Journal of Archaeological Science: Reports 48 (2023) 103837

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

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

Sorting out problems with Late Roman eastern Mediterranean cooking wares from *Tarraco* (Tarragona, Spain) combining archaeology and archaeometry

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ARTICLE INFO

Keywords:
Late Roman
Cooking ware
Provenance
Archaeometry
Petrography
Tarragona

ABSTRACT

Tarraco was the ancient capital of Hispania Tarraconensis, a Roman province in the Western Mediterranean. It was a strategic enclave and one of the most important ports during the Roman Empire and Late Antiquity. The archaeological record of the city shows a variety of imported products arrived from several regions including a significant amount of eastern Mediterranean wares, amongst which there are fine, table-wares, amphorae, and coarse and cooking wares. This work focuses on the integrated archaeological and archaeometric study of these eastern types of Late Roman cooking wares from the mid-7th century to the early 8th century. In previous works, these products were classified as Aegean and North Palestinian imports. However, for some of these materials a detailed macroscopic study revealed similarities with local/regional products, opening the possibility of regional ware imitating eastern prototypes. An analytical study was carried out, applying a combination of WD-XRF and Optical Microscopy to identify their provenance. The results point to the coexistence of imported eastern Mediterranean wares and local/regional imitations. At the same time, some of the typologies identified as eastern Mediterranean products seem to have been produced locally or regionally.

1. Introduction

The city of Tarragona is located on the north-eastern coast of the Iberian Peninsula, between the eastern end of the Pyrenees and the mouth of the Ebro River (Fig. 1a). In the early 5th century, the ancient city of *Tarraco* became the gateway to the armies of Rome once again, and the last Roman provincial capital in *Hispania*. By the last quarter of that century, the city of *Tarraco*(*na*) was incorporated into the Visigothic kingdom of Toulouse, and then Toledo, but it maintained its political and ecclesiastical role on the north-eastern side. During the Byzantine occupation of the Hispanic southeast in the 6th century, Tarragona was considered the main Visigothic port and one of the leading commercial emporia in the north-western Mediterranean.

Archaeological excavations carried out in recent decades have confirmed the economic and commercial role of the city, revealing an extensive and dynamic urban agglomeration very close to the port area, known as the 'port suburb', that could have covered and area of 2–3 ha (Macias and Remolà, 2010; Lasheras, 2018; Rodríguez et al., 2020). Port service warehouses, suburban domus, private baths and industrial buildings have been extensively recorded, which in some cases were transformed in the early 8th century (Lasheras and Terrado, 2018; Díaz and Roig, 2016; Lasheras, 2017, 2018; Rodríguez, 2017; Remolà and Lasheras, 2018, 2019; Rodríguez et al., 2020; Lasheras and Fortuny, 2021; Lasheras and Rodríguez, in press). Alongside these findings, there was an extensive religious complex of martyr worship (4th to early 5th centuries), which remained in use throughout the Visigothic period (Serra, 1935: 9ff; López, 2006).

As a part of these archaeological records in the western sector of the

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https://doi.org/10.1016/j.jasrep.2023.103837
Received 24 August 2022; Received in revised form 11 December 2022; Accepted 10 January 2023
Available online 31 January 2023

port area, numerous pottery contexts were recovered but only a few cases have been analyzed and published (Macias, 1999: 250–252; Remolà, 2000: 96-98; Macias and Remolà, 2000; Lasheras, 2015; Rodríguez and Macias, 2016, 2018, in press; Rodríguez, 2020). The first ceramic approach came from a small dump and several layers from the abandonment of a *balnea* building, located in the current 10–12 Felip Pedrell St. and dated to the mid-7th century onwards (Macias, 1999: 250–252; Remolà, 2000: 96-98; Macias and Remolà, 2000, 2005; a new analysis of this deposit in Rodríguez, 2020: 52-64; Rodríguez and Macias, in press). The preliminary analyses revealed many eastern Mediterranean cooking wares and amphorae; the study was based on a typological comparison with other Mediterranean sites and its

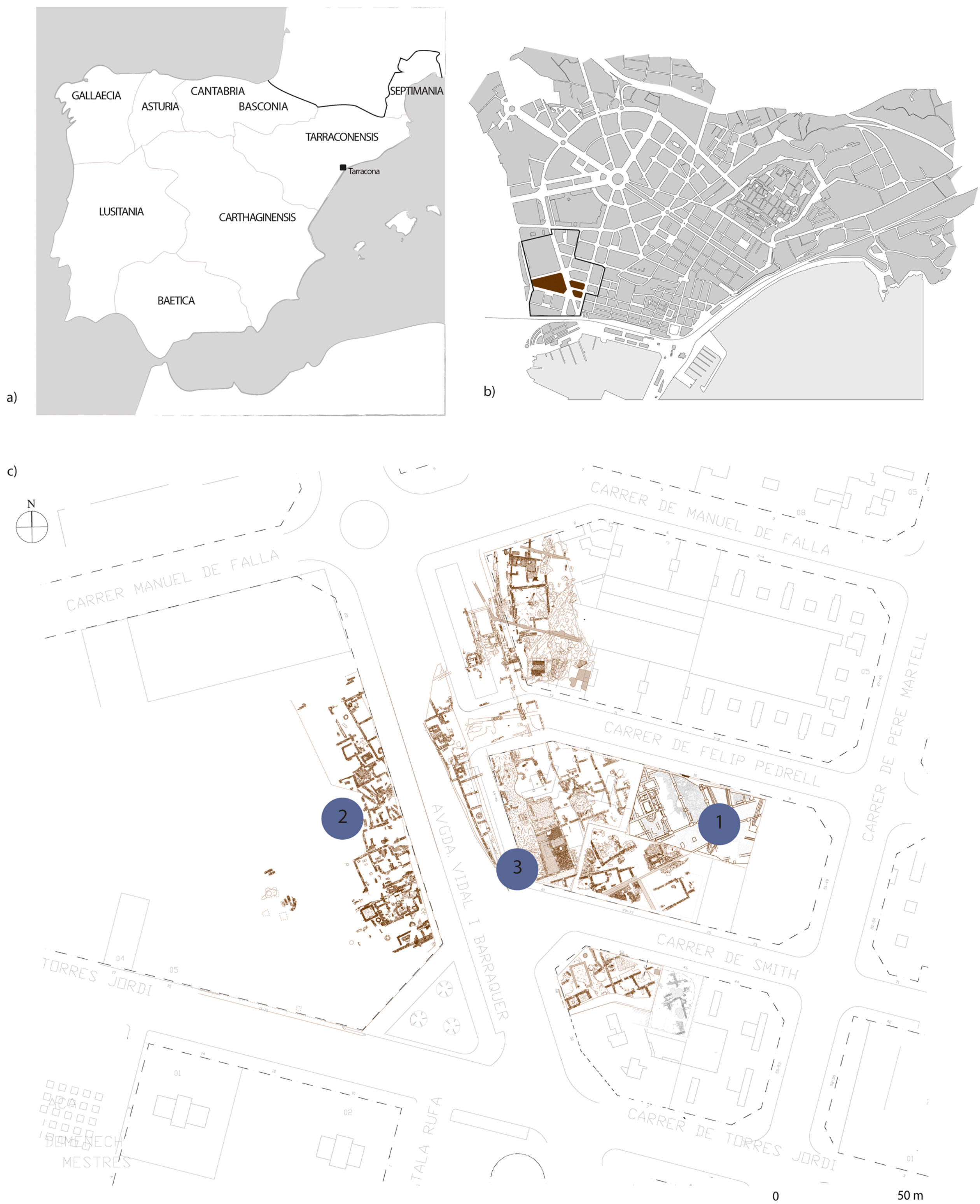

Fig. 1. Map of Tarragona (Spain) and the excavations treated in the text. 1, 10–12 Felip Pedrell St; 2, Vidal i Barraquer Ave.; 3, 12 Felip Pedrell St., 81 Smith St. and 44–46 Vidal i Barraquer Ave.

corresponding macroscopic observation of their fabrics (Macias, 1999: 45, 81, 140–142).

Among the cooking pots and casseroles that appeared, the most important type is Oc/Or/62, a recipient that Macias (1999: 140) considers like Saraçhane CW3 type B, Scorpan Pots-Brocs type B and CATHMA 23 (cf. Hayes, 1968: 214, fig. 108, 1992: 54–55; Scorpan, 1977: fig. 33.7; CATHMA, 1991: 27, fig. 22). Macias describes this form as globular and with large dimensions, with convex walls and vertical orientation. The rim is presented as straight and differentiated from the wall, with an internal ledge set halfway down. The two handles, which start just below the neck and return to the lower part of the wall, are twisted and circular in section (Macias, 1999: 153, fig. 56. 62; Macias and Remolà, 2000: 491, fig. 4.1). The surfaces are smooth and turned. The fabric is described as black-colored with a rough texture and fracture and contains white particles of medium to very coarse grain size (Macias, 1999: 45–46, fabric: 40). According to Hayes (1980: 378, 1992: 54–55), this form could belong to the ware 3 attested in Saraçhane (Istanbul), also called "Grey gritty ware".

Apart from that type of cooking pot, other 13 forms were identified, in different variants depending on the morphology of the rim (Macias, 1999: 153, fig. 56. 63–66.8; Macias and Remolà, 2000: 491, fig. 4.2–7, 9–10). They also conserved a convex bottom and circular section handles, which also began below the edge and ended at the bottom of the wall. Although with doubts, physical and formal similarities with eastern Mediterranean wares led to the assumption that they would share the same origin (Macias and Remolà, 2000: 490; Macias, 2003: 30; for a comparative profile with eastern wares see: Hayes, 1992: 154, fig. 33. 27–34, 156, fig. 35.13, 196, fig. 76.19, 197, fig. 47–49). Besides these cooking pots, a set of casseroles with low walls and two horizontal handles was also identified. They stand out for having a beveled rim towards the inside and presenting a slight depression in the central part. The formal scheme of these casseroles, as well as the presence of identical fabrics to the supposed eastern cooking pots, were elements that led Macias (1999) to propose that they could resemble the forms CATHMA 4, FCW Cass 38 and Uscatescu XVI and XVIII (CATHMA, 1991: 35, fig. 16; Fulford and Peacock, 1984: fig. 70.38; Uscatescu, 1996: 111).

A recent study (Rodríguez, 2020) has significantly increased the typological and chronological knowledge of the different ceramics found in the port suburb between the 7th and 8th centuries. Sixteen ceramic deposits have been analyzed, which included>23,500 fragments and 10,000 ceramic individuals, of which 2,281 were ascribed chronologically to these centuries. The results confirm that Tarragona not only received products close to and located near our study area but also from more distant regions such as North Africa, the Italian Peninsula, Egypt, Syria, Palestine, Asia Minor, the Aegean Islands and Constantinople. Concerning the eastern Mediterranean cooking wares, Rodríguez (2020: 525-527 and fig. 157) has suggested the presence of imports from the Aegean area and Asia Minor, as well as the Workshop 'X' production from the Levantine area, based on typological comparison with other sites of the Mediterranean. He has also detected for the first time in the Iberian Peninsula the presence of the Glazed White Ware I (Rodríguez, 2020: 230, lam. 4.28 and 450–451, fig. 130.47). Besides these products, the author documented a greater variability of profiles and size of cooking pots and casseroles than that identified by Macias (1999) and, also relying on a first set of analytical data on these ceramics, has proposed that they do not have an eastern Mediterranean origin but a local or regional one, based on macroscopic comparison with other local fabrics (Rodríguez, 2020: 381-386, fabric 1 to 3, cf. 10 to 12). A similar idea has been argued by Reynolds (2015: 191, note 156 and 198), who compared these fabrics with an example of cooking pot found in Puig-Rom (Roses).

These new findings have motivated the development of an archaeometric study of these wares found in the port suburb of Tarragona, through a combined petrographic and chemical approach, with the aim of gaining additional information on their composition and, on this basis, achieving a better understanding of their provenance. A similar line of research was successfully applied in the past for the provenance determination of eastern Mediterranean amphorae from the same site (Fantuzzi et al., 2019). In the present paper, the objective is to shed light on the provenance of cooking wares with a presumable eastern Mediterranean provenance, in order to verify this hypothesis and examine the possible occurrence of local/regional imitations or forms inspired by these eastern Mediterranean types.

2. Archaeological contexts and sampling

A total of 45 cooking wares were selected for analysis (Table 1; Figs. 2 and 3).

Considering their typology, macroscopic characteristics and their comparison with already published materials from other Mediterranean ceramic contexts, nine of these are samples can be clearly considered as eastern Mediterranean imports. These include: three samples of the cooking pot form Oc/Or/62 (TA002, TAR072 and TAR073), that we interpret as equivalent to Saraçhane CW3 type B (Hayes, 1968: 214, fig. 108 and 1992: 54–55); three samples of form Oc/Or/69 (TAR030, TAR042 and TB001), equivalent to type Reynolds 4.1/CATHMA 11 or CW 34 (Reynolds and Waksman, 2007: 63; CATHMA, 1991: 39, fig. 29); and three samples of forms Oc/Or/104 (TAR 078 and TB011) and Oc/Or/104.2 (TAR053), that cannot be related to a clear typological parallel, but show identical macroscopic fabrics to Saraçhane CW3 type B and give the impression of being similar to other 'Grey gritty ware' cooking-pots and casseroles identified by Hayes in Saraçhane and Paphos (Hayes, 1992: 55, 165, fig. 45.136,137 and 140, 166, fig. 46.141–142; 2003: 511–512, fig. 35.380a and 381).

For most of the samples analyzed in this study, including 19 cooking pots (forms Oc/Gre/64, 66, 72.3, 73, 77, 81, 84, and 129 – TA001, TA005, TAR010, TAR019, TAR022, TAR023, TAR029, TAR047, TAR049, TAR050, TAR051, TAR058, TAR060, TAR061, TAR063, TAR080, TAR081, TAR082 and TAR083 –) and 11 casseroles (forms Ca/Gre/50, 56, 65, Cb/Gre/6 and Cb/Gre/7 – TA003, TA007, TAR003, TAR007, TAR025, TAR052, TAR054, TAR055, TAR056, TAR059 and TAR079 –), the typological and macroscopic characteristics leave doubts about their provenance, which can be either from the eastern Mediterranean or local/regional products. For this reason, and to verify the hypothetical local/regional provenance of some of these wares, we have included in the analysis four samples of cooking pots (forms Oc/Gre/57.3, Oc/Gre/68 and Oc/Gre/70 – TAR024, TAR027, TAR028 and TAR012 –) and two of casseroles (Cb/Gre/24.2 and Cb/Gre/60 – TAR009 and TAR048 –) that are very probably local/regional products, as reference materials for comparison. Their consideration as local or regional products is based on their ubiquitous presence in the late antique contexts of the city and its scarcity in contemporary contexts outside Tarragona.

The analyzed materials were found in various excavations carried out in the port suburb of Tarragona, dated between AD 650 to 715+ (Fig. 1b). Here we include materials from six ceramic deposits (see Rodríguez, 2020 for further details about the stratigraphic data and ceramic contexts). Firstly, we incorporate part of the materials from the first dump published by Macias and Remolà in 2000 (Fig. 1c n.1) (*P*2-7-22a/1; Macias and Remolà, 2000; Rodríguez, 2020: 54ff). Likewise, we include two construction horizons with overlapping layers (TVB27/1 and TVB27b/2.1) documented at 27 Vidal i Barraquer Ave., and dated between 675 and 700 and 675/700–715, respectively (Fig. 1c n.2) (Rodríguez and Macias, 2016; Rodríguez, 2020: 149ff; Rodríguez and Macias, in press). Another extension of industrial buildings with the same chronology was attested at 12 Felip Pedrell St., 81 Smith St. and 44–46 Vidal i Barraquer Ave. (Fig. 1c n.3). Here we documented three overlapping horizons. The first is the construction of a pit that collects the black waters from the private *balnea* of 10–12 Felip Pedrell St. (*P*2-7-22b/1; Rodríguez, 2020: 67ff). The second deposit came from a dump inserted in the construction levels of a large productive building (*P*2-7-22b/2; Rodríguez, 2020: 78ff). The last horizon from this excavation

Table 1
List of the analyzed samples, with their main archaeological information.

Sample	Inventory number	Archaeological site	Type	Chronology
TA001	*P*2-7-22a/1. / UE 1059–2	10–12 Felip Pedrell St	Oc/Gre/66.2	650–725+
TA002	*P*2-7-22a/1. / UE 1082–25	10–12 Felip Pedrell St	Oc/Or/62	650–715+
TA003	*P*2-7-22a/1. / UE 1071–7	10–12 Felip Pedrell St	Cb/Gre/6.2	650–725+
TA004	*P*2-7-22a/1. / UE 1073–1	10–12 Felip Pedrell St	Cb/Gre/7	650–725+
TA005	*P*2-7-22a/1. / UE 1059	10–12 Felip Pedrell St	Oc/Gre/66.3	650–725+
TAR003	TVB27/1. / UE 31197–21	27 Vidal i Barraquer Av.	Ca/Gre/50	675–725+
TAR007	TVB27/1. / UE 31119–11	27 Vidal i Barraquer Av.	Ca/Gre/50	675–725+
TAR009	TVB27/1. / UE 31122–10	27 Vidal i Barraquer Av.	Cb/Gre/24.2	650–725+
TAR010	TVB27/1. / UE 31197–17	27 Vidal i Barraquer Av.	Oc/Gre/73	675–725+
TAR012	TVB27/1. / UE 31150–4	27 Vidal i Barraquer Av.	Oc/Gre/70	675–700
TAR019	TVB27/1. / UE 31122–14	27 Vidal i Barraquer Av.	Oc/Gre/77	675–700
TAR022	TVB27/1. / UE 31128–8	27 Vidal i Barraquer Av.	Oc/Gre/73	675–725+
TAR023	TVB27/1. / UE 3005–1	27 Vidal i Barraquer Av.	Oc/Gre/66.2	650–725+
TAR024	TVB27/1. / UE 31121–10	27 Vidal i Barraquer Av.	Oc/Gre/57.3	650–700
TAR025	TVB27/1. / UE 4005–2	27 Vidal i Barraquer Av.	Ca/Gre/65	675–725+
TAR027	TVB27/1. / UE 2015–48	27 Vidal i Barraquer Av.	Oc/Gre/68	675–700
TAR028	TVB27/1. / UE 2015	27 Vidal i Barraquer Av.	Oc/Gre/68	675–700
TAR029	TVB27/1. / UE 31197–18	27 Vidal i Barraquer Av.	Oc/Gre/64	675–725+
TAR030	TVB27/1. / UE 31191–18	27 Vidal i Barraquer Av.	Oc/Or/69	650–715+
TAR042	TVB27/1. / UE 31130 – 1	27 Vidal i Barraquer Av.	Oc/Or/69	650–715+
TAR047	TVB27b/2.1. / UE 142–13	27 Vidal i Barraquer Av.	Oc/Gre/64.4	675–725+
TAR048	TVB27b/2.1. / UE 143–53	27 Vidal i Barraquer Av.	Cb/Gre/60	650–715+
TAR049	TVB27/2.1. / UE 114–19	27 Vidal i Barraquer Av.	Oc/Gre/84	715–725+
TAR050	TVB27/1. / UE 232–5	27 Vidal i Barraquer Av.	Oc/Gre/129	675–715+
TAR051	TVB27b/2.1. / UE 440–3	27 Vidal i Barraquer Av.	Oc/Gre/64	675–725+
TAR052	TVB27b/2.1. / UE 439–6	27 Vidal i Barraquer Av.	Ca/Gre/65	675–725+
TAR053	TVB27b/2.1. / UE 143–88	27 Vidal i Barraquer Av.	Oc/Or/104.2	650–725
TAR054	TVB27b/2.1. / UE 143	27 Vidal i Barraquer Av.	Ca/Gre/56	675–715
TAR055	TVB27b/2.1. / UE 439–5	27 Vidal i Barraquer Av.	Ca/Gre/65	675–725+
TAR056	TVB27b/2.1. / UE 143–18	27 Vidal i Barraquer Av.	Ca/Gre/50.3	675–725+
TAR058	TVB27b/2.1. / UE 143–76	27 Vidal i Barraquer Av.	Oc/Gre/64	675–725+
TAR059	TVB27b/2.1. / UE 143–54	27 Vidal i Barraquer Av.	Cb/Gre/7.2	650–725+
TAR060	TVB27b/2.1. / UE 142–14	27 Vidal i Barraquer Av.	Oc/Gre/64	675–725+
TAR061	TVB27b/2.1. / UE 143–81	27 Vidal i Barraquer Av.	Oc/Gre/72.3	650–725
TAR063	TVB27b/2.1. / UE 142–12	27 Vidal i Barraquer Av.	Oc/Gre/81	675–715
TAR072	TVB27b/2.1. / UE 160–49	27 Vidal i Barraquer Av.	Oc/Or/62	650–715
TAR073	TVB27b/2.1. / UE 143–62	27 Vidal i Barraquer Av.	Oc/Or/62	650–715
TAR078	*P*2-7-22b/2. / UE 5216–5	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av.	Oc/Or/104	650–725
TAR079	*P*2-7-22b/4. / UE 5136–13	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Cb/Gre/7.4	650–725+
TAR080	*P*2-7-22b/1. / UE 5288–20	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Gre/66	650–725+
TAR081	*P*2-7-22b/1. / UE 5288–21	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Gre/66.5	650–725+
TAR082	*P*2-7-22b/1. / UE 5288–34	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Gre/66.9	650–725+
TAR083	*P*2-7-22b/1. / UE 5288–35	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Gre/66.5	650–725+
TB001	*P*2-7-22b/2. / UE 5257–2	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Or/69	650–715+
TB011	*P*2-7-22b/2. / UE 5257–3	12 Felip Pedrell St, 81 Smith St and 44–46 Vidal i Barraquer Av	Oc/Or/104	650–715

corresponds to the layers of their abandonment (*P*2-7-22b/4; Rodríguez, 2020: 97ff).

3. Analytical methods

The selected ceramic samples were analyzed by using Wavelength Dispersive X-ray Fluorescence Spectroscopy (WD-XRF) for their chemical characterization and optical microscopy (OM) by thin section analysis for their petrographic-mineralogical study.

The OM petrographic-mineralogical analysis of thin sections was carried out using an Olympus BX41 polarizing microscope, coupled with a D70 Olympus camera (12,5 megapixels) working with a magnification between 20X and 200X. Each ceramic specimen was impregnated with epoxy resin, mounted using Loctite UV glue, and sectioned using a Struers Discoplan TS. The thin sections were finished by hand using a powder abrasive until reaching a thickness of 30 μm in which quartz presents a grey-white first order interference color. Photomicrographs were taken using a digital camera Olympus DP-70 attached to the microscope and controlled by specific software. The fabrics were identified and analyzed following the methodology by Whitbread (1989, 1995) and Quinn (2013). Grain size modes have been determined measuring the major axis of the grains of the more represented granulometric classes both for the fine and the coarse fractions.

The WD-XRF chemical analysis was conducted using a Panalytical Axios Max Advanced Sequential Spectrometer equipped with SuperQ5 Chemical Software. The samples were powdered and homogenized after drying at 100 °C for 24 h. Major and minor elements were determined by preparing duplicates of fused beads using 0.3 g of a specimen in an alkaline fusion with lithium tetraborate (1/20 solution). Trace elements

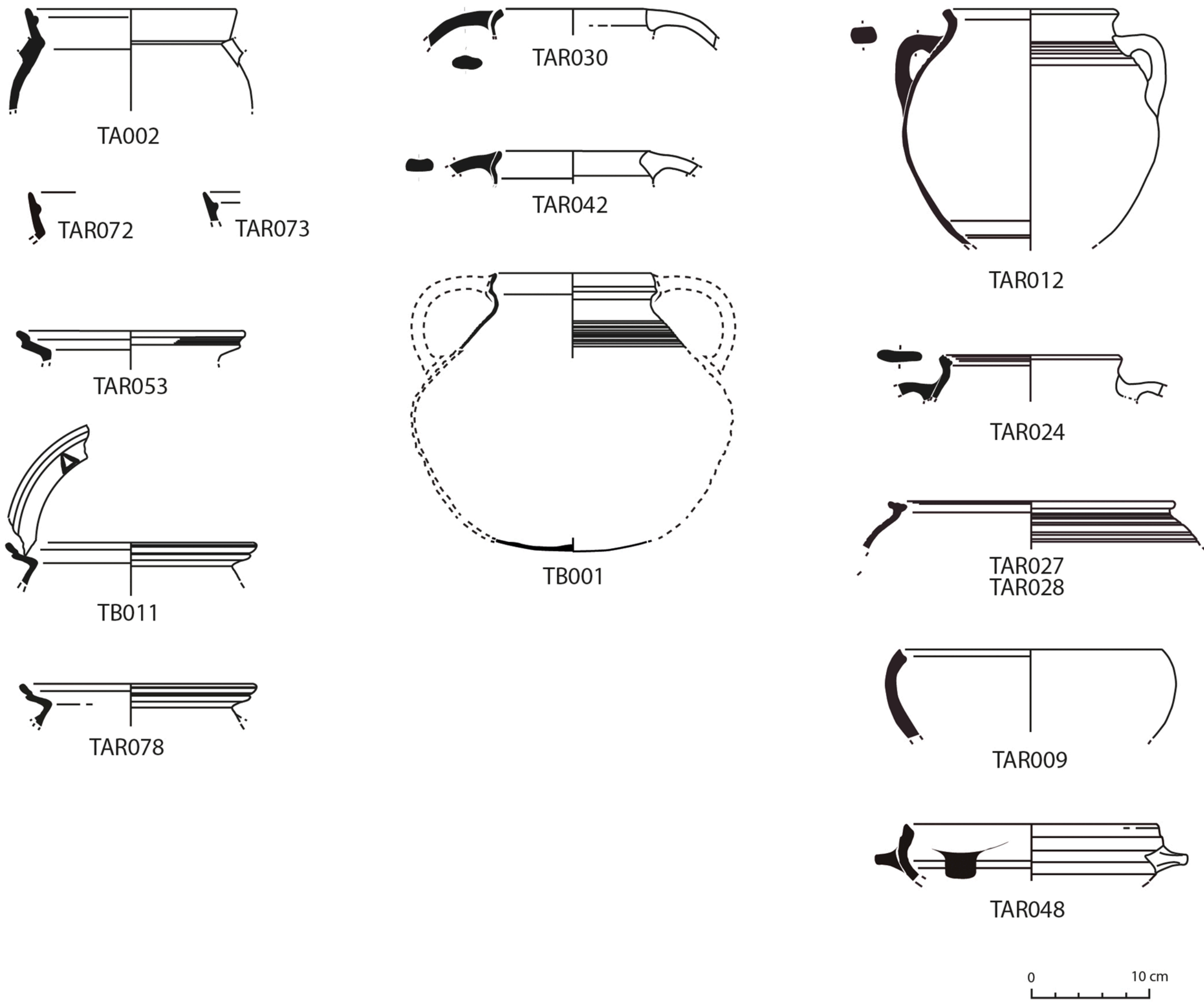

Fig. 2. Illustrations of the analyzed cooking wares.

and Na_2O were determined through pressed powder pellets, made from 5 g of specimen mixed with Elvacite agglutinating, placed over boric acid in an aluminum capsule and pressed during 60 s at 200 kN. The concentrations of 29 major, minor and trace elements were obtained: Fe_2O_3 (as total Fe), Al_2O_3, MnO, P_2O_5, TiO_2, MgO, CaO, Na_2O, K_2O, SiO_2, Ba, Rb, Mo, Th, Nb, Pb, Zr, Y, Sr, Sn, Ce, Co, Ga, V, Zn, W, Cu, Ni and Cr. Some of these elements were not included in the statistical analysis, particularly Mo, Sn and W for their low counting statistics, and Co and W due to possible contamination from the tungsten carbide cell of the mill used to prepare the samples. A calibration line based on 60 International Geological Standards was used for quantifying the elemental concentrations. The loss on ignition (LOI) was estimated by firing 0.3 g of a dried specimen at 950 °C for 3 h. For the multivariate statistical treatment of the chemical data, the chemical concentrations were transformed into additive log-ratios (alr), following the methodology proposed by Aitchison (1986, 1992) and Buxeda (1999). We use the log-ratio transformation to scale the data avoiding, at the same time, possible problems of perturbation that might be introduced by elemental alterations that could not be detected. The statistical software applied for the multivariate statistical treatment was Splus2000.

4. Results

4.1. Petrographic analysis

The OM thin-section analysis allowed the differentiation of six petrographic fabrics, although only Fabrics 1 and, to a lesser degree, Fabrics 2, 4 and 6, are well represented in the ceramic assemblage (Table 2).

Most of the assemblage can be included in Fabric 1 (Table 2; Fig. 4 a-c), with predominant inclusions of quartz and alkali feldspar, in addition to common/few low-grade metamorphic rock fragments derived from pelites and psammites (mostly slate or phyllite), and few granitoid rock fragments. There are also common-few sedimentary rock fragments ranging from mudstone and shale to quartz sandstone. Quartz inclusions, which tend to be subangular, are mainly monocrystalline, although polycrystalline quartz or quartzite is also commonly observed. Minor amounts of plagioclase, chert and micritic lumps can also be found. This fabric is characterized by a bimodal grain-size distribution of the inclusions, with a moderately abundant, poorly sorted coarse fraction (>0.25 mm) ranging from medium to very coarse sand, and a very abundant fine fraction (0.25–0.01 mm, mode < 0.10 mm). In addition to the aforementioned inclusions, the fine fraction also contains frequent to common micas (mostly muscovite and, to a lesser extent, biotite), usually very fine-grained (mode < 0.05/0.10 mm) but occasional coarse-grained laths of biotite or muscovite are also present. Accessory minerals in the fine fraction include epidote, garnet, and zircon. The clay matrix in Fabric 1 is non-calcareous, with light brown or brown to grey-black color under plane-polarized light (PPL), usually showing variations related to core/margin color differentiation and displaying optical activity in crossed polars (XP).

Fabric 2, observed in six of the samples analyzed (Table 2), has broad

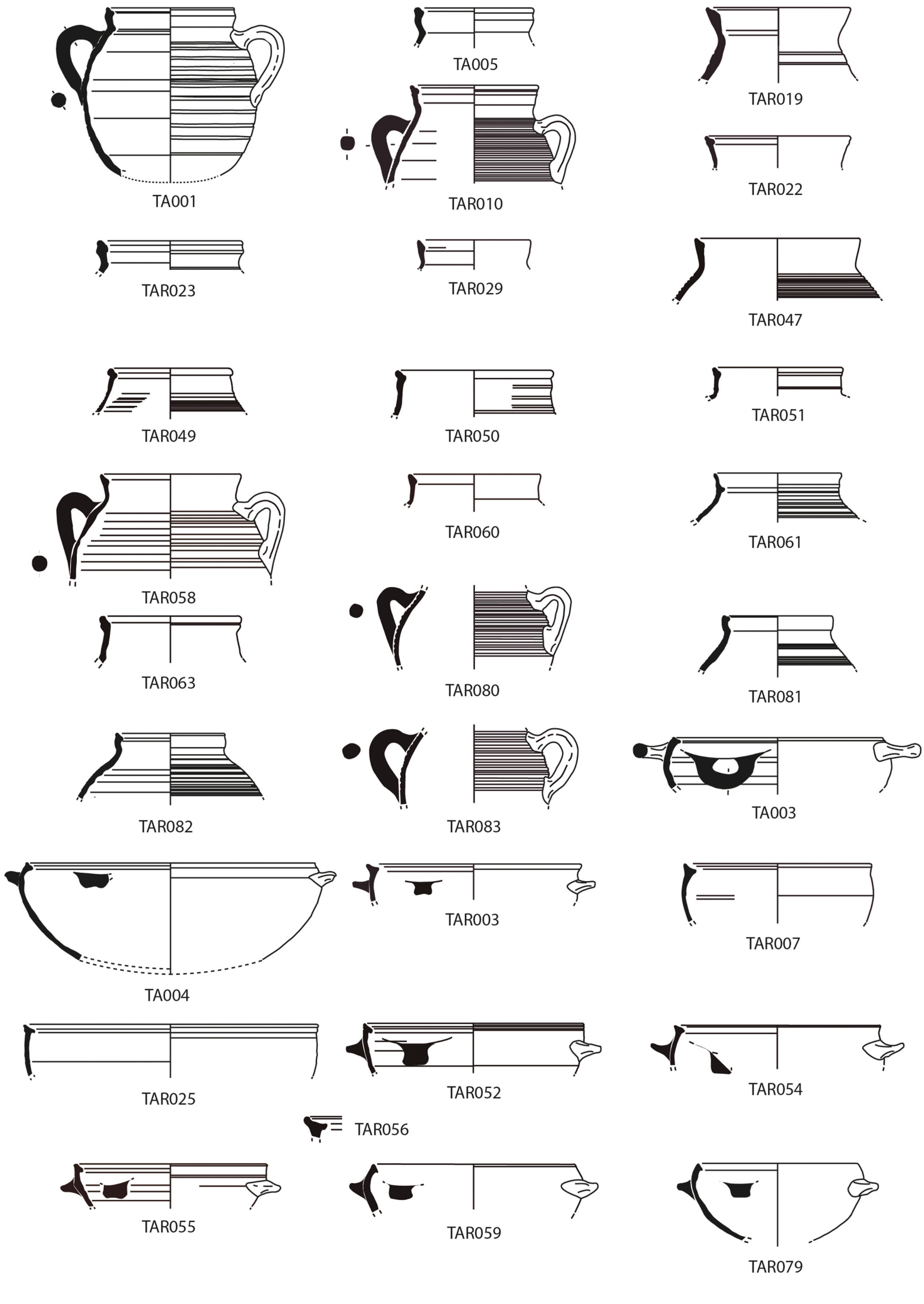

Fig. 3. Illustrations of the analyzed cooking wares.

Table 2
Summary of the results obtained from the thin section petrographic analysis.

Petrographic fabric	Number of samples	Samples
Fabric 1	29	TA001, TA003, TA004, TA005; TAR003, TAR007, TAR010, TAR012, TAR019, TAR022, TAR023, TAR025, TAR029, TAR047, TAR048, TAR049, TAR050, TAR051, TAR052, TAR054, TAR055, TAR056, TAR058, TAR060, TAR063, TAR079, TAR080, TAR082, TAR083
Fabric 2	6	TAR009, TAR024, TAR027, TAR028, TAR059, TAR061
Fabric 3	1	TAR081
Fabric 4	4	TB0011, TAR053, TAR072, TAR073, TAR078
Fabric 5	1	TA002
Fabric 6	3	TB001, TAR030, TAR042

similarities with Fabric 1 regarding the main types of inclusions, but shows some important differences (Fig. 4 d-e). The coarse fraction (>0.25 mm), more abundant than in Fabric 1, contains a higher frequency of plutonic rock fragments (granitoids), which, in addition to quartz and alkali feldspar, commonly also include plagioclase. Coarse laths or aggregates of biotite are also slightly more abundant than in Fabric 1. In general terms, the petrographic evidence points to a higher contribution of granodiorite in the inclusions of Fabric 2. There are also minor amounts of micritic lumps, chert and, in some cases, low-grade metamorphic rock fragments, and accessory inclusions of amphibole, epidote, garnet and tourmaline. The matrix in this fabric showed a grey-black to dark brown color in PPL and it is optically active in XP.

A somewhat different fabric (Fabric 3) is found in one sample, TAR081 (Fig. 4 f). This is a very coarse-grained fabric, with a poorly sorted coarse fraction (0.25–7.00 mm) composed of quartz, alkali feldspar and, to a lesser degree, plagioclase, in addition to granitoid rock fragments and common sedimentary rock fragments ranging from mudstone to sandstone. Even if the nature of the inclusions is broadly similar to those found in the previous fabrics (and especially in Fabric 1), this fabric is clearly different in terms of textural parameters, as the fine fraction (0.25–0.01 mm) here is very scarce and, for this reason, the fabric exhibits a clean matrix, with a brown-orange to the yellowish-brown color in PPL. These features seem to indicate the use of different clayey raw materials than those used for manufacturing the ceramics in Fabrics 1–2.

Fabrics 4 and 5 are characterized, again, by dominant inclusions of quartz and feldspars, but in this case with acidic metamorphic rocks along with occasional volcanic inclusions. In the case of Fabric 4, observed in five samples (Table 2; Fig. 4g), both monocrystalline and polycrystalline quartz inclusions are dominant, in addition to alkali feldspar and plagioclase, and few metamorphic rock fragments containing these inclusions which likely derive from metagranitoids. There are also a few coarse argillaceous inclusions (Whitbread, 1986) that correspond to clay pellets and possible claystone. This fabric also comprises common-few micas (muscovite and biotite) and carbonate inclusions (with few-rare calcareous microfossils), a few cherts, and a few to very rare volcanic rock fragments consisting in an altered fine-grained groundmass that in some cases contain phenocrysts of quartz. It is a medium-grained fabric, with very abundant inclusions from silt to medium sand (<0.50 mm), and lesser amounts of coarse and very coarse

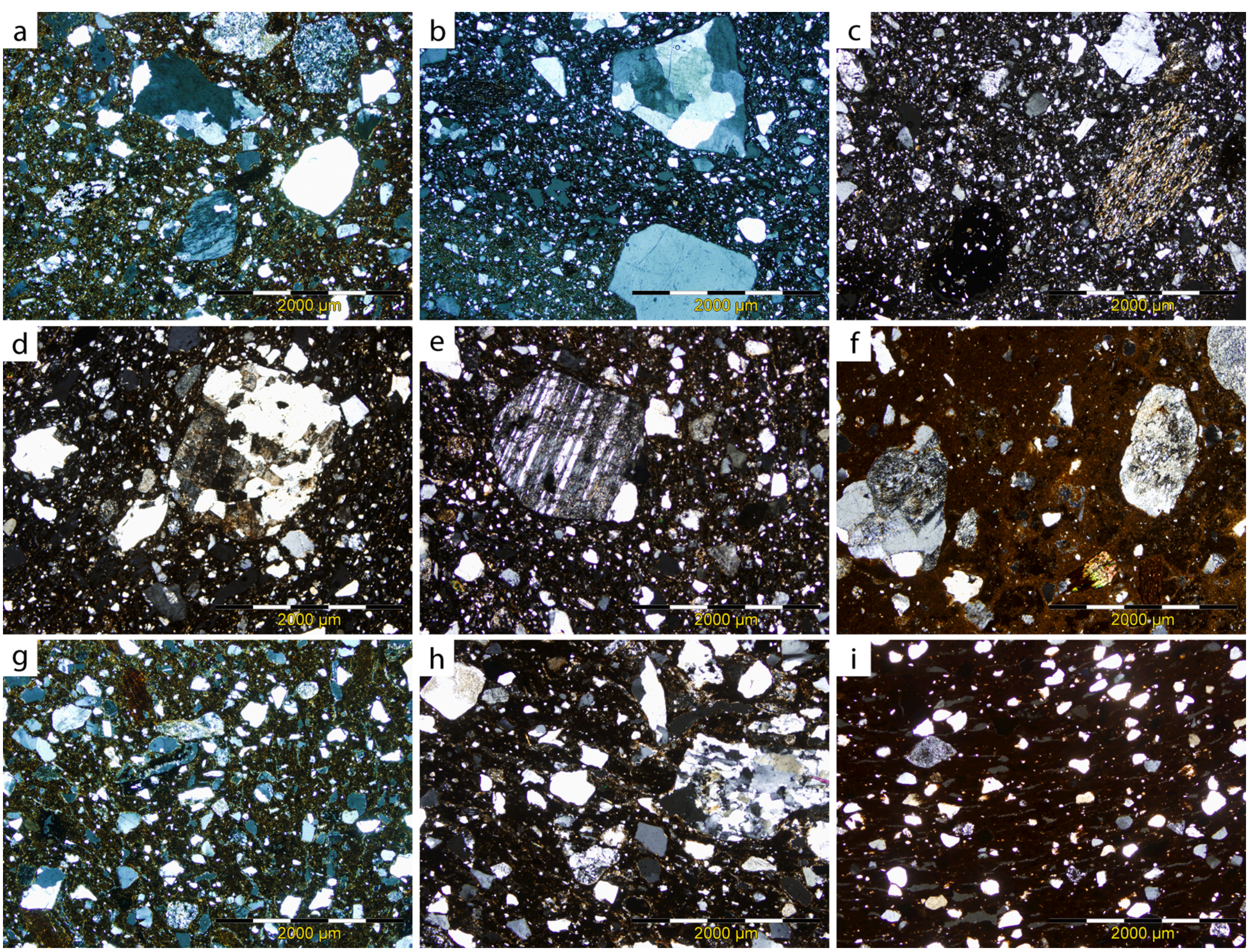

Fig. 4. Photomicrographs of ceramic thin sections, taken under crossed polars (XP) at 40x. a-c, Fabric 1, samples TA003 (a), TAR010 (b) and TAR047 (c); d-e, Fabric 2, samples TAR027 (d) and TAR028 (e); f, Fabric 3, sample TAR081; g, Fabric 4, sample TAR072; h, Fabric 5, sample TA002; i, Fabric 6, sample TAR042.

sand. The fine fraction (0.10–0.01 mm) also contains accessory epidote and clinopyroxene. The matrix, optically active in XP, shows a brown to yellowish-brown color in PPL, sometimes with grey colored (reduced) zones.

On the other hand, Fabric 5, found only in sample TA002 (Fig. 4h), is relatively similar to Fabric 4 in terms of the nature of the inclusions, but it is texturally coarser than the latter, with a higher frequency of coarse to very coarse sand, while the matrix is similar in both fabrics. Like Fabric 4, it is also composed of dominant quartz, alkali feldspar and plagioclase, but here a higher frequency of coarse metamorphic rock fragments – derived from quartzite and metagranitoid – can be found, in addition to very rare marble. Very few volcanic rock fragments, like those found in Fabric 4, are observed. There are also a few fine-grained micas and carbonate inclusions (calcite and microfossils), and accessory clinopiroxene and epidote.

The last fabric identified in the ceramic assemblage, Fabric 6, was observed in three samples (Table 2; Fig. 4i). It is composed of fine-medium sand inclusions of quartz (subangular to rounded) on a red-colored clay matrix that is very rich in iron nodules; the fraction between silt and very fine sand is very scarce, resulting in a 'clean' matrix. The fabric also contains common inclusions of chert (up to 1.8 mm, but mostly fine-medium sand), as well as rare micritic calcite and very rare feldspars. The matrix is optically inactive in XP, suggesting relatively high firing temperatures.

4.2. Chemical analysis

The chemical composition of the analyzed samples is presented in Table 3. We have calculated the compositional variation matrix (CVM) (Buxeda and Kilikoglou, 2003) for the 44 individuals (Table 3) to explore the chemical variability of the dataset, without including some of the chemical elements. Mo and Sn were excluded due to low concentrations and analytical imprecisions (both are lower than their regression limits in our samples). Co and W were not considered due to possible contaminations during sample preparation (we use tungsten carbide cell for powdering). MnO, P_2O_5 and Pb were omitted as well, due to analytical imprecisions or post-depositional alterations and/or contaminations. The total variation (vt) according to the CVM is equal to 1.86, which is too high for a monogenic sample (homogenous population). The variability introduced by each one of the chemical elements in the data set (t.i) is represented in the line plot of Fig. 5a. The most variable element is CaO (Fig. 5a). The values of CaO oscillate between 0.61 % (TAR042) and 5.94 % (TAR053) (Table 3) and a certain arrangement can be observed in those differences. The high variability of Sr (Fig. 5a) is also associated with the calcareous nature of the material since it is geochemically associated with CaO. Samples TAR042 and TB001 are very similar typologically and they both present the lowest concentrations in CaO in the data set. The other two elements that introduce significant variability in the data set are Ni and Cr (Fig. 5a), which is important since these elements are usually high in eastern Mediterranean products and low in regional products form northeastern Iberia. There are several individuals with high concentrations in these two elements: TAR042, 53, 72, 73, 78, TA002, TB001 and TB011 (Table 3). Na_2O, Ba and Zn are other elements that also vary considerably according to the CVM. The variability in Na_2O is biased by the relatively very low values in TAR042 and TB001 and the same goes with Ba which is much lower in these two individuals (Table 3).

To summarize the chemical results, a cluster analysis was performed using the Square Euclidean distance and the agglomerative centroid method, based on an additive logratio (alr) transformed composition excluding the above-mentioned elements and dividing with SiO_2 in the additive logratio (arl) transformation, which was the less variable element (Fig. 5b). The cluster tree reveals the presence of three major clusters, the chemical differences between which can be observed in the biplot of the first and second principal component of the principal component analysis on the same alr transformed sub composition (Fig. 6).

The first group (TAR042 and TB001) on the cluster tree corresponds to Fabric 6. Both individuals within the group are similar chemically and with certain singularities compared to the rest of the analyzed material. Their high concentrations in Cr and Ni suggest that they might be eastern Mediterranean products. They also have relatively high Fe_2O3, Al_2O_3, TiO_2, Zr, and V, and low K_2O, Na_2O and Ba percentages (Table 3; Fig. 6).

The second chemical group is formed by individuals of Fabric 4 (TAR53, 72, 73, 78, TB011) and Fabric 5 (TA002). They are all characterized by high concentrations of CaO, Na_2O, Ba, Ni and Cr. TA002 (Fabric 5) shows slightly higher SiO_2 and lower Al2O3, Th and V than the other samples of the same group.

The rest of the samples in the ceramic assemblage seem to form a large common cluster (LoR) in Fig. 5b. Here the main chemical differences from the previous groups are the much lower concentrations in Cr and Ni. The cluster LoR can be subdivided into two main chemical groups (Fig. 5 b): one of them is formed by samples of Fabric 2, while to the other one includes all the samples of Fabric 1 as well as sample TAR081 from Fabric 3. Slight differences in the concentrations of Fe_2O3, Na_2O, Cr and Zn can be observed between these two chemical groups, the first one (related to Fabric 2) showing clearly higher Na_2O and slightly higher Fe_2O, as well as lower Zn and Cr, than the second one (Fabrics 1 and 3).

5. Discussion

The chemical groups defined from the results of WD-XRF analysis correlate well with the petrographic fabrics identified through thin section analysis. Further details are obtained by also integrating the archaeological evidence, in particular the typology of the samples. In addition, a comparison with previous analysis on Late Roman cooking wares from the eastern Mediterranean allowed for a better characterization and classification of some of the cooking wares found in Tarragona.

For some of these wares, the obtained results supported the hypothesis of a provenance in the eastern Mediterranean and provided further evidence about their likely production areas. This is the case, for instance, of the samples included in Fabric 6 (TB001, TAR030, and TAR042); two of these samples were analyzed through WD-XRF and revealed a particular chemical composition for the samples in this fabric (Fig. 5b). This chemical composition is clearly similar to the one that characterizes the Levantine 'Workshop X' defined by Waksman et al. (2003, 2005), a term used to refer to an unknown and yet unlocated workshop (or group of workshops) that produced a series of cooking wares and common wares from the end of the 4th to the 7th century CE, and based on the available archaeological and archaeometric evidence it could have been located in the Levantine area. Also, Fabric 6 described in this study correlates well with the fabric described by Vokaer (2010) for this 'Workshop X'. The three samples in Fabric 6 are related to a typical form for this 'Workshop X' production, the cooking pot type Oc/Or/69 (Macias, 1999: 139–140 and 153, plate. 56; Rodríguez, 2020: 471 and 495, Fg. 138), equivalent to Reynolds & Waksman type 4.1/CATHMA 11 and CW 34 (Reynolds and Waksman, 2007: 63). This kind of pot intended for cooking has a globular profile, with an expanded belly towards the center, very thin walls, grooved surfaces with signs of fast turning, and a slip with somewhat smoked tones. It presents two long and vertical handles, with an oval section, which join the rim and the wall of the body. The rim is re-entrant, concave in shape and has a rounded lip. Its diameter varies between 12 and 13 cm, while the approximate height of the vessel is around 20 cm. The examples from Tarragona, like others found in Paphos (Hayes, 2003: 491, fig. 23,256 and 492, fig. 24,261), the Yassiada wreck (Bass and Van Doorninck, 1982: 176, fig. 8–15. P. 53), Saint-Blaise (CATHMA, 1991: fig. 31.29), Marseille (Bien, 2005: 294, fig. 5.12, Bien, 2007: 268, fig. 1.14) and Carthage (Hayes, 1978: 52, fig. 13.31), seem to come from the

Table 3
Normalized elemental composition of the 44 samples analyzed by WD-XRF.

Sample	Fabric	Fe_2O_3	MnO	TiO_2	CaO	K_2O	P_2O_5	SiO_2	Al_2O_3	MgO	Na_2O	Ba	Ce	Cr	Cu	Ga	Nb	Ni	Pb	Rb	Sr	Th	V	Y	Zn	Zr
TAR042	FAB 6	9.65	0.05	2.03	0.61	0.66	0.23	65.35	20.41	0.69	0.17	0.0185	0.0101	0.0213	0.0031	0.0024	0.0036	0.0087	0.0044	0.0050	0.0085	0.0015	0.0143	0.0030	0.0091	0.0365
TB001		10.00	0.07	2.00	1.23	0.65	0.22	65.20	19.59	0.70	0.17	0.0141	0.0092	0.0216	0.0039	0.0027	0.0037	0.0093	0.0030	0.0074	0.0111	0.0009	0.0203	0.0029	0.0101	0.0384
TAR053		5.59	0.12	0.72	5.94	2.64	0.25	65.31	16.18	1.79	1.23	0.1162	0.0069	0.0177	0.0039	0.0017	0.0013	0.0101	0.0042	0.0087	0.0272	0.0014	0.0100	0.0026	0.0077	0.0165
TAR072		5.61	0.08	0.66	4.70	2.71	0.21	66.87	15.96	1.75	1.25	0.0877	0.0062	0.0192	0.0044	0.0017	0.0013	0.0111	0.0049	0.0091	0.0259	0.0015	0.0100	0.0024	0.0081	0.0161
TAR078	FAB4	5.60	0.08	0.68	6.14	2.60	0.22	65.43	15.98	1.83	1.20	0.1040	0.0073	0.0208	0.0026	0.0016	0.0017	0.0103	0.0039	0.0088	0.0433	0.0016	0.0094	0.0024	0.0075	0.0155
TB011		5.66	0.08	0.70	5.45	2.57	0.19	66.34	16.14	1.75	0.88	0.1106	0.0058	0.0183	0.0037	0.0021	0.0016	0.0118	0.0043	0.0107	0.0467	0.0014	0.0102	0.0026	0.0084	0.0178
TAR073		5.80	0.06	0.69	3.02	2.97	0.14	68.14	16.21	1.60	1.19	0.0700	0.0067	0.0206	0.0021	0.0017	0.0013	0.0104	0.0037	0.0109	0.0179	0.0016	0.0096	0.0023	0.0068	0.0169
TA002	FAB 5	4.80	0.08	0.60	3.26	2.74	0.14	70.79	14.85	1.38	1.16	0.0849	0.0076	0.0174	0.0026	0.0020	0.0015	0.0100	0.0038	0.0104	0.0342	0.0012	0.0090	0.0024	0.0070	0.0171
TAR027		5.56	0.06	0.64	1.85	3.29	0.08	68.54	17.27	1.52	1.02	0.0760	0.0081	0.0053	0.0021	0.0020	0.0012	0.0022	0.0042	0.0114	0.0130	0.0016	0.0100	0.0023	0.0070	0.0192
TAR028		5.50	0.05	0.63	1.91	3.28	0.12	68.58	17.21	1.48	1.06	0.0759	0.0068	0.0052	0.0027	0.0019	0.0012	0.0020	0.0053	0.0112	0.0136	0.0015	0.0098	0.0022	0.0070	0.0193
TAR061	FAB.2	4.90	0.05	0.56	5.13	3.47	0.18	66.67	16.06	1.71	1.11	0.0809	0.0062	0.0047	0.0012	0.0017	0.0012	0.0021	0.0033	0.0117	0.0216	0.0014	0.0092	0.0022	0.0063	0.0177
TAR059		5.42	0.07	0.69	2.74	3.58	0.10	67.66	16.68	1.73	1.15	0.0834	0.0082	0.0060	0.0013	0.0019	0.0014	0.0022	0.0037	0.0121	0.0166	0.0016	0.0108	0.0025	0.0083	0.0198
TAR009		4.61	0.06	0.63	3.59	3.38	0.20	69.21	15.62	1.52	1.01	0.0758	0.0078	0.0052	0.0012	0.0017	0.0013	0.0022	0.0046	0.0114	0.0172	0.0014	0.0087	0.0025	0.0073	0.0221
TAR024		4.92	0.06	0.65	2.57	3.37	0.13	70.05	15.71	1.45	0.91	0.0779	0.0073	0.0067	0.0011	0.0018	0.0013	0.0025	0.0037	0.0118	0.0133	0.0015	0.0093	0.0026	0.0077	0.0223
TAR029		6.04	0.04	0.73	1.53	3.57	0.37	69.15	16.08	1.62	0.68	0.0787	0.0077	0.0061	0.0025	0.0018	0.0013	0.0030	0.0092	0.0110	0.0191	0.0015	0.0120	0.0025	0.0187	0.0233
TAR079		5.56	0.08	0.79	1.30	3.38	0.16	69.51	16.44	1.94	0.60	0.0843	0.0075	0.0081	0.0034	0.0017	0.0017	0.0031	0.0106	0.0121	0.0323	0.0015	0.0112	0.0023	0.0223	0.0189
TA004		5.77	0.06	0.75	1.98	3.11	0.14	68.99	16.75	1.79	0.42	0.0940	0.0087	0.0067	0.0036	0.0023	0.0015	0.0027	0.0124	0.0118	0.0257	0.0014	0.0121	0.0025	0.0237	0.0222
TA003		5.97	0.10	0.80	1.36	3.39	0.11	69.00	16.79	1.71	0.55	0.0875	0.0070	0.0071	0.0030	0.0023	0.0016	0.0029	0.0110	0.0126	0.0262	0.0013	0.0120	0.0028	0.0246	0.0229
TA001		5.90	0.10	0.79	1.69	3.43	0.14	69.14	16.21	1.74	0.63	0.0952	0.0074	0.0066	0.0033	0.0023	0.0017	0.0029	0.0126	0.0131	0.0195	0.0014	0.0117	0.0026	0.0214	0.0243
TAR012		5.52	0.05	0.76	2.26	3.41	1.27	67.91	16.50	1.54	0.51	0.1099	0.0074	0.0061	0.0043	0.0019	0.0013	0.0033	0.0093	0.0116	0.0359	0.0014	0.0113	0.0024	0.0287	0.0209
TAR025		5.35	0.04	0.72	2.61	2.78	0.78	69.10	15.99	1.55	0.82	0.1095	0.0079	0.0069	0.0026	0.0019	0.0013	0.0031	0.0066	0.0101	0.0351	0.0015	0.0118	0.0025	0.0189	0.0234
TAR054		5.45	0.08	0.79	2.43	3.30	0.22	69.04	15.97	1.82	0.67	0.1008	0.0083	0.0079	0.0034	0.0018	0.0013	0.0030	0.0096	0.0110	0.0316	0.0014	0.0120	0.0026	0.0206	0.0216
TAR019		5.50	0.07	0.78	1.15	3.57	0.17	70.04	16.17	1.67	0.68	0.0830	0.0080	0.0069	0.0024	0.0019	0.0014	0.0032	0.0111	0.0125	0.0109	0.0013	0.0108	0.0027	0.0221	0.0221
TAR047		6.06	0.05	0.75	1.22	3.14	0.12	69.38	16.63	1.83	0.63	0.0716	0.0074	0.0074	0.0025	0.0019	0.0013	0.0030	0.0085	0.0113	0.0110	0.0014	0.0115	0.0025	0.0198	0.0237
TAR023		6.08	0.09	0.82	1.70	3.53	0.16	67.55	17.45	1.87	0.53	0.0798	0.0079	0.0070	0.0020	0.0021	0.0014	0.0035	0.0127	0.0133	0.0120	0.0015	0.0123	0.0030	0.0264	0.0212
TA005	FAB. 1	5.88	0.10	0.80	1.86	3.47	0.07	68.28	17.05	1.80	0.48	0.0696	0.0080	0.0064	0.0031	0.0025	0.0017	0.0029	0.0131	0.0148	0.0132	0.0014	0.0119	0.0028	0.0280	0.0235
TAR050		5.40	0.04	0.75	0.98	2.81	0.06	72.20	15.35	1.52	0.72	0.0667	0.0069	0.0075	0.0014	0.0018	0.0014	0.0028	0.0062	0.0107	0.0088	0.0014	0.0108	0.0024	0.0133	0.0241
TAR082		5.61	0.07	0.73	1.19	3.03	0.09	71.50	15.51	1.42	0.68	0.0584	0.0074	0.0091	0.0017	0.0017	0.0018	0.0034	0.0058	0.0115	0.0115	0.0015	0.0113	0.0027	0.0131	0.0225
TAR083		5.66	0.07	0.74	0.99	3.01	0.11	71.65	15.53	1.39	0.69	0.0571	0.0081	0.0087	0.0017	0.0017	0.0017	0.0032	0.0056	0.0112	0.0120	0.0015	0.0109	0.0027	0.0130	0.0225
TAR080		5.66	0.07	0.73	1.38	3.03	0.10	71.40	15.38	1.41	0.69	0.0570	0.0081	0.0086	0.0025	0.0016	0.0018	0.0033	0.0065	0.0114	0.0123	0.0015	0.0108	0.0028	0.0131	0.0226
TAR010		5.57	0.05	0.77	1.67	2.83	0.20	70.72	15.71	1.57	0.75	0.0692	0.0070	0.0077	0.0019	0.0019	0.0014	0.0032	0.0079	0.0108	0.0116	0.0014	0.0112	0.0025	0.0147	0.0249
TAR022		5.57	0.05	0.76	2.00	2.86	0.17	70.43	15.64	1.60	0.74	0.0684	0.0072	0.0070	0.0016	0.0018	0.0014	0.0028	0.0070	0.0106	0.0116	0.0014	0.0108	0.0025	0.0141	0.0242
TAR058		5.81	0.06	0.76	1.97	2.80	0.07	70.01	16.02	1.64	0.70	0.0674	0.0078	0.0083	0.0016	0.0018	0.0014	0.0033	0.0071	0.0105	0.0099	0.0014	0.0110	0.0025	0.0140	0.0235
TAR060		5.41	0.04	0.72	3.39	2.70	0.10	69.91	15.25	1.59	0.73	0.0697	0.0066	0.0067	0.0013	0.0018	0.0013	0.0027	0.0061	0.0100	0.0128	0.0014	0.0105	0.0023	0.0129	0.0231
TAR055		5.41	0.05	0.72	2.93	2.84	0.18	69.58	15.69	1.72	0.71	0.0700	0.0065	0.0075	0.0017	0.0018	0.0013	0.0028	0.0062	0.0105	0.0133	0.0014	0.0106	0.0023	0.0148	0.0226
TAR051		5.35	0.04	0.72	3.21	2.77	0.10	69.64	15.67	1.63	0.69	0.0735	0.0068	0.0081	0.0017	0.0018	0.0013	0.0028	0.0066	0.0104	0.0120	0.0014	0.0106	0.0023	0.0143	0.0228
TAR056		5.55	0.05	0.75	1.49	2.69	0.11	71.75	15.07	1.59	0.76	0.0937	0.0062	0.0072	0.0020	0.0017	0.0013	0.0029	0.0055	0.0093	0.0166	0.0013	0.0104	0.0023	0.0129	0.0231
TAR007		5.38	0.04	0.73	3.52	2.79	0.28	69.68	15.29	1.37	0.73	0.0876	0.0062	0.0069	0.0022	0.0018	0.0013	0.0028	0.0074	0.0096	0.0212	0.0013	0.0115	0.0024	0.0145	0.0224
TAR003		5.34	0.05	0.73	2.22	2.78	0.38	70.61	15.37	1.57	0.75	0.0979	0.0058	0.0064	0.0030	0.0018	0.0013	0.0033	0.0074	0.0097	0.0248	0.0013	0.0112	0.0023	0.0160	0.0228
TAR049		5.59	0.04	0.74	2.11	2.82	0.18	71.00	15.16	1.40	0.78	0.0836	0.0061	0.0072	0.0026	0.0017	0.0013	0.0029	0.0065	0.0097	0.0191	0.0013	0.0110	0.0024	0.0131	0.0230
TAR063		5.52	0.05	0.71	2.20	2.91	0.23	69.94	16.08	1.46	0.71	0.0846	0.0056	0.0073	0.0023	0.0018	0.0012	0.0029	0.0061	0.0100	0.0173	0.0013	0.0112	0.0023	0.0139	0.0207
TAR048		5.90	0.10	0.78	3.89	3.47	0.09	66.18	16.86	2.03	0.49	0.0801	0.0080	0.0068	0.0031	0.0020	0.0014	0.0032	0.0114	0.0127	0.0156	0.0015	0.0119	0.0025	0.0245	0.0201
TAR052		5.16	0.04	0.70	4.90	2.73	0.21	68.60	14.99	1.68	0.78	0.0868	0.0069	0.0084	0.0025	0.0017	0.0012	0.0033	0.0068	0.0093	0.0236	0.0014	0.0107	0.0022	0.0149	0.0216
TAR081	FAB. 3	5.54	0.07	0.71	1.75	2.90	0.33	71.43	15.03	1.34	0.71	0.0680	0.0084	0.0082	0.0023	0.0015	0.0016	0.0031	0.0058	0.0106	0.0291	0.0014	0.0113	0.0026	0.0122	0.0217

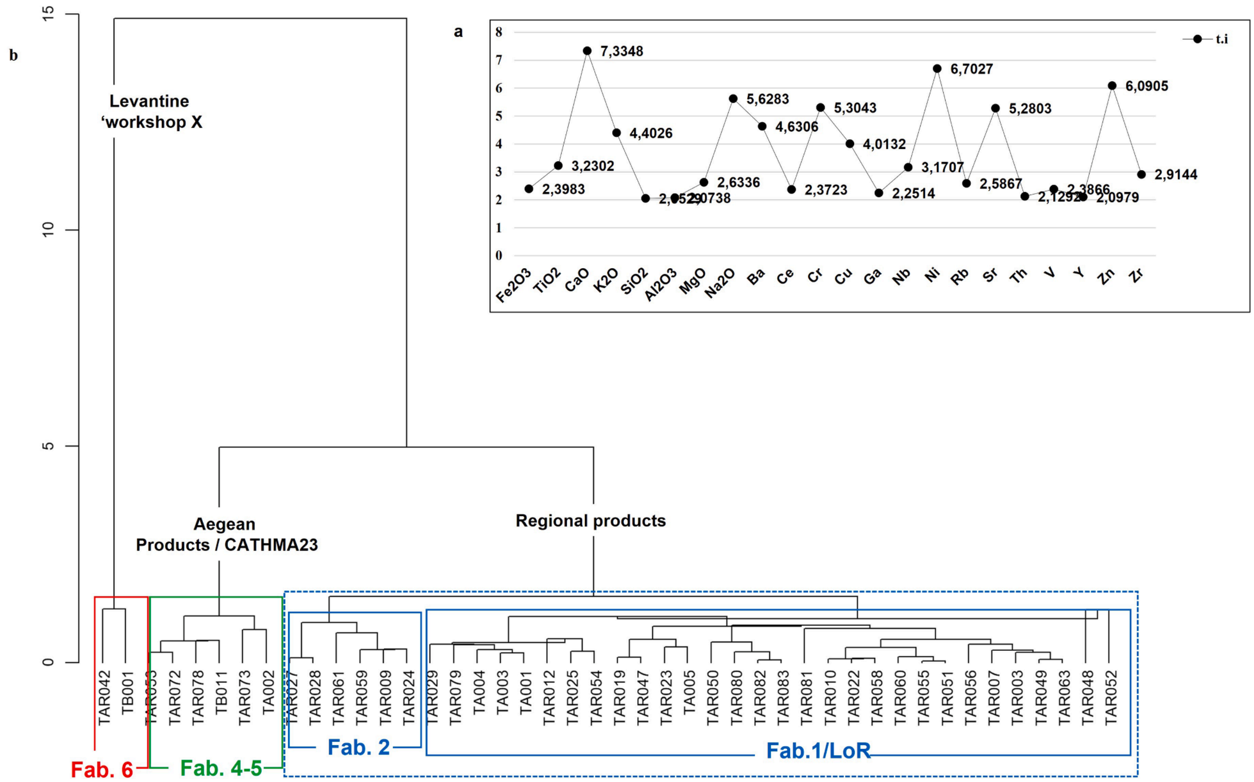

Fig. 5. a) Lineplot representing the t.i. value for each of the chemical elements after the calculation of the compositional variation matrix providing and indication of the variability introduced by each chemical element in the dataset in the data set; b) Dendrogram resulting from cluster analysis (CA), using the centroid agglomerative method and the squared Euclidean distance, based on the subcomposition Fe_2O_3 (as total Fe), Al_2O_3, TiO_2, MgO, CaO, Na_2O, K_2O, Ba, Rb, Mo, Th, Nb, Zr, Y, Sr, Sn, Ce, Ga, V, Zn, Cu, Ni and Cr, using SiO_2 as divisor in the log-ratio transformation of the data.

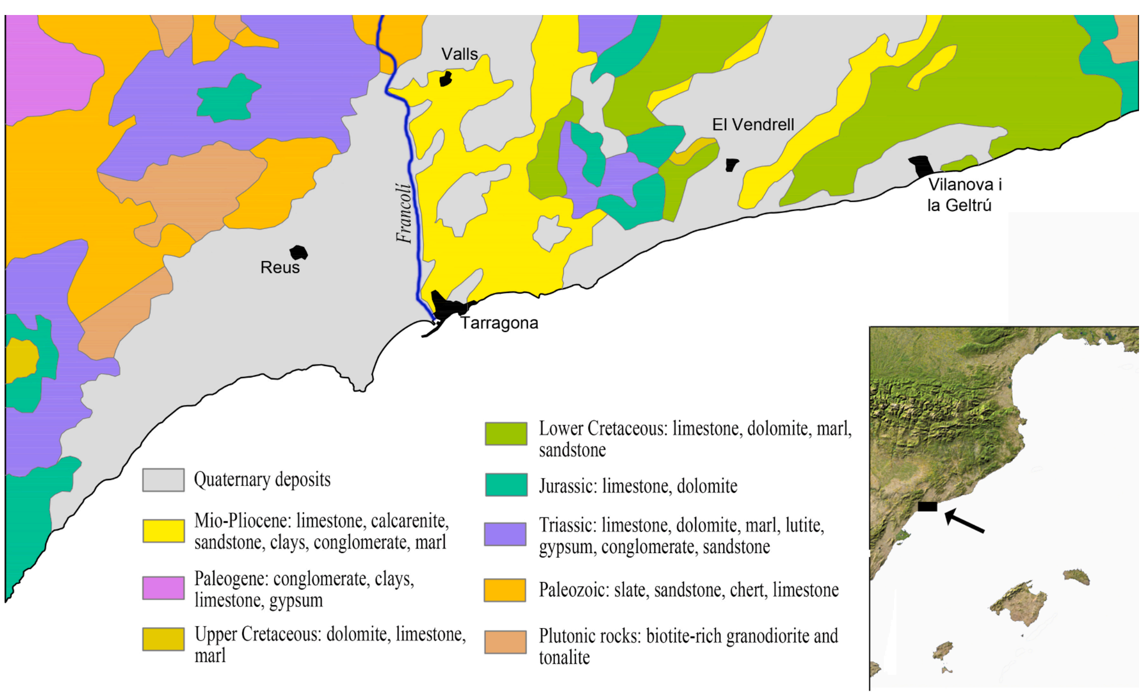

Fig. 6. Geological map of the area of Tarragona (based on IGME 1987).

'Workshop X'. An element to take into consideration is that this form is attested in France during the first half of the 7th century, but not later (Reynolds, 2010: 131ff). In Tarragona, the presence of this cooking pot is documented hereinafter and suggests continued imports until the transition between the late 7th and the early 8th century.

Another six samples analyzed, TA002, TB0011, TAR053, TAR072, TAR073, and TAR078, form a separate group in the multivariate statistical treatment of the XRF chemical data (Fig. 5b). Five of these six samples showed the same petrographic fabric in this section (Fabric 4). The only exception, sample TA002, showed a fabric (Fabric 5) which shares many similarities in inclusion composition with Fabric 4 and based on the combined petrographic and chemical data, it may be interpreted as a coarser version of the latter. The samples TA002, TAR072 and TAR073 belong to the cooking pot type Oc/Or/62, which can be related to Saraçhane CW3 type B (Hayes, 1968: 214 and 1992: 54). According to Hayes, the version B is present in deposit 12 of Paphos (dated with the destruction of AD 654, as stated by Hayes, 2003: 489 and 491, fig. 23.257) and is absent in the Knossos cistern (dated between AD 620 and 640: Hayes 2001). It also seems to be detected in Crypta Balbi, a great deposit dated to the end of the 7th century (Ricci, 1998: 358, fig. 4.2; Arena et al., 2001: 304, fig. II. 3.251–253), and similar forms have also been attested in Halmyris (Topoleanu, 2000: 318, pl. XXVI. 231 and 319, pl. XXVIII. 232), Murighiol (Opait, 1991: 196, fig. 32,191–192 and 197, fig. 33,190), Alexandria (Tréglia, 2003: 453, fig. 63), Kythera (Johnston et al., 2014: 32, fig. 21 d, e and f), Gortina (Martin, 1997: pl. CVVXIII, 4–5), Yassi Ada shipwreck (Bass and Van Doorninck, 1982: 176, fig. 8–15p. 43), Carthage (Hayes, 1978: 44, fig. 8.11 and 49), Marseille (Bien, 2005: 288 and 298, fig. 9.2–4, Bien, 2007: 270, fig. 3.47–48 and 273, fig. 7.88–89; Tréglia, 2005: 301 and 307, fig. 3.3–10), Naples (Arthur, 1985: fig. 16.2; Carsana, 1994: fig. 122. 116.1) and Leptiminus (Dore and Schinke, 1992: 141, fig. 24). On the other hand, sample TAR053 should be associated to a group of casseroles or cooking pots identified in Istanbul and Paphos and described as having a "wide sloping rim bearing a raised band at the lip and one or more grooves on the outer edge" (Hayes, 1992: 55, 165, fig. 45.136,137 and 140, 166, fig. 46.141–142; 2003: 511–512, fig. 35.380a and 381). We consider that the samples TAR078 and TB011 present a similar profile (perhaps more stylized) and that they should be associated with the same form (Rodríguez, 2020: 481, Oc/Or/104). In this sense, these cooking pots are described as having a pear-shaped profile, with smooth walls and surfaces very similar to the Saraçhane CW3 type B. They also have two grooves on the outer edge and, in one case, a *post-cocturam* graffiti with a Greek letter alpha.

The chemical composition of the samples in these Fabrics 4 and 5 showed certain features – particularly the relatively high concentrations in Ni, Cr and Na_20 – that are comparable to Late Roman cooking wares associated with an Aegean provenance (Waksman and Tréglia, 2007; Cau et al., 2019), but still with some differences in the bulk composition that do not allow for a clear correlation with the latter. It is worth mentioning, however, that a similar petrographic fabric to that of Fabric 4 has been also described for other cooking pots of Saraçhane type B by Slane and Kiriatzi (2014). Given the composition of this fabric, with inclusions derived from metamorphosed granitic rocks, the authors suggest that it may not come from the immediate area around Istanbul (as suggested initially, based on the abundance of these pots in this city: cf. Hayes, 1992: 54-55; for the geological background of the Istanbul area, see Şenel, 2002; Okay, 2008), but likely from the south coast of the Sea of Marmara or the Biga peninsula (Slane and Kiriatzi, 2014), although further evidence is still required to verify this hypothesis.

Except for the samples described above, most of the cooking wares analyzed in this study (36 out of 45) formed a large compositional group in the chemical analysis (group LoR), in which two subgroups were identified. One of these subgroups is related to petrographic Fabric 1 and includes the only sample of Fabric 3 (TAR081); despite the textural differences observed in thin section between these two fabrics, their similarities in terms of the nature of the inclusions and, also, in the bulk chemical composition may suggest a provenance in the same area for both fabrics. The other chemical subgroup in LoR correlates well with petrographic Fabric 2, in which the higher frequency of plagioclase inclusions observed in thin section – compared to Fabrics 1 and 3 – must be related to the higher concentrations in Na_2O that distinguishes this subgroup from the first one. In any case, despite these minor differences, the similarities between these three fabrics must also be highlighted, as they were all made from low calcareous clay pastes containing dominant quartz and feldspars inclusions with contribution – in variable amounts – of granitoid and metamorphic rock fragments, resulting also in two slightly differentiated chemical subgroups but clearly related to each other (Fig. 5b).

Regarding the origin of this large group of cooking wares, neither the petrographic fabrics nor the chemical composition provide any evidence for an eastern Mediterranean provenance. Conversely, the composition of these samples resembles the one that characterizes cooking wares and other ceramics produced in northeastern Iberia in Late Antiquity (Buxeda and Cau, 2004, 2005; Riutort et al., 2017, 2018, 2020; Riutort and Cau, 2021). The petrographic composition has also general similarities with the one observed in Early Roman amphora fabrics produced in the Catalan coastal territory (Martínez Ferreras, 2014). In fact, the inclusions contained in these ceramic fabrics are compatible with the geological background of the area of Tarragona, where various outcrops of low-grade metamorphic rocks (mostly slate), plutonick rocks (mainly granodiorite and tonalite), and sedimentary rocks can be found (IGME, 1987; ICGC, 2006), as well as a series of water courses – most notably the Francolí river – that may transport these materials to the surroundings of the city (Fig. 6). In any case, similar geological formations are widespread in various other parts of the current Catalan coastal territory, for this reason it is not possible for the moment to propose a local provenance for the Fabrics 1 to 3 identified in this study, but it would be more prudent to pose the hypothesis of a wider regional provenance.

The results suggest that the local potters of *Tarracona,* with a long-standing tradition of production of grey ware for cooking purposes (Macias, 1999, 2003; Macias & Cau, 2012), imitated Eastern Mediterranean prototypes to supply an increasing demand. We could even consider, as a hypothesis, the presence of potters within the Eastern Mediterranean communities that surely inhabited or frequented the suburb of the port. This process of imitation of forms was not exclusive to the 7th century, as it seems to be attested also in the 5th and early 6th centuries. In *Tarracona*, when the Annona mechanism breaks down in the Western Roman Empire and the north-African cooking ware or Late Roman Cooking Ware I begin to disappear, the local potters imitate forms like the Fulford Casserole 19/Vila-roma 5.40 and manufacture the cooking pots Oc/Gre/15, 16 and 17 (Macias, 1999: 135ff). In both cases, the cooking pots Oc/Gre/16 and 17 or Oc/Gre/64 and 66 break the previous morphological local tradition based on cooking pot with the so-called "S" profile and flat base. The same can be stated for the casseroles, as before the mid-7th century the local types consisted of a simple profile with convex walls, and re-entrant orientation, with undifferentiated rim and rounded or pointed lip. Hereafter, casseroles with new morphological attributes seem to replace the previous ones. The arrival of the sliced-rim casseroles from Workshop X probably had a local response by potters who started to produce imitations of the new models. This is clear with the introduction of the horizontal handle and the triangular rim that copies the characteristic slice to easily preserve the content with a lid.

The phenomenon of the production of wares inspired in Eastern Mediterranean prototypes is clear also in Otranto in the so-called "cantiere Mitello" where globular amphorae and grey-wares were also produced, probably following a long tradition of Greek influence in the ceramic repertoire due to the geographical proximity (e.g. Arthur et al., 1992; Imperiale, 2004). Also, in San Giusto (Lucera, Foggia) the local production of cooking wares imitates some Eastern Mediterranean types (e.g., Gliozzo et al., 2005a, 2005b). The analysis of ceramic materials found in a Late Roman well in the necropolis of Cuma (Naples) demonstrated that some Aegean-like cooking wares were in fact local imitations (Germinario et al., 2019). In addition, some imitations have been also detected on the eastern shores of the Adriatic, for instance, in Ljubljana/Emona (Istenič and Schneider, 2000). These few exemples show that the phenomenon of imitations of Eastern Mediterranean materials on the wester shores of the Mare Nostrum are not uncommon, and *Tarracona* could have enter in this typological *koine* even if it was not under the territories conquered by the Byzantine in *Spania*.

6. Conclusions

The analytical study has confirmed the presence of eastern Mediterranean imports in the Hispanic port of *Tarraco*. This reality coincides with the presence of eastern Mediterranean amphorae in the same contexts and, from a chronological point of view, extends their period of distribution to the end of the 7th century and the beginning of the 8th century. *Tarracona* was well connected in the trade routes of the Mediterranean in this period.

The results revealed that the large group of cooking wares included in Fabrics 1 to 3, that we had initially considered to be from the eastern Mediterranean, were actually local or regional products. This evidence is important because it allows us to suggest that around Tarragona there would be an unlocated workshop, or rather a group of unlocated workshops, producing a series of cooking wares that moves away from the typical ceramic repertoire in the area. Furthermore, the combination of archaeology and archaeometry confirms the influence that foreign cooking wares had on local potters and workshops. The introduction of cooking pot types Oc/Gre/64 and 66 in the *instrumentum domesticum* of Tarragona suggests that the traditional approaches to the regionalization and the simplification of production processes, the dismantling of the urban markets and the ruralization of societies such as the port suburb must be reviewed.

It is difficult to know if the presence of Eastern Mediterranean prototypes in the suburb of the port of *Tarracona* was linked to the presence of ethnic and/or cultural groups clearly differentiated from the rest of the inhabitants of the city. This possibility must be assessed in terms of the population heterogeneity of Mediterranean ports and the high presence eastern Mediterranean communities. It is true that this local or regional pottery is difficult to identify outside Tarragona and its rural *hinterland*, but we must await the identification of new contexts to corroborate this hypothesis. In any case, the production workshops could have been located in the area of Tarragona, which is a plausible hypothesis according to the results obtained from the analytical study of the ceramics.

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.

Data availability

Data will be made available on request.

Acknowledgements

This work was performed in the framework of the project *Late Roman Pottery in the Western Mediterranean: exploring regional and global trade networks through experimental sciences (LRPWESTMED)* (ref. HAR2013-45874-P), funded by the National Plan of I + D + I Ministerio de Economía y Competitividad, Secretaría de Estado de Investigación, Desarrollo e Innovación, with contributions from FEDER funds, PI: Miguel Ángel Cau Ontiveros. This is part of the activities of the Equip de Recerca Arqueològica i Arqueomètrica de la Universitat de Barcelona (ERAAUB), Consolidated Group (2021 SGR 00696), thanks to the support of the Comissionat per a Universitats i Recerca del DIUE de la Generalitat de Catalunya. The work of L. Fantuzzi was also possible thanks to a Juan de la Cierva-Incorporación grant (IJC2019-039327-I) from the Spanish Ministry of Science and Innovation (MCIN/AEI/10.13039/501100011033). We are also grateful to two anonymous reviewers and the editors for the comments and suggestions that have certainly helped to improve the final version of this manuscript.

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