Received: 5 October 2022 | Accepted: 25 February 2023

DOI: 10.1111/arcm.12867

ORIGINAL ARTICLE

Phoenician–Punic amphorae in northern coastal Etruria: New evidence from Pisa (Italy)

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Abstract

This study outlines the circulation of Phoenician–Punic amphorae in northern coastal Etruria, with a particular focus on Pisa (Italy), where their presence has been attested since the mid-eighth century BCE. A set of specimens from Piazza del Duomo was analysed by minero-petrographic and geochemical techniques. The results were compared with literature data from Mediterranean production areas. The research allowed a better definition of the role of Etruscan Pisa in the frame of commercial and cultural routes in the Mediterranean, specifically in the Tyrrhenian area, also providing the opportunity to review the attestations of Phoenician–Punic amphora on a regional scale.

KEYWORDS

Etruscan period, northern Tuscany, petrography, TGA, transport amphorae, XRD, XRF

INTRODUCTION

Since ancient times, northern coastal Etruria has been the stage of intense commercial and cultural exchanges. During the Etruscan period (ninth–third centuries BCE), historical and archaeological evidence suggest that the coasts of present-day Tuscany were involved in medium and long-range commercial circuits managed by many carriers. Merchants and navigators were mainly attracted and driven by the mineral resources, of which the district, centred around Populonia and the Island of Elba, was particularly rich.

In this scenario, the Phoenician–Punic presence in the upper Tyrrhenian Sea promoted a centuries-old tradition of hospitality and political, economic and cultural ties between Etruscans and Carthaginians. Scholars have emphasized this network regarding the Etruscan period's most ancient and recent centuries (Michetti, 2007).

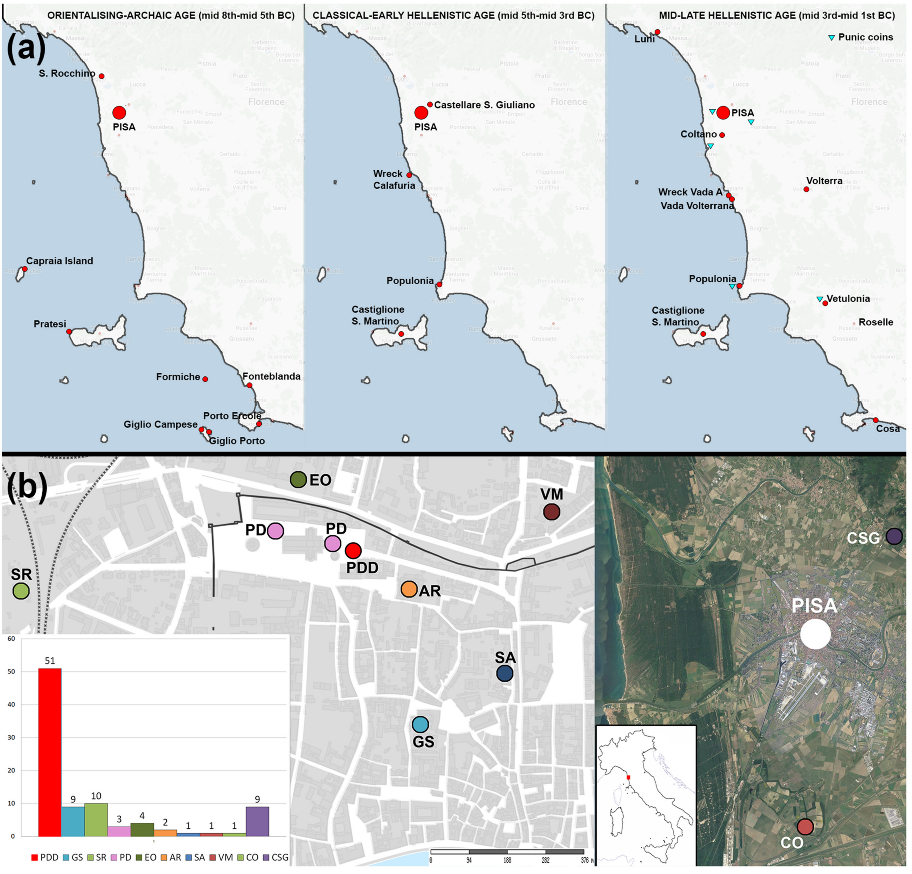

FIGURE 1 (a) Main discovery sites of Phoenician–Punic amphorae in northern Etruria; (b) distribution of Phoenician–Punic amphorae in Pisa with the chart of specimens found per site (PPD: Piazza del Duomo trench D; GS: S. Sisto's garden; SR: urban harbour of S. Rossore; PD: Piazza del Duomo; EO: *Emporikós oikos*; AR: Archbishopric's Garden; SA: Via S. Apollonia; VM: Via Marche; CO: Coltano; CSG: Mount Castellare)

Transport amphorae undoubtedly stand out among the artefacts that contribute to defining this network of commercial relations: the attestation of this peculiar ceramic class greatly varies in quantity along the northern coastal district of Etruria, depending on the historical period (Figure 1a). Documentation is remarkably consistent for the middle and late Hellenistic period (third–second centuries BCE), while it is much sparser and more fragmentary for the previous centuries; in addition, archaeometric studies dedicated to this type of container are almost absent in this geographical context. In detail, in the middle and late Hellenistic period, the presence of Punic amphorae along the northern Tyrrhenian coast is notable, homogeneously widespread and documented (e.g., Angelini, 2002: 226–228, tav. 5, 6, 1–3; Corretti et al., 2016: 83–84, tav. 38, 5–10; Genovesi et al., 2014: 78, tav. I, 5; Lusuardi Siena, 1977: 209–213, figs 6–15; Lyding Will & Warner Slane, 2019: 70–71, pl. 23, 309–314; Pasquinucci & Menchelli, 2005: 226; Rizzitelli, 2006: 163–165, fig. 7, 3–4; Romualdi, 1988: 37, fig. 31, 94; Romualdi & Michelucci, 1977: 94, fig. 24), even if scholars have not yet analytically addressed the issue of Punic trading activity in this area for this period (Sáez Romero & Zamora López, 2019: 78; Taccola, 2022: 676–677). Moreover, objects, such as coins (Romualdi, 1996: 316, fig. 1, a–b; Taccola, 2019: 238–239, tav. LXXXV, 542–543) and specific artefacts (Shepherd, 1992: 171, fig. 57), would suggest a permanent presence of Punic individuals, introduced into the social fabric of the two main centres of the area, namely Pisa and Populonia. Epigraphic documents in funerary contexts also allow us to hypothesize that some of them have become fully integrated into the local community

(Romualdi & Amadasi, 2007). On the contrary, the finds of Phoenician–Punic amphorae become progressively rarefied from the early Hellenistic period (second half of fourth century BCE) to the Classical (fifth century BCE), Archaic (sixth century BCE) and Orientalizing era (mid-eighth–early sixth centuries BCE). Those latter are mainly attested in the northernmost part of the coastal district, primarily in Pisa and in the settlements more or less directly controlled by the city (Bonamici, 2006: 505, tab. 1), and, secondly, in the inhabited areas and on the seabed along the southern coast of Tuscany, as well as in the islands of the Tuscan archipelago (Agricoli et al., 1991: 28, fig. 15; Bound, 1991: 187, fig. 1, 25; Ciampoltrini, 2016: 29, 35, figs 29, 31; Ciampoltrini & Rendini, 2012: 386, fig. 9, 6; Ciampoltrini & Rendini, 1992: 992; Cibecchini, 2006: 548; Corretti et al., 2016: 83, 85, pls. 38, 1, 39, 12–15; D'Angelo, 1991). At the present state of knowledge, the documentation of Phoenician–Punic amphorae in Populonia before the third century BCE is limited to a single attestation (Bonamici, 2015: 436, fig. 7, 65).

In this complex scenario, recent acquisitions from Pisa have offered the opportunity to build on the frame of circulation of Phoenician–Punic amphorae in northern Etruria based on a combined chrono-typological and archaeometric approach. Traditionally, the study of Phoenician–Punic amphorae is based on the chrono-typological sequence created by Joan Ramón Torres (Ramón Torres, 1995). Despite the enormous importance of his work, the classification put forward by Torres has gaps, essentially linked to the multiplication of discoveries regarding the finding of amphorae and production centres in the Mediterranean context, as well as to the progress of methods and tools of archaeometric analysis. Over the last two decades, several studies have highlighted the importance of the systematic use of minero-petrographic and geochemical analysis on ceramic fabrics to elaborate updated types within the context of local productions. These studies provided numerous scientific contributions in recent years, as evidenced by the bibliographic collections and online databases (e.g., https://ergasteriaproject.com/bahia-de-cadiz/; http://amphorae.icac.cat/). Among the recent works, it is worth mentioning the contributions of Babette Bechtold (Bechtold, 2015; Montana et al., 2020) on the amphorae of western Sicily and Massimo Botto for the amphorae of Sardinia (Botto et al., 2006), and finally the remarkable scientific production of Spanish scholars dedicated to the South Iberian ateliers (Fantuzzi et al., 2020; García Fernández & Sáez Romero, 2021).

In this study, the cross-results between chrono-typological and analytical data conducted on Phoenician–Punic amphorae found in Pisa highlight a plurality of production centres in the central–western Mediterranean under Punic control, mainly Carthage and North Africa, western Sicily, and the southern coast of the Iberian Peninsula. A further set of amphorae, not subjected to mineral–petrographic analyses, is typologically referable to Sardinian, Catalan and Balearic workshops. In these cases, morphotype and production area are uniquely correlated, so much so as not to have required archaeometric validation, as further discussed below.

MATERIALS AND METHODS

The Phoenician–Punic amphorae in Pisa

In Pisa and its territory, Phoenician–Punic amphorae are documented without interruption from the Orientalizing to the late Hellenistic periods, with a quantitative concentration between the end of the fifth and the mid-first century BCE.

The primary contexts and sites where specimens of Phoenician–Punic amphorae have been attested are: Piazza del Duomo (PDD-PD in Figure 1b) (Alberti et al., 2015; Costantini, 2011: 395, fig. 3, 4; Taccola, 2019: 196–199, nos 430–437), the church of S. Sisto in Cortevecchia (GS) (Cantini, 2021: 54, fig. 4.1.34–35 and unpublished), the urban harbour of S. Rossore (SR) (Bruni, 2006; Pisanu, 2003), and *Emporikós oikos* in Via Contessa Matilde (EO) (Maggiani, 2018). Other sporadic attestations are from the Archbishopric's Garden (AR) (Storti, 1987: 951–952, pl. LXXXIII, 2, 5; Storti, 1989: 116–117, n. 1213, pl. 32, 16), Via S. Apollonia (SA) (Corretti & Vaggioli, 2005: 219, fig. 46), an

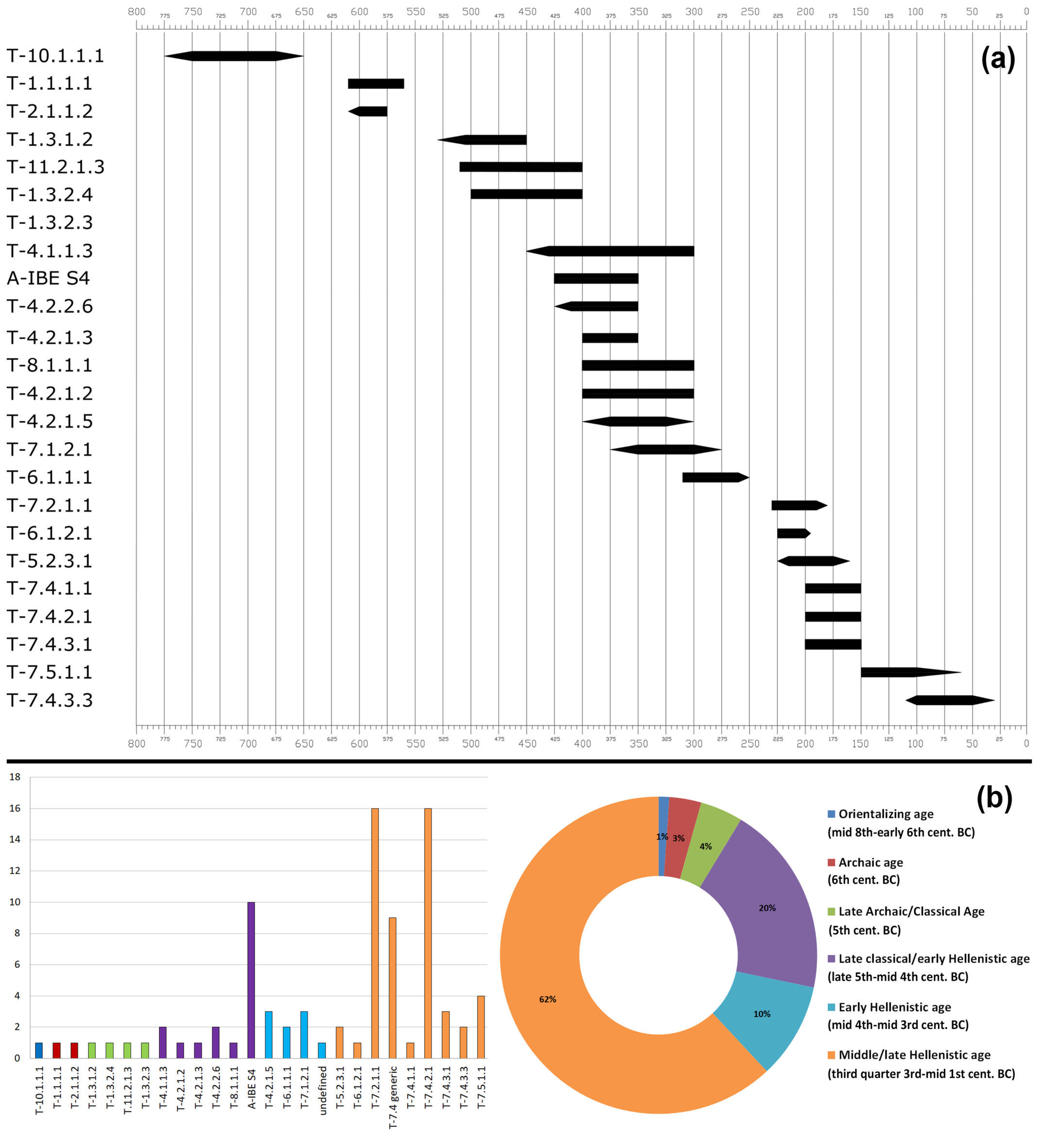

FIGURE 2 (a) Chronological distribution of Phoenician–Punic amphora types found in Pisa; and (b) chrono-quantitative charts of Phoenician–Punic amphorae found in Pisa

unmarked locality of Pisa (Pasquinucci et al., 1989, fig. 2, 3), Via Marche (VM) (unpublished), Coltano (CO) (Panicucci et al., 1986: 115, fig. 12, 1) and Mount Castellare in San Giuliano Terme (CSG) (Maggiani, 2007: 185–186, fig. 12, b).

The most consistent nucleus of Phoenician–Punic amphorae of Pisa comes from the eastern sector of Piazza del Duomo (PDD), where 806 fragments have been identified relating to at least 52 specimens referable to 16 different types of the Torres classification.

Overall, the chronology of the Phoenician–Punic amphorae found in Pisa is achieved by crossing the data proposed by the literature with the stratigraphic context (where available, verified and dependable) between the mid-eighth and mid-first centuries BCE (Figure 2a). Their attestation and distribution in the periods are illustrated in Figure 2(b).

Following a chronological sequence, the oldest fragment of a Phoenician amphora belongs to the classification T-10.1.1.1 (Figure 3: 1). The type, manufactured in the Phoenician centres of the Straits of Gibraltar, dates to between the mid-eighth and mid-seventh centuries BCE (Ramón, 2000: 280, fig. 3, 7–8; Ramón Torres, 1995: 229–230, figs 108, 17 and 195, 390, 392). In the Italian peninsula, this amphora was only attested in Ischia/Pithecusa (Pedrazzi, 2005). Together with another fragment from the lake village of S. Rocchino, just north of Pisa (Bonamici, 2006: 505, tab. 1), the specimen testifies to the inclusion of the district in the Phoenician trade routes already to the Orientalizing period, attracted here by the availability of mineral resources, as already mentioned above. Types T-1.1.1.1 and T-2.1.1.2 are attested in the late Orientalizing and at the beginning of the Archaic age (Figure 3: 2–3). Both date to between the late seventh and first third of the sixth centuries BCE. If the production area of the first type is limited to Carthage (Ramón, 2000: 283, fig. 3, 5; Ramón Torres, 1995: 163–165, figs 1, 1 and 142, 1), for the second, the area is wider, namely Sardinia, western Sicily and North Africa (Ramón Torres, 1995: 178, figs 25, 5 and 152, 77). Types T-1.3.1.2, T-11.2.1.3, T-1.3.2.4 and T-1.3.2.3 (Figure 3: 4–7) belong to the fifth century BCE (late Archaic/Classical ages). T-1.3.1.2, attributed to workshops in Eivissa (Ibiza, Balearic Islands), has been widespread since the last decades of the sixth century and mainly in the first half of the fifth century BCE (Ramón Torres, 1995: 170, fig. 11, 3 and 144, 19). Type T-11.2.1.3, already produced at the end of the sixth century BCE in the Phoenician centres of the Straits of Gibraltar and Morocco, is attested throughout the following century (Mora Serrano & Arancibia Román, 2018: 126, fig. 8, 1–3; Ramón Torres, 1995: 235–236, figs 116, 12 and 202, 443; Sáez Romero, 2021: 772, fig. 4, 1–16). Type T-1.3.2.4 was produced during the fifth century BCE in the Villaricos region, in the south-eastern Iberian Peninsula (Ramón Torres, 1995: 172–173, figs 16 and 148, 45). Type T-1.3.2.3, attributed to Ebusitan workshops, is concentrated in the second half of the century (Ramón Torres, 1995: 172, figs 15, 3–4 and 146, 31, 35). Types T-4.1.1.3, A-IBE S4, T-4.2.2.6, T-4.2.1.3, T-8.1.1.1, T-4.2.1.2, T-4.2.1.5, T-7.1.2.1 and T-6.1.1.1 are placed between the last quarter of the fifth and the mid-third centuries BCE (late Classical/early Hellenistic period). The shape T-4.1.1.3 (Figure 3: 8–9) of the Sardinian workshop dates to the middle last third of the fifth century BCE, and it is widespread until the beginning of the fourth century BCE (Ramón Torres, 1995: 185–186, figs 38, 1 and 158, 128). The specimens from Pisa show affinities also with another Sardinian type, T-4.2.1.10, attested for the entire fourth century BCE. The shape A-IBE S4 (Py, 2001: 88–89) is attributed to no fewer than 10 specimens found in contexts dated between the late fifth and the mid-fourth century BCE (Figure 3: 14). According to Adriano Maggiani (Maggiani, 2007: 185; 2018: 457), the A-IBE S4 fragments from Pisa have technical features compatible with Iberian amphorae produced on the Catalan coast, inspired by Punic models. The amphora T-4.2.2.6 (Figure 3: 10) is an (apparently) exclusive production of western Sicily, dated to between the last quarter of the fifth and the first half of the fourth centuries BCE (Ramón Torres, 1995: 194, figs 56, 1 and 163, 158). Types T-4.2.1.3, T-4.2.1.2, T-4.2.1.5, T-7.1.2.1 and T-6.1.1.1 (Figure 3: 11, 13, 15–20) were produced in both the centres of western Sicily and North Africa (Carthage, Tripolitania), and distributed between the fourth and first half of the third centuries BCE (Ramón Torres, 1995: 188, fig. 160, 142; 188, figs 44, 7 and 160, 141; 189, fig. 44, 7; 205, figs 73, 2–3 and 171, 208; 200, figs 65, 1 and 170, 193). On the other hand, the amphora T-8.1.1.1 (Figure 3: 12) was manufactured in Ibiza throughout the fourth century BCE and widespread limitedly to the coasts of Catalonia and Provence, as well as in the Balearics (Ramón Torres, 1995: 221–222, figs 95.1 and, 184, 303, 305–306). Types T-7.2.1.1, T-5.2.3.1, T-6.1.2.1, T-7.4.1.1, T-7.4.2.1 and T-7.4.3.1 (Figure 3: 21–27, 32–34) can be placed between the last quarter of the third and the mid-second centuries BCE (middle/late Hellenistic period). The production of these amphorae, which constitute the most widespread nucleus in Pisa and the rest of northern coastal Etruria, was manufactured in western Sicily, around Carthage and in Tripolitania (Ramón Torres, 1995: 205–206, figs 74, 7 and 173, 225; 206–207, fig. 75; 202, figs 69, 5 and 170, 199; 197–198, figs 63, 10 and 166, 174; 209–210, fig. 79; 210–211, fig. 81; for type T-7.1.2.1, see also Olcese, 2012: 592, pl. 6, II.4; and Cibecchini et al., 2006: 15, fig. 4, 2). The last types attested in Pisa, namely T-7.5.1.1 and T-7.4.3.3, date from the late Republican period, that is, between the end of the second and the middle, or shortly after, of the first centuries BCE. The

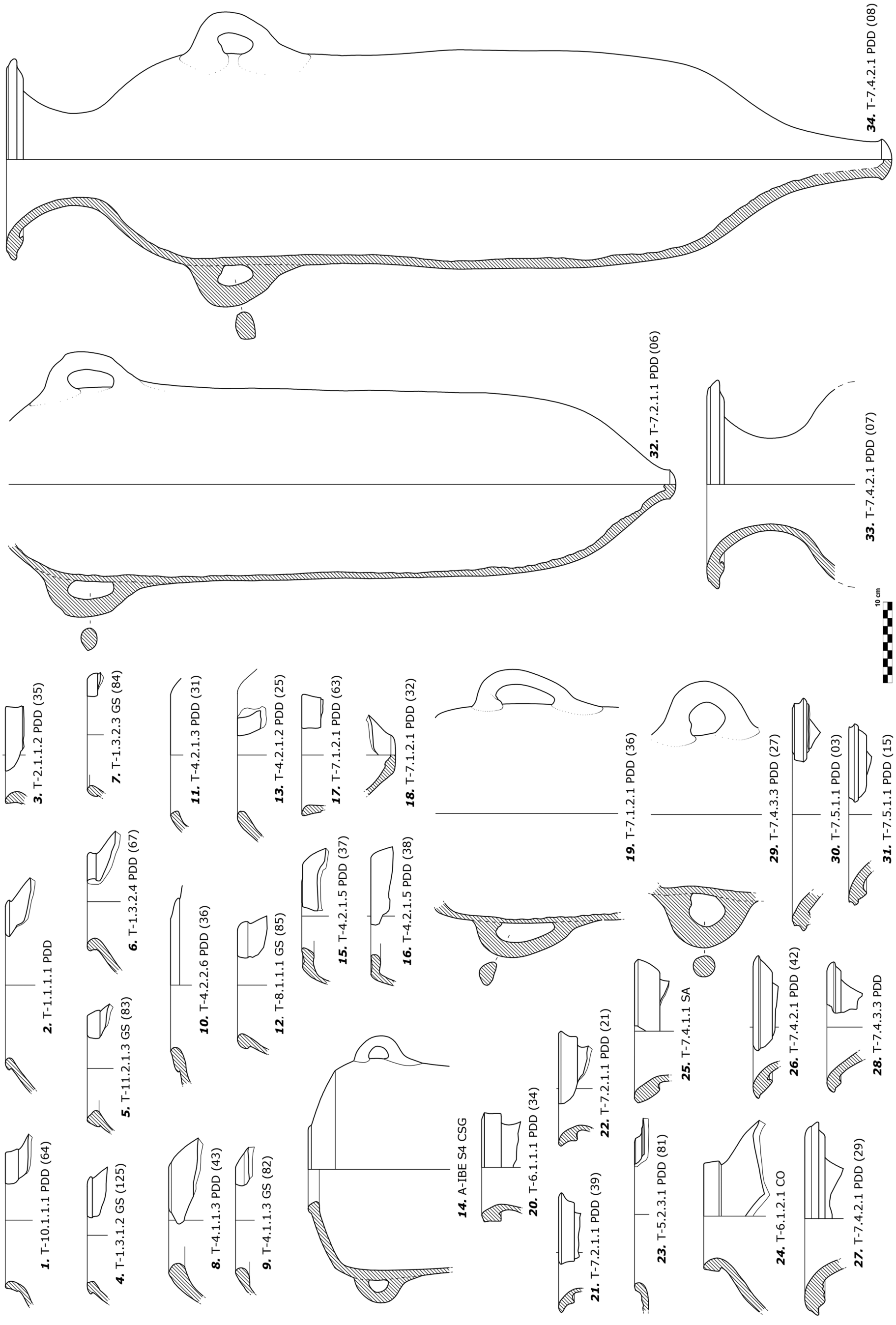

FIGURE 3 Selection of Phoenician–Punic amphorae found in Pisa (sample numbers are shown in parentheses)

first shape (Figure 3: 30–31) was produced mainly in North Africa (Tunisian Sahel), but also in western Sicily (Ramón Torres, 1995: 214, figs 85, 4, 181, 278–279). Type T-7.4.3.3 (Figure 3: 28–29) is attributable to workshops located on the southern coast of the Iberian Peninsula, mainly in the Malaga area (Corredor, 2015: 187, fig. 3, 10; Ramón Torres, 1995: 212–213).

Experimental

Reviewing the attestation in Pisa and its surroundings, Piazza del Duomo remains the most important site for occurrence of both types and chronology. A total of 52 samples from this city area have thus been examined and discussed here: 45 samples related to 18 classified amphora types, while seven samples not typologically attributable (fragments from amphora walls). All specimens have been documented with macro-photos of the fresh breaks, acquired with a Leica Microsystems EZ4 10× Stereomicroscope (12.5× magnification). Minero-petrographic and geochemical analysis was carried out on a sub-selection of 38 specimens, including also uncertain productions and types for which multiple manufacturing areas are attested within the Punic settlement areas of the central–western Mediterranean or more workshops within the same region (e.g., Western Sicily and North Africa).

Specimens easily traceable from a morpho-typological point of view to single and ascertained production areas were not selected for analytical investigation.

The 38 selected specimens were analysed by thermogravimetric analysis (TGA), X-ray fluorescence (XRF) and X-ray diffraction (XRD) to determine geochemical and mineralogical composition. A selection of samples—based on macroscopic fabrics—was also investigated in thin section; petrographic analysis was carried out on 27 specimens by using a © Zeiss Axioscope 5 system to describe compositional and textural features; classification was provided according to Whitbread (1995).

The qualitative mineralogical composition of the samples was studied using a Bruker D8 Advance X-ray powder diffractometer (XRPD) with Cu–Ka radiation, operating at 40 kV and 40 mA. Powder diffraction data were collected in the range 3–60°/2Θ in steps of 0.02°/2Θ (step time 0.4 s). The EVA software program (DIFFRACplus EVA) was used to identify the mineralogical phases in each X-ray powder spectrum by comparing experimental peaks with PDF2 reference patterns.

To improve knowledge of the mineralogical composition and provide weight loss data, TGA was performed using an SII ETG/DTA 7200 EXSTAR Seiko instrument (Chiba, Japan). Before analysis, all samples were dried under vacuum at 40°C for 18 h. Samples of 5–10 mg were placed in alumina sample pans (70 μL) and runs were carried out at the standard heating rate of $10°C \cdot min^{-1}$ from 30 to 910°C under air ($200\,mL \cdot min^{-1}$). The weight loss per different temperature ranges was graphically determined (Moropoulou et al., 1995).

XRF-WD was carried out to determine the chemical composition of major and trace elements. The analysis was performed on pressed pellets made up of 6 g of specimen placed over boric acid (maximum working pressure 25 bar), through a Bruker S8 Tiger WD X-ray fluorescence spectrometer, with a rhodium tube with 4 kW power and size of analysis of 34 mm (using adequate mask). To determine loss on ignition (LOI) gravimetrically, the samples were heated to 1050°C for 3 h according to the method proposed by Lechler and Desilets (1987).

Geochemical data were treated by a statistical approach introduced by Aitchison (1986) and implemented for compositional data analysis through freeware software (CoDaPack) (Comas-Cufi & Thió-Henestrosa, 2011). The software provides plots of principal components based on log-ratio transformed-normal distribution of input data.

RESULTS

Minero-petrographic examination

Thin section analysis made it possible to discriminate four petrofabrics and one singleton, according to textural and compositional features.

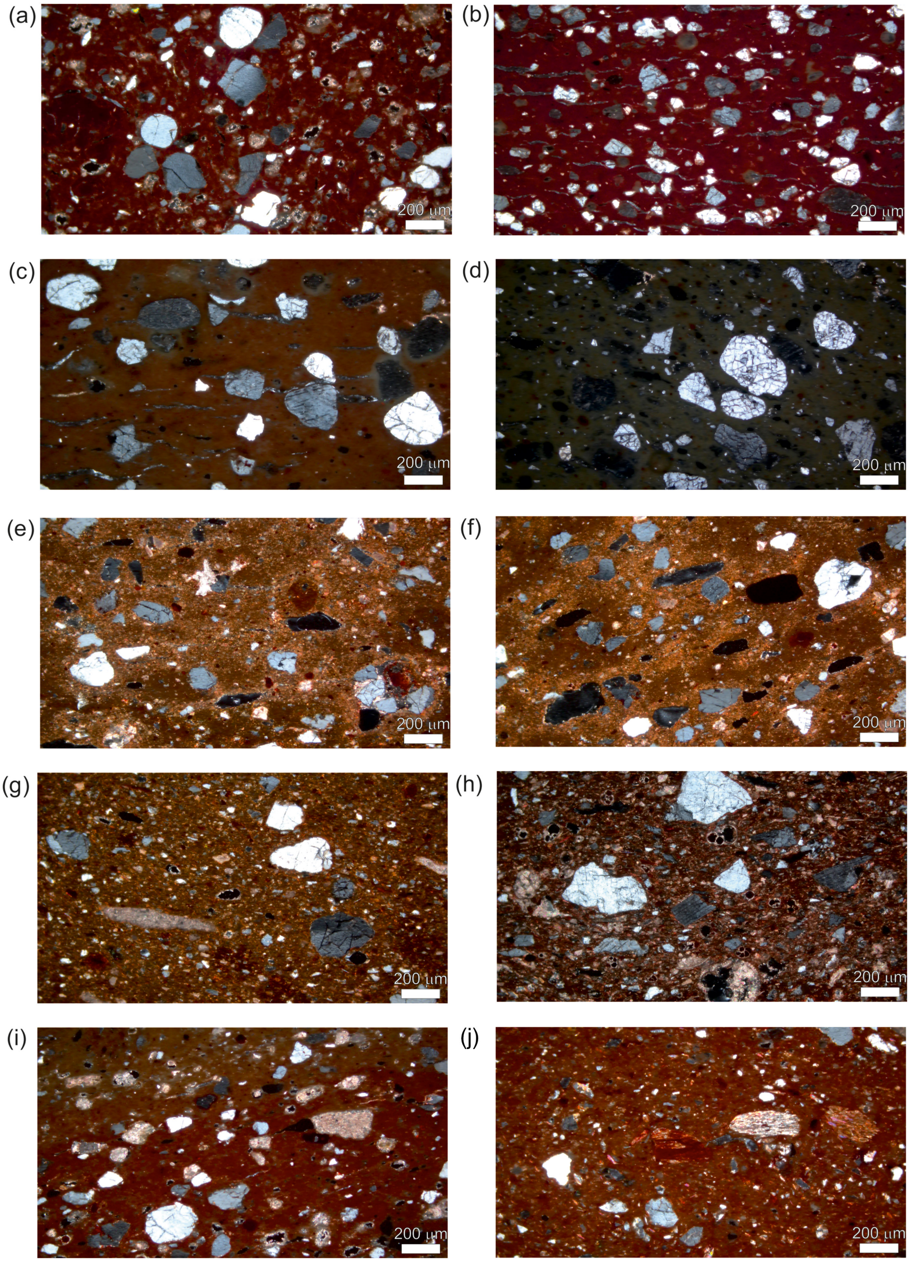

FIGURE 4 Representative photomicrographs: fabric F1: (a) 22, (b) 34; fabric F2: (c) 19, (d) 37; fabric F3: (e) 12, (f) 20, (g) 25, (h) 43; and fabric F4: (i) 36; singleton: (j) 27

The first group (F1) includes samples 3, 6, 10, 22, 34, 35 and 39 (Figure 4a,b), which are characterized by homogenous reddish-brown and inactive micromass, with mica and scarce microfossils (mainly foraminifera). The void microstructure is due to elongated pores, sometimes with preferential orientation, and scarce irregular voids. The development of carbonate reaction rims is particularly visible in samples 6, 10, 22 and 39. In samples 3, 6, 10, 21 and 22, inclusions are due to fine-medium sand of sub-rounded monocrystalline quartz (rarely polycrystalline) also fractured, rare pyroxene and feldspars, rare chert, and sandstone fragments. Secondary calcite is present filling the voids; in some cases, calcareous lithoclasts are also present. In samples 34, 35 and 39, inclusions are due to monocrystalline quartz (rarely polycrystalline) very fine sand, rare pyroxene and feldspars, rare chert, and sandstone fragments. Red-brown amorphous concentration features (Acf) are present.

The second petrofabric group is composed of samples 7, 19, 31 and 37 (Figure 4c,d) (F2). Samples 7 and 19 are characterised by homogeneous, isotropic, pale-brown micromass with fossils and abundant elongated voids with preferential orientation, while in samples 31 and 37 the micromass is pale-ochre. Inclusions are exclusively due to rounded monocrystalline (rare polycrystalline) quartz medium sand and rare chert. Secondary calcite is also visible, filling voids. Scarce rounded and red-brown Acf are present.

The petrofabric F3 includes samples 12, 15, 20, 25, 40 and 43, characterized by highly heterogeneous micaceous, fossil-rich (mainly planktonic foraminifera) and optically active micromass, with colour ranging from brownish-orange to yellowish-brown. Inclusions are due to monocrystalline quartz (from rounded to sub-rounded) fine sand and micritic limestone fragments; in samples 12 and 20 clastic rock fragments are also visible. Very fine sand of sub/rounded–sub/angular monocrystalline quartz and omicritic fragments is dispersed in the micromass (Figure 4e,f). Abundant bright red Acf are present. It is noteworthy that samples 25 and 43 exhibit slightly different features, being characterised also by inclusions due to sub-angular and highly fractured quartz (Figure 4g,h).

Samples 17, 26, 36, 41 and 42 (F4 petrofabric; Figure 4i), are characterized by inactive micromass, from bright red to brown-red in colour, with abundant fossil tests and fossil moulds. The void microstructure is due to irregular voids, in some cases elongated and preferentially oriented. Inclusions are due to sub-rounded fine sand of monocrystalline quartz and micritic carbonate fragments, scarce/rare polycrystalline quartz, rare pyroxene, and sandstone fragments. Abundant red Acf are present.

Finally, sample 27 is a singleton. Micromass is inactive, heterogeneous, silty, mica-rich, with red-brown colour exhibiting textural variation attributable to firing conditions (Figure 4j). The void microstructure is due to few irregular voids. Inclusions consist of coarse/very coarse sand of polycrystalline quartz and metamorphic rock fragments (acid suite, medium grade), mainly derived from schist; fine sand is due to quartz, mica and opaque minerals.

The mineralogical composition determined through XRD diffraction is quite in accordance with petrographic observations (see Table S1 in the additional supporting information). The detected mineral assemblages seem to be imprinted by the composition of inclusions detected through optical microscopy. Temperature indicators, such as gehlenite and pyroxene (when not present as primary mineral phase among inclusions) would suggest medium-high firing conditions for most samples. Only in some cases (e.g., samples belonging to petrofabric F3) can calcite be attributed to matrix composition, while in most samples is present as secondary phase filling voids, according to petrographic observations.

TGA/DTG

Table S2 in the additional supporting information reports the TGA results in weight loss % per temperature ranges, relevant for ancient ceramic studies. TGA/DTG analysis shows that all samples present a weight loss within the 3.2–14.3% range, and it occurs in two or three steps having the maximum degradation rate (determined by DTG curves) in the intervals: 100–125 °C, 320–360 °C and 700–770°C. The highest weight loss is generally observed at about 700°C. Based on the literature data (Sousa & Holanda, 2007), the first weight loss can be due to the loss of adsorbed water and the dehydration of clays. The second weight loss can be due to the decomposition of organic matter, while the higher temperature weight loss can be associated with carbonate decomposition. Interestingly, many samples show a shoulder around 560–600°C which, based on the literature (Sousa & Holanda, 2007), can be attributed to the quartz inversion from the alpha to beta form that generally occurs at about 570°C, confirming that quartz is present in the samples. The Ca-rich samples (group F3, samples 12, 15, 20, 40, 25 and 43) show a higher overall weight loss than the other samples, which is mainly caused by thermal decomposition in the 650–770°C temperature range. Finally, samples 3, 21 and 34 show very limited weight loss, probably because they do not contain calcite (see Table S1 in the additional supporting information).

Geochemistry

Geochemical data (see Table S3 in the additional supporting information) were treated by a statistical approach and a biplot of the principal components was obtained through CoDaPack software (Comas-Cufì & Thió-Henestrosa, 2011) (Figure 5a). The biplot efficiently groups samples, with a good match with petrographic observations, when available; in fact, petrofabric F1 is well distinguished from the other groups, along with samples 4, 9 and 24 for which petrography is not available; petrofabrics F2 and F3 fall in the same compositional area, where numerous other samples are scattered, for which petrographic data are not available. Sample 27 is quite well separated from the main two groups, especially concerning major elements; similarly, samples 43 and 25 appear to be separated, based on their slightly different features, within petrofabric F3. Finally, samples belonging to F4 are plotted in between F1 and F2/F3, with special consideration awarded to the major elements.

DISCUSSION

From the archaeological point of view, findings from Pisa distinguish the centre from the other coastal settlements for the percentage-relevant attestation of specimens datable between the end of the fifth and the mid-third centuries BCE and the presence, albeit with smaller numbers, of Phoenician–Punic amphorae of the Orientalizing, Archaic and Classical ages (see Table S4 in the additional supporting information).

The massive frequency of so-called neo-Punic amphorae (middle/late Hellenistic period) in Pisa compared with the specimens of previous centuries is not an element of novelty, as it well-matches the trend already observed elsewhere in the northern coastal Etruria.

However, despite the known manufacturing areas, namely Sicily, Sardinia, North Africa, the southern coast of the Iberian Peninsula and the Balearic Islands—where a tradition of studies is established—there are still few reports on minero-petrographic and geochemical analysis on Phoenician–Punic amphorae in the Italian peninsula (De Francesco et al., 2012), and even less research on contents or organic residues (Bordignon et al., 2006; Fantuzzi et al., 2020). Narrowing the field to the northern coastal district of Etruria, such studies are (almost) absent (Cantisani et al., 2003: 168–169), in comparison, for example, with the substantial literature available for other classes of amphorae, especially the Greco-Italics or Dressel 1 (Olcese, 2010; for local productions Menchelli et al., 2007, 2013).

The minero-petrographic and geochemical analysis carried out on the studied set of amphorae from Pisa evidenced the occurrence of different compositional groups. Comparative evaluations of geochemical results with XRF reference data available in the literature were thus carried out to shed light on the possible provenance of the examined materials. In particular, results have been compared with reference data on Phoenician–Punic amphorae whose productions are attested in the Mediterranean area, from Spain to western Sicily, and North Africa (Amadori et al., 2002, 2017; Fantuzzi et al., 2020; Montana & Randazzo, 2015; Montana et al., 2020). Among compositional diagrams, the Si/Ca versus Al/Ca binary graph appeared particularly meaningful in discriminating between petrofabrics and production areas (Figure 5b). In fact, petrofabrics F2 and F3, along with other samples not investigated in thin sections (namely, samples 1, 2, 5, 8, 11, 13, 14, 16, 18, 19, 29 and 30) match well with reference materials from North African regions, especially Carthage areas (Amadori et al., 2002, 2017); this evidence is in accordance with petrographic investigation. In particular, samples belonging to fabric F2 exhibit the classical compositional and textural features attributable to North African productions, namely fossil-rich micromass and sub-rounded monocrystalline quartz sand as inclusions. The fossil- and Ca-rich samples grouped in petrofabric F3 are attested in African regions as local productions, as reported by Amadori

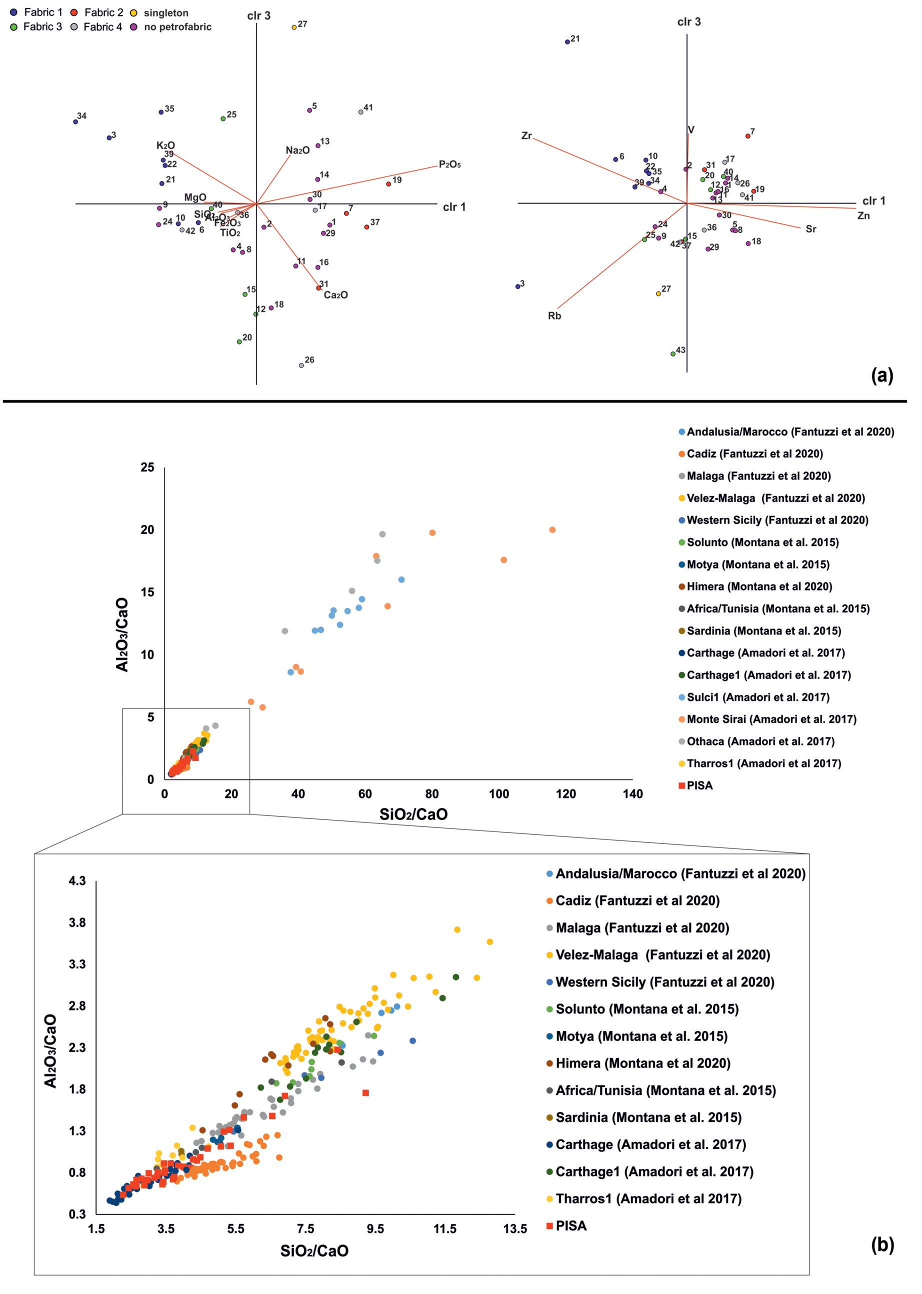

FIGURE 5 (a) Biplot of the principal components for major and minor/trace elements; and (b) binary diagram Si/Ca versus Al/Ca. Studied samples and reference data are plotted for comparative purposes

et al. (2017), except for samples 25 and 43. Specifically, these two specimens exhibited slightly different petrographic features when observed in thin sections, suggesting a possible different provenance location; the comparison with reference data would indicate, in fact, a good match with the Cadiz workshop (Fantuzzi et al., 2020), characterized by quartz, microfossils and calcite inclusions, calcareous micromass. Otherwise, fabrics F1 and F4 can be interpreted as Sicilian productions, whose peculiar compositional features are extensively described in the literature (Fantuzzi et al., 2020; Montana & Randazzo, 2015; Montana et al., 2020). It is noteworthy that Motyian and Soluntine production areas can be discrimi-

TABLE 1 Summary of the results obtained from thin section and geochemical analysis

Sample ID	*Amphora type*	*Petrofabric features*	*Provenance (petrography combined with chemistry)*
3, 6, 10, 21, 22, 34, 35, 39	T-2.1.1.2 T-6.1.1.1 T-7.2.1.1 T-7.4 generic T-5.1.1.1	F1 = monocrystalline quartz, pyroxene, sandstones, locally micritic limestones	Motya and Solunto (Montana & Randazzo, 2015; Montana et al., 2020)
17, 26, 36, 41, 42	T-4.2.2.6 T-7.1.2.1 T-7.4 generic T-7.4.2.1	F4 = monocrystalline quartz, pyroxene, sandstones, carbonate inclusions	Motya (Montana & Randazzo, 2015)
4, 9, 24	Wall (not classifiable)	None	Motya (Montana & Randazzo, 2015)
7, 19, 31, 37	T-4.2.1.3 T-4.2.1.5 T-7.2.1.1 T-7.4.2.1	F2 = rounded quartz, microfossils	North Africa (Amadori et al., 2017; Fantuzzi et al., 2020)
12, 15, 20, 40	T-7.4 generic T-7.4.2.1 T-5.1.1.1	F3 = rounded monocrystalline quartz, fossils, Ca-rich matrix	North Africa (Amadori et al., 2017)
1, 2, 5, 8, 11, 13, 14, 16, 18, 29, 30	T-7.4 generic T-7.4.2.1	None	North Africa (Amadori et al., 2017; Fantuzzi et al., 2020)
25, 43	T-4.2.2.5 Castro Marin 1	F3 = sub/angular and highly fractured monocrystalline quartz, fossils, Ca-rich matrix	Cadiz (Fantuzzi et al., 2020)
27	T-7.4.3.3	Singleton: mica-rich matrix with metamorphic inclusions (acid suite, medium grade)	Malaga (Fantuzzi et al., 2020)

nated among studied amphorae; in fact, samples 3, 21, 34, 35 and 39 seem to match well with reference samples from Solunto, characterized by the predominant presence of monocrystalline quartz sand, rare pyroxene and feldspars, rare chert, and sandstone fragments, while samples 6, 10, 22, 41 and 42 (along with 4, 9 and 24 for which thin sections are not available) seems to be more related to Motya production, identified by the predominant presence of calcareous lithoclasts, along with monocrystalline quartz sand. Samples 17, 26 and 36 seem to be chemically related to African productions; however, petrography suggests a western Sicilian provenance based on their clear distinguishable textural and compositional features. Finally, for sample 27 both petrography and chemistry seem to be quite different from the other studied materials; the comparison with reference data would suggest a provenance from the Malaga area (Fantuzzi et al., 2020) due to the peculiar metamorphic rock fragments identified as inclusions.

By correlating petrofabrics identified by archaeometric analysis and the amphoric types determined by the chrono-typological classification method, it is possible to delineate a pretty interesting scenario on the attestation of Phoenician–Punic amphorae from different manufacturing centres circulating in northern Etruria in the studied chronological periods (Table 1).

As far as western Sicily productions are concerned, all the analysed samples of the T-7.2.1.1 type (230–180 BCE ±) belong to the Motya–Solunto fabric, including also types T-2.1.1.2 (610–575 BCE ±), T-6.1.1.1 (310–250 BCE ±), and some specimens attributable to the generic type T-4 and T-5.1.1.1

(200–80 BCE ±). Types T-4.2.2.6 (425–350 BCE ±), T-7.1.2.1 (375–275 BCE ±) and T-7.4.2.1 (200–150 BCE ±) are to be referred as to one of the two fabrics attributable to Motya, while the other is associated only with samples taken from walls and therefore not classifiable.

The North African productions are divided into three groups. The first is referable to the Carthage area and includes types T-4.2.1.3 (400–350 BCE ±), T-4.2.1.5 (375–275 BCE ±), T-7.2.1.1 and T-7.4.2.1 (230–150 BCE ±). The second refers only to late productions (150–60 BCE ±), that is, types T-7.4.2.1, T-7.4 generic, T-7.5.1.1. A third group, whose provenance has been assessed purely based on the geochemical analysis, is the most represented and includes only late Hellenistic types T-7.4.2.1 and T-7.4 generic (200–150 BCE ±).

Attestations from the southern coast of the Iberian Peninsula include the type T-7.4.3.3 (110–30 BCE ±), associated with the Malaga area workshops, and specimens classified on a macroscopic basis as T-4.1.1.3 and T-4.2.1.2 compatible with the Cadiz area. However, according to Torres' classification, these two shapes seem exclusive to Sardinian workshops. For this apparent significant anomaly, it is possible to find an alternative solution that makes the morpho-typological data agree with the analytical results. As for T-4.1.1.3, it is possible to associate specimen 43 (Figure 3: 8) with a variant of the Pellicer type D (= T-4.2.2.5), one of the most common shapes of the Guadalquivir valley. The Pellicer D amphora was produced with four variants between the mid-third and mid-first centuries BCE. However, it is also attested in contexts dated to the end of the fifth century BCE (Belén, 2006: 219, fig. 14.13). This latter chronological data seems confirmed by the Pisan specimen since it was found within a late classical period level. Instead, as regards the T-4.2.1.2 (Figure 3: 13), the rim profile can be compared with the Castro Marim 1 amphora. The shape, widely spread on the southern coast of the Iberian Peninsula, is concentrated between the end of the second and about the mid-first centuries BCE. Still, it is not excluded that the production could be anticipated at the end of the third century BCE (Arruda & Bargão, 2017, fig. 11). On the other hand, since the specimen from Pisa comes from a level datable to the second half of the fourth century BCE, a chronological anomaly continues to exist unless considering the fragment as an outlier.

In addition to the examples described above, it was possible to review some classifications of Punic amphorae already published thanks to a more in-depth typological study approach and the contribution of archaeometric analyses. These are two samples from Piazza del Duomo trench D: a rim initially attributed to the Sardinian shape T-4.2.1.10 (Taccola, 2019: 197, pl. LXV, 432), for which the analysis of the fabric has instead highlighted the North African provenance of the specimen (T-4.2.1.3, 350–300 BCE ±; Figure 3: 11); and a rim attributed to shape 6.1.1.2 (Taccola, 2019: 198, pl. LXV, 435), actually more similar to type T-2.1.1.2. (610–575 BCE ±; Figure 3: 3).

For samples not subjected to analytical investigation due to their very close and evident relationship between amphora typology and manufacturing area, it is possible to propose attribution based on both the chrono-typological classification and comparison of the fabric with analysed specimens. For example, sample 64, pertaining to type T-10.1.1.1 (Figure 3: 1), which is classified as produced on the southern coasts of the Iberian Peninsula (750–650 BCE ±), is compatible with sample 27 (T-7.4.3.3., 110–30 BCE ±; Figure 3: 29), attributed to the workshops of Malaga. Attention can be drawn to a substantial difference in fabrics between samples attributed to the same type: this is the case of the amphora classified on a macroscopic basis as T-4.1.1.3, then Pellicer D = T-4.2.2.5 (Figure 3: 8). The sample (43) shows a completely different texture from the other specimen attributed to type T-4.1.1.3, thereby offering a much better match with the latter classification (Figure 3: 9).

CONCLUSIONS

The investigation on Phoenician–Punic amphorae from Pisa testified—for the first time—a large, representative and continuous circulation of these containers over the centuries in the city, enlarging the current historical and archaeological interpretations so far based on few specimens attested in the urban harbour and dated to late Hellenistic period.

To our knowledge, the present work represents the first contribution providing a typological and diachronic synthesis of the Phoenician–Punic amphorae in northern Etruria, with a focus on Pisa. In fact, although contributions which deal more or less directly with the subject are known, no scholar has tackled the question on a broader scale.

In addition, the results of the archaeometric analysis provide a considerable reference group describing the distribution of the different types and productions in the Tyrrhenian area, filling a further deep gap in the scientific literature which is still poor about similar investigations in the Italian peninsula.

Ongoing research will certainly integrate and enrich the consistent nucleus of Phoenician–Punic amphorae in Pisa. The data emerging from this research and others' published contributions (e.g., Taccola, 2022) are helping to outline the role of Etruscan Pisa in the chessboard of the upper Tyrrhenian, with ever more precise contours as a crossroad of fundamental commercial and cultural relevance in the northern district of Etruria.

AUTHOR CONTRIBUTIONS

Typological classification of the Phoenician–Punic amphorae and historical–archaeological study and contextualisation by E.T.; petrographic analysis carried out by S.R.; TGA analysis performed by F.C. and S.C.; XRD and XRF analysis performed by D.M. and R. D. L. and G.G.; data processing and interpretation are by S.R.

ACKNOWLEDGEMENTS

The authors are deeply grateful to Claudia Rizzitelli (Superintendence Archaeology, Fine Arts and Landscape for the provinces of Pisa and Livorno), who kindly granted the study of the archaeological material of Piazza del Duomo trench D; and to Federico Cantini and Lisa Rosselli (University of Pisa, Department of Civilization and Forms of Knowledge) for providing unpublished data about S. Sisto in Cortevecchia and Via Marche.

Open Access Funding provided by Universita degli Studi di Pisa within the CRUI-CARE Agreement.

DATA AVAILABILITY STATEMENT

The data supporting the findings from this study are available from the corresponding author upon reasonable request.

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How to cite this article: Taccola, E., Miriello, D., De Luca, R., Cicogna, F., Coiai, S., Girimonte, G., & Raneri, S. (2023). Phoenician–Punic amphorae in northern coastal Etruria: New evidence from Pisa (Italy). *Archaeometry*, *65*(5), 955–971. https://doi.org/10.1111/arcm.12867