be adapted for creating flat photomosaics. The first step was the creation of 'control-points' for each overlapping image-pair. Control-points are corresponding points between two images (for example, pixel 665x, 921y in image A is the same point in space as pixel 682x, 2139y in image B), and they are used for estimating the positions and lens parameters of the images within the photomosaic. At least 10 control-points were created for each image-pair (both between images in the same strip, and between adjacent images from neighbouring strips).

Control-points can be created manually in Hugin or they can be 'discovered' automatically by auxiliary programs such as Autopano-Sift (http://user.cs.tu-berlin.de/~nowozin/autopano-sift/). For the Mazotos photomosaic, given the large number of initial images, small programmes were written in the Perl scripting language which used Autopano-Sift to automate much of the work of control-point discovery and creation. Images were matched against all their neighbours one-by-one throughout the entire photomosaic and control-points were collected and merged from all these individual matches, a technique we found more successful than simply allowing Autopano-Sift to analyze all the images simultaneously. When the Autopano-Sift algorithm was unsuccessful in detecting correspondences between image-pairs, control-points were added manually in Hugin.

Once control-points were created for each image-pair, all images were then aligned in Hugin. Optimization is the process of determining the necessary warping for an image-pair in order to align given control-point pairs. Images connected by control-points can be moved, scaled, or rotated in order to find the best overlapping fit. Optimization works in Hugin by selecting one or more parameters (such as position, rotation, or scale), and then allowing Hugin to automatically vary these values until the distance between all control-points is minimized.

Typically one optimizes the alignment of photographs in Hugin by adjusting the yaw, pitch, and roll parameters of the individual images (since 360° panoramic images are created by keeping the camera's position fixed while capturing images). But in an underwater photomosaic, since the camera *moves* while capturing images (rather than yawing and pitching), one must deviate slightly from the standard Hugin workflow: one does not optimize the yaw and pitch parameters of the images, one instead optimizes the x- and y-shift values (Hugin's 'e' and 'd' parameters) which correspond to a fictitious shift in the optical axis of the camera lens. This process is more fully described in two tutorials located on the main Hugin website called 'Stitching flat-scanned images' and 'Creating linear panoramas with Hugin'. Normally alignment parameters such as position, rotation, and scale are optimized simultaneously by Hugin. However, we found that optimizing the parameters in stages tended to produce a more aesthetically-pleasing final arrangement. For example, first the positions of the images were adjusted by optimizing the optical axes of the individual images ('e' and 'd' parameters). Then the positions *and* rotation ('r' parameter) of the images were optimized together. And finally, the position, rotation, and scale ('v' parameter) were optimized simultaneously.

After the individual images were moved, rotated, and scaled onto our final mosaic canvas, the next task was to blend these images together. The primary problem at this stage is parallax error, defined as 'an apparent displacement of an object viewed along two different lines of sight'. Since each successive photograph in a strip or row captures objects in the frame from a slightly different line of sight, then the blending process, in order to create a seamless and

Figure 9. Amphora NM5 (142). (S. Demesticha © University of Cyprus, ARU)

Figure 10. Amphora NM6 (145). (B. Hartzler © University of Cyprus, ARU)

uniform final photomosaic, must select from each overlapping area only one perspective to be included in the final mosaic (Fig. 9). Three different blending algorithms were used to create this photomosaic: Enblend (http://enblend.sourceforge.net/) (Fig. 10); Smartblend (http://wiki.panotools.org/SmartBlend) (Fig. 11); and Adobe Photoshop CS3's auto-blend function.

These three algorithms were easy to obtain and we found they consistently produced results of acceptable quality. Since blending two overlapping images is largely a compromise (that is, blending one part of an overlapping region in an aesthetically-pleasing fashion inevitably results in blending another part poorly), a technique was devised where multiple blend-attempts were stacked on top of each other in order to provide a series of possible blends for each overlapping area. After placing the three different algorithms' blend attempts on top of each other in Photoshop layers, the best blend result in each local area was selected for inclusion in the final mosaic. Using this technique, we were able to quickly and dramatically reduce visual artefacts resulting from

Figure 11. A blend attempt performed using SmartBlend. (B. Hartzler © University of Cyprus, ARU)

parallax error (such as multiple amphora necks) in the final photomosaic (Fig. 12). Although it is possible to adjust manually the blend seams in order to reduce the amount of parallax error present in the final mosaic, we generally found it more convenient and efficient simply to select from the results of different blending algorithms. Very occasionally some manual adjustments needed to be made when all three blending algorithms failed to produce an aesthetically-pleasing result.

Final correction and results

Once the images were blended together, colour and exposure correction were performed on the mosaic as a whole (using Photoshop's 'Color Balance' and 'Curves' commands), as well as some minimal image manipulation (using Photoshop's 'Clone Stamping' tool), primarily to remove the ropes from the final image. Using Hypercube's 'Affine' transformation function (http://www.agc.army.mil/Hypercube/), the entire mosaic was then warped to 92 underwater control-points obtained from PhotoModeler (see Appendix 2), in order to fit the image to the topography of the sea-bed and produce a truer representation of underwater distances and perspectives.

The physics of underwater light-diffusion requires that we photograph relatively close to a shipwreck. The resulting parallax error creates multiple perspectives which must be reconciled during the blending process, which inevitably produces a photomosaic that is an artificial and compromised view of reality. Throughout this process our goal was not the creation of an underwater photomosaic that perfectly captures the actual orientation of each artefact. If we wish to know what is actually present, then we need to return to the original images, which do provide an accurate picture of reality. If the goal, however, is the creation of a qualitatively-appealing picture of a shipwreck, then underwater photomosaics created with this technique can function as a useful tool within the larger archaeological process.

Appendix 2: surveying the Mazotos wreck

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The pre-disturbance survey of the Mazotos shipwreck is work still in progress, initiated in November 2007. Challenges included the time limitations of diving at –44 m and the complexity of the site, exemplified mainly by

Figure 12. The final results for this area. Note that this mosaic still contains image artefacts as a result of parallax error. Additional post-processing and manual editing of the individual blend-seams would be required to further reduce the visible errors.

a large accumulation of amphoras in different layers. The fundamental objective of the documentation project was to overlay different methods of data acquisition from the wreck-site for further processing and assessment. The first priority was to produce a photomosaic and a two-dimensional archaeological plan of the wreck, providing an overview of the entire site. It is well-known that conventional mapping is a process subject to human error in underwater archaeology (Canciani *et al*., 2002: 97; Holt, 2003: 251; Patias, 2006: 11), while photogrammetry has long been a viable technique in such situations (Drap *et al*., 2005). Thus the main objective was to create a 3-dimensional model of the site using photogrammetry, which could be updated dynamically according to the progress in the archaeological excavation.

Instrumentation

The method used to produce the photomosaic is discussed in Appendix 1. This photomosaic also served as a basis for the 2-dimensional plan of the wreck which was completed after the first preliminary field season (Fig. 3). The photogrammetric survey of the wreck was executed with user-friendly software and low-cost instruments. For the image acquisition, we used a Canon A620 camera with a 35-mm lens, in an Ikelite underwater housing. The orientation of the photographs and the plotting of 3-D points, was done with Eos Systems PhotoModeler software (www.photomodeler.com). Scaling and vertical reference were included in the photographs using a 2-m plastic ruler and several sub-bottom buoys respectively. We used Autodesk AutoCAD architecture software (www.autodesk.com) for the 3-D modelling.

The drawing of the different types of amphoras was done under water during the preliminary phase of the project, using conventional instruments (plastic tape-measure, calipers, quadrant compass, metal rulers). Multi-tape trilateration mapping of several key finds and fixed points served as a backup to the photogrammetric survey work. Site Recorder SE software (www.3hconsulting.com) was used for the processing of the underwater measurements taken from the reference frame of fixed points, and the results were exported into an Autocad 3-D environment.

Documentation procedures

The PhotoModeler software has already been used for different applications and in several underwater archaeology photogrammetric surveys (Franke, 1999; Canciani *et al.*, 2002; Drap *et al.*, 2002; Green *et al.*, 2002; Drap *et al.*, 2005; Drap *et al.*, 2007). The main intention of the photogrammetric project was to survey and plot artificial 3-D points on artefacts, in order to record their exact location in three-dimensional space, a technique that has been used before, at the Tektas Burnu shipwreck excavation (Green *et al.*, 2002). For the Mazotos wreck, PhotoModeler software was used to calibrate the camera-housing as well as to orient the photographs taken during three dives (Drap *et al.*, 2005) during two different field-seasons (November 2007, May 2008). The plotting of the reference-points for the positioning of each amphora in three-dimensional space was also done with the use of PhotoModeler software and target-markers.

Each target-marker used for this application was a plastic disk with a preprinted surveying target and an identification number on its surface. This disk was 10 cm in diameter (made after having measured the main rim-diameter of the cargo amphoras), with a cross-wire black and yellow colour surface. The markers were positioned on the mouth of each amphora with the number of the label aligned to the handles of the amphora (Fig. 12), using plastic tie-wraps (a technique that proved not to be very successful, due to the build-up of concretions on the plastic parts, which loosened the tie-wraps after a period of a few months). From the surveying target on the plastic label, five reference points could be derived for each amphora, from which at least three common points were used during the process of plotting in PhotoModeler. In this way, the surface plane of the mouth of the amphora could be plotted and, consequently, the whole amphora could be positioned in three-dimensional space.

Fixed points were created on the perimeter of the wreck, to be used for both multi-tape trilateration survey and photogrammetric survey. These fixed points, made of plastic tubes approximately 1 m tall, fitted to cement blocks

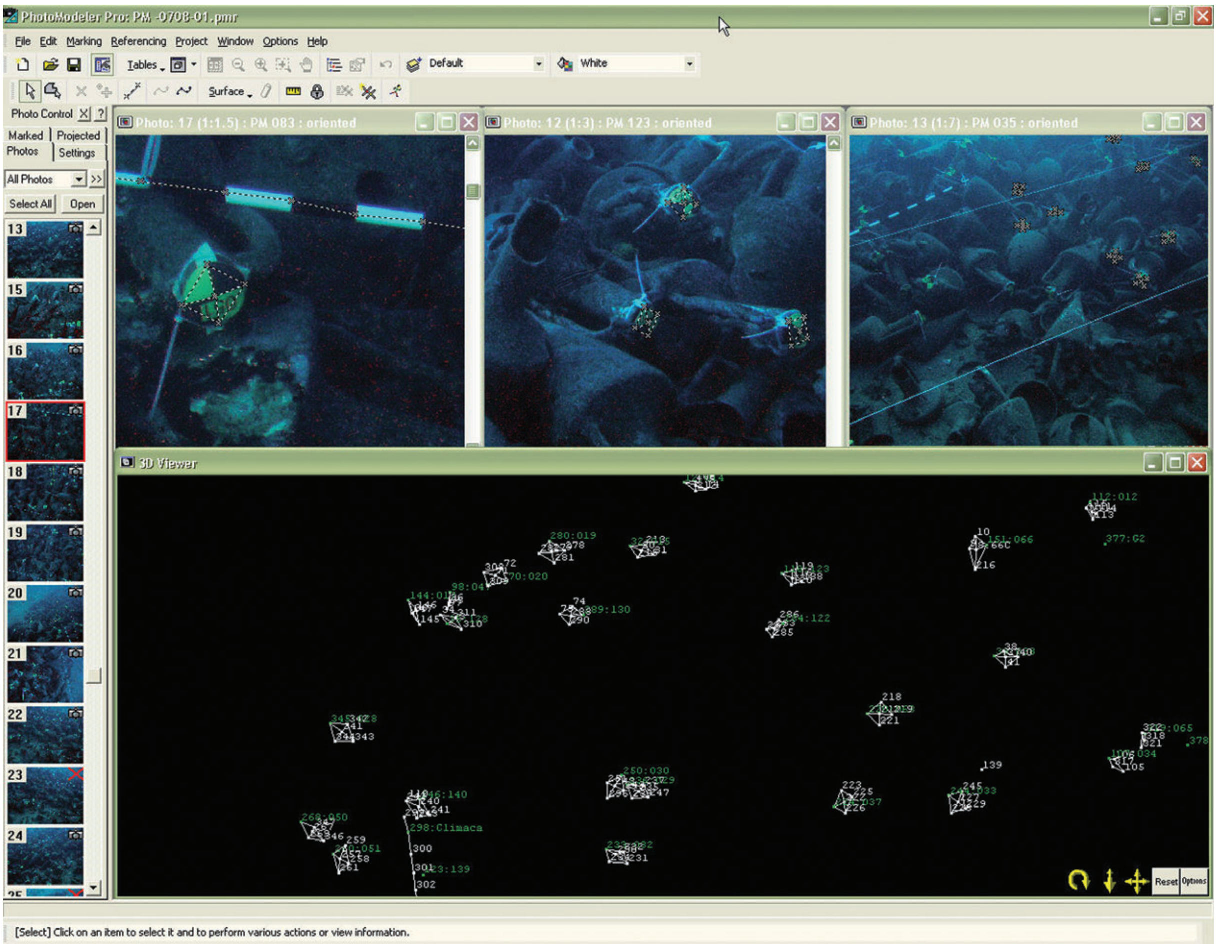

Figure 13. PhotoModeler screen with the 3D wireframe model and plotting of points. (© University of Cyprus, ARU)

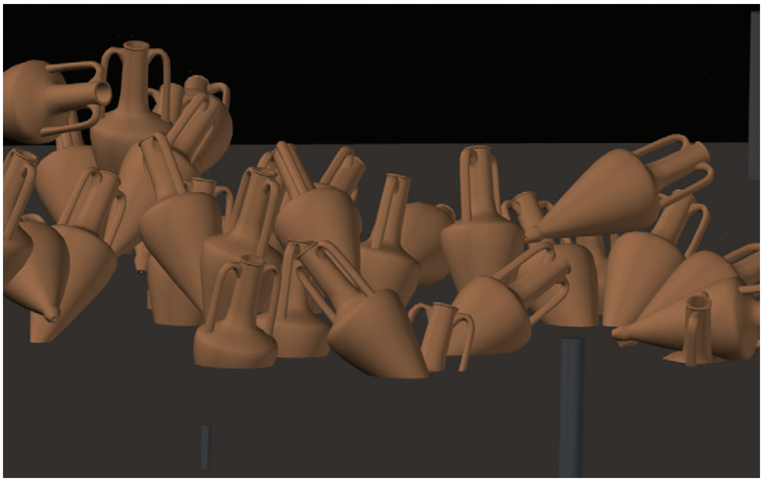

Figure 14. Detail of the 3-D rendered model of surveyed surface cargo amphoras. (Foteini Vlachaki, © University of Cyprus, ARU)

on the sea-bed and standing clear from the accumulation of amphoras in order to be viewed from several angles, were photographed along with the target-markers of each group of amphoras.

During this phase of the project more than 350 photographs were taken in the course of three dives. Different areas of the amphora accumulation were photographed from various angles along their perimeter and from alternate heights, with the camera orientation at an angle of approximately 45° and 90° from the sea-bottom. The orientation of the photographs was done in pairs, by referencing at least seven common points in each pair. Each time a new photograph was added, all photographs were re-processed through PhotoModeler. For the photogrammetric surveying of the first 140 surface finds, 120 photographs were processed. The derived wire-frame model with the location of the amphora-mouth planes was exported into an Autocad 3D environment (Fig. 13). In order to create a total 3-D model of the marked surface-finds processed through PhotoModeler, a 3-D model of each type of amphora—created using Autocad 3D software from the measurements and photographs taken underwater—was aligned to the respective mouth-plane (Fig. 14). For the finds which could not be labelled with markers, due to fragmented shapes or inaccessible positions, provision was made for the creation of a smaller control-point grid-system, close to the artefacts, in order to select and plot points on them (Green *et al*., 2002).

Conclusions

The aim of a 3D model of the wreck created using PhotoModeler and Autocad is not only to produce a 3-D representation of the surface finds prior to the disturbance of the site, but also to serve as a tool for the interpretation and understanding of the full volume, the loading arrangement and the possible tilting of amphoras when it sank. Furthermore, this process is enriched by overlaying the data acquired through the photomosaic. In the 3-D model of the site created thus far, the dimensional error over the full length of the wreck (19.8 m) was ±5 cm. In addition, 92 target-points over the whole length of the 3-D model were used to warp the photomosaic into scale, in order to have corresponding x, y co-ordinates in the two different means of documentation (see Appendix 1). The application of photogrammetry with the use of simple instruments and user-friendly software has proven to be accurate and efficient in producing the first 3-D model of the wreck-site in a short time, decreasing bottom dive-time and allowing flexibility during the software simulation of the data acquired.

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