Journal of Roman Archaeology 36 (2023), 368–396
doi:10.1017/S1047759423000351

Do shape and size matter? The distribution of *Amphore Crétoise* 4 containers, 1st–3rd c. CE

Scott Gallimore

Wilfrid Laurier University <sgallimore@wlu.ca>

Abstract: This paper examines the distinctive distribution patterns of *Amphore Crétoise* (AC) 4 amphoras within Roman trade networks through critical assessment of the morphological attributes of this amphora type compared to AC1–3 jars and through consideration of the mechanisms that underlie these patterns. This builds on a growing number of studies that have focused on the design attributes of amphoras as important factors tied to their economic role. It also demonstrates the importance of engaging in more nuanced and detailed investigations that question assumptions about amphora distribution within the Roman world. The AC4 is the primary, and often only, Cretan type found at sites in Rome's northwestern provinces and along the Danube frontier. A narrower profile and smaller capacity appear to have made this amphora type more attractive than other Cretan forms for transport along river and overland routes.

Keywords: Roman economy, amphora design, Roman Crete, river transport, Rhône-Rhine axis, Atlantic trade

The economic connections of the Greek island of Crete under Roman rule have been a significant point of scholarly focus over the past few decades.[1] Of central importance in these discussions is the distribution of products packaged in amphoras manufactured on the island, which serve as the key archaeological indicator of Crete's export economy.[2] For the 1st–3rd c. CE, there are four amphora types manufactured on Crete, the *Amphores Crétoise* (AC) 1–4, relevant to discussions of economic connectivity. While each type is attested at various sites in the Mediterranean basin, the AC4 is the primary, and often the only, Cretan type found in Rome's northwestern provinces and along the Danube frontier. This paper examines the distinctive distribution patterns of AC4 amphoras within Roman trade networks through critical assessment of the morphological attributes of this amphora type compared to AC1–3 jars and through consideration of the mechanisms that underlie these patterns. Following an overview of the attributes and distribution of products packaged in AC4 amphoras, the discussion turns to river and overland transport and the benefits of the AC4 for this type of trade. A brief overview of Atlantic trade as a potential alternative means of distribution is also undertaken. This analysis, overall, builds on a growing number of studies that have focused on the design attributes of amphoras as important factors tied to their economic role.[3] It also demonstrates the importance of engaging in more nuanced and detailed investigations that question assumptions about amphora distribution within the Roman world.

What is distinct about the AC4?

The AC4 amphora, also known as the Dressel 43, is among the most recognizable Early Roman Cretan types (Fig. 1). John Hayes connected the AC4 with production on Crete

1 Chaniotis 1988; Marangou-Lerat 1995; Marangou 1999; Gallimore 2015; Gallimore 2016.

2 Marangou-Lerat 1995, 67–89; Gallimore 2015, 286–95, 307–14; Gallimore 2016, 178–82.

3 See, for example, Peña 2007; Rauh et al. 2013; Bevan 2014; Muslin 2019.

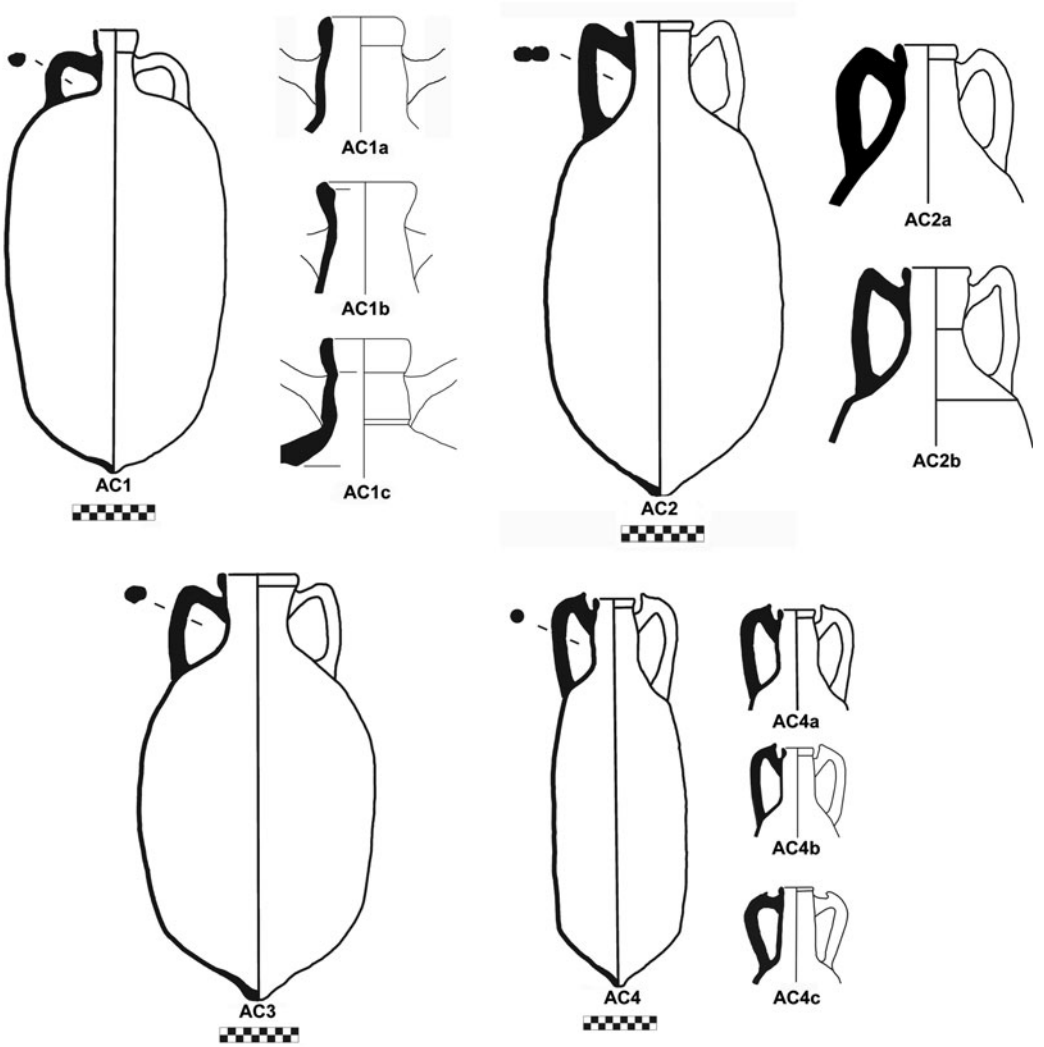

Fig. 1. *AC1–4 Amphoras. (After Marangou-Lerat 1995, fig. 29, fig. 30:A19, fig. 37:A37, fig. 42:A57, fig. 52, fig. 58:d, fig. 62:c, fig. 64, fig. 69, figs. 74–75.)*

following analysis of finds from the Villa Dionysos at Knossos, and manufacture is now documented at four sites on the island: Dermatos, Heraklion, Hierapytna, and Tsoutsouros-East.[4] In her study of amphora production on Crete, Antigone Marangou-Lerat identified three variants, which corresponded to different production sites (AC4a – Heraklion; AC4b – Dermatos; AC4c – Tsoutsouros-East).[5] At Hieraptyna, production may have included both the AC4a and AC4b. The AC4a has a button point, narrow ovoid body, vertical handles with prominent horns at the top that terminate above the rim, a swollen neck, and a folded, triangular rim. AC4b vessels have the same

[4] Hayes 1983, 145 types 4–5. A subsequent study by Clementina Panella (1986, 620–22) also emphasized a Cretan provenance for this type. For sites documented as locations of AC4 manufacture, see Marangou-Lerat 1995, 85–86; Sofianou and Gallimore 2019, 14.

[5] Marangou-Lerat 1995, 84–89.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

body shape, handles, and rim as the AC4a, but the neck is cylindrical. The AC4c has the same body as the above two variants, and a neck and rim comparable to the AC4b, but the handles have a smaller horn that tends to terminate below the rim.

Marangou-Lerat argued that production of the AC4 began in the early 1st c. CE and continued into the first half of the 3rd c.[6] A later publication based on finds at the Cretan site of Gortyn suggested a more contracted chronology (mid-1st c. CE to mid-2nd c. CE), but there is additional data to support Marangou-Lerat's interpretation.[7] For the beginning of production, Marangou-Lerat cited finds of AC4 vessels at Vindonissa, Switzerland from a context of the first half of the 1st c. CE, and from two deposits excavated at the Meta Sudans in Rome, one dated to 20–30 CE and the other to 14–40 CE.[8] In addition, the assemblage of the La Chrétienne H shipwreck near Saint-Raphaël, France, dated to 15–20 CE, included one AC4 container.[9]

Evidence for small-scale exports this early into the 1st c. CE may signal that production of the AC4 type began by the latter part of the 1st c. BCE, even earlier than suggested by Marangou-Lerat. The AC4 developed from the Rhodian amphora tradition, and in several publications these vessels are even mistaken as coming from Rhodes.[10] This is an example of a shared regional style, and Crete had strong economic connections with the southeastern Aegean, including Rhodes, throughout the Hellenistic period as the island helped to facilitate trade between that region and Egypt.[11] In eastern Crete, an amphora type described as East Crete type 2, datable from the late 2nd c. through 1st c. BCE, is interpreted as an imitation of Rhodian amphoras.[12] Petrographic analysis of the clay fabric of East Crete type amphoras indicates they were manufactured within the Hellenistic territory of Hierapytna, one of the documented locations of AC4 production.[13] Unfortunately, surviving examples of the East Crete type 2 are limited to two stamped handles found at the site of Mochlos in northeast Crete. Neither comes from a well-dated context, making it challenging to assess the overall morphology and the chronology of this type. This also restricts identification of when vessels specifically identifiable as AC4 amphoras appeared, but the above evidence suggests that this had occurred at least by the late 1st c. BCE/early 1st c. CE.

In her assessment of the end of production, Marangou-Lerat highlighted 38 fragments of AC4 vessels recovered from contexts dated between 230 and 250 CE at Ostia.[14] Additional finds from 3rd-c. deposits at other sites indicate that production may have continued into that century. This includes Rome, where small numbers of AC4 jars are attested

---

6 Marangou-Lerat 1995, 87.

7 Portale and Romeo 2001, 275, 372.

8 Marangou-Lerat 1995, 87, 159. For the data from the Meta Sudans, Marangou-Lerat reports that this is based on a personal communication from C. Panella.

9 Santamaria 1984, 41 no. 31, fig. 23; Parker 1992, 143 no. 307. This amphora is listed as part of the Rhodian tradition in the original publication, and the illustration suggests either an AC4a or AC4b container.

10 For example, Liou and Marichal 1978, 159–60, 162 no. 62. See also n. 9 above.

11 Gallimore 2019, 605.

12 Vogeikoff-Brogan 2014, 38–39; Vogeikoff-Brogan and Apostolakou 2004, 418, 427; Vogeikoff-Brogan et al. 2004, 329–30.

13 The fabric in question is known as East Cretan Cream Ware. See Boileau and Whitbread 2014, 82–84.

14 Marangou-Lerat 1995, 87–88.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

in early 3rd-c. deposits.[15] At Viminacium (modern Kostolac) in Serbia, AC4 amphoras appear predominately in contexts datable from the second half of the 2nd c. to the early 3rd c. CE.[16] AC4 amphoras also account for 11 percent of eastern amphoras recovered at Lyon from deposits dated from 190 to 250 CE.[17] At Colchester, England, a single AC4 container was recovered from a deposit dated to 225–250 CE and a second from a deposit of 250–275 CE.[18] Additional evidence comes from Corinth, Greece, where AC4 jars account for 9.4 percent of amphoras by count and approximately 5.9 percent by weight from a dump dated between 250 and 300 CE.[19] While it is possible that some proportion of AC4 amphoras at any or all of these sites are residual in 3rd-c. deposits or represent vessels that were in use for extended periods of time, or were perhaps even in a state of re-use, a hypothesis that manufacture continued into the first half of the 3rd c. is not unreasonable.[20]

The AC4, along with AC1–3 jars, is part of a tradition of ovoid amphoras that rose to prominence across the Mediterranean from the 2nd c. BCE through the 1st c. CE.[21] According to Enrique García Vargas and collaborators, the shape, chronological and geographical range, and historical significance of ovoid amphoras suggest that "they make up a kind of homogenous family."[22] This "family" has different branches, including containers inspired by Koan vessels, such as the AC2.[23] Rhodian amphoras and their offshoots form another branch. Chronologically, there is some overlap between the various Early Roman Cretan types. The AC2 and AC3, analogous to the AC4, have connections to Hellenistic traditions on Crete and likely arose as independent types during the latter part of the 1st c. BCE or the early 1st c. CE.[24] Both continued to be manufactured through the 2nd c. CE.[25] The AC1 first appears by the mid-1st c. CE and was produced at least into the late 3rd c.[26]

---

15 Puig Palerm and Ruíz del Pozo 2010, 420.

16 Bjeljac 1996, 39–41.

17 Lemaître 2000, 467, fig. 2.

18 Vilvorder et al. 2000, 479–80.

19 Slane 2004, 366–67. Based on the date of this deposit and the morphology of these vessels, Kathleen Slane argues that they are not imports from Crete but rather local imitations. The morphological attributes she references are the cylindrical rather than swollen neck, the sloped shoulders, and the horns that terminate below the rim. These criteria, however, are characteristic of AC4c vessels manufactured at the Tsoutsouros-East kiln site on Crete.

20 Re-use of amphoras as packaging containers has seen increased attention in recent scholarship (e.g., Duckworth and Wilson 2020; Bernal-Casasola et al. 2021) and is an important consideration when studying distribution patterns of these vessels.

21 See García Vargas et al. 2019.

22 García Vargas et al. 2019, 403–4.

23 Marangou-Lerat 1995, 77–82; Lawall 2011, 50–52; Moore 2011.

24 Koan-style amphoras of Hellenistic date manufactured on Crete have been documented in the eastern part of the island as East Crete type 3. One example from a mid-1st c. BCE floor deposit at Mochlos has a rim and double-round handle characteristic of Koan jars. See Vogeikoff-Brogan 2014, 39, 41 no. III.74, fig. 24. A Hellenistic type known as the AC7 is thought to be the predecessor of the AC3, and evidence from a Late Hellenistic kiln site at Loutra in northwestern Crete has further suggested a connection between the two types. See Portale and Romeo 2001, 266; Tsatsaki and Nodarou 2014, 292.

25 Marangou-Lerat 1995, 81, 83; Portale and Romeo 2001, 274.

26 John Riley (1979, 181) suggests that examples of AC1 vessels are present at Berenice, Cyrenaica in Augustan contexts. This is unconfirmed, however, and the specific finds are not illustrated in that publication. For a critique of Riley's hypothesis, see Marangou-Lerat 1995, 74. For the end of

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

A comparison of AC4 versus AC1–3 amphoras shows several similarities along with several key differences (Table 1). All four types, for example, tend to be thin walled but well fired. This ensured a favorable capacity-to-empty-weight ratio and the possibility of packaging the greatest volume of liquid in the lightest possible container.[27] The overall morphology of the AC1–3 is also consistent with AC4 containers.[28] They typically comprise a rounded base, often with a button toe, an ovoid body, and a cylindrical neck in the case of AC1 and AC2 amphoras, or a swollen neck for AC3s. Rim profiles vary across each type, which contributes to the identification of particular sub-types. AC2b vessels also tend to have a distinct ledge on the shoulder. Average height is comparable across the four types.[29] A distinguishing feature between Early Roman Cretan amphoras, on the other hand, is the shape of handles. The AC1 has handles that are smaller than the other types and lack the more triangular outline of those characteristic of the AC2 and AC3. Handles on the AC1 and AC3 tend to be round in profile, while on the AC2 they are either pseudo-bifid or double-round. None of these types, however, has examples of the horns seen on AC4 handles.

A significant point of distinction between the AC4 and the AC1–3 is their capacity. The AC4 is the smallest of the four Early Roman Cretan types with an average capacity of 10.9 L.[30] Marangou-Lerat also reports that two half-size AC4s have been documented on Crete, with a capacity of 5–6 L.[31] For the other three types, average capacity is more consistent and approximately double that of a standard AC4.[32] Some half-size examples of the AC3 have also been identified, one from the sea near the coastal site of Kaloi Limenes in south-central Crete and a second at Pompeii.[33] Smaller capacity meant, in addition, that the AC4 tends to have a narrower overall diameter than the other three types.[34]

Where are AC4 amphoras found?

As excavations continue and classification of AC amphoras becomes more refined, distribution maps are regularly augmented. This section discusses the current state of the question. The distribution of products packaged in AC4 amphoras was more extensive than that of goods in AC1–3 containers. Each type is well attested at sites across the Mediterranean basin, in some cases in quite large quantities, but the AC4 is the only one to appear regularly along the Danube frontier and in Rome's northwestern provinces. This pattern was first revealed by Marangou-Lerat in her monograph on Cretan amphoras. An important element of her work was the creation of distribution maps that showed sites

AC1 production, finds of AC1a and AC1c vessels in 4th c. deposits at Gortyn could suggest a small-scale, localized continuation of production into that century. See Portale and Romeo 2001, 270–71.

27 Muslin 2019, 185.

28 For discussion of the AC1–3, see Marangou-Lerat 1995, 67–84.

29 Marangou-Lerat 1995, pls. XI, XVI, XVII, XIX.

30 Vidal and Corredor 2018, 305, Table 1.

31 Marangou-Lerat 1995, 89, 120 nos. A143–A144. One of these half-size AC4s was recovered off the coast of Loutro in northwestern Crete, while the other was found during excavations of a necropolis at Kydonia (modern Chania), also in northwestern Crete.

32 Vidal and Corredor 2018, 304, Table 1.

33 Marangou-Lerat 1995, 84.

34 Marangou-Lerat 1995, pls. XI, XVI–XVII, XIX.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Table 1.
Comparison of characteristics of AC1–4 amphoras.

	AC1			*AC2*		*AC3*	*AC4*		
Amphora Characteristic	*AC1a*	*AC1b*	*AC1c*	*AC2a*	*AC2b*		*AC4a*	*AC4b*	*AC4c*
Chronology	Mid-1st c. CE to late 4th c. CE	Early 2nd c. CE to late 3rd c. CE	Late 2nd c. CE to late 4th c. CE	Mid-1st c. CE to late 2nd c. CE	Late 1st c. BCE to late 2nd c. CE	Late 1st c. BCE to late 2nd c. CE	Late 1st c. BCE to first half of 3rd c. CE		
Base	Button point			Button point		Button point	Button point		
Body	Ovoid			Ovoid		Ovoid	Ovoid		
Shoulder	Rounded			Rounded	Ledge	Rounded	Rounded		
Neck	Swollen	Cylindrical		Cylindrical		Swollen	Swollen	Cylindrical	
Rim	Outward-thickened	Flaring	Vertical	Rolled		Squared	Folded		
Rim Diameter	6–7 cm	6–8 cm	5–10 cm	6–8 cm		11–15 cm	6–7 cm		
Handles	Vertical, round in profile			Pseudo-bifid	Double-round	Vertical, round in profile	Horned, terminate above rim		Horned, terminate below rim
Average Height	59 cm			63 cm		60 cm	58.5 cm		
Capacity	25.7 L			21.8 L		22.3 L (half-size approx. 11 L)	10.9 L (half-size approx. 5–6 L)		
Maximum Diameter	27–30 cm			28–30 cm		28–30 cm	20–25 cm		

across the Roman Empire where Cretan amphoras had been attested.[35] She created an individual map for each of the Early Roman types and an additional map that combined their distributions. In a later study, she published an updated comprehensive map.[36] As datasets from different sites continue to be published, this has enabled further modification of distribution maps for Cretan amphoras.[37]

While distribution maps like those created by Marangou-Lerat and later scholars can provide important aids for investigating economic patterns across the Roman world, they do have limitations. One issue is recognizing that these maps are never complete and require constant updating. Any conclusions must be taken with caution since new data could provide alternative perspectives. Most of the maps representing distribution of Cretan amphoras are also hindered by the fact that they only contain dots marking known findspots. Important variables like the chronology of the finds and the quantity of Cretan amphoras at a given site are not documented. This can lead to the false assumption that all dots are equal even though the number of vessels found at some sites may be far larger than at most of the sites represented on the map.

To populate these maps with findspots presents the additional challenge of reviewing significant numbers of published reports, looking for attested examples of specific types. Many publications pre-date the development of typologies for various amphoras, and some act as the source of a particular typology. This has led to several names being applied to individual types. The AC1, for instance, has been described in different publications as the Agora G197, Mid-Roman Amphora 2, Peacock and Williams class 41, Schöne-Mau 10, Cretan 1, etc. A search for findspots requires looking for examples under each potential name. Misidentification can be another issue, such as the challenge noted above where AC4 amphoras have been misattributed as Rhodian.[38] Detailed catalogue descriptions and illustrations are vital for assessing the identification of specific vessels. There is also the potential issue of including local or regional imitations of widely distributed types, which may only become apparent after archaeometric analysis. For instance, an amphora that morphologically appears to be an AC4 or very closely related type recovered from a villa in the area of Venice, Italy was assigned a local provenance following petrographic analysis.[39] None of these issues invalidate the benefits of creating distribution maps for amphora types, but they do point to the importance of working with multiple variables to tease out novel perspectives.

Marangou-Lerat's original overarching distribution maps demonstrated the benefits of not simply placing generic dots on a map but instead focusing on particular amphora types. Her most informative map was one that showed the distribution of AC1–3 amphoras alongside the distribution of AC4 vessels.[40] This organizational strategy reflected the distinct morphology of the AC4 and helped to highlight its unique presence in certain regions compared to the other three types. Rita Auriemma and Elena Quiri, in a later study, also emphasized the distinction in distribution between the Early Roman Cretan types and

---

35 Marangou-Lerat 1995, pls. XLI, XLIII, XLV, XLVII, XLIX.

36 Marangou 1999, 277, fig. 4.

37 Auriemma and Quiri 2006, 228–29, figs. 8–9; Gallimore 2015, 288, fig. 10:6; Gallimore 2016, 177, fig. 12:1; Gallimore 2019, 602, fig. 5.

38 See n. 9 and n. 10.

39 Toniolo 1994, 142.

40 Marangou-Lerat 1995, pl. XLIX.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

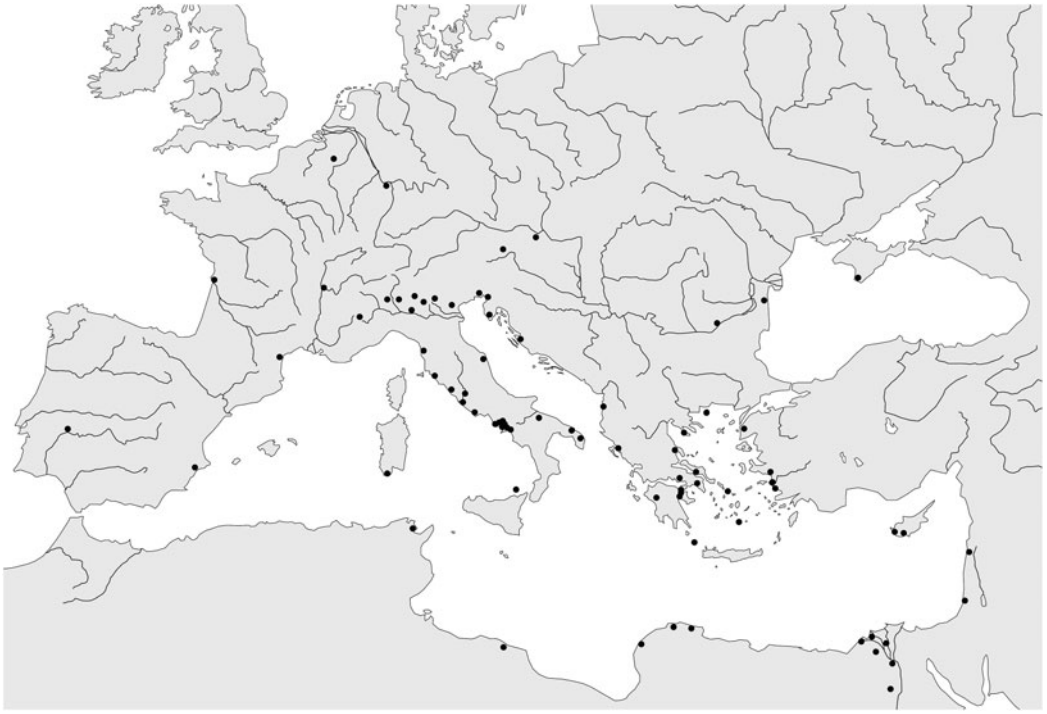

Fig. 2. *Distribution of AC1–3 Amphoras, 1st to 3rd c. CE. Sites represented on the map: Abusir, Abyar el Njam, Alexandria, Alicante, Antikythera, Aquileia, Argos, Ashekelon, Athens, Barzan, Berenice, Boscoreale, Braives, Brescia, Brindisi, Butrint, Caesarea, Capomulini, Carunutum, Carthage, Cassandra, Chersonesos, Corinth, Cremona, Cyrene, Demetrias, Didyma, Dreamer's Bay, Durres, Ephesus, Eretria, Herculaneum, Isthmia, Istria, Leptis Magna, Lipari, Lyon, Magdalensberg, Mainz, Marina el-Alamein, Merida, Milan, Miletus, Naples, Nettuno, Nora, Novae, Novara, Olympia, Oplontis, Ostia, Padua, Paphos, Perissa, Pisa, Pompeii, Port-la-Nautique, Porto Recanati, Puteoli, Pyrgi, Rome, San Foca, Schedia, Settefinestre, Stabiae, Susa, Tebtynis, Tenos, Thasos, Thebes, Trieste, Troy, Turin, Verona, Veštar Port, Vicenza, Zadar. (Map by S. Gallimore.)*

produced maps to help illustrate this.[41] They did not elaborate on a reason behind this pattern, however. The number of sites where Cretan amphoras have been documented has grown substantially in the three decades since both Marangou-Lerat and Auriemma and Quiri's studies, and it is necessary to see if the addition of new data continues to emphasize the same dichotomy in distribution. A revised map for AC1–3 vessels (Fig. 2) shows a few more inland European sites, while distribution continues to focus around the Mediterranean. For AC4 amphoras (Fig. 3), along with a well-documented presence at Mediterranean sites, distribution of these containers and their contents throughout Rome's northwestern provinces and along the Danube frontier is even more apparent.

Why is the distribution pattern of AC4 amphoras different than AC1–3 amphoras?

The distribution pattern for AC4 amphoras clearly differs from that of AC1–3 containers, and the number of sites involved confirms that this is not a random phenomenon.

[41] Auriemma and Quiri 2004, 46; Auriemma and Quiri 2006, 228–29, figs. 8–9. Dobreva (2017, 215–16) also observed that AC4 amphoras are found in elevated numbers at sites north of the Alps.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

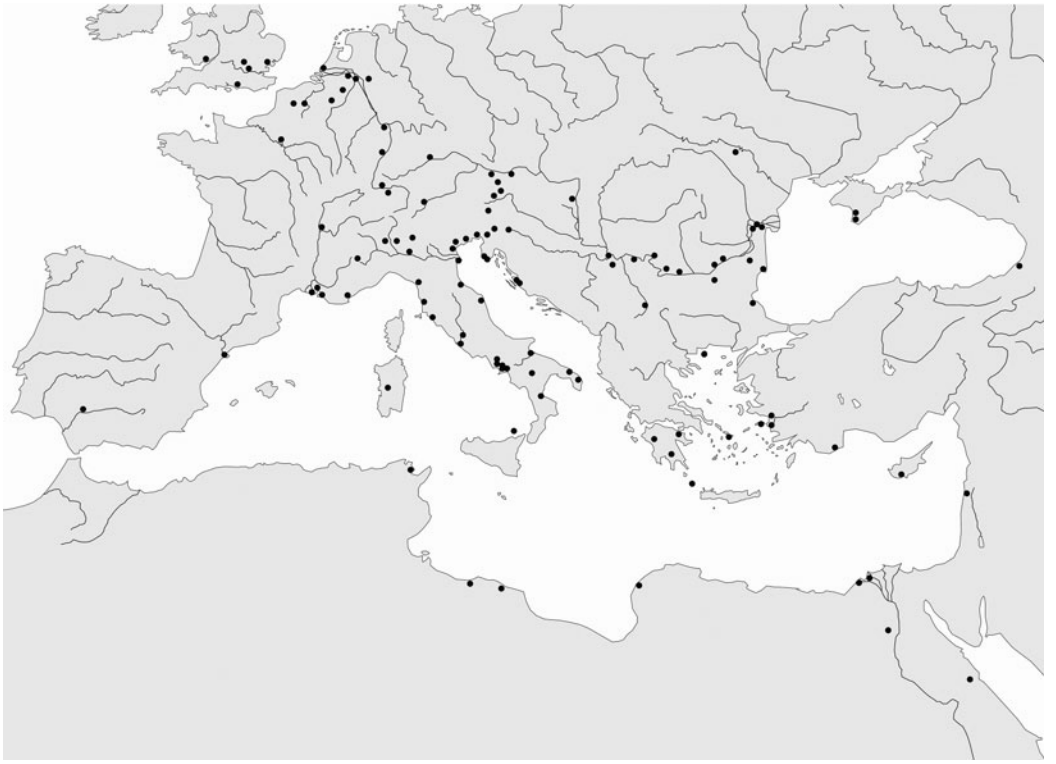

Fig. 3. *Distribution of AC4 Amphoras, 1st to 3rd c. CE. Sites represented on the map: Adamclisi, Adony Fort, Aegyssus, Aenona, Ajdovšina, Alexandria, Altinum, Antikythera, Apollonia Pontica, Aquileia, Arras, Augst, Ausburg, Bavay, Berenice, Belgrad, Braives, Brescia, Brijuni, Brindisi, Caerleon, Caesarea, Capua, Carnuntum, Carthage, Celje, Chersonesos, Cioroiu Nou, Colchester, Corinth, Cremona, Delos, Dobruja, Dreamer's Bay, Emona, Ephesus, Fishbourne, Fos, Frejus, Gonio-Apsarus, Haltern, Herculaneum, Istres, Kempten, Kostol, Kostolac, Kurvingrad, Leptis Magna, Lipari, London, Luni, Lyon, Magdalensberg, Mainz, Mala Vrbica, Margherita di Savoie, Marina el-Alamein, Marseille, Mesola, Milan, Miletus, Mons Claudianus, Naples, Nijmegen, Novae, Novara, Nuragha Losa di Abbasanta, Oderzo, Olympia, Orange, Orlea, Ostia, Ottagono, Pola, Pompeii, Porto Recanati, Potenza, Ptuj, Rimini, Rome, Sabratha, Samos, San Foca, Settefinestre, Seville, Sexaginta Prista, Sopron, Sparta, Stabiae, Strasbourg, Sybaris, Sympherpol, Szombathely, Tebtynis, Thasos, Tongeren, Tortosa, Troesmis, Tulcea, Turin, Vada Volaterrana, Veliko Tarnovo, Verulamium, Vienna, Voorburg, Windisch, Xanten, Zadar, Zalalöv. (Map by S. Gallimore.)*

Instead, it must be the result of certain factors that are poorly defined at present and require further investigation. The distinct characteristics of AC4 vessels, particularly their smaller capacity and narrower profile, are important variables to consider as informing these patterns. Marangou-Lerat suggested that the smaller capacity of this type points to use as packaging for higher-quality wine.[42] Unfortunately, she did not provide data to support that hypothesis and available evidence is limited. An AC4a amphora found in a mid-1st c. CE deposit at Caerleon, Britain, bears a painted inscription on the shoulder that has been reconstructed as: *III/AACII/(passum) perprimum*.[43] The latter part may translate as "first-grade raisin wine." This reading is not secure, however. *Perprimum* is otherwise

[42] Marangou-Lerat 1995, 89.

[43] Burnham et al. 1994, 310–12 no. 92, fig. 9; Williams 2003, 30–31 no. 5.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

unattested in Latin and interpreting it as an assessment of quality is tied to the fact that grading wine in tiers occurred within the Roman world.[44] Pliny the Elder (*HN* 14.82), for instance, described *secundarium passum* as a second-grade version of raisin wine where water was added to the grape skins after pressing. Even if *perprimum* does refer to quality, such a designation on an amphora could have been more of an attempt at marketing than an accurate reflection of its contents. Perhaps comparable is the use of the phrase *Cret(icum vinum) Exc(ellens)* in a painted inscription on an AC2 container found at Pompeii.[45] Even if AC4 amphoras did contain higher-quality vintages, which seems unlikely, that variable by itself does not explain their near monopoly among Cretan amphora types at sites outside of the Mediterranean basin.

The attraction of Cretan products north of Mediterranean

While this study focuses to a large extent on the morphology of AC4 amphoras as a reason behind their presence north of the Mediterranean, there must always be concern in amphora studies that these were packaging containers for particular contents. Available evidence indicates that raisin wine (*passum* in Latin; *γλυκύς* in Greek) was the primary contents of Cretan amphoras.[46] Cretan *passum* was distributed widely across the Roman Empire and appears in large quantities, based on amphora evidence, at sites like Rome, as will be discussed below. There were several reasons behind this popularity, including the low cost of the product, its stability (i.e., resistance to transforming into vinegar), its use in cooking (as *passum* is a common ingredient in many Roman recipes), and its medicinal properties.[47] Such attributes had broad appeal and help to explain the presence of AC4 containers at both civilian and military settlements in the northern provinces. It is also likely that Cretan *passum* was consumed primarily by members of the lower classes as a product that was low cost and could be used in multiple ways.[48]

The draw of Cretan products like *passum* to Rome's northern provinces, analogous to other goods from the eastern Mediterranean, was tied to the growth of economic networks in the Late Republic and Early Empire. In part, the development of such networks was driven by the importance of ensuring a steady supply of products to the thousands of soldiers stationed along the Rhine and Danube frontiers, or in outlying regions like Britannia. Greg Woolf argues that this helped contribute to a "consumer revolution" in this region.[49] The rapid appearance of various types of Roman material culture both before and after conquest was, in part, connected to this consumer revolution. Early in this process, merchants

---

44 Burnham et al. 1994, 313 n. 77. The authors suggest an alternate translation where *perprimum* perhaps indicates an association with a coastal site on Crete called Pergamum. Geographic designations do appear as part of painted inscriptions on Cretan amphoras, but this would be an obscure reference here and not one that is clearly stated on the jar.

45 *CIL* IV 5526 = Marangou-Lerat 1995, 131 no. P6.

46 Marangou 1999, 269; Gallimore 2017, 143–44.

47 For a detailed discussion of the attributes that contributed to the popularity of Cretan wine, see Gallimore 2017, 144–47.

48 Several literary references indicate Cretan wine was not highly regarded by the upper classes in Roman society. This includes Martial (13.106) who classifies Cretan *passum* as a poor person's substitute for honeyed wine and Fronto (*Ad Verum(?) Imp. i.1*), who, in a letter written to the emperor Marcus Aurelius, derides Cretan wine as a choice of beverage.

49 Woolf 1998, 174.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

relied heavily on Mediterranean products, particularly those packaged in amphoras.[50] Diana Dobreva has noted the same phenomenon for the provinces of Moesia Inferior and Thrace during the Late Hellenistic and Early Roman periods.[51] Production and distribution of these goods had developed during the Hellenistic period, and they were readily available to mobilize to different locations. Reliance on commodities imported from the Mediterranean shifted over time as local and regional markets at both military and civilian sites stimulated trade in equivalent regional goods.[52]

Contextualizing the quantity of AC4 amphoras north of the Mediterranean

Distribution maps illustrate that the AC4 is much more common at sites north of the Mediterranean than the other Early Roman Cretan types. An important consideration, however, is that the overall number of attested vessels is low despite the number of identified sites being high. For many of these sites, a single AC4 container has been attested in the archaeological record. In Pannonia, as an example, the AC4 is considered the rarest imported amphora type.[53] When the number of AC4s identified at each site is considered (Fig. 4), some interesting patterns become clear, including a concentration of these amphoras around Italy. Using Rome as an example, during the mid-1st c. CE, Cretan amphoras account for approximately 5.0 percent of overall amphora finds, with the AC4 the most commonly attested type.[54] Cretan amphoras found at Rome reach their highest quantities by the mid-2nd c., when they account for approximately 11.83 percent of overall amphoras.[55] Given the size of the market at Rome for amphora-borne goods, this points to significant numbers of Cretan containers being brought into the city.[56]

The quantity of AC4s and other Cretan amphora types found at Rome helps to illustrate the most important distribution network for the island's products during the Early Roman period. André Tchernia has argued that the Egyptian grain trade was an important

---

50 Verboven 2007, 305–6.

51 Dobreva 2017, 325–27, graph 6. From the end of the 2nd c. BCE to the third quarter of the 1st c. CE, Dobreva records that 72 percent of amphoras attested at different sites in Moesia Inferior and Thrace originated from production centers in the Aegean and Asia Minor.

52 Franconi 2018, 8. For Moesia Inferior and Thrace during the third quarter of the 1st c. CE to the third quarter of the 2nd c. CE, Dobreva (2017, 327–29, graph 7) observes that 53 percent of amphoras originated from Pontic production centers, while the number from the Aegean and Asia Minor was reduced to 24 percent.

53 Hárshegyi 2008, 173.

54 Rizzo 2003, 146, table 26:b. According to Giorgio Rizzo, AC4 amphoras account for 3.61 percent of overall amphora finds, while AC1 jars represent 1.31 percent and AC3 jars, 0.08 percent. Rizzo (2003, 155) also records that the AC4 is the second most common type of Aegean amphora attested at Rome during this period after the Camulodunum 184 type from Rhodes. More recent excavations in the area of Monte Testaccio in Rome also document the AC4 as the most common Cretan type during the 1st c. CE, with the AC1 taking its place by the early 2nd c. A total of 1,884 fragments of AC4 vessels were recovered during these excavations from layers dating to the 1st c. CE through first half of the 2nd c. See Coletti and Lorenzetti 2010, 155, 159, fig. 3.

55 Rizzo 2003, 180, table 30:b. By the mid-2nd c., the AC1 is the most common Cretan type at Rome, comprising 7.91 percent of overall amphora finds. It is followed by the AC4 (1.97 percent), AC2 (1.53 percent), and AC3 (0.21 percent).

56 For additional discussion of the import of Cretan amphora-borne products to Italy, see Andreau 2008, 195–97; Tchernia 2011, 345–49.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

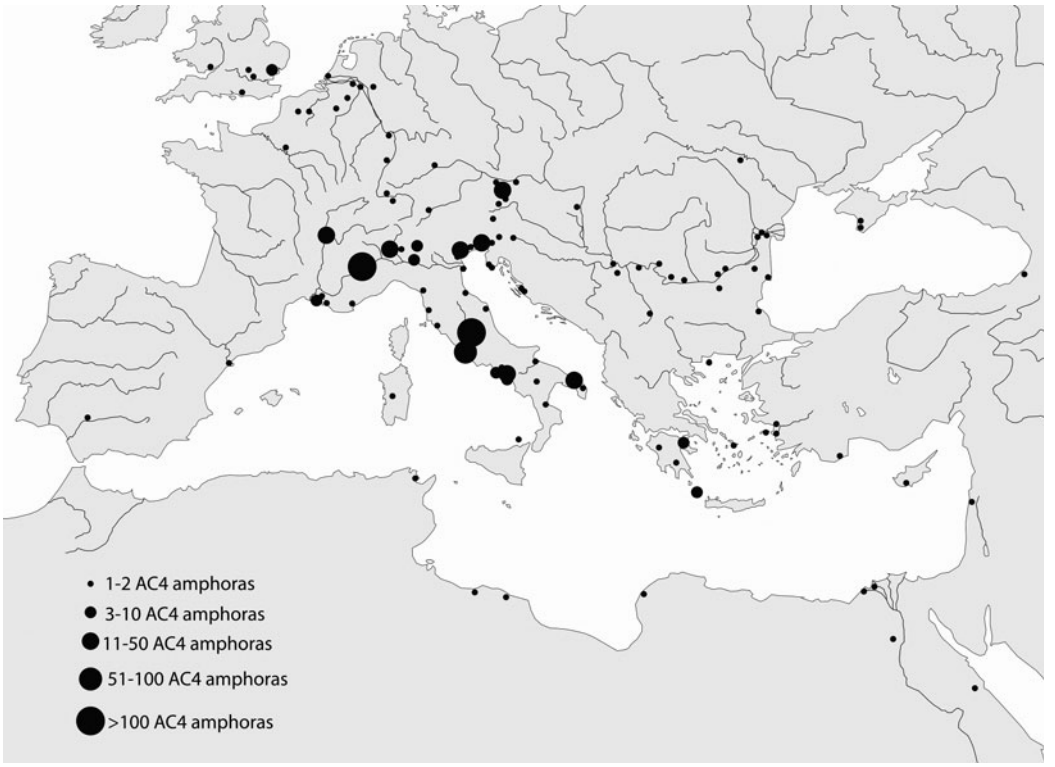

Fig. 4. *Quantity of AC4 Amphoras attested by site, 1st to 3rd c. CE. (Map by S. Gallimore.)*

stimulus behind the movement of Cretan goods to Italy.[57] Cretan containers are among the most common imported types at sites along the Bay of Naples in the 1st c. CE, when Puteoli served as the primary harbor of Rome.[58] At Herculaneum, for instance, 35 AC4 amphoras were found in a shop in Regio IV.14.[59] When Ostia and Portus took over as the main destination for Egyptian grain by the late 1st/early 2nd c. CE, this corresponded with the increase in finds of Cretan amphoras at Rome as illustrated in Giorgio Rizzo's study mentioned above. This suggests that Cretan products were piggyback commodities along east–west trade networks, with the island's harbors likely functioning as important stopover ports for ships sailing from Egypt and other eastern regions.[60] The draw of

[57] Tchernia 1986, 244, 298. See also Gallimore 2015, 289–91.

[58] Marangou 1994, 138–40; Marangou-Lerat 1995, 159.

[59] Maiuri 1958, 436; Camardo and Notomista 2017, 204. Amedeo Maiuri argued that this shop comprised a *taberna vasaria* or pottery shop that was engaged primarily in selling amphoras rather than their contents. He pointed to a one-word graffito (*CIL* IV 10527) that reads VASA in the room and also noted the lack of other commercial infrastructure like a counter, storage vessels, or equipment for food preparation. This could suggest that some AC4 amphoras were re-used as packaging containers within Roman trade networks.

[60] The *Book of Acts* (27, 28.11–14) in the New Testament describes Paul sailing along the south coast of Crete in a grain ship that originated from Alexandria prior to being shipwrecked on the island of Malta. At the site of Phoenix along the coast of southwest Crete, an inscription (*I.Cret.* 2.20.7) dated to the early 2nd c. CE preserves a dedication to several deities erected by a helmsman of an Egyptian grain ship.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

products to Rome also supports the distribution of AC4 amphoras across Italy and to neighboring coastal regions like the north Adriatic and the southern coast of France, as cargoes would have dispersed and goods packaged in these containers would have gained a foothold within many networks connecting east and west.

North–south trade between the Aegean basin, including Greece and western Anatolia, and North Africa was also important for the dissemination of Cretan products, including those packaged in AC4 amphoras, during the Early Roman period. AC4 containers are not particularly common across this region but are widespread, with examples attested within Greece and the Aegean (Antikythera, Corinth, Delos, Sparta), Asia Minor (Ephesos, Limyra, Miletos, Samos), Cyrenaica (Berenice), and Egypt (Alexandria, Marina el-Alamein, Mons Claudianus, and Tebtynis).[61] Crete was an important node for supporting trade between these different regions. Berenice, where several types of Cretan amphoras are well documented from the 1st through 3rd c. CE, helps to illustrate this network.[62] Along with Cretan amphoras, products that are well attested at Berenice include amphoras from the Black Sea, Pontic Sigillata, and Eastern Sigillata C (also known as Çandarli Ware).[63] Black Sea amphoras, along with Pontic Sigillata and Eastern Sigillata C, are also attested on various Cretan sites, including Knossos and Gortyn.[64] This highlights a pattern where ships carrying products along north–south networks passed through Crete, which in turn spurred the export of Cretan goods to the associated regions.[65]

For AC4 amphoras north of the Mediterranean, the low overall numbers have been noted previously. According to Joost van den Berg in a study of amphoras found at Kops Plateau, Nijmegen:

> In the western part of the Empire Cretan amphorae occur mostly in the forts and settlements along the Rhone-Rhine trade route. Given the small numbers it seems likely that Cretan wine reaches the people in the North as a lucrative form of side business, perhaps by hitchhiking on the trade vessels transporting the large quantities of Baetican olive oil or South Gaulish wine.[66]

Publication of amphora data from Rome's northern provinces tends to be quite robust. A focus on amphoras as key archaeological data in the region is apparent from several early 20th-c. publications.[67] In a recent study of amphoras from the eastern Mediterranean found in the Rhône-Rhine area, Tyler Franconi identified at least 65 sites with quantified amphora assemblages.[68] This amount of data has also permitted larger economic studies of the region and consideration of economic networks that spread throughout northern

[61] Riley 1979, 148 nos. D108–D109; Pülz 1985, 97 no. 58; Marangou-Lerat 1995, 88; Bailey 1993, 229 no. 45; Simossi 1991, 285 no. 8:2; Marangou 2004, 1031; Slane 2004, 366–67; Tomber 2006, 164–65; Majcherek 2007, 11–13; Marksteiner et al. 2008, 220; Quercia et al. 2011, 51; Ballet and Południkiewicz 2012, 168 no. 724; Bezeczky 2013, 76–78 Type 10.

[62] Riley 1979, 145–46 nos. D104–D105, 148 nos. D108–D109, 180–83 nos. D222–D227.

[63] Riley 1979, 188–89; Kenrick 1985, 257–65, 271–82.

[64] Hayes 1983, 104, 147 type 14, 151 types 23–27, 153–55 types 34–35, 38–39; Lippolis 2001, 33–35; Portale and Romeo 2001, 294–95 type 48, 296–97 type 50.

[65] Gallimore 2022, 117–18.

[66] van den Berg 2012, 220.

[67] Examples of these early studies include publications of excavations at Alzey (Unverzagt 1916), Haltern (Loeschcke 1909), Hofheim (Ritterling 1913), and Niederbieber (Oelmann 1914).

[68] Franconi 2018, 2.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Europe.[69] This robustness helps to substantiate that the widespread identification of small numbers of AC4 vessels in this region is a distinct pattern. Important amphora studies are also available from the Danube frontier, including those by Dobreva and by Ljiljana Bjelajac.[70]

There are some exceptions to the overall low quantity of AC4 containers north of the Mediterranean, however, especially when distribution hubs like Lyon, Aquileia, Scarbantia (modern Sopron), and Turin are considered. Lyon, located approximately 270 km north of the Mediterranean coast at the confluence of the Rhône and Saône Rivers, was one of the most important distribution hubs in the northwestern Roman Empire. Not surprisingly, a high concentration of individuals with business interests are attested at the site. Of the 23 inscriptions found in the province of Gallia Lugdunensis that record businessmen, 22 have been identified at Lyon.[71] Similar names are attested at other coastal distribution hubs like Aquileia, demonstrating the importance of these sites within Roman exchange networks.[72] AC4 amphoras are well documented at Lyon. Séverine Lemaître, in a deposit dated between 190 and 250 CE, records 34 AC4 amphoras, accounting for approximately 11 percent of overall amphora finds from the eastern Mediterranean.[73]

For Aquileia, Strabo (5.1.8) discussed its importance as an *emporion* that supported the overland trade of goods brought to the site by sea. Founded in the early 2nd c. BCE, the site served as a gateway from the Adriatic into several European provinces. Of key importance for Aquileia as a distribution hub was its connection to overland routes, particularly the Amber Road, an important route for both trade and military supply. That route is represented by a clear line of sites where AC4 amphoras are attested, stretching from the coastal sites of Aquileia and Trieste toward Vindobona (modern Vienna) and Carnuntum.[74] At Aquileia, AC4 containers have been attested in several excavations and are noted as being much more common than other Cretan types.[75]

Scarbantia is significant for being one of the final settlements before reaching the Danube along the Amber Road and for being one of the earliest Roman settlements along this route.[76] It was a civic rather than military site and may have acted as a distribution hub for the large military centers at Vindobona and Carnuntum on the Danube, along with the smaller, surrounding forts. Recent excavations at Scarbantia, in a sanctuary complex comprising three temples, recovered approximately 50 fragments of AC4 containers from levels dating from 35/40 CE to 70 CE.[77]

---

69 E.g., Ehmig 2007; Laubenheimer and Marlière 2010.

70 Bjelajac 1996; Dobreva 2017.

71 Verboven 2007, 299–300.

72 Verboven 2007, 300.

73 Lemaître 2000, 467, fig. 2.

74 The sites in question are Castra (modern Ajdovščina); Celeia (modern Celje); Poetovium (modern Ptuj); Salla (modern Zalalövő); Scarbantia (modern Sopron); Savaria (modern Szombathely). See Bezeczky 1987, 27, 73 no. 268; Kelemen 1988, 128; Vidrih Perko and Žbona Trkman 2005, 280, fig. 4:1; Hárshegyi 2008, 174, fig. 1.

75 Verzár-Bass 1991, 204 no. AO.1; Ceazzi and Del Brusco 2014, 946; Auriemma and Quiri 2015, 146–47.

76 Mráv 2010–13, 68.

77 Schucany and Schwarz 2011, 579, table 3.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Turin, which was founded as *Augusta Taurinorum* in the late 1st c. BCE, served as a key distribution hub within the Po River valley, helping to connect trade moving inland from the northern Adriatic to land and river routes, including those that crossed into transalpine regions.[78] All Early Roman Cretan amphora types are attested at the site, but the AC4 is by far the most common. During excavations between 1991 and 2000 in two parts of the site, the Piazzo Castello and around the Royal Gardens, with layers datable between the 1st and 4th c. CE, approximately 2,453 fragments of eastern amphoras were recovered. AC4 amphoras account for 184 of those fragments.[79] At the site of Novara approximately 100 km to the west of Turin, there is another concentration of AC4 amphoras, perhaps because this site also served as a hub connecting sites along the Po and one its tributaries, the Ticino, along with various overland routes.[80]

These distribution hubs help to contextualize the small number of finds of amphora types like the AC4 at most sites in northern Europe since cargoes would have been broken up at those places to accommodate different supply needs. Auriemma and Quiri describe this as a form of capillary trade, with the increasing dispersal of products leading to smaller quantities at individual sites as you continue further along the economic network.[81] As part of this capillary distribution, products packaged in AC4 amphoras could be purchased or perhaps, in the context of the Roman military, requisitioned. An AC4 amphora found in a mid-1st c. CE deposit at Caerleon, Britain may provide an example of supplies being purchased or requisitioned by the army (Fig. 5).[82] This amphora, which was identified in the publication as Rhodian but instead can be classified as an AC4a container, was discussed above with respect to a painted inscription on its upper shoulder, written in cursive Greek, that describes the contents as *passum*, or raisin wine. A second painted inscription is visible along the neck and part of one of the handles. Written in block letters in Latin, it reads: *Leg(ionis) II Aug(ustae)* "Property of the Second Legion *Augustan*."[83] The reference to the legion appears to be a later addition and may indicate that this amphora and its contents were requisitioned or purchased by a military supplier trying to support forces stationed at Caerleon. Similar processes may lie behind the presence of AC4 amphoras attested at other sites across northern Europe and the Danube frontier.

River and land transport

Even if the overall number of AC4 amphoras north of the Mediterranean is low, it is still necessary to explain the mechanisms behind their distribution. For these regions, transport

---

78 Rousse 2006; Quiri 2015.

79 Quiri 2015, 164–72, fig. 4. There were also 16 AC1 fragments, 61 AC2 fragments, 49 AC3 fragments, and 14 fragments designated only as Cretan.

80 Amphoras from the eastern Mediterranean comprise 23 percent (n = 656) of the amphora assemblage from excavations at the site. The AC4 is described as the most common eastern type, although a specific number of fragments is not provided. See Quiri and Spagnolo Garzoli 2015, 181–83, fig. 2.

81 Auriemma and Quiri 2004, 46; Auriemma and Quiri 2006, 228–29, figs. 8–9. Wickham (2005, 781) also uses the term "capillary distribution" to discuss connections between coastal centers and other nodes within economic networks of the Late Roman Empire.

82 Burnham et al. 1994, 310–12, fig. 9; Williams 2003, 30–31 no. 5.

83 Burnham et al. 1994, 312.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Fig. 5. *AC4a Amphora found at Caerleon, Britain (Burnham et al. 1994, 311, fig. 9.)*

of amphora-borne commodities was primarily by river or road.[84] Both overland and fluvial transport may have been necessary in many cases since, as Christoph Schäfer observes for the northern provinces, "there existed no unbroken river route."[85] In western Europe, the Rhône-Rhine axis, which comprised a series of riverways and overland routes, may have been "the most important commercial, military and civil route linking the Mediterranean and the Gallic and Germanic territories."[86] Ships from across the Mediterranean could access this economic network by first sailing to Marseille, with direct access to the mouth of the Rhône established by construction from 104 to 102 BCE of the *fossa mariana*, a canal that bypassed the coastal delta where accumulated sediment made accessing the river difficult. Goods were then brought up the river to Lyon for dispersal throughout the region. The third quarter of the 1st c. BCE through the mid-1st c. CE saw significant Roman investment in Gaul and along the Rhine frontier aimed at infrastructure for river and land transport.[87] Colonization in this region, including at sites like Arles, Lyon, Nîmes, Orange, Valence, and Vienne, was an important stimulus, as was the growing presence of Roman soldiers who required reliable supply lines. These efforts solidified Lyon as the central node within these networks. A combination of river and land transport was also important for reaching regions to the north of the Adriatic Sea and along the Danube frontier.

Transport of amphoras by river was not a simple matter of transferring whatever containers arrived by sea to smaller barges. The largest Roman river boats may have reached 34 metric tons, but most were smaller (Fig. 6).[88] Even a small amount of breakage would be amplified by their reduced cargo capacity. Attributes of amphora design that were conducive to large seafaring ships were not always beneficial for smaller river barges. This led to special considerations, as Jennifer Muslin describes:

> the appearance of…more compact forms marks an important shift, since it suggests that seafaring ships were not the only watercraft that carried amphorae;

[84] Carroll 2001, 84.

[85] Schäfer 2016, 220.

[86] González Cesteros 2019, 330. For discussion of the Rhône-Rhine axis as a commercial route, see Desbat and Martin-Kilcher 1989.

[87] González Cesteros 2019, 330.

[88] Roth 1999, 197.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Fig. 6. *Example of a river barge, the Arles-Rhône 3 wreck (mid-1st c. CE). From Wikimedia Commons; image by L. Brighton (CC-by-SA-4.0.)*

> flatbottomed and half-capacity amphorae are often found in first and second century C.E. river boat wrecks, suggesting that their spiked counterparts were as not [*sic*] well-equipped for the wide, shallow hulls of river boats, which were only one or two meters in height.[89]

Amphora manufacturing traditions in Gaul provide a clear example in support of this argument. Types manufactured in Gaul from the 1st c. BCE to 2nd c. CE are typically flat-bottomed and relatively short. The Gauloise 1, for instance ranged in height from 47 to 53 cm, while taller forms like the Gauloise 4 may have reached up to 69 cm.[90] The flat bases provided more stability during transport by river boat, and the height of these jars prevented the cargo from being top-heavy. Not surprisingly, while Gauloise-type amphoras are documented in different Mediterranean regions, they appear most frequently in the Rhône-Rhine axis.[91] Production of amphoras with flat bottoms, such as the Dressel 28 and Oberaden 74 during the Early Roman period, is also attested in the Guadalquiver and Ebro River valleys in Spain.[92] Such types were suitable for river transport and devel-

[89] Muslin 2019, 23.

[90] For height ranges of Gauloise-type amphoras, see entries in the Southampton Amphora Database: https://doi.org/10.5284/1028192.

[91] Laubenheimer 1985; Peacock and Williams 1986, 142–48.

[92] García Vargas et al. 2011, 248–52; Carreras and González Cesteros 2012; Almeida and González Cesteros 2017.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

oped when Roman trade along river networks was increasing in volume and frequency during the 1st c. BCE and 1st c. CE.[93]

Dressel 2–4 amphoras, a common Early Roman type manufactured in numerous regions of the Mediterranean, offer a contrasting example. As Muslin observes for Dressel 2–4 containers manufactured in the Campanian region of Italy, they were nearly as tall (ca. 95 cm) as a standard river boat hull, meaning the ship would be top heavy, making the containers more likely to jostle during transport.[94] The long spikes of amphora types like the Dressel 2–4 also made them less stable in these types of ships and could have contributed to breakage. Despite these limitations, some spike-bottomed Dressel 2–4s did find their way onto river barges.[95] As noted above, development of trade as part of a Roman commercial revolution along the Rhine and Danube frontiers was reliant primarily on Mediterranean products prior to the rise of more local and regional markets. This likely spurred the import of a variety of products to civilian and military sites in these regions, including wine from Italy. Eastern versions of the Dressel 2–4 types also appear on numerous sites north of the Mediterranean, particularly in the first half of the 1st c. CE.[96] Some scholars, in addition, have argued that a flat-bottomed version of the Dressel 2–4 manufactured in the black-sand fabric characteristic of the Bay of Naples region was developed to accommodate river transport.[97]

Cretan types like the AC1–3 had heights (ca. 60 cm) more in line with Gauloise-type containers, but their small button toes and wider diameter may not have been ideal for river boats. They lacked stability and stackability, and likely were not popular choices for transport of goods by river. This is evident in the small number of AC1–3 jars identified at sites in northern provinces. The shape of AC4 amphoras also does not, at first glance, appear advantageous for transport by river barge, but this type does have certain advantages including its narrower profile and smaller capacity. These attributes may have made these containers more stable and stackable as part of a river-barge cargo, increasing their appeal to merchants seeking cargo for boats heading into the Rhône-Rhine axis and other river routes. For this reason, perhaps it is also not surprising that Camulodunum 184 amphoras from Rhodes, which are very similar in morphology to AC4 amphoras, are the most common eastern type attested north of the Mediterranean in the Early Roman period.[98] In other regions where river travel may also have been important, such as sites along the northern Adriatic, AC4 vessels are often found together with flat-bottomed amphoras like the Forlimpopoli type.[99]

Amphoras in the Rhodian tradition may have had a reputation for traveling well as part of shipboard cargoes. A recent study by Anno Hein and Vassilis Kilikoglou analyzed the mechanical performance of Rhodian and Koan amphoras of Hellenistic date through

---

93 García Vargas et al. 2011, 250; Carreras and González Cesteros 2012, 214–15; Almeida and González Cesteros 2017, 109.

94 Muslin 2019, 23.

95 See, for example, Long et al. 2006, 586, fig. 10:12.

96 Franconi 2018, 6.

97 Panella 2001, 194; Iavarone and Olcese 2013, 222; Muslin 2019, 187–88.

98 Franconi 2018, 6.

99 Vidrih Perko and Žbona Trkman 2005, 280.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

virtual simulation using three-dimensional models.[100] Particular points of focus were the vertical load on the shoulder when amphoras were stacked as part of a cargo and the horizontal load on the body because jars were positioned side-by-side. Both the external surface at specific contact zones and the internal surface opposite those contact zones were examined. The Rhodian amphoras under consideration included types datable from the 4th through 2nd c. B.C. According to Hein and Kilikoglou, these simulations demonstrate that later Rhodian amphoras showed a decrease in documented vertical load stresses compared to earlier types for both the external and internal surfaces. They argue that this represents "an improvement and effectual technological development after the 4th century BC."[101] Koan amphora types from the 4th to 1st c. BCE, on the other hand, did not show any improvement in documented vertical stresses on the external surface but had some improvement to stresses on the internal surfaces. Horizontal stresses did not change for either amphora type.[102] For Rhodian amphoras, morphological development continued after the 2nd c. BCE, and AC4 amphoras more closely resemble the form that originated by the 1st c. BCE. If vertical load continued to be a concern during development of these types, that could indicate they did not face the same amount of breakage and damage as other amphora forms, making them good choices for cargoes, including on river barges. This does not mean that Rhodian amphoras and associated types like the AC4 were developed initially with river transport in mind but shows that improvement of attributes that made these containers suitable for overseas transport were also applicable and advantageous for fluvial transport.

Underwater excavations in the Rhône River as it passes through Arles, France help to corroborate the presence of AC4 amphoras on river barges. Along with over a dozen wrecks that have been discovered in this part of the Rhône, excavations have revealed several large underwater pottery dumps. One of these dumps is situated near the right bank and overlays the Arles-Rhône 3 and Arles-Rhône 4 shipwrecks.[103] Excavation of this deposit prior to the discovery and subsequent investigation of the Arles-Rhône 3 wreck recovered several thousand ceramic vessels, including a large number of amphoras, all dating from the mid-1st c. CE through the mid-2nd c. Over half of these containers were Gauloise-type amphoras, but examples from many other regions were also attested.[104] Among the finds from the eastern Mediterranean were a small number of AC4 containers and a couple of AC1 jars.[105] The presence of AC1 and types like the traditional spike-bottomed Dressel 2–4 in this deposit shows that even amphoras that were not well suited to transport by river barge could still be carried on these ships. For Cretan vessels, however, a larger number of AC4 amphoras were recovered than AC1 containers, suggesting this was a preferred type for transport aboard river barges.

Finds of AC4 containers at sites to the north of the Adriatic likely also arrived first at coastal ports and were then transported by river barges and/or overland caravans.[106] A

[100] Hein and Kilikoglou 2020.

[101] Hein and Kilikoglou 2020, 198.

[102] In response to this finding, the authors argue that "if mechanical performance was considered in the development of vessel shapes after all, the focus was probably on weight loads during packaging rather than horizontal loads emerging due to rough sea" (Hein and Kilikoglou 2020, 198).

[103] Long 1998; Long et al. 2006.

[104] Bigot and Djaoui 2013.

[105] Long 1998, 90–91, fig. 5:A; Long et al. 2006, 586; Lemaître 2011.

[106] Schindler Kaudelka and Zabehlicky-Scheffenegger 2006, 158.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

shipwreck discovered off the coast of Croatia in Koromašna Bay, along the northern side of Žirje island, may point to cargoes of goods packaged in these containers being transported to the northern coast of the Adriatic.[107] This wreck, datable to the 1st c. CE, had over 100 AC4s as part of its cargo along with some AC2s and Rhodian amphoras. While a shipwreck's final destination can only ever be a tentative hypothesis, the presence of AC4 amphoras at harbor sites in the northern Adriatic and at sites in regions to the north of the Adriatic could indicate the ship was destined for a harbor like Aquileia, as noted above.[108] Another option could be Altinum, an important port site just to the east of Venice. Nearly two dozen AC4 amphoras are noted in excavations there.[109] AC2s also appear in this region occasionally, including at Trieste on the Adriatic coast and inland at Magdalensberg.[110] This trade, as discussed above, likely followed overland routes, including the Amber Road, as one mechanism of distributing products arriving at the coast across a wider region. The northern Adriatic was also tied to the fluvial and overland routes of the Po River valley.

AC4s are attested at a number of sites along the Danube to the east of Vindobona and Carnuntum.[111] Transport of these containers to these sites was likely by river and could have come from two directions. Some AC4 amphoras may have been shipped to these other centers after arriving at Vindobona or Carnuntum and being placed on river barges at those sites.[112] There are also finds of AC4 jars at sites located at or near the mouth of the Danube, including Aegyssus (modern Tulcea).[113] Interestingly, at Histria, which is located just to the south of the mouth of the Danube along the coast of the Black Sea, single examples of both the AC1 and the AC2 amphora have been found.[114] These containers made it close to the Danube but rarely appear to have traveled down the river as part of river barge cargoes. Other sites where AC4 amphoras have been identified in this region, like Troesmis in Romania, are located on tributaries of the Danube, and likely were supplied by river barges.[115] For some locations that were not positioned along a river, such as Tropaeum Traiani (modern Adamclisi) to the south of the Danube or Dobruja (modern Dobrogea) to the north of the Danube, overland transport would have provided an essential means of supply.[116] Dobreva has observed the elevated number of sites where AC4 amphoras are attested along the Danube frontier, especially in comparison to other Cretan types.[117] She also notes that Popilian's type I amphora from his 1976 publication, which

---

107 Jurišić 2000, 14, 67 no. 30.

108 For evidence of AC4s at Aquileia, see Verzár-Bass 1991, 204 no. AO.1; Ceazzi and Del Brusco 2014, 946. For examples of AC4s at sites to the north of Adriatic, see Kelemen 1988, 128; Vidrih Perko and Žbona Trkman 2005, 280; Schindler Kaudelka and Zabehlicky-Scheffenegger 2006, 158–59, fig. 10; Hárshegyi 2008, 174, fig. 1.

109 Toniolo 1991, 63 nos. 5–6, 12 nos. 23–32, 80 nos. 47–52, 154 nos. 193–197.

110 Auriemma and Quiri 2004, 46 n. 4; Schindler Kaudelka and Zabehlicky-Scheffenegger 2006, 159, fig. 10.

111 Bjelajac 1996, 39–41; Dyczek 1999, 116, fig. 106.

112 Dobreva 2017, 342, fig. 249.

113 Nuțu and Costea 2010, 148.

114 Dyczek 1999, 119, fig. 107; Băjenaru 2014, 109 no. 41.

115 Opaiț 1980, 301 type 5; Dyczek 1999, 116, fig. 106.

116 Barnea et al. 1979, 179 no. 3.1; Opaiț 1980, 299, pl. 5.3; Dyczek 1999, 116, fig. 106.

117 Dobreva 2017, 213–16.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

comprises containers in the Rhodian tradition, may include the AC4, raising its profile in the region even higher.[118] Analogous to the Rhône-Rhine axis, the AC4 appears to have been ideal for overland and river transport along the Danube frontier as part of Early Roman trade networks.

Alternative routes? A consideration of Atlantic trade

We can identify the final resting place of an amphora, but its journey to that location, and potential stops along that route, are incredibly challenging if not impossible to discern. While the above discussion focuses primarily on the dissemination of AC4 amphoras throughout Rome's northern provinces via river and land routes that originated along the coast of the Mediterranean, consideration must also be given to trade routes along the western Atlantic. The importance of Atlantic sea trade between Spain, western France, and Britain has seen increased attention over the past few decades.[119] It was a vital economic network, particularly for the dissemination of olive oil from the Baetican region of Spain to military forces stationed along the Rhine frontier and in Britain. Perhaps some AC4 amphoras that have been documented in these same regions traveled aboard ships that plied the Atlantic.

Much of the focus on Atlantic trade has been on its role in the distribution of Dressel 20 amphoras, the primary container for packaging and transporting olive oil from Baetica.[120] The Dressel 20, in many ways, offers an interesting contrast to the AC4. Morphologically, the Dressel 20 has a rounded point at the base, a thick-walled, wide, globular body, a short, vertical neck, and an outward-thickened, rounded rim. Large handles, round in section, attach to the neck and upper shoulder. The average capacity of the Dressel 20 amphora is approximately 75 L, while its height ranges from 70 to 97 cm.[121] Its size and base type do not appear, at first glance, to be conducive to travel by river barge, but this amphora type is attested in substantial quantities at numerous sites in northern Europe.[122] The importance of a steady supply of products like olive oil to the army was likely a key driver behind this, with the need to mobilize large-scale supplies from a region capable of producing it at the time. Distribution of Baetican olive oil appears to have been organized through the Roman state beginning at least by the 1st c. CE.[123] By building on earlier assessments and additional amphora assemblage data, Schäfer estimates that olive oil equivalent to the contents of approximately 23,000 amphoras was required per annum in the German provinces.[124] Much of this trade, as discussed below, may have been tied to ships plying the Atlantic as opposed to relying primarily on river barges.

---

118 Popilian 1976, 40, pl. XV:1. For this assessment, see Dobreva 2017, 215.

119 Carreras Monfort 1998; Carreras Monfort and Funari 1998; Cunliffe 2001; Carreras and Morais 2010; Carreras and Morais 2012; Morillo et al. 2016.

120 E.g., Remesal Rodríguez 1986; Remesal Rodríguez 2011; Funari 1996; Carreras Monfort 1998; Carreras Monfort and Funari 1998; Schäfer 2016; Schäfer 2017; Coto-Sarmiento and Rubio-Campillo 2021.

121 Vidal and Corredor 2018, 304, Table 1. For height, see the entry for the Dressel 20 in the Southampton Amphora Database: https://doi.org/10.5284/1028192.

122 Carreras and Morais 2012, 435, fig. 11; Schäfer 2016, 214.

123 Remesal Rodríguez 1986; Carreras Monfort 1998, 161–66; Morillo et al. 2016, 279.

124 Schäfer 2016, 213; Schäfer 2022, 47.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

There has been much debate concerning the routes by which olive oil packaged in Dressel 20 amphoras reached these northern sites. Some scholars have argued that ships from Spain sailed across the Mediterranean to southern France, where these containers were transferred onto river barges for transport into Rome's northern provinces.[125] Others have argued that Atlantic trade routes were more important for distribution of Dressel 20 amphoras.[126] Schäfer, more recently, has examined variables like meteorological conditions, distance, cost of sea versus river versus land travel, and estimates of travel time along different routes, and argued that these all support Atlantic trade as being more favorable for distribution of Baetican products to northern provinces.[127] Other scholars have posed related arguments, and the current consensus does seem to favor Atlantic trades as central to distribution patterns for Dressel 20 containers.[128] The sheer mass of olive oil transported in these amphoras along this trade route likely had a significant influence on other products as well.

Did AC4 amphoras travel along Atlantic trade routes? Evidence supporting this is limited at present. There are a small number of sites in Spain where AC4 amphoras are documented, suggesting these vessels and their contents reached that province intermittently but never in large quantities.[129] AC4 amphoras are also essentially unattested at sites along the Atlantic coasts of Spain and France. One possible exception is a single fragment identified at Setúbal that may be from an AC4 amphora.[130] The excavators suggest this interpretation quite tentatively and observe that other interpretations are also feasible. Along the Atlantic coast between Spain and western France, the only attested Cretan amphoras are two fragments of AC3 jars at Barzan where the Monards Channel meets the sea.[131] A cluster of sites in Belgium and the Netherlands with attested AC4 amphoras could perhaps suggest some degree of Atlantic trade reached those sites, but it is equally feasible to hypothesize that those containers arrived in that region via the overland and river routes of the Rhône-Rhine axis.

In contrast, AC4 containers are documented in underwater assemblages and at several terrestrial sites around the mouth of the Rhône River in southern France, which led to Lyon where AC4 amphoras are well documented.[132] The evident concentration of AC4 jars along the northern Adriatic, particularly the western side that led into the Po River valley, with routes connecting to transalpine regions, also provides indications of how AC4 amphoras and their contents would regularly make their way into northern Europe. The massive draw of Cretan goods to Italy and Rome during the Early Roman period may have facilitated trade more regularly to the coastal regions of southern France and the northern

---

125 Rougé 1966, 93; Tchernia 2011, 327.

126 Reddé 1979, 487; Remesal Rodríguez 1986, 78; Remesal Rodríguez 2010, 147. For a summary of this debate, see also Schäfer 2016, 212.

127 Schäfer 2016, 231–38; Schäfer 2017, 100–6; Schäfer 2022.

128 Carreras and Morais 2012; Coto-Sarmiento and Rubio-Campillo 2021.

129 Seville: García Vargas 2012, 258. Tortosa: Genera I Monells and Járrega Domínguez 2009, 80.

130 Dias Diogo and Cavaleiro Paixão 2001, 120.

131 Sanchez 2011, 365, figs. 25:18, 37:2.

132 Arles: Long 1998, 90–91, fig. 5:A; Long et al. 2006, 586; Lemaître 2011. Fos: Liou 1987, 91 no. F132. Frejus: Liou 1992, 95, fig. 10.19. Istes: Panella 1986, 620 n. 1; Marseille: Marangou-Lerat 1995, 86. Narbonne: Liou 1987, 112 no. PN1; Liou 1993, 137 no. PN15. Saint-Gervaise Shipwreck: Liou and Marichal 1978, 159–65 nos. 61–68; Parker 1992, 373–74 no. 1002.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Adriatic, emphasizing the importance of these networks, as opposed to Atlantic trade, for disseminating Cretan products within the Rhône-Rhine axis.

Conclusions

The distribution of AC4 amphoras and their contents is distinct from AC1–3 containers during the 1st to 2nd c. C.E. for their presence in Rome's northwestern provinces, along the Amber Road, and across the Danube frontier. Critical assessment of the mechanisms that contributed to this pattern suggests that morphological attributes of AC4 containers, including their smaller capacity and slimmer shape, may have been significant factors. Cretan wine, the presumed contents of these amphora types, had great appeal, but the AC4 was most practical for river and overland transport to the regions in question. The implication of this is significant because the AC4, as part of the Rhodian family of amphoras, was likely designed originally with the intention of overseas shipment in cargo ships to destinations within the Mediterranean. Its selection by merchants over other Cretan forms for transport of goods north of the Mediterranean along road and river routes shows an important modification to its intended function. It is possible that this modification influenced subsequent use and distribution of these containers over time, perhaps prompting stronger connections between Cretan sites and trade centers along the coast of the northern Adriatic and southern France that fed into networks north of the Mediterranean.

This assessment builds on an increasing body of work that focuses on design attributes of amphoras and the importance these played in their use and distribution. It demonstrates that such attributes were critical points of consideration for merchants and consumers who needed to ensure a steady supply of different commodities to sites whose supply chains extended beyond the coast of the Mediterranean. While focus on the distribution of pottery types like amphoras is a vital part of economic analysis in the Roman world, continued emphasis on additional variables like design is necessary to develop more detailed interpretations of the structures within economic networks and past decision-making that contributed to patterns evident in the archaeological record.

References

Almeida, R. R., and H. González Cesteros. 2017. "Las excepciones sudhispánicas: las ánforas de tipo *urceus* y las Dressel 28." In *Amphorae from the Kops Plateau (Nijmegen): Trade and Supply to the Lower-Rhineland from the Augustan Period to AD 69/70*, ed. C. Carreras and J. van den Berg, 105–10. Archaeopress Roman Archaeology 20. Oxford: Archaeopress.

Andreau, J. 2008. "Remarques sur l'épigraphie de l'*instrumentum domesticum* dans les provinces de langue Grecque." *Cahiers du Centre Gustave Glotz* 19: 187–99.

Auriemma, R., and E. Quiri. 2004. "Importazioni di anfore orientali nell'Adriatico tra primo e medio impero." In *Transport Amphorae and Trade in the Eastern Mediterranean*, ed. J. Eiring and J. Lund, 43–55. Aarhus: Aarhus University Press.

Auriemma, R., and E. Quiri. 2006. "Importazioni di anfore orientali nel Salento tra primo e medio Impero." In *Les routes de l'Adriatique antique: géographie et économie*, ed. S. Čače, A. Kurilić, and F. Tassaux, 225–51. Bordeaux: Institut Ausonius.

Auriemma, R., and E. Quiri. 2015. "Eastern amphora imports in the Adriatic Sea: Evidence from terrestrial and underwater contexts of the Roman Imperial Age." In *Per Terram, Per Mare. Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean*, ed. S. Demesticha, 139–60. Stockholm: Paul Åströms förlag.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Bailey, D. M. 1993. "Excavations at Sparta: The Roman stoa, 1988–91 preliminary report, part 1: (b) Hellenistic and Roman pottery." *BSA* 88: 221–49.
Băjenaru, C. 2014. "Early Roman pottery groups from the central sector of the Late Roman city at Histria." *Materiale şi cercetări arheologice* 10: 105–31.
Ballet, P., and A. Południkiewicz. 2012. *Tebtynis V. La céramique des époques hellénistique et imperiale, campagnes 1988–1993*. Cairo: Institut français d'archéologie orientale.
Barnea, A., I. Barnea, I. B. Cătăniciu, M. Mărgineanu-Cârstoiu, and G. Papuc. 1979. *Tropaeum Traiani I*. Bucharest: Editura Academiei Republicii Socialiste România.
Bernal-Casasola, D., M. Bonifay, A. Pecci, and V. Leitch, eds. 2021. *Roman Amphora Contents: Reflecting on the Maritime Trade of Foodstuffs in Antiquity*. Roman and Late Antique Mediterranean Pottery 17. Oxford: Archaeopress.
Bezeczky, T. 1987. *Roman Amphorae from the Amber Route in Western Pannonia*. BAR-IS 386. Oxford: Archaeopress.
Bezeczky, T. 2013. *The Amphorae of Roman Ephesus*. Vienna: Verlag der Österreichischen Akademie der Wissenschaften.
Bevan, A. 2014. "Mediterranean containerization." *CurrAnthr* 55: 387–418.
Bigot, F., and D. Djaoui. 2013. "Étude préliminaire des amphores gauloises des fouilles de l'épave *Arles-Rhône* 3 (Arles, B.-du-Rh.) (2e motié du Ier s.–1ère motié du IIe s. ap. J.-C.)." *RANarb* 46: 375–93.
Bjeljac, L. 1996. *Amfore Gornjo Mezijskog Podunavlja*. Belgrade: Arheološki institut.
Boileau, M.-C., and I. Whitbread. 2014. "Petrographic analysis of local and imported transport amphorae from Knossos, Mochlos, and Myrtos Pyrgos." In *Mochlos III. The Late Hellenistic Settlement: The Beam-Press Complex*, ed. N. Vogeikoff-Brogan, 79–102. Prehistory Monographs 48. Philadelphia: INSTAP Academic Press.
Burnham, B. C., L. J. F. Keppie, A. S. Esmonde Cleary, M. W. C. Hassall, and R. S. O. Tomlin. 1994. "Roman Britain in 1993." *Britannia* 25: 245–314.
Camardo, D., and M. Notomista, eds. 2017. *Ercolano: 1927–1961. L'impresa archeologica di Amedeo Maiuri e l'esperimento della città museo*. Rome: L'Erma di Bretschneider.
Carreras, C., and H. González Cesteros. 2012. "Ánforas tarraconenses para el *limes* germane: una nueva visión de las Oberaden 74." In *Cerámicas hispanorromanas II. Producciones regionales*, ed. D. Bernal-Casasola and A. Ribera, 207–30. Cadiz: Universidad de Cádiz.
Carreras, C., and R. Morais, eds. 2010. *The Western Roman Atlantic Façade. A Study of the Economy and Trade in the Mar Exterior from the Republic to the Principate*. BAR-IS 2162. Oxford: Archaeopress.
Carreras, C., and R. Morais. 2012. "The Atlantic Roman trade during the Principate: New evidence from the western façade." *OJA* 31, no. 4: 419–41.
Carreras Monfort, C. 1998. "Britannia and the imports of Baetican and Lusitanian amphorae." *Journal of Iberian Archaeology* 1: 159–72.
Carreras Monfort, C., and P. P. A. Funari. 1998. *Britannia y el Mediterráneo: estudios sobre el abastecimiento de aceite bético y africano en Britannia*. Barcelona: Universitat de Barcelona.
Carroll, M. 2001. *Romans, Celts & Germans: The German Provinces of Rome*. Stroud: Tempus.
Ceazzi, A., and A. Del Brusco. 2014. "La ceramica comune, la ceramica da cucina locale e importata, e le anfore dallo scavo di via Bolivia, Aquileia (Udine-Italia)." In *LRCW4. Late Roman Coarse Wares, Cooking Wares and Amphorae in the Mediterranean: Archaeology and Archaeometry*, ed. N. Poulou-Papadimitriou, E. Nodarou, and V. Kilikoglou, 943–54. BAR-IS 2616. Oxford: Archaeopress.
Chaniotis, A. 1988. "*Vinum Creticum excellens:* Zum Weinhandel Kretas." *Münstersche Beiträge zur antiken Handelsgeschichte* 7: 62–89.
Coletti, F., and E. G. Lorenzetti. 2010. "Anfore orientali a Roma: nuovi dati dagli scavi della Soprintendenza Archeologica di Roma nell'area del Testaccio." *RCRFActa* 41: 155–64.
Coto-Sarmiento, M., and X. Rubio-Campillo. 2021. "The tracing of trade: Exploring the patterns of olive oil production and distribution from Roman Baetica." *Archaeological and Anthropological Sciences* 13: 1–15.
Cunliffe, B. 2001. *Facing the Ocean. The Atlantic and its Peoples, 8000 BC to AD 1500*. Oxford: Oxford University Press.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Desbat, A., and S. Martin-Kilcher. 1989. "Les amphores sur l'axe Rhône-Rhin à l'époque d'Auguste." In *Amphores romaines et histoire économique: dix ans de recherche: actes du colloque de Sienne, 22–24 mai 1986*, 339–65. Rome: École française de Rome.

Dias Diogo, A. M., and A. Cavaleiro Paixão. 2001. "Ânforas de escavações no povoado industrial romano de Tróia, Setúbal." *Revista portuguesa de arqueologia* 4: 117–40.

Dobreva, D. 2017. *Tra oriente e occidente. Dinamiche commerciali in Moesia Inferior e Thracia in epoca romana: i dati delle anfore*. Padua: Università degli Studi di Padova.

Duckworth, C. N., and A. Wilson, eds. 2020. *Recycling and Reuse in the Roman Economy*. Oxford: Oxford University Press.

Dyczek, P. 1999. *Amfory rzymskie z obszaru dolnego Dunaju: Dystrybucja amfor i transportowanych w nich produktów w I – III w. po Chr*. Warsaw: Institut Archeologii UW.

Ehmig, U. 2007. *Die römischen Amphoren in Umland von Mainz*. Wiesbaden: Reichert.

Franconi, T. 2018. "The import and distribution of eastern amphorae within the Rhine provinces." *Journal of Roman Pottery Studies* 17: 1–10.

Funari, P. P. A. 1996. *Dressel 20 Inscriptions from Britain and the Consumption of Spanish Olive Oil*. BAR-BS 250. Oxford: Archaeopress.

Gallimore, S. 2015. *An Island Economy: Hellenistic and Roman Pottery from Hierapytna, Crete*. New York: Peter Lang.

Gallimore, S. 2016. "Crete's economic transformation in the Late Roman period." In *Roman Crete: New Perspectives*, ed. J. Francis and A. Kouremenos, 171–84. Oxford: Oxbow Books.

Gallimore, S. 2017. "Food surplus and archaeological proxies: A case study from Roman Crete." *WorldArch* 49, no. 1: 138–50.

Gallimore, S. 2019. "An island in crisis? Reconsidering the formation of Roman Crete." *AJA* 123, no. 4: 589–617.

Gallimore, S. 2022. "Amphorae and the economy of the eastern Mediterranean in the 3rd century AD: the case of Crete." In *Amphorae from the Eastern Mediterranean and Beyond: Production and Distribution from the Early to the Late Roman Period*, ed. A. Kaldeli, 107–22. Stockholm: Paul Åströms förlag.

García Vargas, E. 2012. "*Hispalis* (Sevilla, España) y el comercio mediterráneo en el Alto Imperio romano. El testimonio de las ánforas." In *Rome, Portus and the Mediterranean*, ed. S. Keay, 245–66. London: British School at Rome.

García Vargas, E., R. R. Almeida, and H. González Cesteros. 2011. "Los tipos anfóricos del Guadalquivir en el marco de los envases Hispanos del siglo I A.C. Un universo heterogéneo entre la imitación y la estandarización." *SPAL Revista de Prehistoria y Arqueología de la Universidad de Sevilla* 20 : 185–283.

García Vargas, E., H. González Cesteros, R. R. Almeida, and A. Sáez Romero. 2019. "Ovoid amphorae in the Mediterranean (2nd century BC–early 1st century AD). State of the play and future research perspectives." In *The Ovoid Amphorae in the Central and Western Mediterranean: Between the Last Two Centuries of the Republic and the Early Days of the Roman Empire*, ed. E. García Vargas, H. González Cesteros, R. Roberto de Almeida, and A. Sáez Romero, 403–13. Roman and Late Antique Mediterranean Pottery 13. Oxford: Archaeopress.

Genera I Monells, M., and R. Járrega Domínguez. 2009. *Aproximació a la Dertosa romana: resultats de les investigacions arqueològiques al solar de la Costa dels Capellans*. Tarragona: Pragma General d'Edicions.

González Cesteros, H. 2019. "Distribution of ovoid amphorae in north-west Europe. Consumption contexts and main trade routes." In *The Ovoid Amphorae in the Central and Western Mediterranean: Between the Last Two Centuries of the Republic and the Early Days of the Roman Empire*, ed. E. García Vargas, H. González Cesteros, R. Roberto de Almeida, and A. Sáez Romero, 315–36. Roman and Late Antique Mediterranean Pottery 13. Oxford: Archaeopress.

Hárshegyi, P. 2008. "Roman amphorae from the East along the *Ripa Pannonica*." *RCRFActa* 40: 173–78.

Hayes, J. W. 1983. "The Villa Dionysos excavations, Knossos: The pottery." *BSA* 78: 97–169.

Hein, A., and V. Kilikoglou. 2020. "Digital modeling of function and performance of transport amphorae." *International Journal of Ceramic Engineering & Science* 2, no. 4: 187–200.

Iavarone, S., and G. Olcese. 2013. "Le anfore Dressel 2–4 di produzione tirrenica: una proposta di progetto archeologico ed archeometrico." In *Immensa Aequora. Ricerche archeologiche, archeometriche*

e informatiche per la ricostruzione dell'economia e dei commerci nel bacino occidentale del Mediterraneo (metà IV sec. a.C.–I sec. d.C.), ed. G. Olcese, 221–26. Rome: Quasar.

Jurišić, M. 2000. *Ancient Shipwrecks of the Adriatic: Maritime Transport During the First and Second Centuries AD*. BAR-IS 828. Oxford: Archaeopress.

Kelemen, M. 1988. "Roman amphorae in Pannonia II (Italian amphorae II)." *ActaArchHung* 40: 111–50.

Kenrick, P. M. 1985. *Excavations at Sidi Khrebish, Benghazi (Berenice) vol. III.1. The Fine Pottery*. Tripoli: Department of Antiquities, Ministry of Teaching and Education People's Socialist Libyan Arab Jamahiriya.

Laubenheimer, F. 1985. *La production des amphores en Gaule Narbonnaise*. Paris: Les Belles Lettres.

Laubenheimer, F., and É. Marlière. 2010. *Échanges et vie économique dans le Nord-Ouest des Gaules (Nord/Pas-de-Calais, Picardie, Haute-Normandie): le témoignage des amphores du IIe s. av. J.-C. au IVe s. ap. J.-C*. Besançon: Presses universitaires de Franche-Comté.

Lawall, M. 2011. "Imitative amphoras in the Greek world." *Marburger Beiträge zur antiken Handels-, Wirtschafts- und Sozialgeschichte* 28: 45–88.

Lemaître, S. 2000. "Les importations d'amphores de Méditerranée orientale à Lyon au IIIe siècle ap. J.-C." *RCRFActa* 36: 467–76.

Lemaître, S. 2011. "Une amphore crétoise dans le Rhône à Arles." In *Arles-Rhône 3: le naufrage d'un chaland antique dans le Rhône, enquête pluridisciplinaire*, ed. D. Djaoui, S. Greck, and S. Marleir, 104. Arles: Actes Sud.

Liou, B. 1987. "Inscriptions peintes sur amphores: Fos (suite), Marseille, Toulon, Port-la-Nautique, Arles, Saint-Blaise, Saint-Martin-de-Crau, Mâcon, Calvi." *Archaeonautica* 7: 55–139.

Liou, B. 1992. "Les amphores de la Plate-Forme à Fréjus." *Mélanges Février, Provence Historique* 42: 83–108.

Liou, B. 1993. "Inscriptions peintes sur amphores de Narbonne (Port-la-Nautique)." *Archaeonautica* 11: 131–48.

Liou, B., and R. Marichal. 1978. "Les inscriptions peintes sur amphores de l'anse Saint-Gervaise à Fos-sur-Mer." *Archaeonautica* 2: 109–81.

Lippolis, E. 2001. "Terra sigillata orientale." In *Gortina V.3. Lo scavo del Pretorio (1989–1995), t.I, I materiali*, ed. A. Di Vita, 26–35. Padua: Bottega d'Erasmo.

Loeschcke, S. 1909. *Keramische Funde in Haltern*. Bonn: Carl Georgi, Universitäts-Buchdruckerei und Verlag.

Long, L. 1998. "Inventaire des amphores du Rhône à Arles (Bouches-du-Rhône), un aspect des échanges à l'époque impériale." In *Importations d'amphores en Gaule de Sud du règne d'Auguste à l'antiquité tardive, actualité des recherches céramiques*, ed. L. Rivet, 85–95. Marseille: Société française d'étude de la céramique antique en Gaule.

Long, L., J. Piton, and D. Djaoui. 2006. "Le dépotoir portuaire d'Arles sous le Haut-Empire. Fouilles subaquatique du Rhône, Gisement A (Ier-IIe s. apr. J.-C.)." In *Actes du Congrès de Pézenas, 25–28 mai 2006*, ed. P.-Y. Genty, 579–88. Marseille: Société française d'étude de la céramique antique en Gaule.

Maiuri, A. 1958. *Ercolano: I nuovi scavi (1927–1958)*. Rome: Istituto poligrafico dello Stato.

Majcherek, G. 2007. "Aegean and Asia Minor amphorae from Marina el-Alamein." In *Amphores d'Égypte de la Basse Époque à l'époque arabe*, ed. S. Marchand and A. Marangou, 9–31. Cairo: IFAO.

Marangou, A. 1994. "Vin et amphores de Crète en Campanie." In *Ενκρατα: mélanges offerts à Claude Vatin*, ed. M.-C. Amouretti and P. Villard, 137–43. Aix-en-Provence: Université de Provence.

Marangou, A. 1999. "Wine in the Cretan economy." In *From Minoan Farmers to Roman Traders: Sidelights on the Economy of Ancient Crete*, ed. A. Chaniotis, 269–78. Stuttgart: F. Steiner.

Marangou, A. 2004. "Alexandrie: une destination pour le vin crétois." In *Creta romana e protobizantina*, ed. M. Livadiotti and I. Simiakaki, 1029–38. Padua: Bottega d'Erasmo.

Marangou-Lerat, A. 1995. *Le vin et les amphores de Crète de l'époque classique à l'époque impériale*. Athens: École française d'Athènes.

Marksteiner, T., S. Lemaître, and B. Yener-Marksteiner. 2008. "Die Grabungen am Südtor von Limyra: Die Grabungen der Jahre 1982–1986 am Südtor von Limyra, Vaisselle antique à Limyra en Lycie orientale (sondages 3A et 3B), Keramik aus der Sondage 5 in der Weststadt von Limyra." *ÖJh* 76: 171–277.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Moore, J. 2011. "When not just any wine will do…? The proliferation of Coan-type wine and amphoras in the Greco-Roman world." *Marburger Beiträge zur antiken Handels-, Wirtschafts- und Sozialgeschichte* 28: 89–122.

Morillo, Á., C. Fernández Ochoa, and J. Salido Domínguez. 2016. "*Hispania* and the Atlantic route in Roman times: New approaches to ports and trade." *OJA* 35, no. 3: 267–84.

Mráv, Z. 2010–13. "The Roman army along the Amber Road between Poetovio and Carnuntum in the 1st century A.D. – archaeological evidence." *Communicationes Archaelogicae Hungariae* 2010–13: 49–100.

Muslin, J. L. 2019. "Between Farm and Table: Oplontis B and the Dynamics of Amphora Packaging, Design, and Reuse on the Bay of Naples." PhD diss., University of Texas, Austin.

Nuțu, G., and G. Costea. 2010. "Ceramică fină descoperită la Aegyssus." *Peuce S.N*. 8: 147–62.

Oelmann, F. 1914. *Die Keramik des Kastells Niederbieber*. Bonn: Habelt.

Opaiț, A. 1980. "Considerații preliminare asupra amforelor romane şi romano-bizantine din Dobrogea." *Peuce S.V.* 8: 291–327.

Panella, C. 1986. "Oriente ed occidente: considerazioni su alcune anfore 'egee' di età imperiale à Ostia." In *Recherches sur les amphores grecques*, ed. J-Y. Empereur and Y. Garlan, 609–36. Paris: Diffusion de Boccard.

Panella, C. 2001. "Le anfore di età imperiale del Mediterraneo occidentale." In *Céramiques hellénistiques et romaines III*, 177–276. Paris: Les Belles Lettres.

Parker, A. J. 1992. *Ancient Shipwrecks of the Mediterranean and Roman Provinces*. BAR-IS 580. Oxford: Tempus Reparatum.

Peacock, D. P. S., and D. F. Williams. 1986. *Amphorae and the Roman Economy*. London and New York: Longman.

Peña, J. T. 2007. *Roman Pottery in the Archaeological Record*. Cambridge: Cambridge University Press.

Popilian, G. 1976. *Ceramica romană din Oltenia*. Craiova: Scrisul Românesc.

Portale, E. C., and I. Romeo. 2001. "Contenitori da trasporto." In *Gortina V.3. Lo scavo del Pretorio (1989–1995), t.I, I materiali*, ed. A. Di Vita, 260–410. Padua: Bottega d'Erasmo.

Puig Palerm, A., and P. Ruíz del Pozo. 2010. "Miscelánea: las ánforas del Mediterráneo oriental, Galas, Itálicas y las otras ánforas Hispanas." In *Estudios sobre el Monte Testaccio (Roma) V*, ed. J. Mª. Blázquez Martínez and J. Remesal Rodríguez, 415–38. Barcelona: Universitat de Barcelona.

Pülz, S. 1985. "Kaiserzeitliche Keramik aus dem Heroon III." *IstMitt* 35: 77–115.

Quercia, A., A. Johnston, A. Bevan, J. Conolly, and A. Tsaravopoulos. 2011. "Roman pottery from an intensive survey of Antikythera, Greece." *BSA* 106: 47–98.

Quiri, E. 2015. "Imports of eastern transport amphorae to Turin (Italy)." In *Per Terram, Per Mare. Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean*, ed. S. Demesticha, 161–80. Stockholm: Paul Åströms förlag.

Quiri, E., and G. Spagnolo Garzoli. 2015. "Imports of alum from Milos to Novara (Italy)." In *Per Terram, Per Mare. Seaborne Trade and the Distribution of Roman Amphorae in the Mediterranean*, ed. S. Demesticha, 181–88. Stockholm: Paul Åströms förlag.

Rauh, N., C. Autret, and J. Lund. 2013. "Amphora design and marketing in antiquity." In *Kauf, Konsum und Märkte. Wirtschaftswelten im Fokus – Von der römischen Antike bis zur Gegenwart*, ed. M. Frass, 145–81. Wiesbaden: Otto Harrassowitz GmbH & Co.

Reddé, M. 1979. "La navigation au large des côtes atlantiques de la Gaule à l'époque romaine." *MEFRA* 91: 481–89.

Remesal Rodríguez, J. 1986. *La annona militaris y la exportación del aceite bético a Germania*. Madrid: Editorial de la Universidad Complutense.

Remesal Rodríguez, J. 2010. "De Baetica a Germania, consideraciones sobre la ruta y el comercio atlántico en el Imperio Romano." In *Viajeros, peregrinos y aventureros en el mundo antiguo*, ed. F. Marco Simon, F. Pina Polo, and J. Remesal Rodríguez, 147–60. Barcelona: Universitat de Barcelona.

Remesal Rodríguez, J. 2011. *La Bética en el concierto del Imperio Romano*. Madrid: Real Academia de la Historia.

Riley, J. T. 1979. "The coarse pottery from Berenice." In *Excavations at Sidi Khrebish Benghazi (Berenice)*, Vol. 2, ed. J. A. Lloyd, 91–467. Tripoli: Department of Antiquities, Ministry of Teaching and Education People's Socialist Libyan Arab Jamahiriya.

Ritterling, E. 1913. *Das frührömische Lager bei Hofheim im Taunus*. Wiesbaden: Selbstverlag des Vereins.
Rizzo, G. 2003. *Instrumenta Urbis I. Ceramiche fini da mensa, Lucerne ed anfore a Roma nei primi due secoli dell'impero*. Rome: École française de Rome.
Roth, J. P. 1999. *The Logistics of the Roman Army at War (264 B.C.–A.D. 235)*. Leiden: Brill.
Rougé, J. 1966. *Recherches sur l'organisation du commerce maritime en Méditerranée sous l'Empire romain*. Paris: S.E.V.P.E.N.
Rousse, C. 2006. "La navigation fluviale et endolagunaire en Italie du Nord á l'époque romaine. Aménagements des courses d'eau et représentations cartographiques: perspectives de recherche." In *Les routes de l'Adriatique antique: géographie et économie*, ed. S. Čače, A. Kurilić, and F. Tassaux, 137–48. Bordeaux: Institut Ausonius.
Sanchez, C. 2011. "La céramique du secteur d'habitat à l'ouest des thermes entre 50 a.C. et le IIIe s. p.C." In *Un secteur d'habitat dans le Quartier du Sanctuaire du Moulin du Fâ à Barzan (Charente-Maritime)*, ed. A. Bouet, 329–454. Bordeaux: Ausonius.
Santamaria, C. 1984. "L'épave 'H' de la Chrétienne à Saint Raphaël (Var.)." *Archaeonautica* 4: 9–52.
Schäfer, C. 2016. "Oil for Germany. Some thoughts on Roman long-distance trade." In *Connecting the Ancient World: Mediterranean Shipping, Maritime Networks and their Impact*, ed. C. Schäfer, 211–48. Rahden: Verlag Marie Leidorf GmBH.
Schäfer, C. 2017. "The debate on the ancient economy as a 'battlefield' and the question of transport routes to the Rhine region." In *Economía romana. Nuevas perspectivas/The Roman Economy. New Perspectives*, ed. J. Remesal Rodríguez, 89–118. Barcelona: Edicions Universitat de Barcelona.
Schäfer, C. 2022. "Seaborne trade and field trials with Roman vessels on Rhine, Moselle and Danube." In *New Approaches to Seaborne Commerce in the Roman Empire*, ed. T. Schmidts and M. Seifert, 47–54. Heidelberg: Propylaeum.
Schindler Kaudelka, E., and S. Zabehlicky-Scheffenegger. 2006. "Le commerce entre l'Adriatique et le Magdalensberg." In *Les routes de l'Adriatique antique: géographie et économie*, ed. S. Čače, A. Kurilić, and F. Tassaux, 151–65. Bordeaux: Institut Ausonius.
Schucany, C., and P.-A. Schwarz. 2011. "Le sanctuaire d'Oedenburg (Biesheim, Haut-Rhin)." In *Aspects de la Romanisation dans l'Est de la Gaule*, ed. M. Reddé, P. Barral, F. Favory, J.-P. Guillaumet, M. Joly, J.-Y. Marc, P. Nouvel, L. Nuninger, and C. Petit, 575–86. Glux-en-Glenne: Bibracte.
Simossi, A. 1991. "Underwater excavation research in the ancient harbour of Samos: September–October 1988." *IJNA* 20: 281–98.
Slane, K. W. 2004. "Amphoras – used and reused – at Corinth." In *Transport Amphorae and Trade in the Eastern Mediterranean*, ed. J. Eiring and J. Lund, 361–69. Aarhus: Aarhus University Press.
Sofianou, C., and S. Gallimore. 2019. "Recent excavations at the small theater in ancient Hierapytna." *Kentro. The Newsletter of the INSTAP Study Center for East Crete* 19: 13–15.
Tchernia, A. 1986. *Le vin de l'Italie romaine*. Rome: de Boccard.
Tchernia, A. 2011. *Les Romains et le commerce*. Paris: Publications de Centre Jean Bérard.
Tomber, R. 2006. "The pottery." In *Survey and Excavation: Mons Claudianus 1987–1993. Volume III: Ceramic Vessels & Related Objects*, ed. V. A. Maxfield and D. P. S. Peacock, 3–236. Cairo: IFAO.
Toniolo, A. 1991. *Le anfore di Altino*. Padua: Società Archeologica.
Toniolo, A. 1994. "Anfore commerciali a Corte Cavanella. Alcune precisazioni." *AquilNost* 65: 142–48.
Tsatsaki, N., and E. Nodarou. 2014. "A new Hellenistic amphora production centre in West Crete (Loutra, Rethymnon): Study and petrographic analysis of the pottery assemblage." *BSA* 109: 287–315.
Unverzagt, W. 1916. *Die Keramik des Kastells Alzei*. Bonn: Habelt.
van den Berg, J. 2012. "Rare and exotic amphorae in North-West Europe: Finds from the Roman fort on the Kops Plateau, Nijmegen." *Journal of Roman Pottery Studies* 15: 215–35.
Verboven, K. S. 2007. "Good for business. The Roman army and the emergence of a 'business class' in the northwestern provinces of the Roman Empire (1st century BCE – 3rd century CE)." In *The Impact of the Roman Army (200 BC – AD 476): Economic, Social, Political, Religious and Cultural Aspects*, ed. L. de Blois and E. Lo Cascio, 295–313. Leiden: Brill.
Verzár-Bass, M. 1991. *Scavi ad Aquileia I. L'area a est del foro*. Rome: Quasar.
Vidal, J. M., and D. M. Corredor. 2018. "The Roman amphorae average capacity (AC)." *OJA* 37, no. 3: 299–311.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press

Vidrih Perko, V., and B. Žbona Trkman. 2005. "Ceramic finds from Ajdovščina-*Fluvio Frigido*, an Early Roman road station and Late Roman fortress *Castra*." *RCRFActa* 39: 277–86.

Vilvorder, F., R. P. Symonds, and S. Rekk. 2000. "Les amphores orientales en Gaule septentrionale et au sud-est de la Grande Bretagne." *RCRFAct* 36*:* 477–86.

Vogeikoff-Brogan, N. 2014. *Mochlos III. The Late Hellenistic Settlement: The Beam-Press Complex*. Prehistory Monographs 48. Philadelphia: INSTAP Academic Press.

Vogeikoff-Brogan, N., and S. Apostolakou. 2004. "New evidence of wine production in East Crete in the Hellenistic period." In *Transport Amphorae and Trade in the Eastern Mediterranean*, ed. J. Eiring and J. Lund, 417–27. Aarhus: Aarhus University Press.

Vogeikoff-Brogan, N., J. Eiring, M.-C. Boileau, and I. Whitbread. 2004. "Transport amphoras and wine trade in East Crete in the Late Hellenistic period." In *ΣΤ' Επιστημονική Συνάντηση για την Ελληνιστική Κεραμική*, ed. D. Zapheiropoulou and M. Kazakou, 327–32. Athens: Fund for Archaeological Resources and Expropriations.

Wickham, C. 2005. *Framing the Early Middle Ages*. Oxford: Oxford University Press.

Williams, D. W. 2003. "Cretan wine in Roman Britain." *Journal of Roman Pottery Studies* 10: 26–31.

Woolf, G. 1998. *Becoming Roman: The Origins of Provincial Civilization in Gaul*. Cambridge: Cambridge University Press.

https://doi.org/10.1017/S1047759423000351 Published online by Cambridge University Press