Journal of Archaeological Science: Reports 72 (2026) 105750

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Networks and transcultural evidence in late iron age Bisenzio (Capodimonte, VT, Italy, 750–730 BCE)

A. Babbi [a,b,*], A. Celant [c], G. Germinario [d], J. Hertzog [e,f,g], M. Lamonaca [h], F. Michelangeli [c], P. Schmitt-Kopplin [e,f], R. Schwab [b]

[a] Consiglio Nazionale delle Ricerche, Istituto delle Scienze del Patrimonio Culturale (CNR ISPC), Strada Provinciale 35d, n. 9, 00010 Montelibretti (RM), Italy
[b] Leibniz-Zentrum für Archäologie (LEIZA), Ludwig-Lindenschmit-Forum 1, 55116 Mainz, Germany
[c] Sapienza Università di Roma, Dipartimento di Biologia Ambientale, Piazzale Aldo Moro 5, 00185 Roma, Italy
[d] Consiglio Nazionale delle Ricerche, Istituto delle Scienze del Patrimonio Culturale (CNR ISPC), Prov.le Lecce-Monteroni, 73100 Lecce (LE), Italy
[e] Technische Universität München (TUM), Analytical Food Chemistry, Maximus-von-Imhof-Forum 2, 85354 Freising, Germany
[f] Helmholtz Munich, Research Unit Analytical BioGeoChemistry (BGC), Ingolstädter Landstraße 1, 85764 Neuherberg, Germany
[g] Université de Lorraine, LCP-A2MC, 57000 Metz, France
[h] Museo Nazionale Etrusco di Villa Giulia, Piazzale di Villa Giulia, 9, 00196 Roma, Italy

A R T I C L E I N F O

Keywords:
Bisenzio
Iron Age
Funerary rituals and goods
Transculturality
Archaeometallurgy
High resolution mass spectrometry
Palaeobotany

A B S T R A C T

The community that thrived between the 2nd millennium BCE and the 5th century BCE at Bisenzio, near Capodimonte on Lake Bolsena, i.e. the hinterland of Southern Etruria (today's Northern Latium), is counted among the most important proto-urban communities of the early phase of the Early Iron Age in the Italian Peninsula (ca. 930/20–800 BCE). Despite this reading, some scholars believe that already during the 8th century BCE, Bisenzio was dependent on another neighbouring centre, i.e. Vulci, Tarquinia, or Orvieto.

Thanks to the mass of data being systematically collected by 'The Bisenzio Project', an unexpected picture is emerging that prompts a rethink of the aforementioned paradigm. Among the many contexts considered by the project are the burials of the rich Olmo Bello necropolis.

In this paper, the features of grave Olmo Bello 16 are commented on. In particular the investigation of the chemical composition, the isotope ratios, and the manufacturing of a silver wire, as well as the identification of some unique and highly informative organic substances, and the discussion of the contents of a flask made of perishable material, provide important new insights on the geographical and cultural dynamism of the highest echelons of Bisenzio, otherwise considered as a peripheric community.

1. Introduction

Over the last three decades, archaeological studies have demonstrated the liveliness and continuity of interactions between the shores of the ancient Mediterranean during chronological windows characterised by paramount socio-economic changes (Broodbank, 2013; Babbi et al., 2015; Sherratt, 2016a, 2016b). Two telling examples of such horizons are the Late Bronze Age (ca. 1200–1000 BCE) with the collapse of palatial societies in the Eastern regions (Morris, 2003), and the end of the Early Iron Age (ca. 800–730/720 BCE) with a reassessment of long lasting regional balances in the central and western districts due to the increasing emergence of Levantine and Aegean newcomers (Malkin, 2011).

This has led the scientific community to reshape the traditional heuristic models and theoretical constructs used to describe the socio-economic balances and dynamics of these periods. Consequently, the classic dichotomy between Braudel's 1995 model of the Mediterranean as a homogeneous region and Horden and Purcell's 2000 view of it as a patchwork of varied microgeographical conditions is being resolved through a multi-scalar approach to / a 'glocal' view of the past. Such an approach combines both a diachronic and generalising perspective (i.e., globalising) and a synchronic, particularising (i.e. localising) analysis

* Corresponding author at: Consiglio Nazionale delle Ricerche, Istituto delle Scienze del Patrimonio Culturale (CNR ISPC), Strada Provinciale 35d, n. 9, 00010 Montelibretti (RM), Italy.

E-mail addresses: andrea.babbi@cnr.it, andrea.babbi@leiza.de (A. Babbi), alessandra.celant@uniroma1.it (A. Celant), giulia.germinario@cnr.it (G. Germinario), jasmine.hertzog@univ-lorraine.fr (J. Hertzog), miriam.lamonaca@cultura.gov.it (M. Lamonaca), fabrizio.michelangeli@uniroma1.it (F. Michelangeli), schmitt-kopplin@tum.de (P. Schmitt-Kopplin), roland.schwab@leiza.de (R. Schwab).

https://doi.org/10.1016/j.jasrep.2026.105750
Received 7 October 2025; Received in revised form 8 March 2026; Accepted 1 April 2026
Available online 13 April 2026

(Broodbank, 2013; Babbi, 2021).

The argument that the aforementioned liveliness and continuity of interactions took place during periods of profound change and animated socio-economic realities undergoing redefinition, convinced scholars to attribute them to not hierarchical but fluid and 'shapeless' forms of interaction (Sherratt, 2010). Thus, academia has moved from the rigid tripartite division of core, semi-periphery and periphery of Wallerstein's (1974, 2004) World-System Theory to the Network Theory's web. The former claims that the balance of a complex system is rooted in inequality, which is fostered by the leading elements of the system itself driving the flow of raw materials and labour from the periphery to the core. In Network Theory, however, it is asserted that 'weak ties' play a significant, continuously evolving and self-constituting role in a widespread web of connections along which different 'contents' move in multidirectional ways, even in the absence of a centralised authority and control (Granovetter, 1983; Barabási, 2003; Watts, 2003; Knappett, 2011, 2020; Malkin, 2011; Donnellan 2020).

The outcome of said new way of perceiving the past has led to a reconsideration of both the 'osmosis surfaces' between the actors and the actors themselves.

The 'osmosis surfaces' have become increasingly three-dimensional and worthy of analysis. From the concept of 'frontier' traditionally understood as liminal and almost static, but which the seminal studies of Moses Finley (1968) and Friederick Barth (1969, 2000) emphasised to be a relative and relational social situation as well as the main place for the creation of new identities both social and ethnic, scholarship has moved on to that of the 'middle ground' (White, 1991). This is quite a useful conceptual tool that describes a 'contact zone' (Pratt, 1991), a 'third space' (Bhabha, 1994) that is not primarily physical, as wisely suggested by Arjun Appadurai (1995) and his deterritorialised 'scapes'. Besides, a 'middle ground' is not located exclusively at the margins of otherwise homogeneous entities, but also within them; furthermore, it is a 'scape' where a new and unprecedented asset of identity traits is generated by the blending of the characteristics of adjacent entities (Maran, 2019). Finally, interactions occur in a 'middle ground' through either understanding fostered by affinities, or creative reinterpretation of external suggestions due to conscious adaptation to contingent expectations and needs or more prosaic and unintentional misunderstandings (Babbi, 2018a).

In relation to 'actors', this term refers to both collective and single entities, such as groups/communities and individuals. The focus of research is increasingly on the multiple specificities of these entities (e.g. interests, priorities, values, worldviews, etc…) (Maran, 2019). Hence, the scholarly vision has moved from one of cultural homogeneity, through the intermediate models of multiculturality and interculturality, to a description of the identities of the 'actors' in a transcultural sense, i.e., profoundly reconfigured by the specific and peculiar agency that allows them to "free themselves from their own culture, and acquire several cultural identities" (Panagiotopoulos, 2011, quotation from p. 36). These 'actors' are therefore "cultural entities […] permeating and shaping each other by their multi-layered connection, non-linear temporalities and transgressions" (Abu-El-Rub et al., 2019, quotation from p. XXVII). Furthermore, such cultural entities are ceaselessly "performed and renegotiated" (Welsch, 1992; Babbi, 2018a; Maran, 2019, quotation from p. 53; Babbi, 2021).

The theoretical prisms described so far offer fundamental tools to better understand the dynamics of the 'middle ground' corresponding to the middle-Tyrrhenian region during the late 8th century BCE (Malkin, 2002, 2011; Cerchiai, 2017). In truth, this landlocked Mediterranean sub-basin has always been a geographical and socio-cultural space of interaction due to its role as a bridge between the Western and Eastern Mediterranean (Babbi, 2013, 2018a, 2018b, 2021). There is no doubt that the local proto-urban communities of the Early Iron Age pinpointed near the coast (e.g. Tarquinia, Cerveteri, Cumae), or even in the immediate hinterland, provided they were located along fast river communication routes (e.g. Vulci on the river Fiora, Rome on the river Tiber), were more exposed to forms of connectivity and interaction.

Nevertheless, recent research has shown that the networks in the interior regions of the Italian Peninsula were also driven by comparable lively dynamics, i.e. a real plethora of 'small worlds' made up of 'nodes' connected through 'ties' spread across the landscape (e.g. Njiboer, 2010; Cerchiai, 2017; Cuozzo and Pellegrino, 2016; Babbi, 2021; Fulminante, 2021; Pellegrino, 2021; Piergrossi, 2022).

In an attempt to contribute and enrich such a picture, this study offers a trans-disciplinary re-examination of a grave hosting one of the above-mentioned 'actors'. The burial turned to light in 1927 at the site of Bisenzio located in the interior of northern Latium (Viterbo), i.e. inland of ancient southern Etruria. Although both the site and the context have long been known, it is thanks to 'The Bisenzio Project' that new knowledge is being systematically acquired and traditional interpretative paradigms about Bisenzio, Southern Etruria and their middle-Tyrrhenian networks are beginning to be readdressed (Babbi, in press).

2. Site, burial ground and burial plot

2.1. The archaeological site at Bisenzio

About 90 kilometres in a beeline NW of Rome (Fig. 1) and four kilometres NW of Capodimonte in the province of Viterbo, the "Monte Bisenzio" promontory rises on the SW shore of the beautiful "Lake Bolsena" (Fig. 2).

Between the 2nd and 1st millennium BCE, an entrepreneurial proto-urban community thrived on and around the promontory. The richness of the burial assemblages and the size of the settlement (90 hectares ca, 130 with the district now under water) make it comparable to the more renowned proto-urban centres of southern Etruria, such as Vulci, Tarquinia, Cerveteri, Veio and Orvieto (Fig. 3).

According to the traditional interpretative paradigm, this community was a secondary centre since the advanced 8th century BCE, while from the seventh century onwards, it would have undergone a gradual and inexorable crisis, culminating in the early 5th century BCE.

Since 2015, the numerous discoveries made by 'The Bisenzio Project' have canvassed a new picture and provided numerous insights that

Fig. 1. Location of Bisenzio in Italy (© The Bisenzio Project, elaboration A. Babbi based on the DEM by Tarquini et al., 2007).

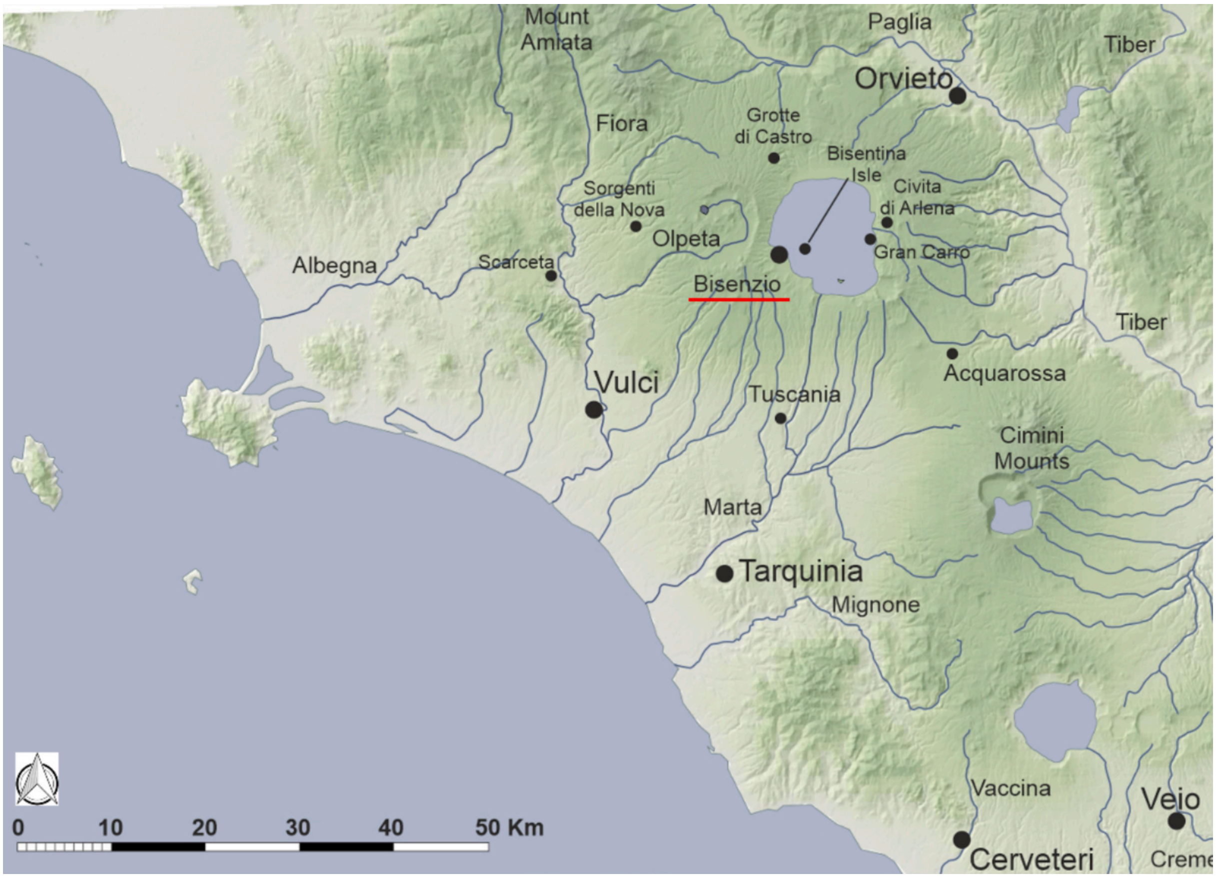

Fig. 2. Location of Bisenzio in Southern Etruria (© The Bisenzio Project, elaboration A. Babbi based on the DEM by Jarvis et al., 2008).

make it urgent to reconsider the traditional socio-historical framework of the region between the 2nd millennium and the 5th century BCE. Actually, it has been possible to backdate the first frequentation of the promontory to at least the beginning of the 2nd millennium (Babbi and Delpino, 2019), to gather clear indications of social enterprise and complexity between the 8th and beginning of the 5th century BCE, for example burials of individuals acting as "nodes" of interregional networks of significance (Babbi and Celant, 2023), a not occasional use of burial mounds still during the transition between the 7th and 6th centuries BCE, the construction of a majestic lithic harbour infrastructure likely in the advanced 6th century BCE (Babbi et al., 2024). This paper discusses some material and ritual features of one of the burials mentioned above, grave 16 from the Olmo Bello necropolis.

2.2. *The Olmo Bello necropolis*

The residential area originally extended on and around "Monte Bisenzio", even where the lake is present today, and was bordered to the S, W and N by extensive burial plots (Fig. 3), most of which were investigated mainly between the late 1800s and the 1960s.

Of the 210 tombs discovered between 1927 and 1931 in the Olmo Bello district, only 75 had not been looted. Sixteen of these were published in 1928 (Babbi et al., 2019).

The graves, grouped into five clusters (A-E), date between the 8th and early 5th century BCE (Fig. 4). In the 8th century BCE, during the period to which the subject of this article, i.e. grave 16, belongs, both pit and trench tombs were documented. These tombs were either simple or contained cylindrical or quadrangular stone cists or wooden or stone sarcophagi. Sometimes the grave was protected and marked by a heap of stones, while the presence of a respect surface could hint at the existence of an actual funerary mound (e.g. grave 2).

2.3. *The burial cluster of grave Olmo Bello 16: highlights*

Grave Olmo Bello 16 belongs to cluster B: 123 burials, 36 of which are preserved and dated mostly to the eighth century BCE. This group can be split into subclusters N, E, S, SW, W.

Grave 16 is part of subcluster N, consisting of varied agglutinations. One of them counts ten preserved burials, nine of which date to the 8th century and one to the 6th century BCE. This agglutination consists of three nuclei: 10, 11, 33, 34; 8, 9; 16, 18–19 (Fig. 5).

Grave 12 can be attributed to the first nucleus due to its isolation from the others and its features: infant interment; 'female' personal accoutrements, varied, and rich in terms of both the intrinsic value of the materials and the technological know-how; buffer area around the grave (occurrence of a burial mound?).

If the cohesive grounds of the first nucleus, based on the archaeological gender, can be biological reproduction-based, those of the other nuclei, consisting of individuals whose social persons were represented and honoured through the display and burial of 'male' objects, seem to be based on other forms of sodality (e.g. kinship, power of function, emotional/love ties). What is certain is that the 'male' accoutrements have yielded offensive and, in four out of five cases, also defensive weapons, albeit in different versions (i.e. functional, parade, and purely symbolic) (Fig. 6).

3. Burial context

3.1. *Structure*

Between 750 and 725 BCE, the rectangular body and slightly convex lid, both monolithic, of an imposing grey tufa cist (1.56×1.01x1.20 m) were laid in a large E-W oriented quadrangular pit (ca. 1.70×1.30 m)

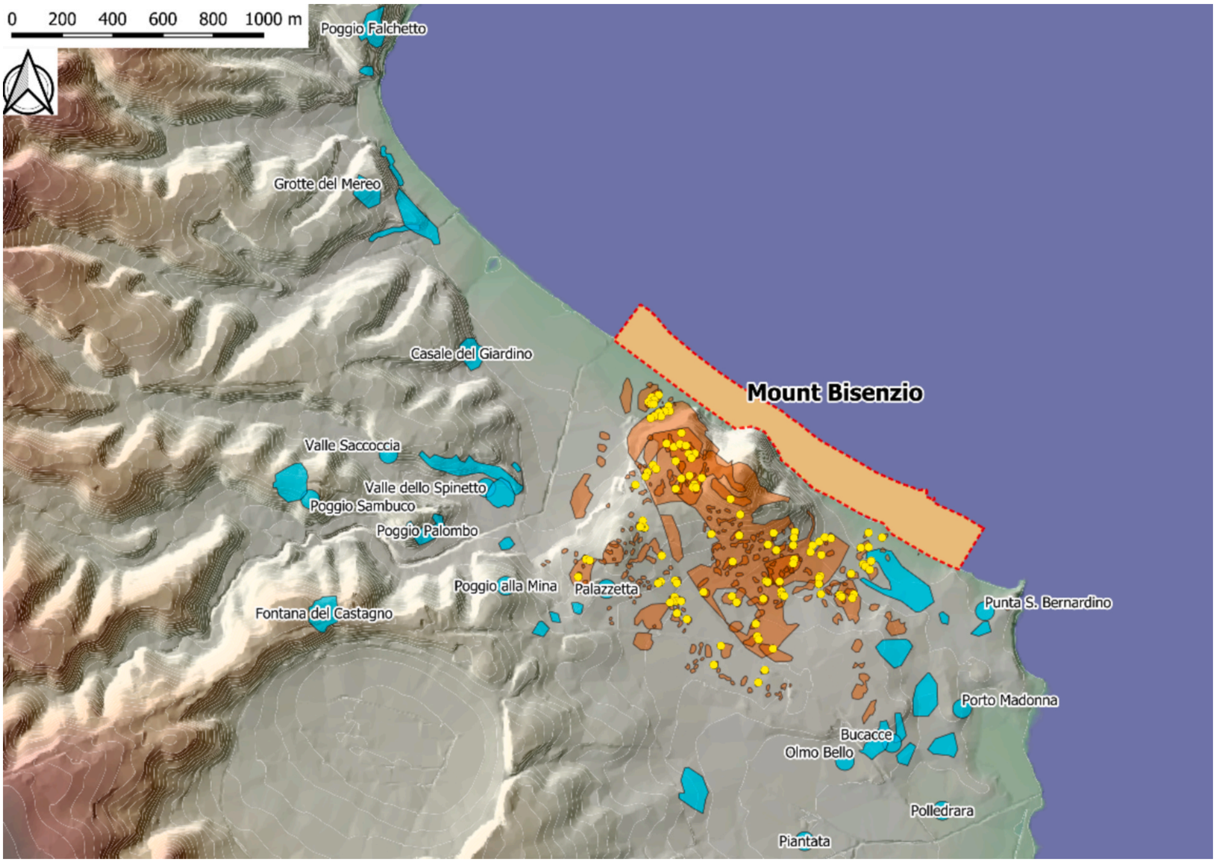

Fig. 3. Bisenzio, residential area (brown, yellow circles location of loom weights), cemeteries (light blue), hypothetical settlement area now underwater (light brown within the red dotted line) (© The Bisenzio Project, A. Babbi).

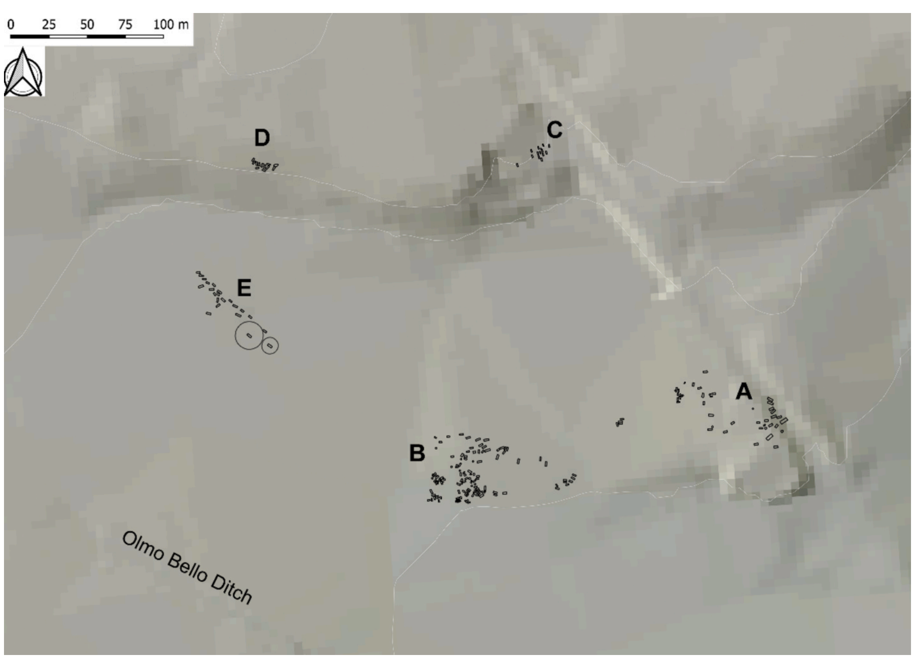

Fig. 4. Bisenzio, Olmo Bello Necropolis, vectorisation of the necropolis plan of the 1930s (© The Bisenzio Project, A. Babbi).

filled by irregular stones (Fig. 7).

In southern Etruria, since the Late Bronze Age, urn and funeral gifts have been deposited in a quadrangular stone cist (Domanico, 1995). However, between the mid-9th and mid-8th centuries BCE, there is an increase in occurrences associated with mostly 'male' grave goods and war markers (Delpino, 1995; Iaia, 1999; Delpino, 2008).

At Bisenzio, only one more rectangular lithic cist was known. This had been found in the 'male' Olmo Bello 10 grave, which dates to the

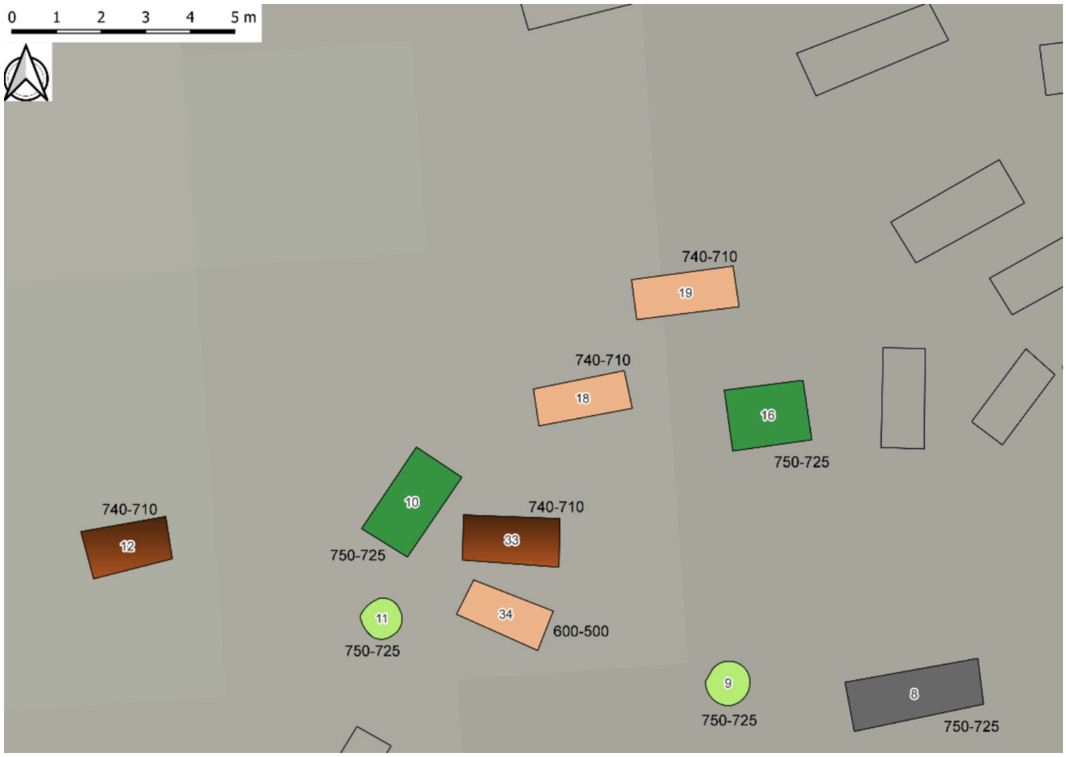

Fig. 5. Bisenzio, Olmo Bello Necropolis, Cluster B, Subcluster N, chronology (meant to be BCE circa), ritual and burial structure (light green: cremation, simple pit; dark green: cremation, stone quadrangular cist; grey: inhumation, stone sarcophagus; brown shaded filling: inhumation, wooden coffin; light brown: inhumation, simple trench) (© The Bisenzio Project, A. Babbi).

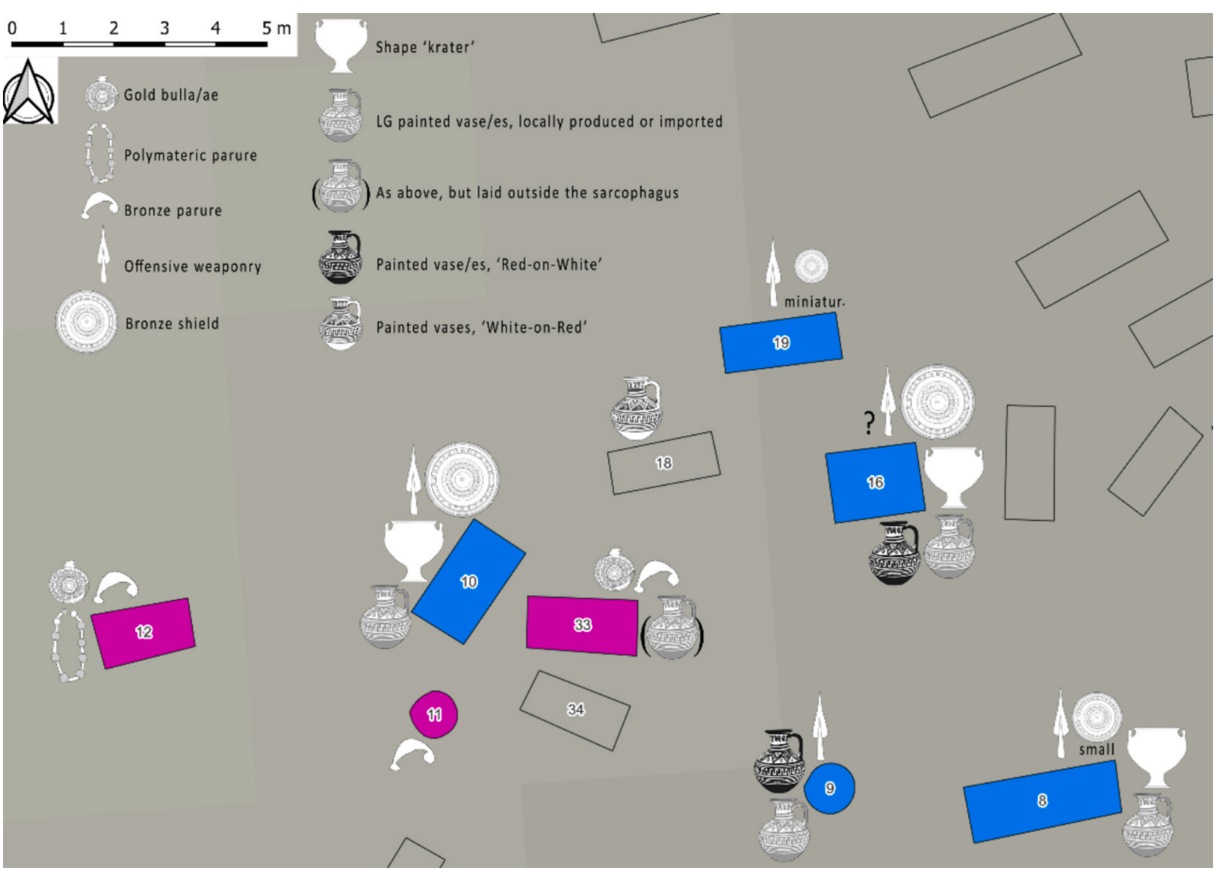

Fig. 6. Bisenzio, Olmo Bello Necropolis, Cluster B, Subcluster N, informative grave offerings and archaeological gender (pink: female; blue: male) (© The Bisenzio Project, A. Babbi).

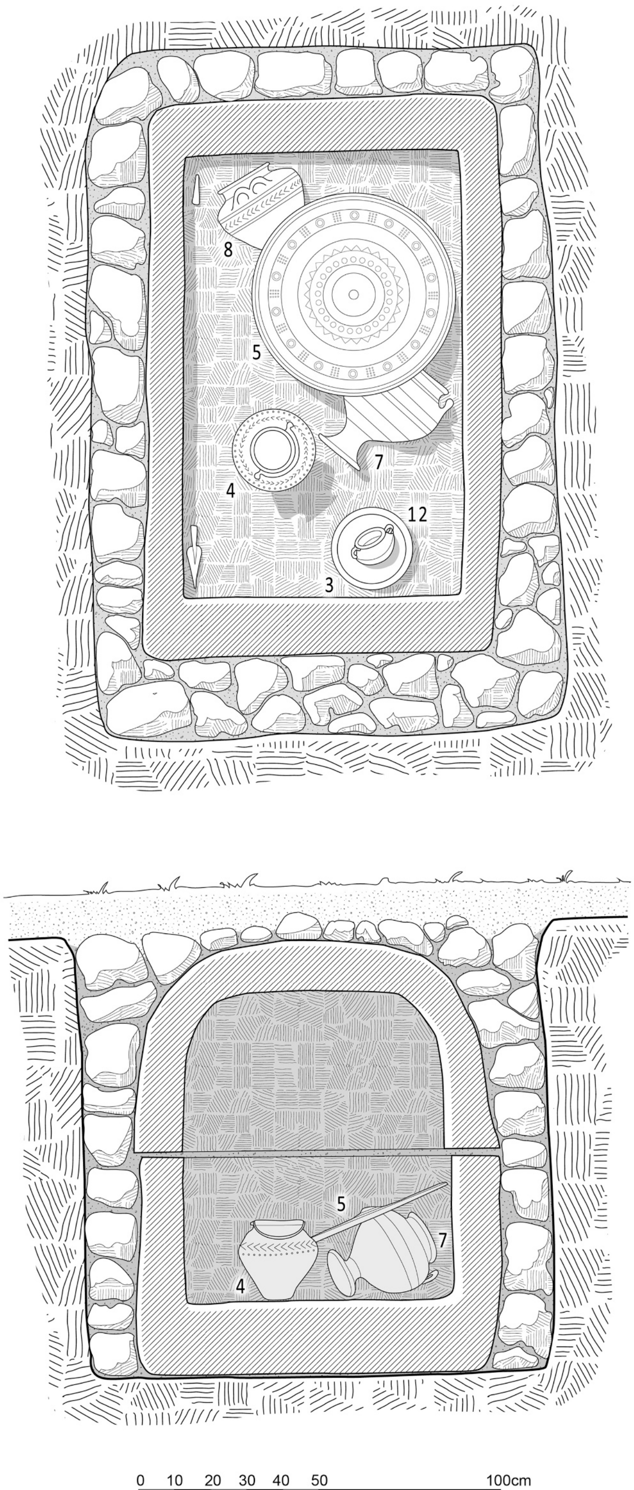

Fig. 7. Bisenzio, Olmo Bello necropolis, Grave 16, Plan and section of the stone cist, and location of some burial gifts (© The Bisenzio Project, T. D'Este based on Paribeni, 1928, Figs. 40-41, and on Biblioteca Apostolica Vaticana, Carte Stefani 53, Foglio 175).

same period as Grave 16. The unpublished documentation from the necropolis revealed the existence of a third specimen from grave Olmo Bello 27, dating to the mid-8th century BCE, and has made it possible to backdate this tradition at Bisenzio and to document its adoption by female figures, too (Babbi and Celant, 2023). Finally, it must be stressed that the occurrences are limited to subcluster N of the cluster B of the necropolis.

3.2. Burial offerings and their location

Grave 16 yielded metal objects, organic remains and clay vessels. Among the former are a bronze serpentine-type fibula with silver thread (1), as well as a cast bronze ring (2), a basin (3), a neck-shaped vase (4) and a round shield (5), all made of bronze sheets (Fig. 8).

The organic finds include two small pieces of wood, the largest of which is worked and shows traces of bronze (6a-b), a small hollow gourd described in the excavation report as a "flask" (6c-d), and leaf remains with bronze oxidation (6e) (Fig. 9).

The ceramic set consists of: three krater-shaped vessels, two of which are globular in fine coarse ware with a cream engobe and red-orange painted decoration (7–8), while the third is pyriform in coarse ware with a dense white engobe and red-orange painted decoration (9); a small fine coarse ware spherical jug with a pierced base, a cream engobe and a red-orange painted decoration (10) (Fig. 10); two coarse ware cups with a high vertical handle (11) and of the "kantharoid" type (12); a coarse ware bowl (13) (Fig. 11). Finally, a lance head and a sauroter occur in the drawing published in 1928, but they are not mentioned in the list of finds, so their real occurrence should be treated with caution.

While vases 7-8 draw on the Late Geometric Euboean/Cycladic repertoire in form as well as in decorative technique and motifs, the other ceramic and metal objects show a local pedigree although 9-10 are hybridised with Aegean influences.

Both the cremated bones and finds 1-2 were in urn 7 which, like 8, lay horizontally under 5. The lance, if really offered, was at one of the long sides of the cist. By the short side, where the spearhead was, and at a short distance from the foot of 7, was 3 containing 12. Near the foot of 7 and the margin of 5 was 4. No location is reported for the other finds.

The social persons of the deceased outlined by the grave goods seem to refer to the spheres of: personal ornamentation (1–2), warfare/legitimacy of the use of violence (lance), political pre-eminence (5), possible aptitude for the performance of rituals (10), geographical mobility (6c-d), availability of solid and semi-solid food (3, 13) and beverages (4, 7–9, 11–12).

3.3. Research questions

Although grave Olmo Bello 16 was published almost one hundred years ago (Paribeni, 1928), the comprehensive study of the Olmo Bello necropolis currently being carried out as part of 'The Bisenzio Project' made it possible to re-examine the burial gifts and to answer the relevant research questions concerning: the origin of the silver and the technological characteristics of the wire wrapped around the fibula (1); the nature of the plant remains to which the organic residues refer (6a-e); the content of the flask (6c-d); the geographical mobility and transcultural attitude of the most prominent actors of the proto-urban communities in the inland middle-Tyrrhenian region.

4. Materials and methods

4.1. Archaeometallurgy of the silver wire

Two samples of the silver wire wrapped around the fibula were made available for archaeometallurgical investigations (Fig. 8.1). One sample has been mounted in epoxy resin and prepared as a flat polished section. The chemical composition of this sample has first been determined by a Micro X-ray fluorescence system (Bruker M4 Tornado) at the Laboratory for Archaeometry at LEIZA in Mainz (Germany). Due to the low lead concentrations, additional Laser Ablation Inductively Coupled Plasma Mass spectrometry (LA-ICP-MS) has been performed at the IRAMAT-CEB laboratory in Orléans (France) using the LA-ICP-MS depth profile mode for two measurements (Blet-Lemarquand, 2021).

After subsequent appropriate specimen repreparation, the flat pol-

Fig. 8. Bisenzio, Olmo Bello necropolis, Grave 16, Metal offerings: 1. fibula, 2. ring, 3. basin, 4. neck-shaped vase, 5. shield (courtesy of Museo Nazionale Etrusco di Villa Giulia. © The Bisenzio Project, A. Babbi, B. Babbi).

ished section has been examined by optical light microscopy (OM) with quantitative image analysis (Leica, LAS X). Grain sizes were determined by the linear intercept procedure and given as mean intercept length $\overline{L}$ (Scott and Schwab, 2019). Micro hardness testing was performed with a Vickers hardness intender at 10 gf test force (HV 0.01) and indentation measurement software (VMS3), with 10 indentations.

The second sample was used for lead isotopic analysis at the German Mining Museum in Bochum (DBM). Lead isotope ratios were determined after chemical separation of the lead following classical HBr based ion exchange chromatography (AG1-X8 resin, Bio-Rad Laboratories, Inc.), with a Thermo-Scientific Neptune Plus high-resolution multi-collector inductively coupled plasma mass spectrometer (HR-MC-ICP-MS). Lead solutions (200 ppb) were doped with 50 ppb thallium (NIST SRM 997) for mass bias correction. ^{202}Hg was recorded for interference correction. The reference material NIST SRM 981 was measured in the same way to compensate drift and ensure accuracy. The recommended values by Taylor et al. (2015) are used for final normalization of the samples. The methodology leads to an external precision better than 50 ppm for ^{204}Pb normalized ratios and 20 ppm for ^{206}Pb normalized ratios (Wajda et al., 2024).

4.2. Technological analysis of the silver wire

The fibula from Tomb 16 at the Olmo Bello necropolis in Bisenzio (Fig. 8.1) represents a valuable example of early metal craftsmanship. Although fibulae were commonly used to fasten clothing in antiquity, they also served as significant archaeological indicators, reflecting cultural identity, socio-economic status, and trade dynamics.

This artefact, a brooch made of copper alloy as hinted at by the green patina and decorated with silver wire wrapped around it, has been

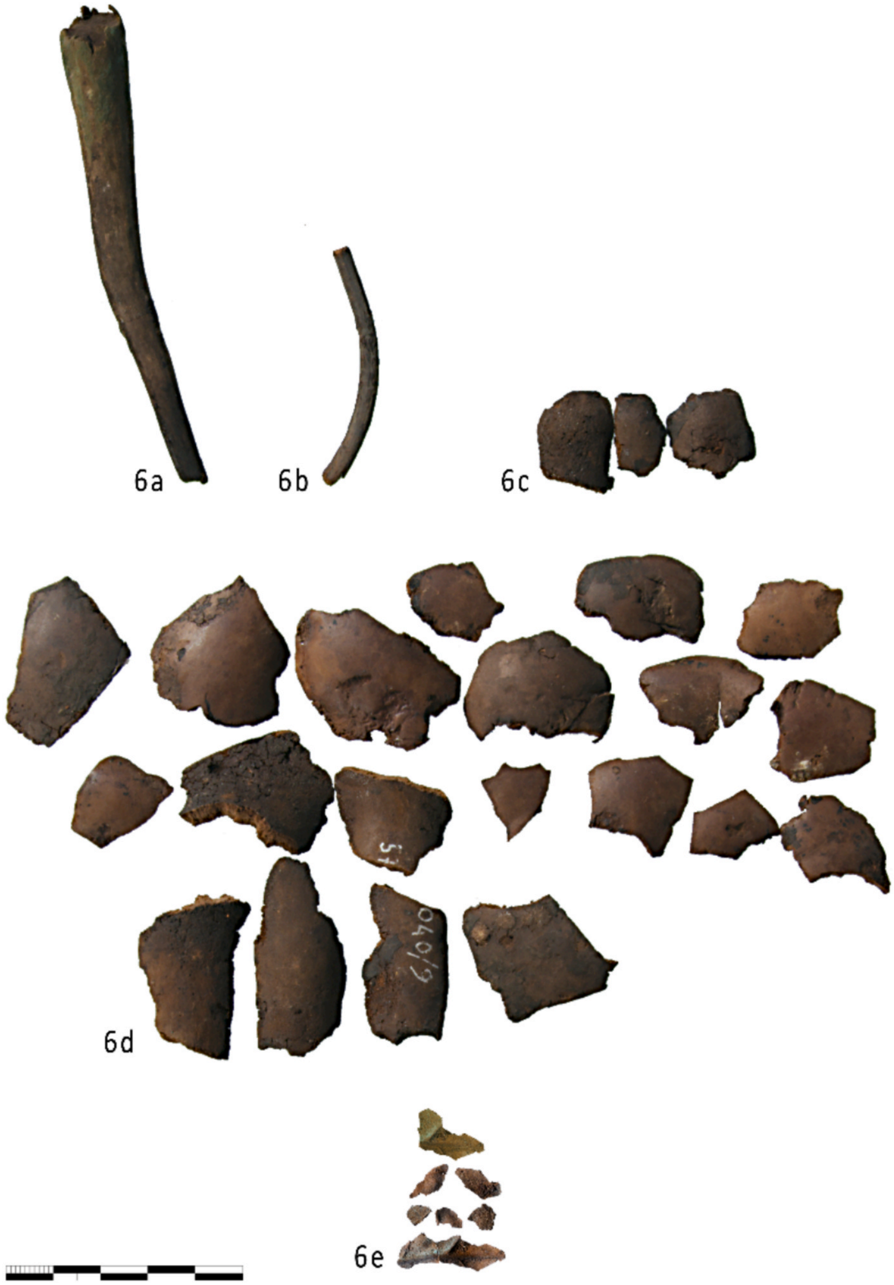

Fig. 9. Bisenzio, Olmo Bello necropolis, Grave 16, Organic offerings: 6a-b. small pieces of wood, 6c-d. gourd-flask, 6e. leaf remains (courtesy of Museo Nazionale Etrusco di Villa Giulia - Rome. © The Bisenzio Project, A. Babbi, B. Babbi).

studied to better understand the technological practices employed in its manufacture and to infer the socio-cultural implications of its design and materials.

The first step involved microscopic observation of the fibula, with the aim of identifying the materials and assessing their state of preservation.

Subsequently, to identify the manufacturing technology of the silver wire, it was essential to document all traces of workmanship, analyse the morphology of the materials, interpret the data, and compare them with analogous cases already published.

Observations were carried out at 50x and 225x magnification by using a digital microscope DinoLite AM 4113 T-FVW.

Only after completing the microscopic observations and the bibliographic research was it possible to hypothesise the use of specific manufacturing techniques and tools, which demonstrate the high level of technical skill achieved by local craftsmen.

4.3. Palaeobotanical analysis

Plant macro-remains, ranging from <1 to ca. 6 cm, were extremely fragile, being mummified by dehydration, sealed off from chemical-physical (oxygen, light, temperature and humidity) and microbiological (fungi, moulds, and bacteria) factors, which usually determine the decomposition of organic plant materials. Wood remains show minimal traces of combustion. Copper oxides, even if they were only partially coating the surface of plant tissues, caused a partial mineralization process and had a biocidal effect.

Wood fragments (Fig. 9.6a-6b) were analysed using non-destructive morphobiometric and histological methods through observation under stereo (20-50x) and metallographic (50-100x) microscopes in order to find diagnostic elements useful for the taxonomic identification (Celant and Coccolini, 2015).

Small amounts of organic powder scraped from the gourd-flask

Fig. 10. Bisenzio, Olmo Bello necropolis, Grave 16, Clay offerings: 7.-8. krater-shaped globular vases, 9. krater-shaped pyriform vase, 10. spherical jug (courtesy of Museo Nazionale Etrusco di Villa Giulia - Rome. © The Bisenzio Project, A. Babbi, B. Babbi).

fragments (Fig. 9.6c-6d) were observed under a light microscope (400x) for phytolith analysis and were processed for pollen analysis using standard techniques (Magri and Di Rita, 2015). The identification of leaf remains (Fig. 9.6e) was done by comparing them to *exsiccata* specimens stored in the Herbarium Museum, Department of Environmental Biology, Sapienza University of Rome.

4.4. ESI FT-ICR MS analysis of samples from the flask

4.4.1. Sample preparation and analysis

Samples 1, 2, and 3 originate respectively from a worked twig (Fig. 9.6a), likely the rim of the opening of the flask (Fig. 9.6c), and the body of the pumpkin gourd (Fig. 9.6d). The analytical methodology is similar to what has been published in previous studies utilizing FT-ICR MS (Hertzog et al., 2021, 2023). Four milligrams of each sample were crushed in an agate mortar with 0.4 mL methanol (LC-MS grade, Fluka, Germany). The achieved mixture was then transferred in a 1.5 mL centrifugation tube, the volume adjusted to 0.5 mL with methanol, and centrifugated. The supernatant was collected to be directly analysed by FT-ICR MS. For sample 2, a dilution by 10 was performed with methanol prior to the analysis. The methanolic solutions were analysed by FT-ICR MS (12 T SolariX, Bruker Daltonics, Germany) in negative-ion mode electrospray (ESI - APOLLO II, Bruker Daltonics, Germany). The source and acquisition parameters were similar to those used in a previous study (Hertzog et al., 2023). Here, 300 scans were accumulated and a resolving power of 280 000 was achieved at m/z 400. The mass spectrometer was calibrated prior to the analysis with a list of well-known fatty acid ions. FT-ICR mass spectra were processed by Compass Data-Analysis 5.0 (Bruker Daltonics, Germany). Internal calibration was performed for each mass spectrum with a list of known archaeological biomarkers and fatty acids, with a standard deviation $<$ 150 ppb.

4.4.2. FT-ICR MS data treatment

A peak list was generated from each mass spectrum with signal-to-noise ratio (S/N) greater than 6 to be then filtered and aligned within a 1 ppm window, as previously described (Hertzog et al., 2023). Molecular assignment was performed with Composer software (Sierra Analytics, Modesto, CA) within a mass accuracy of 1.6 ppm, due to some space charge effects observed with sample 3. Nevertheless, the Root Mean Square deviation achieved from the assignment errors were respectively of 0.09, 0.25, and 0.64 ppm. Compounds were detected in the form of $[M\text{-}H]^-$ and $[M+Cl]^-$ ions. Thus, thousands of features were assigned for the different samples, belonging to CHO, CHON, CHONS, and CHOS heteroatom classes (Fig. 12.c). Assignments were plotted according to their hydrogen-to-carbon (H/C) and oxygen-to-carbon (O/C) ratios to generate a van Krevelen diagram (Fig. 12.d), on which it is possible to evidence biochemical families such as lipids, terpenoids, amino acids, and aromatics (Guigue et al., 2016). Deeper insights into the sample's molecular composition were tentatively done by comparing the achieved elemental molecular formulae with those of known archaeological biomarkers as previously performed (Hertzog et al., 2021, 2023). The obtained concordances allow for some hypotheses on the substances involved in the samples and are gathered in Table 1.

4.5. GC-HRMS analysis of samples from the flask

Two fragments from the pumpkin flask were analysed to identify their organic contents. The former was analysed in its entirety (sample B-1) and subjected to both the Total Lipid Extraction (TLE) and Wine Marker (WM) procedures. The second fragment was mechanically separated under a microscope into two samples: the outer "brownish side" (sample B-2) (Fig. 13.a) and the inner "black side" (sample B-3) (Fig. 13.b), both processed with the TLE protocol.

The TLE and WM extractions were performed with slight modifications to the method described by Garnier and Valamoti (Garnier and Valamoti, 2016). All organic solvents and reagents were of analytical grade and purchased from Sigma-Aldrich. For the TLE, 10 μL of internal standard (IS; tetratriacontane, 1 mg/mL in cyclohexane) was added to the sample, followed by three successive extractions using 2 mL of a dichloromethane–methanol solution (2:1 v/v), aided by vortexing and 15 minutes of sonication. After centrifugation at 3000 rpm for 10 minutes, the combined organic phases were concentrated to 1 mL. From this, 100 μL was recovered and spiked with a second IS (mesaconate, 0.1 mg/mL in water). The sample was dried and derivatized with 40 μL of BSTFA + 1% TMCS in 30 μL of cyclohexane at 70°C for 1 hour (Germinario et al., 2024). For the WM procedure, the TLE-treated sample was dried in an oven at 50°C. To the powdered sample, 10 μL of tridecanoic acid (1 mg/mL in dichloromethane) as IS, 1 mL of boron trifluoride (10% in butanol), and 2 mL of cyclohexane were added. After vortexing, the mixture was incubated overnight at 80°C, instead of 2 hours, proposed by Garnier (Garnier and Valamoti, 2016). This modification was implemented following tests with different standards (malic acid, succinic acid, tartaric acid, vanillic acid, and citric acid), which demonstrated improved efficiency without contamination. The reaction was neutralized with saturated aqueous sodium carbonate, followed by three extractions with 2 mL of cyclohexane each. The extracts were washed with Millipore water and concentrated to 1 mL. From this, a 500 μL aliquot was taken and spiked with 10 μL of mesaconate as IS, then dried and derivatized with 40 μL of BSTFA + 1% TMCS in 30 μL of

Fig. 11. Bisenzio, Olmo Bello necropolis, Grave 16, Clay offerings: 11.-12. cups, 13. bowl (courtesy of Museo Nazionale Etrusco di Villa Giulia - Rome. © The Bisenzio Project, A. Babbi, B. Babbi).

cyclohexane at 70°C for 1 hour.

Blank samples were prepared in parallel without the addition of archaeological material.

All samples were analysed by GC-HRAMS using a Thermo Scientific™ TRACE™ 1310 gas chromatograph coupled with a Q Exactive-GC Orbitrap™ mass spectrometer and equipped with a TriPlus RSH autosampler. One microliter of each derivatized extract was injected into a PTV injector at 300°C in splitless mode. Helium (99.999%) was used as the carrier gas at a flow rate of 1.2 mL/min. Chromatographic separation was achieved on a DB-1HT column (30m × 0.25mm ID × 0.1μm film thickness, Thermo Scientific).

For the TLE analysis, the oven temperature was initially held at 50°C for 2 minutes, then increased at a rate of 10°C/min to 350°C and held for 15 minutes. The transfer line, the auxiliary and ion source temperatures were set at 280°C, 280°C and 320°C, respectively.

For the WM analysis, the oven temperature was held at 50°C for 8 minutes, then ramped at 10°C/min to 350°C and held for 7 minutes. The transfer line, auxiliary, and ion source temperatures were set at 290°C, 290°C, and 320°C, respectively.

Mass spectra were acquired in full scan mode at a resolution of 60,000 FWHM with a scan range of *m/z* 50–750.

5. Results

5.1. Archaeometallurgy of the silver wire

The silver used for the wire has a very high fineness and consists of a more or less unalloyed silver with around one percent of copper and small amounts of minor impurities of gold and bismuth (Tables 2–3).

The lead content of 39 mg Kg^{-1} is unusually low for ancient silver produced by cupellation, which is usually in the permille range up to a few percent (Scott and Schwab, 2019, 162). The microstructure (Table 4) includes no retained cold-work and is heat treated with a few annealing twins but shows several stress corrosion cracks (SCC) on the surface (Wanhill, 2013).

The micro hardness of the samples is still high with 95 HV 0.01, due to the small grain size of 10 μm from the preceded plastic deformation (see below).

For proper discrimination of ore deposits it is necessary to use all isotope ratios, but to illustrate the results, only two bivariate plots are used here. Fig. 14 shows the ratios of radiogenic lead isotopes and figure 15 the ratios normalized to ^{204}Pb compared to those of potential lead/silver deposits. Uranogenic ^{206}Pb is the most mutable variable within the system, which allows an initial assessment of which fields are not applicable, but it has a limited resolution to distinguish between

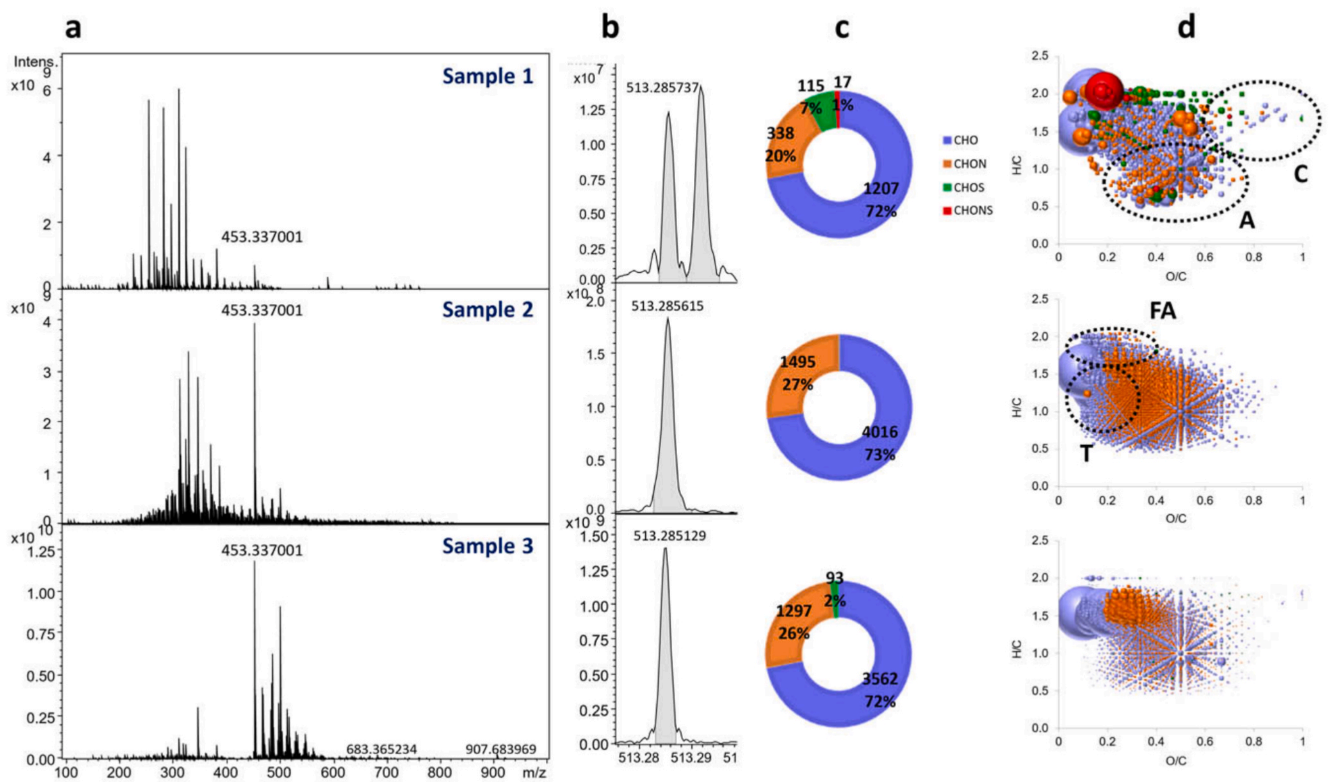

Fig. 12. (a) ESI (-) FT-ICR mass spectra, with (b) expansion at *m/z* 513.285, and corresponding (c) pie charts representing the heteroatom class distribution, and (d) van Krevelen diagrams with bubble size relative to peak intensity obtained for the three Olmo Bello samples, with the area corresponding to the carbohydrates (C), aromatics (A), fatty acids (FA), and terpenoids (T). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.) (© The Bisenzio Project, J. Hertzog, P. Schmitt-Kopplin).

overlapping fields. In any case, it is evident that the lead isotope ratios of the wire do not fit Eastern Mediterranean lead/silver deposits, but best match the lead-zinc ores from the Linares - La Carolina area within the Central Iberian Zone (CIZ) of Spain (Table 5, Fig. 14).

Silver from Spain was used for several objects in Etruria and more generally in the middle-Tyrrhenian district (Fig. 15).

Indeed, the lead content of the wire is not concordant with silver, extracted from argentiferous ores by cupellation. Thus, it cannot derive from argentiferous lead ores and probably consists of native silver or silver smelted directly from silver ores. Similarly, low lead values were found in one sample from silver vessels from a tomb in Tarquinia, which has been interpreted to consist of native silver (Pernicka, 2013, 180-181). Native silver is known from Linares and the composition of native silver also corresponds to the composition of the wire (Murillo-Barroso et al., 2014).

5.2. Technological analysis of the silver wire

Microscopic observation of the structural components of the fibula made it possible to detect traces of workmanship and to identify the technology employed in its manufacture.

The fibula features a serpentine, elbow-shaped arch with two small lateral pointed protrusions (Fig. 16), made of a copper alloy and entirely covered with a thin silver wire, tightly wound along its entire length.

The brooch is extremely thin (1 mm – 1,8 mm) and is now highly corroded. No remains of the metal are preserved on the surface, suggesting its complete loss due to corrosion and/or surface degradation (Fig. 17).

The silver wire is of particular interest. It was applied with extreme precision, closely coiled along the entire visible surface of the bow. Notably, the wire itself is not circular in section and displays pronounced lateral flanges (Fig. 18).

The wire has a variable width of less than 1 mm and a maximum thickness of approximately 0.15 mm.

Wire drawing typically involves pulling metal through a sequence of successively smaller holes, producing a uniform circular cross-section (Formigli, 1971). The absence of the characteristic horizontal striations also speaks against this method.

Instead, the silver wire was likely produced using a rolling technique. A small silver bar was inserted between two grooved rollers, which compressed the metal and gave it a decorative flanged profile. When examining the potential use of rollers during the Etruscan period, it is important to think of a device of remarkable simplicity. The metal sheets or wires are thought to have been processed in several steps to achieve very small thicknesses. Similarly, the rollers, possibly made of hard stone, may have been housed in a simple, box-like frame that allowed them to rotate freely without the need for cranks or gears. It is also conceivable that the wire itself was pulled, causing the rollers to turn and feed the wire through, rather than the rollers being rotated to do so (Formigli, 1989).

By using progressively finer grooves, the craftsman could reduce the thickness of the wire incrementally (Fig. 19).

This method was clearly employed for aesthetic as well as functional reasons. The lateral flanges created a contrast of filled and open spaces, contributing to the overall ornamental effect and firmly anchoring the silver to the brooch (Formigli, 1989). Indeed, the lateral ridges are highly pronounced and exhibit irregular width (a similar feature occurs on a gold wire wrapped around a fibula from Tarquinia nowadays at the National Archaeological Museum of Florence, Formigli, 1989, Pl. LXI.b).

An alternative technique consists of positioning a round wire onto a concave-grooved surface and subsequently hammering it, thereby producing lateral ridges through plastic deformation. However, this method

Table 1
List of archaeological biomarker candidates found by ESI (-) FT-ICR MS in the 3 samples from Olmo Bello based on their molecular formulae. Sample 1 originates from a worked twig, sample 2 from the rim of the opening of the flask, and sample 3 from the body of the pumpkin gourd.

Compound Class	Candidate	Formula	Samples		
			1	2	3
Aromatics	Vanillic acid	$C_8H_8O_4$	x		x
	Vanillin	$C_8H_8O_3$			x
	Homovanillin	$C_9H_{10}O_3$	x		x
	Hydroxycinnamic acid	$C_9H_8O_3$			x
	Syringaldehyde / Veratric acid	$C_9H_{10}O_4$	x	x	x
	Syringic acid	$C_9H_{10}O_5$	x	x	x
	Coniferyl alcohol	$C_{10}H_{12}O_3$	x	x	x
	Methoxycinnamic acid / Coniferaldehyde	$C_{10}H_{10}O_3$	x	x	x
	Dihydroferulic acid	$C_{10}H_{12}O_4$	x	x	x
	Ferulic acid	$C_{10}H_{10}O_4$	x	x	x
Fatty acids	Octanoic acid - FA(C8:0)	$C_8H_{16}O_2$	x		
	Nonanoic acid - FA(C9:0)	$C_9H_{18}O_2$	x		
	Hydroxydecanoic acid	$C_{10}H_{20}O_3$	x		x
	Decanoic acid - FA(C10:0)	$C_{10}H_{20}O_2$	x		
	Undecanoic acid - FA(C11:0)	$C_{11}H_{22}O_2$	x		
	Hydroxyhexadecanoic acid	$C_{16}H_{32}O_3$	x		
	Hexadecanoic acid (palmitic acid) - FA (C16:0)	$C_{16}H_{32}O_2$	x		x
	Hexadecenoic acid (palmitoleic acid) - FA(C16:1)	$C_{16}H_{30}O_2$	x		
	Hydroxyoctadecanoic acid	$C_{18}H_{36}O_3$	x		
	Dihydroxyoctadecanoic acid	$C_{18}H_{36}O_4$	x	x	x
	Linolenic acid - FA(C18:3)	$C_{18}H_{30}O_2$	x		
	Octadecenoic acid (oleic acid) - FA (C18:1)	$C_{18}H_{34}O_2$	x		
	Hydroxyoctadecenoic acid (ricinoleic acid)	$C_{18}H_{34}O_3$	x		x
	Octadecanoic acid (stearic acid) - FA (C18:0)	$C_{18}H_{36}O_2$	x		x
	Octadecatetraenoic acid - FA(C18:4)	$C_{18}H_{28}O_2$	x	x	
	Nonadecylic acid - FA(C19:0)	$C_{19}H_{38}O_2$	x		x
	Hydroxyeicosanoic acid	$C_{20}H_{40}O_3$	x	x	x
	Dihydroxyeicosanoic acid	$C_{20}H_{40}O_4$	x	x	x
	Hydroxydocosanoic acid	$C_{22}H_{44}O_3$	x	x	x
	Docosanoic acid - FA(C22:0)	$C_{22}H_{44}O_2$	x		
	Dihydroxydocosanoic acid	$C_{22}H_{44}O_4$	x	x	x
	Docosenoic acid	$C_{22}H_{42}O_2$	x		
	Tricosanoic acid - FA(C23:0)	$C_{23}H_{46}O_2$	x		
	Dihydroxytetracosanoic acid	$C_{24}H_{48}O_4$	x	x	x
	Tetracosanoic acid - FA(C24:0)	$C_{24}H_{48}O_2$	x	x	
	Tetracosenoic acid	$C_{24}H_{46}O_2$	x		
	Hexacosanoic acid - FA(C26:0)	$C_{26}H_{52}O_2$	x	x	
	Octacosanoic acid - FA(C28:0)	$C_{28}H_{56}O_2$		x	
	Triacontanoic acid - FA(C30:0)	$C_{30}H_{60}O_2$	x	x	
	Dotriacontanoic acid - FA(C32:0)	$C_{32}H_{64}O_2$	x	x	
Diacids	Hexanedioic acid	$C_6H_{10}O_4$			x
	Heptanedioic acid	$C_7H_{12}O_4$	x		x
	Octanedioic acid	$C_8H_{14}O_4$	x		x
	Hydroxynonanedioic acid	$C_9H_{16}O_5$	x	x	x
	Nonanedioic acid	$C_9H_{16}O_4$	x	x	x
	Decanedioic acid	$C_{10}H_{18}O_4$	x	x	x
	Hexadecanedioic acid	$C_{16}H_{30}O_4$			x
	Octadecenedioic acid	$C_{18}H_{32}O_4$	x	x	x
Glycerides	Monoacylglycerol (MAG) - C14:0	$C_{17}H_{34}O_4$	x	x	x
	MAG - C16:0	$C_{19}H_{38}O_4$	x	x	x
	MAG - C18:0	$C_{21}H_{42}O_4$	x	x	x
	MAG - C18:1	$C_{21}H_{40}O_4$	x		
	Diacylglycerol - C14:0	$C_{31}H_{60}O_5$	x		
Diterpenes	15-Hydroxy-7-oxodehydroabietic acid	$C_{20}H_{26}O_4$		x	x
	15-Hydroxydehydroabietic acid / 7-α,7-β Hydroxydehydroabietic acid	$C_{20}H_{28}O_3$	x	x	x
	3-Hydroxy eperuic acid	$C_{20}H_{34}O_3$	x	x	x
	7-Oxodehydroabietic acid	$C_{20}H_{26}O_3$	x	x	x
	Abietic/Sandaracopimaric/ Isopimaric/Communic acid	$C_{20}H_{30}O_2$	x	x	x
	Agathalic acid	$C_{20}H_{30}O_3$	x	x	x
	Agatholic acid	$C_{20}H_{32}O_3$	x	x	x
	Dehydro-7-dehydroabietic acid	$C_{20}H_{26}O_2$		x	
	Dehydroabietic acid	$C_{20}H_{28}O_2$	x	x	x
	Dihydroisopimaric acid	$C_{20}H_{32}O_2$	x	x	x
	Pinifolic acid	$C_{20}H_{32}O_4$	x	x	x
	Methoxydehydroabietic acid	$C_{21}H_{30}O_3$	x	x	x
	Tetradehydroabietic acid	$C_{22}H_{22}O_2$		x	
Diterpenes heated	18-nor-7-Oxo abietane	$C_{19}H_{32}O$			x
	7-Oxodehydroabietic acid (Me)	$C_{21}H_{28}O_3$		x	x
	Methyl dehydrobietate	$C_{21}H_{30}O_2$		x	
Triterpenes	11-Keto-boswellic acid	$C_{30}H_{46}O_4$	x	x	x
	Betulin / Hydroxydammarenone / Hydroxyhopanone	$C_{30}H_{50}O_2$		x	x
	Betulinic / Boswellic / Masticadienolic / Ursolic / Oleanolic acid	$C_{30}H_{48}O_3$	x	x	x
	Moronic / Oleanonic / Masticadienonic / Ursonic acid	$C_{30}H_{46}O_3$	x	x	x
	Oleanonic aldehyde	$C_{30}H_{46}O_2$		x	x
	Ursolic aldehyde /Oleanolic aldehyde / Betulone / Allobetulone	$C_{30}H_{48}O_2$		x	x
	Moronic / Oleanonic methyl ester	$C_{31}H_{48}O_3$			x
	3-O-Acetyl-11-keto-boswellic acid	$C_{32}H_{48}O_5$	x	x	x
	3-O-Acetyl-boswellic acid	$C_{32}H_{50}O_4$	x	x	x

presents certain limitations: the hammering is not always uniform, and the wire may shift from its guiding groove during the process. In the case of the fibula under study, this technique appears unlikely, as no traces of hammering are visible on the flat underside of the wire, which was in contact with the brooch.

The object's poor preservation complicated the interpretation, but the combined analysis of microstructure, fabrication traces, and morphological features supports a complex manufacturing process involving intentional decorative manipulation of silver. It also sheds light on the supply dynamics of raw materials in Bisenzio and the processes through which technical knowledge was transmitted.

5.3. Palaeobotanical analysis

Plant macro-remains show a mixed type of fossilization, frequent in ritual contexts and specifically in burials with grave goods characterised by the presence of objects in metal alloys.

The morphological features of the carpological fragments from the gourd-flask allow identifying it as the thick and rigid pericarp of a small fleshy fruit of *Lagenaria siceraria* (Molina) Standl. (family Cucurbitaceae) with a long and narrow neck. The morphology of the phytoliths recovered from the pericarp (Fig. 9.6c-d) is consistent with the description of phytoliths from the mesocarp of Medieval remains of *Lagenaria siceraria* from Hungary (Pető et al., 2017). Specifically, the concave impressions that characterize mesocarp phytoliths of *Lagenaria* are clearly visible in the gourd from Olmo Bello (Fig. 20).

Measurement of 50 phytoliths revealed an average length of 57.62 mm and an average width of 39.44 mm. This size is slightly larger than the Hungarian materials (average length 53.33 mm, average width 21.87 mm). The presence of *Lagenaria* in tomb 16 was possibly connected to the transportation of liquids in the afterlife, but unfortunately pollen analysis did not reveal any content of the gourd. The fragments of *Lagenaria* from Olmo Bello are the oldest evidence of the usage of this plant in Central Italy. In Northern Italy, *Lagenaria siceraria* is sporadically recorded since the Iron Age (Maselli Scotti and Rottoli, 2007) but it spread only in the Roman Imperial period, as attested in several sites (Schlumbaum and Vandorpe, 2012; Bosi et al., 2020, 2023). Archaeobotanical records from Central Europe, including sporadic presence of seeds and fragments of the mummified pericarp, were only connected to domestic activities (wells, pits) in settlement, urban structures, and port areas, located in France, Switzerland, and Germany (Schlumbaum and

Fig. 13. The pumpkin flask samples where a) the outer brownish and b) the inner black layers are clearly visible (courtesy of Museo Nazionale Etrusco di Villa Giulia - Rome. © The Bisenzio Project, A. Babbi, B. Babbi).

Table 2
Composition of the wire by µXRF (in wt %).

Object	Inv. No.	Cu	Ag	Au	Pb	Bi
Wire	57040/2	1.6	97.9	0.4	<0.01	0.1

Vandorpe, 2012). These finds were not older than the 1st century CE and more frequently dated to the Roman Imperial period up to the 5th century CE, testifying to the rapid process of Romanization that spread beyond the Alps.

In the leaf remains from Olmo Bello (Fig. 9.6e), the presence of secondary veins on the lower (abaxial) surface and the ornamentation of the upper (adaxial) surface allowed the identification of *Vitis vinifera* L., grapevine (Fig. 21.a-b). Also, two small wooden fragments (Fig. 9.6a-b), showing large, solitary vessels and wide rays in the transversal surface (Fig. 21.c), belong to *Vitis vinifera*. Both leaf remains and wood testify to the use of grape shoots in funeral rituals.

5.4. ESI FT-ICR MS analysis of samples from the flask

The heteroatom compositions achieved by ESI (-) FT-ICR MS for the 3 different samples are similar with most of the assignments (73%) related to CHO class, followed by CHON compounds (Fig. 12.c).

The van Krevelen diagram of the sample 1 (Fig. 12.d) is in line with a woody material, as areas corresponding to lipids, aromatics from lignin, and a few carbohydrates originating from cellulose and hemicellulose were observed (Qiu et al., 2022; Roullier-Gall et al., 2018). Comparison of achieved assignments with known archaeological biomarkers evidence confirmed the presence of aromatics, and lipids with some fatty acids and monoacylglycerides. Some matchings with terpenoids were obtained with several diterpenes and triterpenes. The former class indicates the presence of conifer resin (Łucejko et al., 2017) while the second one is specific to other kind of trees such as pitch from bark (betulin derivatives), frankincense (boswellic acid derivatives) or resin from *Pistacia lentiscus* (ursonic, ursolic, and oleanane derivatives) (Colombini and Modugno, 2009; Ménager et al., 2014; Orsini et al., 2015). These compounds could originate from the content of the flask embedded with the wood.

More assignments were achieved in sample 2 than in the previous one, with 5500 distinct formulae. Based on the van Krevelen diagram, these species are aromatics, lipids, and terpenoids (Fig. 12.d). Among these assignments, there are some concordances with some aromatics that can originate from vegetal decomposition (Table 2). Conifer resin is also suggested with putative diterpenes. Interestingly, some possible biomarkers of heated pine resin were obtained with, methyl dehydrobietate and methyl 7-oxodehydroabietic acid (Colombini et al., 2005). Heating was also suggested with the presence of putative triterpenes relative to pitch from birchbark or frankincense, related either to a waterproofing material or as part of rituals using incense. Some ursonic and oleanane derivatives were also likely found. Indeed, the

Table 4
Results of the metallographic examination.

Object	Microstructure	L	Corrosion	HV 0.01
Wire	α_{Ag} annealed	10 µm	SCC on the surface	95 ± 5

Table 3
Composition of the wire by LA-ICP-MS.

Object	Inv. No.	Main components [%]			Trace elements [mg/kg]											
		Cu	Ag	Au	Mn	Fe	Co	Ni	Zn	As	Pd	Sn	Sb	Pt	Pb	Bi
Wire	57040/2	1.1	98.6	0.21	0.4	18	0.3	0.1	1.2	3.7	4.1	4	0.3	5.1	39	890

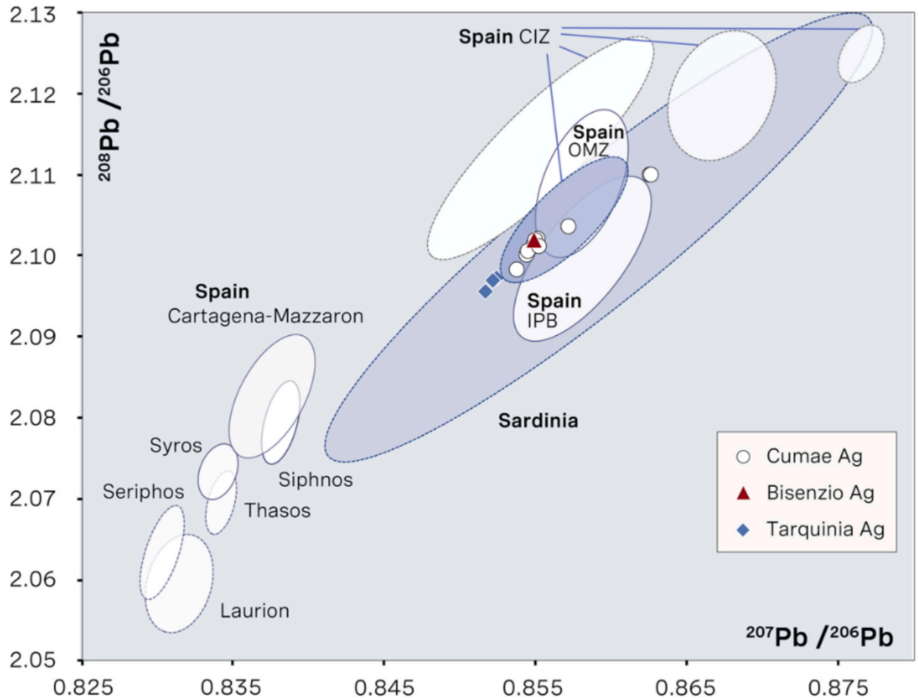

Fig. 14. Pb/Pb diagram showing the isotopic bias between Etruscan silver from Bisenzio, Tarquinia (Pernicka 2013) and Cumae (unpublished) and lead ores from the Mediterranean area (© The Bisenzio Project, R. Schwab). The error bars are smaller than the dots (ore data taken from Arribas and Tosdal, 1994; Baron et al., 2017; Boni and Koeppel, 1985; Graeser and Friedrich, 1970; Hunt Ortiz, 2003; Lillo, 1992; Marcoux, 1998; Orgeval et al., 2000; OXALID; Pomiès et al., 1998; Santos Zalduegui et al., 2004; Santos Zalduegui et al., 2007; Subías et al., 2010; Swainbank et al., 1982; Tornos and Chiaradia, 2004; Valera et al., 2005; Vavelidis et al., 1985).

Table 5
Lead isotope ratios.

Inv. No	Object	$^{208}Pb/^{206}Pb$	2SE	$^{207}Pb/^{206}Pb$	2SE	$^{206}Pb/^{204}Pb$	2SE	$^{207}Pb/^{204}Pb$	2SE	$^{208}Pb/^{204}Pb$	2SE
57040/2	wire	2.1019	0.0002	0.85489	0.00005	18.317	0.003	15.659	0.003	38.501	0,008

most abundant peak observed at *m/z* 453.337001 is assigned with the molecular formula $C_{30}H_{45}O_3^-$, which can correspond to a triterpene such as moronic, oleanonic, masticadienonic, or ursonic acid, observed in resinous material (Colombini and Modugno, 2009).

Regarding sample 3, its global composition is very close to that of sample 2, even with the matchings (Table 2). However, the mass spectrum shows some specific higher-mass (> 450 Da) components (Fig. 12.a). For instance, one peak was more intensely detected at *m/z* 513.285129 that was assigned with the formula $C_{30}H_{41}O_7^-$ (Fig. 12.b). This feature can be putatively regarded as Cucurbitacin I, a triterpene observed in Cucurbitaceae plants (Attar and Ghane, 2018), such as *Lagenaria siceraria*, also known as bottle gourd, already used in Antiquity (Janick et al., 2007).

Overall, the non-targeted FT-ICR MS analyses on the 3 samples originating from a gourd-flask evidenced organics belonging to different biochemical classes. Molecular fingerprint and biochemical classes achieved for sample 1 agreed with a woody material, with possibly some residual flask content. Sample 2 was shown to have more molecular assignments notably relative to diterpenoid and triterpenoid components from resinous materials. Some putative biomarkers of heated pine tree resin were also found. Some aromatics were observed whose origin cannot be ascertained. For sample 3, similar putative biomarkers as in sample 2 were found. But this sample was also characterized by higher mass species comprising some triterpenoid species and more especially, the putative Cucurbitacin I. The results are coherent with those obtained in GC-HRMS (see par. 4.5.), which also evidenced several fatty acids and aromatics, as well as pine tree resin with a heating process, and *Pistacia lentiscus* resin.

5.5. GC-HRMS analysis of samples from the flask

The total lipid extraction (TLE) procedure enabled the recovery of multiple classes of compounds from the entire sample of the pumpkin flask (Table 6).

The detection of glycolic acid, malonic acid, succinic acid, vanillic acid, and syringic acid supports the hypothesis that the flask contained a fermented fruit juice, such as apple, pear, or grape. To exclude the presence of wine, the sample was also subjected to the WM procedure. In the WM chromatogram (not shown), several other monocarboxylic acids (benzoic, octanoic, nonanoic, decanoic, and dodecanoic acids), dicarboxylic acids (oxalic, glycolic, malonic, hydroxybutyric, succinic, malic, and adipic acids), and tricarboxylic acids (glyceric acid, citramalic acid, and 2-hydroxybutanedioic acid) were identified, which are consistent with the presence of fruit juices such as apples, grapes, and/or oranges (Sai Lakshmi et al., 2022).

In the TLE chromatogram (Fig. 22), the presence of saturated fatty acids (C9:0, C10:0, C12:0, C14:0, C16:0, and C18:0) and unsaturated fatty acids (C16:1 and C18:1) suggests the use of vegetable oil. In contrast, the detection of C15:0 and C17:0 and unsaturated C12:1 and C17:1 indicates the possible presence of degraded ruminant fats. The identification of 2-hydroxy-6-pentadecylbenzoic and 2-hydroxy-6-tridecylbenzoic acids, both salicylic acid derivatives, points to medicinal plants belonging to the *Anacardiaceae* family. Among them, *Pistacia lentiscus* (mastic tree) resin was historically used in Central Italy during

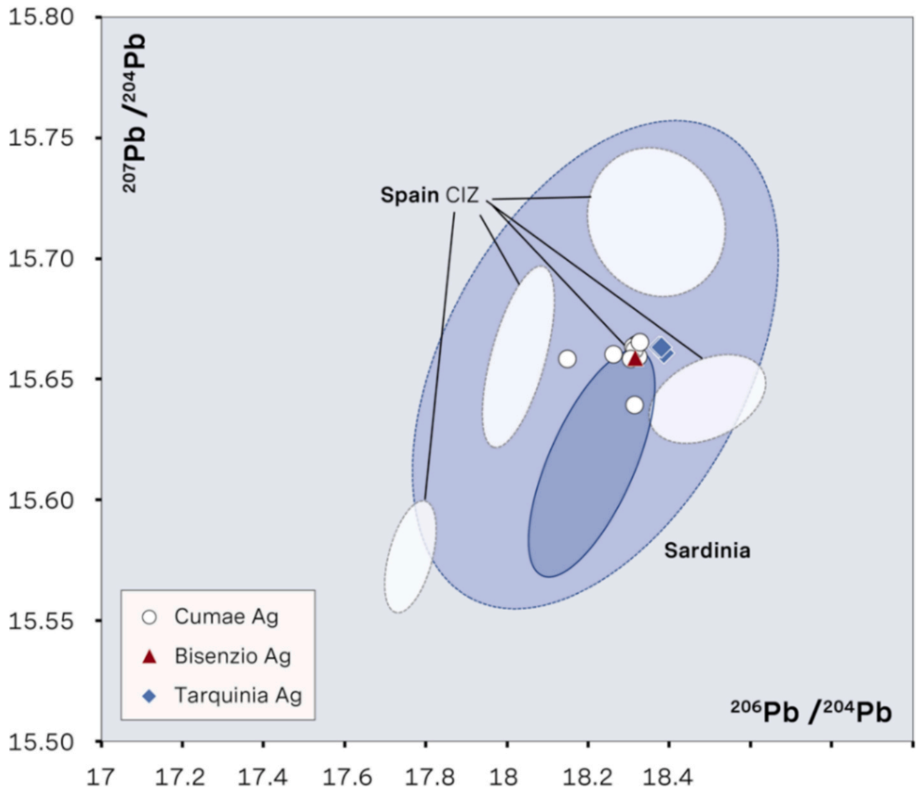

Fig. 15. Comparison of ^{207}Pb/ ^{204}Pb and ^{206}Pb/ ^{204}Pb ratios of Etruscan silver and lead ores from Spain and Sardinia (© The Bisenzio Project, R. Schwab).

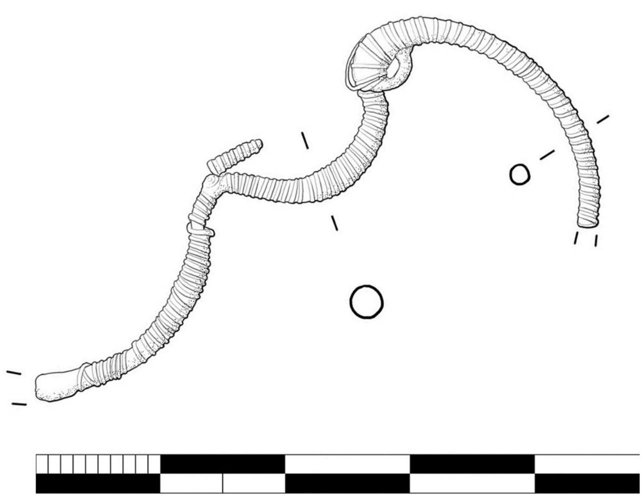

Fig. 16. Bisenzio, Olmo Bello necropolis, Grave 16, Fibula with silver wire, drawing (© The Bisenzio Project, T. D'Este).

the first millennium BCE for treating digestive disorders, ulcers, and infections (Pachi et al., 2020).

Additionally, the detection of monoterpenes, sesquiterpenes, and pentacyclic triterpenes with 12-oleanane (moronic acid, 28-norolean-17-en-3-one and a β-amyrin oxidation product), and lupanes with an unsaturated side chain (masticadienoic acid, iso masticadienoic acid, lupa-12,20(29)-dien-3-one) skeletons is consistent with the presence of an oxidized *Pistacia lentiscus* resin (Assimopoulou and Papageorgiou, 2005). The identification of ursane-type compounds, such as ursolic acid, α-amyrin, and α-amyrone, is not consistent with *Pistacia lentiscus* resin. However, the co-occurrence of ursane-, lupane-, and oleanane-type compounds may be associated with dammar resin. Nevertheless, its presence cannot be confirmed, as no characteristic products were detected by monitoring *m/z* 205, corresponding to the fragment ion generated from the dammarane skeleton. Dehydroabietic acid was also detected, serving as a biomarker for the *Pinus* species. Moreover, the identification of two norabietadiene isomers, 18-norabieta-8,11,13-triene, retene and methyl dehydroabietate supports both oxidative and thermal degradation of this resin (Dimitrakoudi et al., 2011). In particular, the detection of retene and methyl dehydroabietate is considered as key diagnostic diterpenoid biomarkers used to identify Pine pitch (Davara et al., 2023).

Polyphenols and carotenoids identified in the chromatogram are characteristic constituents of pumpkin fruit, particularly concentrated in the peel (Dhenge et al., 2022). The detection of long-chain esters of palmitic and stearic acid, together with odd-numbered alcohols (nonanol, tridecanol, and pentadecanol), likely derives from the cuticular wax of the pumpkin or of the fruit it once contained. These alcohols are interpreted as degradation products of esters. The advanced degradation state of the sample likely accounts for the absence of long-chain even-numbered hydrocarbons and fatty acids (Regert et al., 2001).

Comparison of chromatographic profiles from the outer (B-2) and inner (B-3) layers of the flask (Table 6) yielded noteworthy, albeit inconclusive, results. In both layers, fatty acids of plant and animal origin were identified; however, a higher concentration of animal fats in the outer layer suggests possible environmental contamination. Compounds associated with Pine resin, and its oxidative degradation were present in both layers, whereas retene and methyl dehydroabietate —indicative of Pine pitch treatment—was found exclusively in the outer layer. Signals attributable to *Pistacia lentiscus* resin were absent in both layers, preventing confirmation of its deliberate use within the flask.

6. Discussion and conclusions

The burial assemblage from grave Olmo Bello 16 in Bisenzio, which belonged to one of the preeminent actors in the local community, hints at a combination of native and foreign rituals.

Fig. 17. Bisenzio, Olmo Bello necropolis, Grave 16, Fibula's body, 50x magnification (© The Bisenzio Project, M. Lamonaca).

Fig. 18. Bisenzio, Olmo Bello necropolis, Grave 16, Detail of silver wire, 50x magnification (© The Bisenzio Project, M. Lamonaca).

The former is documented by the tomb structure (a lithic cist composed of two monolithic elements), a large part of the grave goods (ornaments, a bronze ceremonial shield, possibly a spear, bronze vessels, an unpainted coarse-ware ceramic set, a coarse-ware krater-shaped vessel with red engobe and cursive geometric decoration overpainted in red-orange), the cremation ritual, and the deposition of the shield nearby and perhaps at the close of the urn. An exogenous rituality is primarily evident in the shape and decoration of the urn and its sister vessel (Fig. 10.7-8), as well as by the decoration of the jug (Fig. 10.10). Interestingly the latter was not used for pouring, but rather for allowing the liquid inside to percolate (filter?) through the small holes that had been opened in the bottom since its manufacture. Apart from their affinity with Euboean and Cycladic forms and decoration, it is worth emphasising that the two kraters and the jug were most likely produced

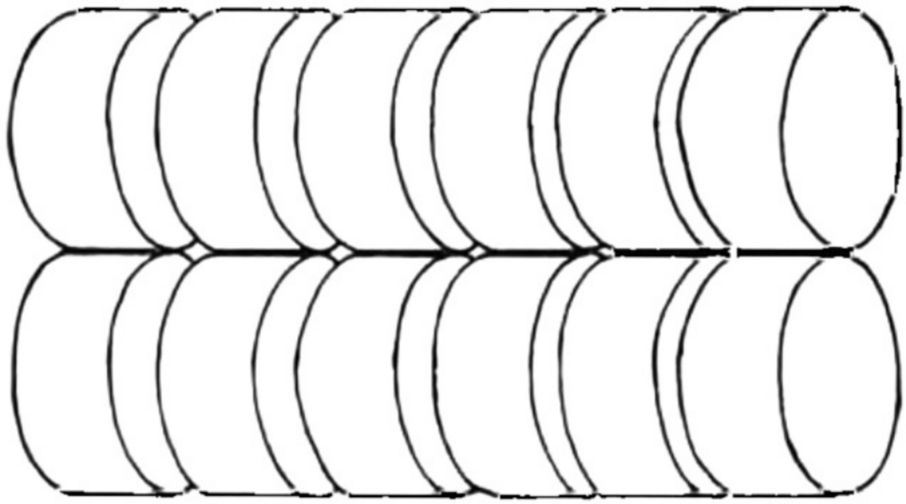

Fig. 19. Example of grooved cylinders used for wire production without drawing (Formigli, 1989, 282, Fig. 1.e).

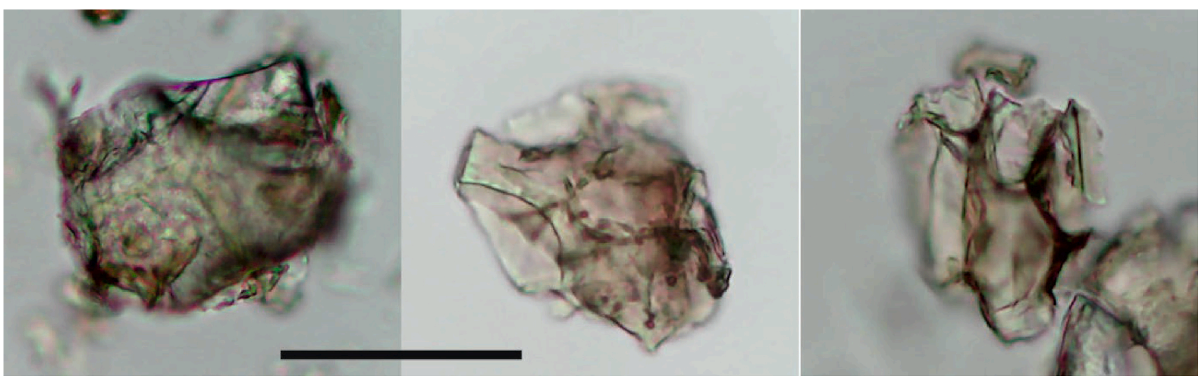

Fig. 20. Phytoliths from the gourd-flask with concave impressions. Scale bar=50 μm (© The Bisenzio Project, A. Celant).

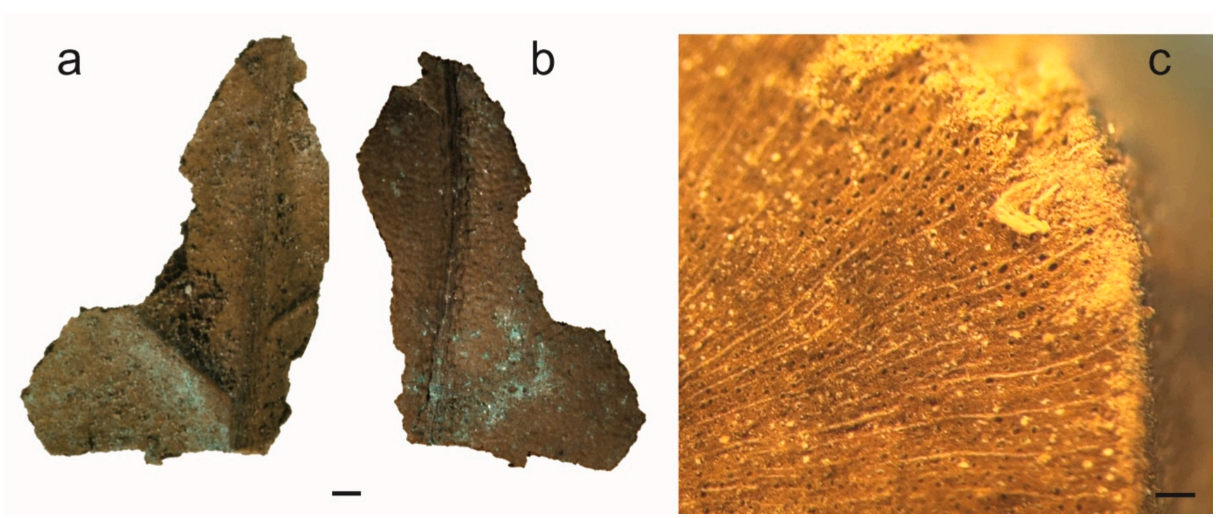

Fig. 21. Macro-remains of *Vitis*: a. abaxial surface of the leaf; b. adaxial surface of the leaf; c. transversal surface of the stem. Scale bar=1 mm (© The Bisenzio Project, a.-b. A. Babbi, B. Babbi, c. A. Celant, F. Michelangeli).

by a workshop in the middle-Tyrrhenian region, as indicated by the coarse ware used to make the vessels. It is certainly informative that an initial phase characterised by imported objects in the late 9th century BCE was followed by a second phase in the 8th century BCE featuring the proliferation of a Tyrrhenian production from workshops with immigrant artisans or mixed know-how (Boitani, 2005, 2019; Kourou, 2005, 2020; Domínguez 2025). This indeed reveals the importance that local rulers attributed to goods with an Euboean/Cycladic aura when shaping their own badges of identification and Selbstdarstellung as the most prominent actors in the local community (Ambrosini 2013;

Table 6
List of compounds identified in the entire sample (B-1) as well as in the outer (B-2) and the inner (B-3) layer of the pumpkin flask.

Compound					Samples		
Class	**ID**	**Candidate**	**Formula**	**Base peak**	**B-1**	**B-2**	**B-3**
Free Fatty acids	1	Octanoic acid, TMS	$C_{11}H_{24}O_2Si$	117.0365		X	X
Monocarboxylic acids	2	Nonanoic acid, TMS	$C_{12}H_{26}O_2Si$	75.0260	X		
	3	Decanoic acid, TMS	$C_{13}H_{28}O_2Si$	117.0365	X	X	X
	4	Dodecanoic acid, TMS	$C_{15}H_{32}O_2Si$	117.0366	X	X	X
	5	Tetradecanoic acid, TMS	$C_{17}H_{36}O_2Si$	117.0365	X	X	X
	6	5-dodecenoic acid, TMS	$C_{15}H_{30}O_2Si$	117.0365	X	X	
	7	Pentadecanoic acid, TMS	$C_{18}H_{38}O_2Si$	117.0366		X	X
	8	Pentadecanoic acid, TMS	$C_{18}H_{38}O_2Si$	117.0366	X	X	X
	9	Palmitelaidic acid, TMS	$C_{19}H_{38}O_2Si$	287.1428		X	
	10	Hexadecanoic acid, TMS	$C_{19}H_{40}O_2Si$	117.0365	X	X	X
	11	10-Heptadecenoic acid, TMS	$C_{20}H_{40}O_2Si$	117.0366	X		
	12	Heptadecanoic acid, TMS	$C_{20}H_{42}O_2Si$	117.0365	X	X	X
	13	Heptadecanoic acid, TMS	$C_{20}H_{42}O_2Si$	117.0365		X	
	14	Heptadecanoic acid, TMS	$C_{20}H_{42}O_2Si$	117.0365		X	
	15	9-Octadecenoic acid, TMS	$C_{21}H_{42}O_2Si$	129.0365	X	X	X
	16	Octadecanoic acid, TMS	$C_{21}H_{44}O_2Si$	117.0366	X	X	X
Hydroxyacids and Dicarboxylic acids	17	Glycolic acid, 2TMS	$C_8H_{20}O_3Si_2$	147.0655	X	X	
	18	Malonic acid, 2TMS	$C_9H_{20}O_4Si_2$	147.0655		X	
	19	Succinic acid, 2TMS	$C_{10}H_{22}O_4Si_2$	147.0655	X		
	20	Methyl malonic acid, 2TMS	$C_{10}H_{22}O_4Si_2$	147.0655	X	X	X
	21	Nonanedioic acid, 2TMS	$C_{15}H_{32}O_4Si_2$	73.0467		X	X
Phenolic	22	Vanillic acid, 2TMS	$C_{14}H_{24}O_4Si_2$	267.0502	X		
	23	Syringic acid, 2TMS	$C_{15}H_{26}O_5Si_2$	297.0606	X		
	24	2-Hydroxy-6-tridecyl benzoic acid, 2TMS	$C_{26}H_{48}O_3Si_2$	449.2899	X		
	25	2-Hydroxy-6-pentadecyl benzoic acid, 2TMS	$C_{28}H_{52}O_3Si_2$	477.3209	X		
	26	Gallacetophenone-4'-methylether, bis(trimethylsilyl) ether	$C_{15}H_{26}O_4Si_2$	311.2943	X		
Alcohols	27	Diethylene glycol, 2TMS	$C_{10}H_{26}O_3Si_2$	73.0468	X		
	28	Glycerol, 3TMS	$C_{12}H_{32}O_3Si_3$	147.0655	X		
	29	Nonanol, TMS	$C_{12}H_{28}OSi$	147.0655	X		
	30	Tridecanol, TMS	$C_{16}H_{36}OSi$	117.0698	X		
	31	Tetradecanol, TMS	$C_{17}H_{38}OSi$	257.2263	X		
	32	Pentadecanol, TMS	$C_{18}H_{40}OSi$	73.0467	X		
Aromatics	33	beta-Caryophyllene	$C_{15}H_{24}$	91.0542	X		
	34	p-cymene	$C_{10}H_{14}$	119.0492		X	
	35	β-Thujaplicin	$C_{10}H_{12}O_2$	221.1353	X		
	36		$C_{17}H_{35}O$	189.1636			X
	37	D-limonene	$C_{10}H_{16}$	93.0366		X	
	38	18-Norabieta-8,11,13-triene	$C_{19}H_{28}$	159.1167	X	X	
	39	β-pinene	$C_{10}H_{16}$	93.0366		X	
	40	Retene	$C_{18}H_{18}$	219.1167	X	X	
	41	Norabietadiene	$C_{19}H_{30}$	219.1167	X	X	X
	42	Norabietadiene	$C_{19}H_{30}$	219.1167	X	X	X
	43	Isopimaric acid, TMS	$C_{23}H_{38}O_2Si$	241.1948		X	
	44	Methyldehydroabietate	$C_{21}H_{30}O_2$	239.1798	X	X	
	45	Dehydroabietic acid, TMS	$C_{23}H_{36}O_2Si$	239.1798	X	X	X
	46	Isopimaral	$C_{20}H_{30}O$	105.0698		X	
	47	Oleana-11-13(18)-diene	$C_{30}H_{48}$	105.0698	X	X	
	48	3-acetyloxy–lup-20(29)-en-28-al	$C_{32}H_{50}O_3$	137.1324		X	X
	49	Cyperene	$C_{15}H_{24}$	189.1636	X		
	50	α-amyrone	$C_{30}H_{48}O$	203.1792	X		
	51	28-Norolean-17-en-3-one	$C_{29}H_{46}O$	163.1480	X		
	52	α-Amyrin	$C_{30}H_{50}O$	203.1792	X		
	53	17,18-didehydro-3-dehydroxy-14,17-Nor-3,21-dioxo-β-amyrin	$C_{28}H_{40}O_2$	202.1714	X		
	54	Lupa-12,20(29)-dien-3-one	$C_{30}H_{46}O$	119.0855	X		
	55	Oleanolic acid, 2TMS	$C_{36}H_{64}O_3Si_2$	189.1635	X	X	X
	56	Moronic acid, TMS	$C_{33}H_{54}O_3Si$	189.1635	X		
	57	Ursolic acid, 2TMS	$C_{36}H_{64}O_3Si_2$	131.0886	X		
	58	Lup-20(29)-ene-3,28-diol	$C_{30}H_{50}O_2$	131.0886	X		
	59	Masticadienoic acid, 2 TMS	$C_{33}H_{54}O_3Si$	119,0855	X		
	60	Iso-masticadienoic acid, 2 TMS	$C_{33}H_{54}O_3Si$	119,0855	X		
	61	3-methyl-(3α)-24-Noroleana-4(23),12-diene	$C_{30}H_{48}$	217.1585	X	X	
Esters	62	Palmitic acid, 2-(1-octadecenyloxy) ethyl ester	$C_{36}H_{70}O_3$	283.2630	X		
	63	Stearic acid, 2-(1-octadecenyloxy) ethyl ester	$C_{38}H_{74}O_3$	311.2942	X		
	64	Heptanoic acid, docosyl ester	$C_{29}H_{58}O_2$	131.0886	X	X	
	65	Methyl 3-hydroxybenzoate	$C_8H_8O_3$	177.0365	X	X	
Alkenes	66	7,7',8,8',11,11',12,12',15,15'-decahydro- psi-Carotene	$C_{40}H_{66}$	95.0855	X		
Aldehydes	67	Vanillin	$C_8H_8O_3$	177.036	X		
Amides	68	Carbamodithioic acid, N,N-dimethyl, methylene ester	$C_7H_{14}N_2S_4$	88.0214	X		

d'Agostino 2017; Babbi and Celant, 2023). Nevertheless, with reference to Tomb 16, the indigenous origin of the two vessels, used respectively for drawing and consuming beverages (the kyathos cup - Fig. 11.11, and the kantharoid cup, Fig. 11.12), arguably reflects the desire to emphasise the deceased's sense of belonging to the local milieu. If the intermingling of indigenous and Aegean elements seems to be a feature shared with the other 'male' burials in the subgroup of burial 16 (Fig. 6), a closer affinity can be found with the nearby contemporary grave 10 (i.

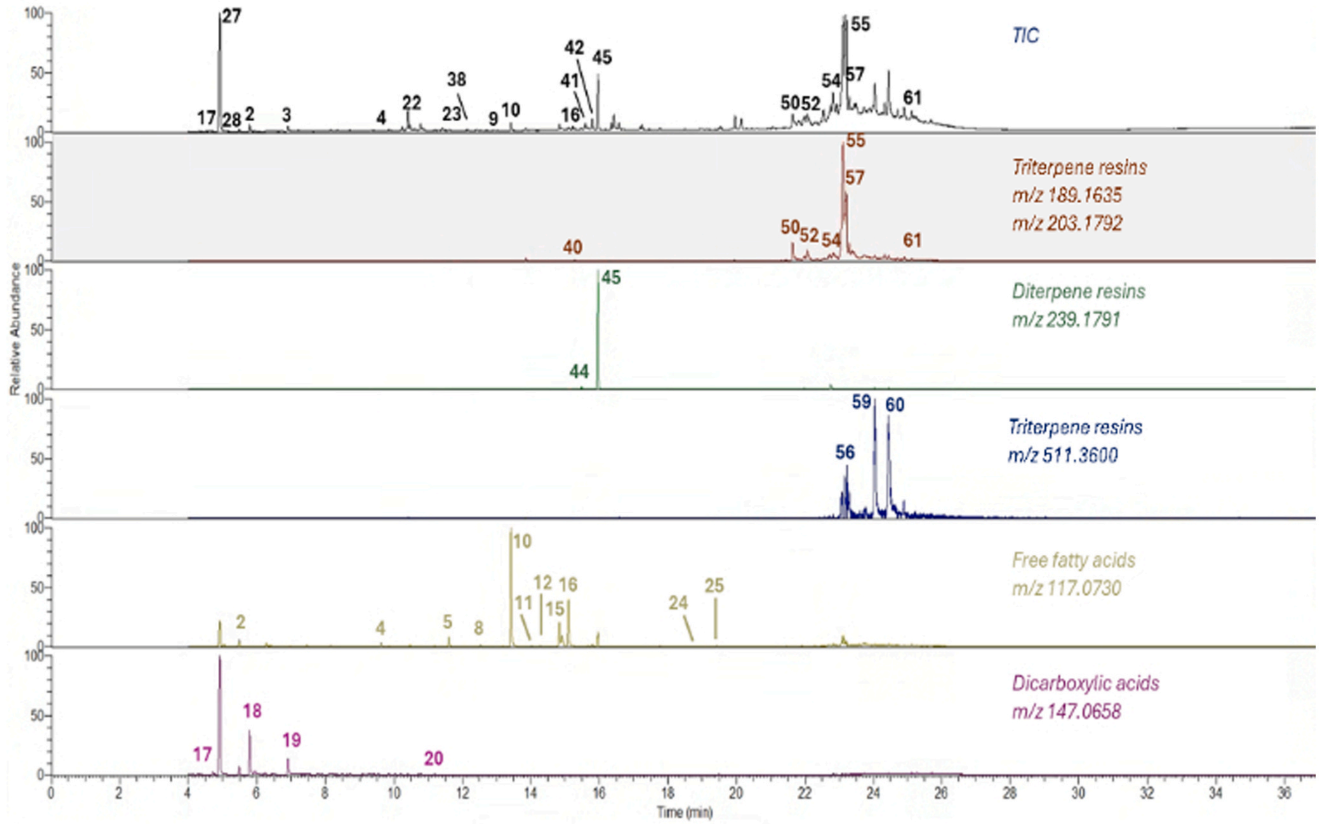

Fig. 22. TIC (in black) and EIC chromatograms, relative to some classes of compounds identified in the entire sample (B-1,) are shown: EIC *m/z* 189.1636 and 203.1792 (in brown), relative to triterpene resin with 12-oleanane and lupane with an unsaturated side chain skeleton; EIC *m/z* 239.1791 (in green), relative to diterpene resin; EIC *m/z* 511.3600 (in blue), relative to triterpene resin; EIC *m/z* 117.0730, relative to free fatty acids and EIC *m/z* 147.0658, relative to dicarboxylic acids. The *m/z* here indicated are relative to silylated compounds. The labels of the compounds identified are reported in the Table 6 (© The Bisenzio Project, G. Germinario).

e. lithic cist, crematory ritual, serpentine dragon-type fibula, spear, krater-shaped urn of Euboean/Cycladic inspiration covered by a bronze ceremonial shield, and jug with Euboean and Cycladic painted decoration and perforated base). Despite such obvious similarity between the two burials, it is now possible to detail a more articulated socio-historical interpretative framework for grave 16 thanks to the results of the analyses carried out during the present study on the silver decoration of the fibula (Figs. 8.1; 16) and the organic finds (Fig. 9).

If, in southern Etruria, the bronze serpentine-shaped brooch is a rather frequent element in 'male' tomb furnishings of medium-high social standing, the occurrence of silver thread connotes it as an object of prestige. It is the case of a true *agalma*, a good with a significant intrinsic and socio-cultural value that brings glory to its owner and inspires admiration, much like the "shining brooch" that Penelope gave to Odysseus (Hom., Od. XIX, 257). This assertion is underpinned by both, the particularly refined know-how to which the manufacture of the wire is attributed, and the use of native silver from the Iberian Peninsula, therefore of the highest quality and originally imported from a distant and exotic overseas land via the networks of sea routes spreading across the western Mediterranean. The availability of such a prized *agalma* in an inland community can perhaps be attributed to the high social rank and special trading power of the buried individual. It is therefore possible to speculate that the deceased had the object imported to Bisenzio, or had it made by itinerant craftsmen there, or even came into possession of it while visiting the coastal 'ports of trade' where raw materials, commodities, and know-how flowed in from all over the Mediterranean thanks to the attractive power of the dynamic markets of the imposing local proto-urban communities (Babbi, in press). In this regard, it is worth noting that some of the authors of this paper have been documenting the occurrence of native Iberian silver artefacts at Tarquinia and Cumae in Campania, in rich late 8th-century BCE burials furnished also with weapons and a large ceremonial bronze shield.

The hypothesis of a geographical mobility draws strength from the remnants of the gourd-flask (Fig. 9.6c-d). As a matter of fact, the 'pilgrim's flask' shape occurs in coeval socially eminent middle-Tyrrhenian grave assemblages, mainly with weapons, albeit only in the elaborate bronze foil version (Marzoli, 1989; Babbi and Peltz, 2013). Of course, the frequency with which 'humble' gourd flasks appear in burial contexts is probably underestimated due to the fragility of the organic material. However, it is evident that the selection of the flask for the composition of the grave inventory stemmed from the agency of the artefact to evoke one or more of the founding aspects of the social *personae*/identities of the deceased in the minds of the survivors. While we cannot pinpoint the exact causes of this agency, it is possible to imagine that the function of the object and/or its content contributed to it. The artefact's main practical function was to ensure a consistent supply of beverages when usual sources were unavailable, e.g. during a journey away from one's territorial district.

With regard to the substance contained in the flask, notwithstanding the caution imposed by the antiquity of the discovery and the subsequent manipulations to which the surviving fragments were probably subjected, the analyses converge on the presence of: fermented fruit juice, likely *Pistacia lentiscus* resin (its absence on one of the sampled fragments is not diriment to exclude its occurrence indeed), heated pine resin. Although the absence of tartaric acid makes the presence of wine questionable, the combination of fermented fruit juice and *Pistacia lentiscus* resin paints the picture of a bracing drink with healing properties. Indeed, the latter were particularly connected with the disinfection of the first airways and the alleviation of indigestion or dysentery, disorders that easily occur during periods of fatigue, exposure to inclement weather and unusual foods, in a nutshell during periods of geographical mobility and displacement. A possible confirmation of the use of beverages with even curative properties could come from the contents of a coeval bronze flask now in the Gregorian Etruscan Museum, i.e. heated pine resin and *Anchusa officinalis* (Sannibale, 2013, it must be emphasised that the attribution of the plant essence to the original contents of the bronze flask is uncertain; as for the occurrence of resins in vessels from the Mediterranean region, see Botto, 2006). While the hypothesis of an insulating function of pine resin is quite plausible in the case of metal specimens, it can also be considered with reference to the Bisenzio gourd-flask, albeit with caution given that the material is waterproof. Alternatively, it can be hypothesised that heated pine resin was used for conservation or decorative purposes, and/or as part of a ritual involving the de-functionalisation of the container following the death of its owner. It may also have been used to seal the flask stopper. In this regard, it is worth mentioning that traces of heated pine resin were found on the carved vine shoot (Fig. 9.6a) which, thanks to a strongly tapered end, could easily close the opening of the flask. Finally, for future analytical studies, it may be useful to consider the possibility that the resin could also have acted as an adhesive, as there are clear remnants of bronze (foil?) preserved at the second end of the shoot.

If a specific function for the worked shoot can be cautiously aired, the selection as funeral offerings of the thinnest shoot (Fig. 9.6b) as well as of likely one or more vine leaves (Fig. 9.6e) arose from other considerations. In the absence of traces of exposure to fire, these eco facts cannot be considered residues of the funeral pyre fuel. Consequently, it is reasonable to see them as remnants of offerings of the vine or of parts of it. Such offerings may have stemmed from the desire to manifest the availability of this plant and its products, and thus the deceased's involvement in the production activities connected with it (consider the large number of domestic vine seeds found in the now submerged perilacustrine village of Gran Carro, located along the eastern shore of Lake Bolsena and dated from the Middle Bronze Age - ca. 15th century BCE, to the Early Iron Age – ca. early 8th century BCE, Delpino, 2012; Acconcia and Piergrossi, 2021; Romagnoli et al., 2025). However, the selection of a krater to evoke the lost corporeity of the deceased during the funeral ceremony and preserve their mortal remains (Delpino, 1997; Cerchiai, 2011; Cerchiai and Cuozzo, 2016; Babbi and Celant, 2023), opens the field to further interpretative reflections.

In the middle-Tyrrhenian region, the use of a local globular jar, a form most likely intended for the serving of beverages and not by chance painted with geometric motifs echoing coeval Aegean patterns, is a ritual custom attested around the mid-8th century BCE at Veio (Fig. 2) sporadically but significantly in a burial with an articulated inventory and weapons (Gr. Z1α) and in a second one, unfortunately looted, but with a cylindrical lithic cist and thus also pertaining to a high ranking actor (Gr. CC5-6A) (Piergrossi, 2022, note 393). If the parallels from Veio hint at the existence of a ritual tradition in which the owners of tombs 10 and 16 at Olmo Bello also participated, the indisputable Euboean/Cycladic style of the Bisenzio urns highlights their distinctiveness. It seems that the deceased of Bisenzio and their family wanted to make their involvement in the flow of materials, goods, know-how and ideas that animated the networks with the middle-Tyrrhenian Coast and possibly the Campania region crystal clear. As for the actor of grave 16, such an involvement was perhaps facilitated by their geographical mobility as indicated by the flask and its contents. The source and outcome of such mobility was probably the transcultural attitude that characterised the individual whose mortal remains were not by chance deposited in a krater with Aegean pedigree. This predisposition to internalise some specific traits of other cultures while not renouncing their own, may have also favoured the acceptance of elements, not only material, originating from other cultural environments. The aforementioned burial contexts not only confirm the well-studied adoption, as early as the eighth century BCE, of a funerary practice echoing the Homeric one by some prominent individuals in the Tyrrhenian communities (Malkin, 2002; d'Agostino, 1999, 2006; Crielaard, 2012, 2018), but also reveal adherence to a ritual behaviour never documented before in the region. As for the Homeric models, it is worth recalling the funeral of Achilles whose cremated bones, after being dipped in ointments and pure wine, were collected in a two-handled golden urn made by Hephaestus and offered as a gift by Dionysos to Thetis (Hom., Od. XXIV, 71-75). In said episode, the urn could have been either an amphora, perhaps krater-shaped specimen, or a krater. The reference to ritual behaviour is to the offering of one or more vine plants or parts thereof. Finally, one wonders whether, in the 8th century BCE, such an offering merely testifies to the pragmatic availability of vines and their precious, inebriating alcoholic beverage, or whether it might already reflect a fascination with eschatological conceptions related to Dionysos. As a matter of fact, in the above-mentioned Homeric passage the relevance of Dionysos is clear: pure wine can only be mastered by him (Cerchiai, 2011); he gives the hero's mother the two-handled urn; both the amphora and the krater are forms closely connected with the itinerant god who "attraverso la vite mette in contatto mondi diversi" (Cerchiai, 2012, quotation from p. 283). Indeed, the antiquity of grave 16 is no longer an obstacle, given that the theonym of the god dates back considerably further than the 8th–7th century BCE period to which the deity's introduction to the Hellenic pantheon was traditionally attributed. This is evidenced by a Linear B tablet discovered at Khania (KH Gq5) dating back to the 13th century BCE (Hallager and Hallager, 2011, on the floor of room E in building 2, much likely a cultic space). The inscription records the names of Zeus and Dionysus, as well as the honey offerings dedicated to them (Hallager et al., 1992; Hallager and Vlasakis, 1997; Palaima, 1998; Duev, 2008). Besides, the occurrence of the theophoric *di-wo-nu-so* on some Linear B tablets from Knossos (KN Dv 1501) and Pylos (Ea 102 + Ea 107, Xa 1419) dating from between the 14th and the end of the 13th century BCE, reveals the broad chronological range of this theonym, as well as the depth of the custom and affection that some Aegean communities had for the god (Palaima, 1998; Duev, 2008). Moreover, the abundant charred remains of vine shoots from geometric cremations of the Kerameikos at Athens, thus chronologically closer to the Bisenzio contexts, could arise as much from the fuel of the pyre as from the *paraphernalia* laid with the deceased on it. Charred remains of vine plants were also found in Athens in the *Opferrinnen* of the Kerameikos as a result of ritual fires lit to 'cremate' the remains of the funeral banquet and its furnishings. Finally, similar remains have been found in slightly later Proto-Attic burials from the 7th century BCE where vine shoots are thought to have embellished the wooden shelves on which the bodies of the deceased lay, as in the case of Dionysian ritual beds (D'Onofrio, 1993; Cerchiai, 2011; Cerchiai and Cuozzo, 2016; Babbi and Celant, 2023).

As for grave Olmo Bello 16 at Bisenzio, the absence of Dionysian iconographic or epigraphic elements imposes a suspension of judgement about the introduction of new eschatological visions at such an early time. Nevertheless, thanks to the important analyses carried out for the present study, the archaeological data suggest geographical mobility and a marked attitude to transculturalism of one of the members of the highest echelons of an inland community – one of the many 'small worlds' whose 'nodes' kept forging their identities by interacting as 'culture switchers' with 'middle ground' realities (as for the seminal concept of 'culture switchers', see Crielaard 2018). This unexpected dynamism, which has also been documented in other Bisenzio burials as well as through recent discoveries made possible by 'The Bisenzio Project', challenges us to reconsider the traditional models used to interpret key aspects of the socio-economic development of the middle-Tyrrhenian region between the 12th and 5th centuries BCE.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work some of the authors used DeepL in order to improve language and readability. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

CRediT authorship contribution statement

A. Babbi: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **A. Celant:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **G. Germinario:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **J. Hertzog:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **M. Lamonaca:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **F. Michelangeli:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation. **P. Schmitt-Kopplin:** Writing – review & editing, Writing – original draft, Validation, Investigation, Formal analysis, Data curation. **R. Schwab:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was entirely funded the Fritz Thyssen Stiftung [Az. 10.20.1.025AA] as part of 'The Bisenzio Project'. For the purpose of open access, the author has applied a CC BY-NC-ND 4.0 public copyright licence to any author accepted manuscript version arising from this submission. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. There has been no additional external funding received for this study.

This contribution is part of 'The Bisenzio Project', which was designed and is being directed by A. Babbi. The project is taking place under the patronage of the National Research Council of Italy – Institute of Heritage Science (CNR ISPC) and the Leibniz-Zentrum für Archäologie, Mainz (LEIZA).

The visual inspection and the fundamental sampling of the finds preserved in the storerooms of the National Etruscan Museum of Villa Giulia in Rome have been made possible thanks to the kindness of successive directors of the National Etruscan Museum of Villa Giulia, i.e. Dr. Alfonsina Russo Tagliente, Dr. Vincenzo Bellelli, Prof. Valentino Nizzo, and Dr. Luana Toniolo. The authors would like to extend their heartfelt thanks to all of them. The authors also express their gratitude to the museum staff who assisted the team during the numerous visits, in particular Dr. Vittoria Lecce and Dr. Valentina Belfiore, for their competence and friendliness.

The authors warmly thank Prof. Donatella Magri from Sapienza University of Rome for her keen and useful suggestions, Dr. Maryse Blet-Lemarquand from the IRAMAT-CEB laboratory in Orléans for the LA-ICP-MS analysis and Dr. Moritz Jansen from the German Mining Museum for the LIA.

Data availability

The archaeological specimens are deposited in the storerooms of the National Etruscan Museum of Villa Giulia in Rome. Besides, all raw data reported in the manuscript will be made available on request.

References

Abu-El-Rub, L., Brosius, C., Meurer, S., Panagiotopoulos, D., Richter, S., 2019. Introduction: engaging transculturality. In: Abu-El-Rub, L., Brosius, C., Meurer, S., Panagiotopoulos, D., Richter, S. (Eds.), Engaging Transculturality. Concepts, Key Terms, Case Studies. Routledge, Abingdon, New York, XXIII-XLIV.

Acconcia, V., Piergrossi, A., 2021. L'archeologia del vino nella penisola italiana e nelle grandi isole del tirreno tra il neolitico e la romanizzazione: tematiche, dati e approcci possibili. accessed 17 September 2025 Bullettino di Archeologia on line 12, 183–230. https://bollettinodiarcheologiaonline.beniculturali.it/wp-content/uploads/2021/08/2021_2_ACCONCIA_PIERGROSSI.pdf.

Ambrosini, L., 2013. The Etruscan Painted Pottery. In: MacIntosh Turfa, J. (Ed.), The Etruscan World. Routledge, London, New York, pp. 943–973.

Appadurai, A., 1995. Modernity at Large. University of Minnesota Press, Minneapolis, Cultural Dimensions of Globalization.

Arribas, A., Tosdal, R.M., 1994. Isotopic composition of Pb in ore-deposits of the Betic Cordillera, Spain. Origin and relationship to other European deposits. Econ. Geol. 89 (5), 1074–1093. https://doi.org/10.2113/gsecongeo.89.5.1074.

Assimopoulou, A.N., Papageorgiou, V.P., 2005. GC-MS analysis of penta- and tetra-cyclic triterpenes from resins of Pistacia species. Part I. Pistacia lentiscus var. Chia. Biomed. Chromatography 19 (4), 285–311. https://doi.org/10.1002/bmc.454.

Attar, U.A., Ghane, S.G., 2018. Optimized extraction of anti-cancer compound – cucurbitacin I and LC–MS identification of major metabolites from wild Bottle gourd (Lagenaria siceraria (Molina) Standl.). S. Afr. J. Bot. 119, 181–187. https://doi.org/10.1016/j.sajb.2018.09.006.

Babbi, A., 2013. La <Tomba del Guerriero> e la sua cornice storico-sociale. In: A. Babbi, U. Peltz, La Tomba del Guerriero di Tarquinia. Identità elitaria, concentrazione del potere e networks dinamici nell'avanzato VIII sec. a.C. – Das Kriegergrab von Tarquinia. Eliteidentität, Machtkonzentration und dynamische Netzwerke im späten 8. Jh. v. Chr., Monographien des Römisch Germanischen Zentralmuseums 109. Mainz, 63-86.

Babbi, A., 2018. Revisiting single stories. Transcultural attitudes in the Middle-Tyrrhenian region during the advanced 8th c. BC. In: Amann, P., Aigner-Foresti, L. (Eds.), Beiträge zur Sozial geschichte der Etrusker, Akten der internationalen Tagung, June 8-10, 2016, Wien, PHERSU: Etrusko-italische Studien 1. Holzhausen Der Verlag, Wien, pp. 333–354.

Babbi, A., 2018b. La Campania, le aristocrazie etrusche e il grande network orientalizzante (IX-inizi del VII sec. a.C.). In: Osanna, M., Verger St. (Eds.), Pompei e gli Etruschi, Exhibition Catalogue, December 12 2018 - May 2 2019, Pompei Palestra Grande. Electa, Milano, 105-107.

Babbi, A., 2021. Mediterranean 'warrior' tombs. A balancing act between the variety of social encounters and the standardizing common discourse among peers during the early 1st Millennium BC. In Bourdin, S., Dally, O., Naso, A., Smith, C. (Eds.), The Orientalizing cultures in the Mediterranean, 8th-6th cent. BC: Origins, cultural contacts and local developments: the case of Italy, Atti del convegno internazionale, January 19-21, 2017, Roma, Mediterranea. Studi e ricerche sul Mediterraneo antico, Supplemento n.s. 1. CNR Edizioni, Roma, 433-477.

Babbi, A. in press. Settlement archaeology at Bisenzio (Capodimonte, VT): new evidence challenging overarching interpretative models. In: Belardelli, C., Sabatini, S., Vanzetti, A. (Eds.), Proturbano. Il principio delle strutture urbane in Italia. Atti dell'8° Peroni Day, December 10, 2021, Roma. Lemma 23 edizioni, Padova.

Babbi, A., Agrafiotis, P., Antoniella, G., Bozzani, A., Bravi, S., Celant, A., De Benedetto, G., Delpino, F., Germinario, G., Guarino, P.M., Hack, D., Lauteri, M., Lucarini, M., Maggi, M., Magri, D., Martinucci, D., Mazzoli, M., Michelangeli, F., Minniti, C., Pazzanese, M., Skarlatos, D., Vizzini, G., Zambrini, R., 2024. Bisenzio – bedeutender Knotenpunkt in Südetrurien. Archäologie in Deutschland 01/2024, Februar-März, Wissenschaftliche Buchgesellschaft (WBG), 42-45. For the extended online version see: https://aid-magazin.de/2023/12/04/bisenzio-bedeutender-knotenpunkt-in-suedetrurien/ (accessed 8 September 2025).

Babbi, A., Bubenheimer-Erhart, F., Marín-Aguilera, B., Mühl, S., (Eds.), 2015. The Mediterranean Mirror. Cultural Contacts in the Mediterranean Sea between 1200 and 750 B.C., Proceedings of the International Conference, October 6-8, 2012, Heidelberg, RGZM-Tagungen 20. Verlag des Römisch-Germanischen Zentralmuseums, Mainz.

Babbi, A., Celant A., 2023. Danzando con Dioniso a nuova vita: Transkulturalität, Worlds in-between e 'Politics of Distance' tra Bisenzio ed Eretria nell'avanzato VIII sec. a.C. Mediterranea. Studi e ricerche sul Mediterraneo antico, Supplementary volume n.s. 2, 2022 (2023), 43-73.

Babbi, A., Delpino, F., Guarino, P.M., Lucarini, M., Miketta, F., Schiel, H., Trinks, I., 2019. Bisenzio (Capodimonte, VT - Italy) between the Bronze and the Archaic Age. A minor centre or a relevant hub in the inland district of South Etruria? Report of the 'Bisenzio Project' research activities, 2015-2016. BABESCH Annual Papers on Mediterranean Archaeology 94, 1–38. https://doi.org/10.2143/BAB.94.0.3286776.

Babbi, A., Delpino, F., 2019. L' Etruria meridionale interna in età protostorica: riflessioni e suggestioni di ricerca. In: L'Etruria delle Necropoli Rupestri. Atti del XXIX Convegno di Studi Etruschi, October 26-28, 2017, Tuscania, Viterbo. Giorgio Bretschneider Editore, Roma, 13-46.

Babbi, A., Peltz, U., 2013. La Tomba del Guerriero di Tarquinia. Identità elita ria, concentrazione del potere e networks dinamici nel tardo VIII sec. a.C. – Das Kriegergrab von Tarquinia. Eliteidenti tät, Machtkonzentration und dynamische Netzwerke im späten 8. Jh. v. Chr. Monographien des Römisch-Germanischen Zentralmuseums 109. Verlag des Römisch-Germanischen Zentralmuseums, Schnell & Steiner, Mainz.

Barabási, A.-L., 2003. Linked: How Everything Is Connected to Everything Else and What It Means for Business, Science, and Everyday life. Basic Books, New York.

Baron, S., Rico, C., Marín, J. A. A., 2017. Le complexe d'ateliers du Cabezo del Pino (Sierra Minera de Cartagena-La Unión, Murcia) et l'organisation de l'activité minière à Carthago Noua à la fin de la République romaine. Apports croisés de l'archéologie et de la géochimie. Archivo español de arqueología: serie Anejos 90 (90), 147-169. Doi: 10.3989/aespa.090.017.007.
Barth, F. (Ed.), 1969. Ethnic Groups and Boundaries. The social Organization of Culture Difference. The Little, Boston.
Barth, F., 2000. Enduring and emerging issues in the analysis of ethnicity. In: Vermeulen H., Govers C. (Eds), The Anthropology of Ethnicity. Beyond 'Ethnic Groups and Boundaries'. Het Spinhuis, Amsterdam 20004, 11-32.
Bhabha, H.K., 1994. The Location of Culture. Routledge, London, New York.
Blet-Lemarquand, M., 2021. LA-ICP-MS analysis of silver coins for the Koinon Project. Historical and numismatic studies in ancient Greek federalism. In: Grandjean, C. (Ed.), The Koina of Southern Greece. Numismatica antiqua 12, Éditions Ausonius, Bordeaux, 239-248.
Boitani, F., 2019. Veii and the Greeks. In: Tabolli, J., Cerasuolo, C. (Eds.), Veii. University of Texas Press, Austin, pp. 95–100.
Boitani, F., 2005. Le più antiche ceramiche greche e di tipo greco a Veio. In: Bartoloni, G., Delpino F. (Eds.), Oriente e Occidente: Metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del ferro italiana, Atti dell'Incontro di Studio, October 30-31, 2003, Roma, Mediterranea 1. Fabrizio Serra Editore, Pisa, Roma, 319-332.
Boni, M., Koeppel, V., 1985. Ore-lead isotope pattern from the Iglesiente-Sulcis Area (SW Sardinia) and the problem of remobilization of metals. Mineralium Deposita 20 (3), 1985, 185-193. Doi: 10.1007/BF00204563.
Bosi, G., Castiglioni, E., Rinaldi, R., Mazzanti, M., Marchesini, M., Rottoli, M., 2020. Archaeobotanical evidence of food plants in Northern Italy during the Roman period. Veget Hist Archaeobot 29, 681–697. https://doi.org/10.1007/s00334-020-00772-4.
Bosi, G., Castiglioni, E., Mazzanti, M., Rottoli, M., 2023. New crops in the 1st millennium ce in northern Italy. Springer Nature, New York, Berlin, London, Shanghai, Beijing, Vegetation History and Archaeobotany, 10.1007/s00334-023-00955-9.
Botto, M., 2006. Da Sulky a Huelva: considerazioni sui commerci fenici nel Mediterraneo antico. AION Annali di archeologia e storia antica 11–12 (2004–2005), 9–27.
Braudel, F., 1995. The Mediterranean and the Mediterranean World in the Age of Philip II. University of California Press, Berkeley.
Broodbank, C., 2013. The Making of the Middle Sea. A History of the Mediterranean from the Beginning to the Emergence of the Classical World. Thames & Hudson, Oxford.
Celant, A., Coccolini, G., 2015. Archaeological Wood Preparation. In: Yeung, E.C.T., Stasolla, C., Sumner, M.J., Huang, B.Q. (Eds.), Plant Microtechniques and Protocols. Springer International Publishing, Cham, pp. 487–493, 10.1007/978-3-319-19944-3_26.
Cerchiai, L., 2011. Culti dionisiaci e rituali funerari tra poleis magnogreche e comunità anelleniche, in La vigna di Dioniso. Vite, vino e culti in Magna Grecia, Atti del 49. Convegno di Studi sulla Magna Grecia, September 24-28, 2009, Taranto. Istituto per la Storia e l'Archeologia della Magna Grecia, Taranto, 486-490.
Cerchiai, L., 2012. In: Ciacci, A., Rendini, P., Zifferero, A. (Eds.), Archeologia della vite e del vino in Toscana e nel Lazio: dalle tecniche dell'indagine archeologica alle prospettive della biologia molecolare, Quaderni del Dipartimento di archeologia e storia delle arti, Sezione archeologica, 65. Università di Siena, Firenze, pp. 277–290.
Cerchiai, L., 2017. Integrazione e ibridismi campani: Etruschi, Opici, Euboici tra VIII e VII sec. a.C. In: Ibridazione e integrazione in Magna Grecia. Forme modelli dinamiche. In: Atti del 54. Convegno di studi sulla Magna Grecia, September 25-28, 2014, Taranto. Istituto per la Storia e l'Archeologia della Magna Grecia, Taranto, pp. 221–243.
Cerchiai, L., Cuozzo, M.A., 2016. Tra Pitecusa e Pontecagnano: il consumo del vino nel rituale funebre tra Greci, Etruschi e Indigeni. In Di Nocera, G.M., Guidi, A., Zifferero A. (Eds.), Archeotipico: l'archeologia come strumento per la ricostruzione del paesaggio e dell'alimentazione antica, Atti del Convegno, October 16, 2015, Viterbo. Rivista di Storia dell'Agricoltura 56. Le Lettere, Firenze, 195-207.
Colombini, M.P., Modugno, F., Ribechini, E., 2005. Direct exposure electron ionization mass spectrometry and gas chromatography/mass spectrometry techniques to study organic coatings on archaeological amphorae. J. Mass Spectrom. 40, 675–687. https://doi.org/10.1002/jms.841.
Colombini, P.M.P., Modugno, P.F., 2009. Organic Mass Spectrometry in Art and Archaeology. John Wiley & Sons, Hoboken.
Crielaard, J.P., 2012. Hygra keleutha. Maritime matters and the ideology of se afaring in the Greek epic Tradition. In: Alle origini della Magna Grecia. Mobilità, migrazioni, fondazioni, Atti del 50. Convegno di studi sulla Magna Grecia, October 1-4, 2010, Taranto. Istituto per la Storia e l'Archeologia della Magna Grecia, Taranto, 135-157.
Crielaard, J.P., 2018. Hybrid go-betweens: the role of individuals with multiple identities in cross-cultural contacts in the Late Bronze Age and Iron Age central and eastern Mediterranean. In: Niesiołowski-Spanò, Ł., Węcowski M. (Eds.), Change, Continuity, and Connectivity. North-Eastern Mediterranean at the turn of the Bronze Age and in the early Iron Age, Philippika - Altertumswissenschaftliche Abhandlungen - Contributions to the Study of Ancient World Cultures 118, 196-220.
Cuozzo, M., Pellegrino, C., 2016. Culture meticce, identità etnica, dinamiche conservatorismo e resistenza: questioni teoriche e casi di studio dalla Campania. In: Donnellan, L., Nizzo, V., Burgers, G.J. (Eds.), Contexts of Early Colonization, Acts of the conference Contextualizing early colonization: archaeology, sources, chronology and interpretative models between Italy and the Mediterranean, 21-23 June, 2012, Rome, Papers of the Royal Netherlands Institute in Rome 64. Palombi Editori, Rome, pp. 117–136.
d'Agostino, B., 1999. I principi dell'Italia centro-tirrenica in epoca orientalizzante. In: Ruby, P. (Ed.), Les princes de la protohistoire et l'émergence de l'état, Actes de la table ronde, 27-29 Octobre, 1994, Naples, Publications de l'École française de Rome 252. École Française de Rome, Rome, pp. 81–95.
d'Agostino, B., 2006. The First Greeks in Italy. In: Tsetskhladze, G.R. (ed.), Greek Colonisation. An Account of Greek Colonies and other Settlements overseas, I, Menmosyne 193. Brill, Leiden, Boston, 201.237.
d'Agostino, B., 2017. The Aegean between East and West. In: Vlachou, V, Gadolou, A. (Eds.), Studies in Mediterranean Archaeology in Honour of Nota Kourou. Centre de Recherches en Archeologie et Patrimoine, Bruxelles, 401-418.
Davara, J., Jambrina-Enríquez, M., Rodríguez de Vera, C., Herrera-Herrera, A.V., Mallol, C., 2023. Pyrotechnology and lipid biomarker variability in pine tar production. Archaeol. Anthropol. Sci. 15, 133. https://doi.org/10.1007/s12520-023-01829-x.
Delpino, F., 1997. I Greci in Etruria prima della colonizzazione euboica: ancora su crateri, vino, vite e pennati nell'Italia centrale protostorica. In: Bartoloni, G. (Ed.), Le necropoli arcaiche di Veio. Università la Sapienza, Roma, Giornata di studio in memoria di Massimo Pallottino, pp. 185–194.
Delpino, F., 1995. Strutture tombali nell'Etruria meridionale villanoviana. In: Negroni Catacchio, N. (Ed.), Tipologia delle necropoli e rituali di deposizione. Ricerche e scavi. Preistoria e protostoria in Etruria, Secondo Incontro di Studi, May 21-23, 1993, Farnese. Arbor Sapientiae, Roma, 217-224.
Delpino, F., 2012. Viticoltura, produzione e consumo del vino nell'Etruria protostorica. In: Ciacci, A., Rendini, P., Zifferero, A. (Eds.), Archeologia della vite e del vino in Toscana e nel Lazio: dalle tecniche dell'indagine archeologica alle prospettive della biologia molecolare, Quaderni del Dipartimento di archeologia e storia delle arti, Sezione archeologica, Università di Siena 65. All'Insegna del Giglio, Firenze, pp. 189–199.
Dhenge, R., Rinaldi, M., Ganino, T., Santi, S., Ferrarese, I., Dall'Acqua, S., 2022. Variations of polyphenols, sugars, carotenoids, and volatile constituents in pumpkin (Cucurbita moschata) during high pressure processing: a kinetic study. Innovative Food Sci. Emerg. Technol. 78, 103005. https://doi.org/10.1016/j.ifset.2022.103005.
Dimitrakoudi, E.A., Mitkidou, S.A., Urem-Kotsou, D., Kotsakis, K., Stephanidou-Stephanatou, J., Stratis, J.A., 2011. Characterization by gas chromatography-mass spectrometry of diterpenoid resinous materials in Roman-age amphorae from northern Greece. Eur. J. Mass Spectrom. 17 (6), 581–591. https://doi.org/10.1255/ejms.1155.
Delpino, F., 2008. La morte ritualizzata. Modalità di sepoltura nell'Etruria protostorica. In: Durpè i Raventós, X., Ribichini, S., Verger S. (Eds.), Saturnia tellus: definizioni dello spazio consacrato in ambiente etrusco, italico, fenicio-punico, iberico e celtico, Atti del Convegno internazionale, November 10-12, 2004, Roma. CNR Edizioni, Roma, 599-608.
Domínguez, A.J., 2025. Cultural Networks and Identities in the Western Mediterranean. In: Lomas, K. (Ed.), The World of the Western Greeks. Routledge, Oxon, New York, pp. 30–45.
Donnellan, L., 2020. Archaeological networks and social interaction. In: Donnellan, L. (Ed.), Archaeological Networks and Social Interaction. Routledge, London, New York, pp. 1–19.
D'Onofrio, A.M., 1993. Le trasformazioni del costume funerario ateniese nella necropoli pre-soloniana del Kerameikos. AION Annali di Archeologia e Storia Antica 15, 143–171.
Duev, R., 2008. Zeus and Dionysus in the light of linear B Records. In: Sacconi, A., Del Freo, M., Godart, L., Negri, M. (Eds.), Colloquium Romanum, Atti del XII colloquio internazionale di Micenologia, February 20-25, Rome, Pasiphae 1. Pisa, Roma, pp. 223–230.
Domanico, L., 1995. Le strutture tombali del Bronzo Finale in Etruria: analisi e osservazioni. In: Negroni Catacchio, N. (Ed.), Tipologia delle necropoli e rituali di deposi zione. Ricerche e scavi. Preistoria e protostoria in Etruria, Secondo Incontro di Studi, May 21-23, 1993, Farnese. Arbor Sapientiae, Roma, 127-145.
Formigli, E., 1971. La tecnica di lavorazione di alcuni bronzi etruschi. Studi Etruschi 39, 127–145.
Formigli, E., 1989. Modi di fabbricazione di filo metallico nell'oreficeria etrusca. Studi Etruschi 47, 281–292.
Finley, M., 1968. Contributions in the discussion and debate. In: La città e il suo territorio, Atti del 7. Convegno di studi sulla Magna Grecia, October 8-12, 1967, Taranto. Istituto per la Storia e l'Archeologia della Magna Grecia, Taranto, 186-188.
Fulminante, F., 2021. I Latini e gli altri. Identificazione di networks sociali e sfere di interazione nella distribuzione degli oggetti d'importazione nei contesti funerari del *Latium vetus* durante l'età del Ferro e l'orientalizzante. In Bourdin, S., Dally, O., Naso, A., Smith, C. (Eds.), The Orientalizing cultures in the Mediterranean, 8th-6th cent. BC: Origins, cultural contacts and local developments: the case of Italy, Atti del convegno internazionale, January 19-21, 2017, Roma, Mediterranea. Studi e ricerche sul Mediterraneo antico, Supplemento n.s. 1. CNR Edizioni, Roma, 231-251.
Garnier, N., Valamoti, S.M., 2016. Prehistoric wine-making at Dikili Tash (Northern Greece): integrating residue analysis and archaeobotany. J. Archaeol. Sci. 74, 195–206. https://doi.org/10.1016/j.jas.2016.03.003.
Germinario, G., De Luca, G., Messina, T., Scerra, S., De Benedetto, G.E., Miliani, C., 2024. Exploring pottery function and cooking practices in bronze age sicily: the results of high-resolution GC-MS of organic residues. Environ. Archaeol. 1–21. https://doi.org/10.1080/14614103.2024.2379639.
Graeser, S., Friedrich, G., 1970. Zur Frage der Altersstellung und Genese der Blei-Zink-Vorkommen der Sierra de Cartagena in Spanien. Miner. Deposita 5, 365–374. https://doi.org/10.1007/BF00206733.
Granovetter, M.S., 1983. The strength of weak ties: a network theory revisited. Sociol Theory 1, 201–233.
Guigue, J., Harir, M., Mathieu, O., Lucio, M., Ranjard, L., Leveque, J., Schmitt-Kopplin, P., 2016. Ultrahigh-resolution FT-ICR mass spectrometry for molecular characterisation of pressurised hot water-extractable organic matter in soils. Biogeochemistry 128, 307–326. https://doi.org/10.1007/s10533-016-0209-5.

Hallager, E., Hallager, B.P., 2011. The Greek-Swedish Excavations at the Ag. Aikaterini Square, Kastelli, Khania 1970-1987 and 2001, vol. IV.1. Text. The Late Minoan IIIB:1 and IIIA:2 settlements. Skrifter utgivna av Svenska Institutet i Athen 4, 47:4:1. Swedish Institute at Athens, Stockholm.
Hallager, E., Vlasakis, M., 1997. New Linear B Tablets from Khania. In: Driessen, J., Farnoux, A. (Eds.), La Crète mycénienne, Actes de la Table Ronde Internationale organisée par l'École française d'Athènes, March 26-28, 1991, Athens, Bulletin de Correspondance Hellénique Supplément 30. École française d'Athènes, Athènes, pp. 169–174.
Hallager, E., Vlasakis, M., Hallager, B.P., 1992. New linear B tablets from Khania. Kadmos 31, 61–87.
Hertzog, J., Fujii, H., Babbi, A., Lattuati-Derieux, A., Schmitt-Kopplin, P., 2021. Chemical composition overview on two organic residues from the inner part of an archaeological bronze vessel from Cumae (Italy) by GC–MS and FTICR MS analyses. Eur. Phys. J. Plus 136, 661. https://doi.org/10.1140/epjp/s13360-021-01627-1.
Hertzog, J., Fujii, H., Žostautaitė, R., Lattuati-Derieux, A., Richardin, P., Carré, V., Aubriet, F., Schmitt-Kopplin, P., 2023. Unravelling the Egyptian embalming materials by a multi-method approach comprising high-resolution mass spectrometry. J. Archaeol. Sci. Rep. 48, 103861. https://doi.org/10.1016/j.jasrep.2023.103861.
Horden, P., Purcell, N., 2000. The corrupting sea. A study of Mediterranean history, Wiley-Blackwell, London.
Hunt Ortiz, M.A., 2003. Prehistoric mining and metallurgy in South West Iberian Peninsula. British Archaeological Reports international series 1188, BAR Publishing, Oxford.
Iaia, C., 1999. Simbolismo funerario e ideologia alle origini di una civiltà urbana. Forme rituali nelle sepolture "villanoviane" a Tarquinia e Vulci, e nel loro entroterra. Grandi Contesti e Problemi della Protostoria Italiana, 3. All'Insegna del Giglio, Sesto Fiorentino.
Janick, J., Paris, H.S., Parrish, D.C., 2007. The cucurbits of mediterranean antiquity: identification of taxa from ancient images and descriptions. Ann. Bot. 100, 1441–1457. https://doi.org/10.1093/aob/mcm242.
Jarvis, A., Reuter, H.I., Nelson, A., Guevara, E. 2008. Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT). http://srtm.csi.cgiar.org.
Knappett, C., 2011. An archaeology of interaction. Network perspectives on material culture and society, Oxford University Press, Oxford.
Knappett, C., 2020. Relational concepts and challenges to network analysis in social archaeology. In: Donnellan, L. (Ed.), Archaeological Networks and Social Interaction. Routledge, London, New York, pp. 20–37.
Kourou, N., 2005. Early Iron Age Greek Import in Italy: A Comparative Approach to a Case Study. In: Bartoloni, G., Delpino F. (Eds.), Oriente e Occidente: Metodi e discipline a confronto. Riflessioni sulla cronologia dell'età del ferro italiana, Atti dell'Incontro di Studio, October 30-31, 2003, Roma, Mediterranea 1. Fabrizio Serra Editore, Pisa, Roma, 497-515.
Kourou, N., 2020. Euboean Pottery in a Mediterranean Perspective. In: Cinquantaquattro, T.E., D'Acunto M. (Eds.), EUBOICA II. Pithekoussai and Euboea between East and West, Proceedings of the conference, May 14-17, 2018, Lacco Ameno (Ischia, Naples), Vol. 1, AION Annali di archeologia e storia antica n.s. 27. Arbor Sapientiae Editore, Napoli, 9-35.
Lillo, J., 1992. Vein-type base-metal ores in Linares-La Carolina (Spain): ore-lead isotopic constrains. Eur. J. Mineral. 4 (2), 337–343. https://doi.org/10.1127/ejm/4/2/0337.
Łucejko, J., Connan, J., Orsini, S., Ribechini, E., Modugno, F., 2017. Chemical analyses of Egyptian mummification balms and organic residues from storage jars dated from the Old Kingdom to the Copto-Byzantine period. J. Archaeol. Sci. 85, 1–12. https://doi.org/10.1016/j.jas.2017.06.015.
Magri, D., Di Rita, F., 2015. Archaeopalynological Preparation Techniques. In: Yeung, E. C.T., Stasolla, C., Sumner, M.J., Huang, B.Q. (Eds.), Plant Microtechniques and Protocols. Springer International Publishing, Cham, pp. 495–506. https://doi.org/10.1007/978-3-319-19944-3_27.
Malkin, I., 2002. A Colonial Middle Ground: Greek, Etruscan, and Local Elites in the Bay of Naples. In: Lyon, C.L., Papadopoulos, J.K. (Eds.), The Archaeology of Colonialism. Getty Publications, Los Angeles.
Malkin, I., 2011. A Small Greek World. Networks in the ancient Mediterranean. Greeks Overseas. Oxford University Press, Oxford, New York.
Maran, J., 2019. Not 'cultures' but culture! The need for a transcultural perspective in archaeology. In: Abu-El-Rub, L., Brosius, C., Meurer, S., Panagiotopoulos, D., Richter, S. (Eds.), Engaging Transculturality. Concepts, Key Terms, Case Studies. Routledge, Abingdon, New York, pp. 52–64.
Marcoux, E., 1998. Lead isotope systematic of the giant massive sulphide deposits in the Iberian Pyrite Belt. Miner. Deposita 33, 45–58. https://doi.org/10.1007/s001260050132.
Marzoli, D., 1989. Bronzefeldflaschen in Italien. Prähistorische Bronzefunde II, 4. C.H. Beck, München.
Maselli Scotti, F., Rottoli, M., 2007. Indagini archeobotaniche all'ex Essiccatoio Nord di Aquileia: i resti vegetali protostorici e romani. In: Cuscito G, Zaccaria C. (eds) Aquileia dalle origini alla costituzione del ducato longobardo. Territorio – Economia – Società. Antichità Altoadriatiche 65. Editreg, Trieste, 783-816.
Ménager, M., Azémard, C., Vieillescazes, C., 2014. Study of Egyptian mummification balms by FT-IR spectroscopy and GC–MS. Microchem. J. 114, 32–41. https://doi.org/10.1016/j.microc.2013.11.018.
Morris, I., 2003. Mediterraneanization. Mediterr. Hist. Rev. 18 (2), 30–55.
Murillo-Barroso, M., Montero Ruiz, I., Bartelheim, M., 2014. Native silver resources in Iberia. In: Meller, H., Risch, R., Pernicka E. (Eds.), Metalle der Macht – Frühes Gold und Silber / Metals of power – Early gold and silver., 6. Mitteldeutscher Archäologentag, October 17-19, 2013, Halle (Saale). Tagungen des Landesmuseums für Vorgeschichte Halle 11 (1). Landesamt für Denkmalpflege und Archäologie Sachsen-Anhalt – Landesmuseum für Vorgeschichte Halle (Saale), Halle, 257-268.
Njiboer, A., 2010. Italy, its Interconnections and Cultural Shifts During Iron Age. In: Atti XVII Congresso Internazionale di Archeologia Classica; Incontri tra Culture nel Mondo Mediterraneo Antico, September 22-26, 2008, Roma, Bullettino di Archeologia *on line* 1, Volume speciale F / F2 / 1. https://bollettinodiarcheologiaonline.beniculturali.it/wp-content/uploads/2020/10/1_NIJBOER.pdf (accessed 8 September 2025).
Orgeval, J.J., Caron, C., Lancelot, J., Omenetto, P., Gandin, A., Libertà, A., Courjault Radé, P., Tollon, F., Laurent, Ph., Maluski, H., Béziat, P., Salpeteur, Y., Sini, G., Elter, F.M., Baratto, M., 2000. Genesis of polymetallic and precious-metal ores in the Western Mediterranean province (Cévennes, France–Sardinia, Italy). Appl. Earth Sci. 109 (2), 77–94. https://doi.org/10.1179/aes.2000.109.2.77.
Orsini, S., Ribechini, E., Modugno, F., Kluegl, J., Di Pietro, G., Colombini, M.P., 2015. Micromorphological and chemical elucidation of the degradation mechanisms of birch bark archaeological artefacts. Heritage Science 3 (2). https://doi.org/10.1186/s40494-015-0032-7.
OXALID: http://oxalid.arch.ox.ac.uk/.
Pachi, V.K., Mikropoulou, E.V., Gkiouvetidis, P., Siafakas, K., Argyropoulou, A., Angelis, A., Mitakou, S., Halabalaki, M., 2020. Traditional uses, phytochemistry and pharmacology of Chios mastic gum (Pistacia lentiscus var. Chia, Anacardiaceae): A review. J. Ethnopharmacol. 254, 112485. https://doi.org/10.1016/j.jep.2019.112485.
Palaima, T.G., 1998. Die Linear-B Texte und der Ursprung der hellenischen Religion: di-wo-nu-so. In: Dimoudis, N., Kyriatsoulis, A. (Eds.), Die Geschichte der Hellenischen Sprache und Schrift vom 2. zum 1. Jahrtausend v. Chr.: Bruch oder Kontinuität?, Tagung, October 03-06, 1996, Ohlstadt. DZA-Verlag für Kultur und Wissenschaft, Altenburg.
Panagiotopoulos, D., 2011. The Stirring Sea. Conceptualising Transculturality in the Late Bronze Age eastern Mediterranean. In: Duistermaat, K., Regulski I. (Eds.), Intercultural Contacts in the Ancient Mediterranean, Proceedings of the International Conference at the Netherlands-Flemish Institute in Cairo, October 25-29, 2008, Cairo, Orientalia Lovaninensia Analecta 202. Peeters, Leuven, 31-51.
Paribeni, R., 1928. Capodimonte – Ritrovamento di tombe arcaiche. Notizie degli scavi di antichità 434–467.
Pernicka, E., 2013. Chemische und Bleiisotopenanalysen an zwei Silbergefäßen aus einem eisenzeitlichen Kriegergrab bei Tarquinia. In: Babbi, A., Peltz, U. (Eds.), La Tomba del Guerriero di Tarquinia Identità elitaria, concentrazione del potere e networks dinamici nell'avanzato VIII sec. a.C. / Das Kriegergrab von Tarquinia Elite-identität, Machtkonzentration und dynamische Netzwerke im späten 8. Jh. v. Chr. Monographien des Römisch-Germanisches Zentralmuseum, 109. Verlag des Römisch-Germanischen Zentralmuseums, Schnell & Steiner, Mainz, 179-181.
Pető, Á., Kenéz, Á., Lisztes-Szabó, Z., Sramkó, G., Laczkó, L., Molnár, M., Bóka, G., 2017. The first archaeobotanical evidence of *Lagenaria siceraria* from the territory of Hungary: histology, phytoliths and (a)DNA. Veg. Hist. Archaeobotany 26, 125–142. https://doi.org/10.1007/s00334-016-0566-y.
Pellegrino, C., 2021. L'"orientalizzante" come processo storico: il caso della Campania. In Bourdin, S., Dally, O., Naso, A., Smith, C. (Eds.), The Orientalizing cultures in the Mediterranean, 8th-6th cent. BC: Origins, cultural contacts and local developments: the case of Italy, Atti del convegno internazionale, January 19-21, 2017, Roma, Mediterranea. Studi e ricerche sul Mediterraneo antico, Supplemento n.s. 1. CNR Edizioni, Roma, 253-282.
Piergrossi, A., 2022. La necropoli di Poggio Montano: un sito di frontiera nell'Etruria interna. Mediterranea. Studi e ricerche sul Mediterraneo antico, Supplemento n.s. 3. CNR Edizioni, Roma.
Pomiès, C., Cocherie, A., Guerrot, C., Marcoux, E., Lancelot, J., 1998. Assessment of precision and accuracy of lead-isotope ratios measured by TIMS for geochemical applications. Example of massive sulphide deposits (Rio Tinto, Spain). Chem. Geol. 144 (1–2), 137–149. https://doi.org/10.1016/S0009-2541(97)00127-7.
Pratt, M.L., 1991. Arts of the contact zone. Profession 91, 33–40.
Qiu, Y., Zhong, D., Zeng, K., Li, J., Flamant, G., Nzihou, A., Yang, H., Chen, H., 2022. Effects of cellulose-lignin interaction on the evolution of biomass pyrolysis bio-oil heavy components. Fuel 323, 124413. https://doi.org/10.1016/j.fuel.2022.124413.
Regert, M., Colinart, S., Degrand, L., Decavallas, O., 2001. Chemical alteration and use of beeswax through time: accelerated ageing. Tests and analyses of archaeological samples from various environmental contexts. Archaeometry 43 (4), 549–569. https://doi.org/10.1111/1475-4754.00036.
Romagnoli, M., Sarlatto, M., Tamantini, S., Gallotta, G., Moscatelli, M.C., Severi, E., Barbaro, B., 2025. Tree-Ring Chronological Investigation on the Oak Poles of the Prehistoric Settlement of "Gran Carro" in Lake Bolsena, Central Italy: Landscape and Human Occupation. Land 14, 1147. https://doi.org/10.3390/land14061147.
Roullier-Gall, C., Signoret, J., Hemmler, D., Witting, M.A., Kanawati, B., Schäfer, B., Gougeon, R.D., Schmitt-Kopplin, P., 2018. Usage of FT-ICR-MS metabolomics for characterizing the chemical signatures of barrel-aged whisky. Front. Chem. 6. https://doi.org/10.3389/fchem.2018.00029.
Sai Lakshmi, K., Srikanth, K., Sahithya, P., Mahesh, 2022. A comprehensive review analysis on organic acids in fruit juices by using various analytical methods. Int. J. Res. Pharm. Chem. 12 (2), 73–83. https://doi.org/10.33289/IJRPC.12.2.2022.12(12).
Sannibale, M., 2013. La 〈Fiasca del Pellegrino〉 al Museo Gregoriano Etrusco. In: Babbi, A., Peltz, U. (Eds.), La Tomba del Guerriero di Tarquinia Identità elitaria, concentrazione del potere e networks dinamici nell'avanzato VIII sec. a.C. / Das Kriegergrab von Tarquinia Elite-identität, Machtkonzentration und dynamische Netzwerke im späten 8. Jh. v. Chr. Monographien des Römisch-Germanisches Zentralmuseum, 109. Verlag des Römisch-Germanischen Zentralmuseums, Schnell & Steiner, Mainz, 199-202.

Santos Zalduegui, J.F., García De Madinabeitia, S., Gil Ibarguchi, J.I., Palero, F., 2004. A lead isotope database. The Los Pedroches – Alcudia area (Spain). Implications for archaeometallurgical connections across southwestern and southeastern Iberia. Archaeometry 46 (4), 625–634. https://doi.org/10.1111/j.1475-4754.2004.00178.x.

Santos Zalduegui, J.F., Guinea, A., Ábalos, B., Gil Ibarguchi, J.I., 2007. Composición isotópica del Pb en galenas de la región de la Falla de Azuaga. Aportaciones al modelo plumbotectónico de la Zona de Ossa-Morena. Geoaceta 43, 7–10.

Schlumbaum, A., Vandorpe, P., 2012. A short history of *Lagenaria siceraria* (bottle gourd) in the Roman provinces: morphotypes and archaeogenetics. Veg. Hist. Archaeobotany 21, 499–509. https://doi.org/10.1007/s00334-011-0343-x.

Scott, D.A., Schwab, R., 2019. Metallography in Archaeology and Art. Springer International Publishing, Cham, Cultural Heritage Science Series.

Sherratt, S., 2010. The Aegean and the wider world. Some thoughts on a world-systems perspective. In: Galaty, M., Parkinson, W. (Eds.), Archaic State Interaction. The Eastern Mediterranean in the Bronze Age. School for Advanced Research Press, Santa Fe, pp. 81–106.

Sherratt, S., 2016a. A globalizing Bronze and Iron Age Mediterranean. In: Hodos, T. (Ed.), The Routledge Handbook of Archaeology and Globalization. Routledge, London, pp. 602–617.

Sherratt, S., 2016b. From 'institutional' to 'private': traders, routes and commerce from the Late Bronze Age to the Iron Age. In: Moreno Garcia, J.C. (Ed.), Dynamics of Production in the Ancient Near East, 1300-500 BC. Oxbow Books, Oxford, Philadelphia, pp. 289–301.

Subías, I., Fanlo, I., Mateo, E., Billström, K., Recio, C., 2010. Isotopic studies of Pb–Zn–(Ag) and barite Alpine vein deposits in the Iberian Range (NE Spain). Chem. Erde 70 (2), 149–158. https://doi.org/10.1016/j.chemer.2009.12.004.

Swainbank, I.G., Shepherd, T.J., Caboi, R., Massoli-Novelli, R., 1982. Lead isotopic composition of some galena ores from Sardinia. Periodico di mineralogia 51 (3), 75–286.

Tarquini, S., Isola, I., Favalli, M., Mazzarini, F., Bisson, M., Pareschi, M.T., Boschi, E., 2007. TINITALY/01: a new Triangular Irregular Network of Italy. Ann. Geophys. 50, 407–425. https://doi.org/10.4401/ag-4424.

Taylor, R.N., Ishizuka, O., Michalik, A., Milton, J.A., Croudace, I.W., 2015. Evaluating the precision of Pb isotope measurement by mass spectrometry. J. Anal. At. Spectrom 30 (1), 198–213. https://doi.org/10.1039/C4JA00279B.

Tornos, F., Chiaradia, M., 2004. Plumbotectonic evolution of the Ossa Morena zone, Iberian Peninsula. Tracing the influence of mantle-crust interaction in ore-forming processes. Econ. Geol. 99, 965–985. https://doi.org/10.2113/gsecongeo.99.5.965.

Valera, R.G., Velera, P.G., Rivoldini, A., 2005. Sardinian ore deposits and metals in the Bronze Age. In: Lo Schiavo, F., Giumlia-Mair, A., Sanna, U., Valera, R. (Eds.), Archaeometallurgy in Sardinia from origins to the beginning of the Early Iron Age, Monographies Instrumentum 30. Éditions Mergoil, Montaggnac, pp. 43–87.

Vavelidis, M., Bassiakos, I., Begemann, F., Patriarcheas, K., Pernicka, E., Schmitt-Strecker, S., Wagner, G.A., 1985. Geologie und Erzvorkommen. In: Wagner, G.A., Weisgerber, G., Silber, Blei und Gold auf Sifnos. Der Anschnitt Beiheft 3, 59-80.

Wajda, S., Merkel, S.W., Florkiewicz, I., Jansen, M., Marciniak-Maliszewska, B., Wagner, B., Wołoszyn, M., 2024. Early mediaeval lead glass bangles from Czermno, Poland: Results of elemental and lead isotopes analyses. Archaeometry 66 (2), 306–325. https://doi.org/10.1111/arcm.12907.

Wallerstein, I., 1974. The Modern World-System 1. Capitalist agriculture and the origins of the European world-economy in the sixteenth century, Modern World-system 1 (1). Academic Press, New York, London.

Wallerstein, I., 2004. World-system analysis. Duke University Press, Durham, London, An introduction.

Wanhill, R.J.H., 2013. Stress corrosion cracking in ancient silver. Stud. Conserv. 58 (1), 41–49.

Watts, D.J., 2003. Six degrees. Norton & Company, New York, The science of a connected age, W.W.

Welsch, W., 1992. Transkulturalität - Lebensformen nach der Auflösung der Kulturen. Information Philosophie 20 (2), 5–20.

White, R., 1991. The Middle Ground. Indians, Empires and Republics in the Great Lakes Region. Cambridge University Press, Cambridge, pp. 1650–1815.