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ARCHAEOMETRIC ANALYSIS OF LATE BRONZE AGE AND EARLY IRON AGE POTTERY FROM SETEFILLA (SW SPAIN)

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ABSTRACT

This paper presents results from the initial stage of an ongoing project exploring changes in pottery production at the Late Bronze Age/Early Iron Age transition in the south-western part of the Iberian Peninsula. For the chosen study area this period is of particular interest because of the introduction of new pottery types, manufacuring techniques, and possibly also different organisational models in the wake of the Phoenician expansion into the western Mediterranean. The initial stage of our project focused on samples from the key site of Setefilla, with a methodology based on both non-destructive and destructive analysis of ceramic samples: 1) non-destructive X-ray fluorescence spectrometry (XRF), 2) very precise optical emission spectrometry (OES) and 3) petrography of pottery samples. The results of this research show a significant correlation between manufacturing techniques, type of clay paste used and elemental composition. Alongside this approach we also conducted a radiocarbon dating programme on cremated human remains from the site, to provide a chronological context for any changes observed in the pottery assemblage over time. Our results demonstrate that through systematic spectrographic and petrographic analysis we can overcome some of the basic problems relating to the chemical and petrographic identification of different pottery groups, with a view to establishing the provenance of so-called "imports".

KEYWORDS: Late Bronze Age, Early Iron Age, Spain, Pottery, Petrographic Analysis, XRF, OES, ^{14}C

1. INTRODUCTION

Pottery sherds are the most abundant category of artefacts in the vast majority of archaeological sites. There are several ways to classify pottery and to determine its provenance. One of the most common approaches in archaeological pottery studies consists in its typological and stylistic classification. The validity of this method is unquestionable (Bortoloni, 2017). However, the recent development of more elaborate archaeometric techniques (spectrometric, petrographic, statistical analysis) permits a deeper understanding of differences and similarities between potsherds, which has significant consequences for provenance studies, especially in prehistoric sites (Holmqvist, 2017; Waksman, 2017; Javanshah 2018; Xanthopoulou et al., 2020; Liritzis et al., 2020). In the case of the south-western part of the Iberian Peninsula at the beginning of the Iron Age, our current knowledge about the origin of non-local pottery remains insufficient, and there is an urgent need to carry out studies which can further our understanding of the cultural process conventionally referred to as "Orientalisation" in the western Mediterranean (Celestino and López-Ruiz, 2016).

In this paper we present initial results from research conducted on material from the site of Setefilla (Lora del Río, Seville) (Figs. 1 and 2). The importance of this site has been emphasised on many occasions, and due to the rigorous excavation of its rich cultural assemblage, availability of the published data (Aubet, 1975; 1978; 1980-81) and the accessibility of the materials for further study, it constitutes a key site for the archaeology of the Lower Guadalquivir region.

Ultimately aiming at a better understanding of the economic and cultural interactions between indigenous communities and Phoenician newcomers to south-western Iberia at the dawn of the Iron Age, our first objective was to determine the provenance of the wheel-thrown and hand-made pottery found in the Setefilla necropolis, and the relevant results constitute the main focus of the present paper. Our second objective was to establish a tighter chronology for the different types of pottery found at the site than hitherto available, through a radiocarbon dating programme of cremated human remains from the necropolis. Details of the respective methodology and initial results from this second stream of the project have already been presented elsewhere (Krueger and Brandherm, 2016) but are drawn upon again in our discussion here to provide a temporal context for the changes observed in the overall pottery assemblage from the Setefilla necropolis at the Late Bronze Age/Early Iron Age transition. Thanks to the results obtained from the site, our understanding of the Late Bronze Age and Early Iron Age in south-western Iberia is now much more comprehensive. The analysis of the material culture from Setefilla allows us to recognise the radical changes in the social use of local and foreign objects.

In order to determine the chemical, mineralogical and microstructural composition of the pottery from the Setefilla necropolis, different archaeometric techniques were employed. Within our project, the ceramic artefacts from the site have been studied under three complementary perspectives: non-destructive X-ray fluorescence spectrometry (XRF), very precise optical emission spectrometry (OES) and petrography of pottery samples.

2. POTTERY SAMPLING STRATEGY

A set of 49 ceramic samples was subject to chemical analyses, both non-destructive and destructive (Table 1). From this set a selection of 38 samples was chosen to be subjected also to petrographic analysis. The analysed pottery includes both wheel-thrown and hand-made specimens (Fig. 3) from Tumulus A and Tumulus B of the Setefilla necropolis and is kept at the Archaeological Museum in Seville. The sampling strategy aimed at choosing technologically diverse material from different archaeological contexts, including a variety of grave assemblages as well as the main bodies of the two tumuli. Between them, 34 samples were selected from Tumulus A (16 from graves, 18 from the body of the tumulus) and 15 samples from Tumulus B (12 from graves, 3 from the body of the tumulus). In tables and figures wheel-thrown pottery is marked as "fen" and hand-made ceramics as "loc". Fabrication techniques have been identified based on diagnostic manufacturing marks on the respective sherd specimens.

Unfortunately, due to the museum's conservation policy, it was not possible to extract samples from pots with completely preserved profiles. In consequence, the sampling was generally limited to highly fragmented material.

Figure 1. Site of Setefilla in western Andalusia (map preparation: Bartłomiej Walkowski, background of the overview map in the lower right-hand corner: Google Earth).

Figure 2. Present-day view of the necropolis of Setefilla (photo: Michał Krueger).

Figure 3. Examples of pottery samples from Setefilla, top row: wheel-thrown pottery, bottom row: hand-made pottery (photo: Michał Krueger).

Table 1. Pottery samples from Setefilla analysed by archaeometric methods.

Nº	Key	Artefact	Archaeological Context	Technology	Shape
1	fen1	amorphic	Tumulus A, fill	wheel-made	unknown
2	fen2	amorphic	Tumulus A, fill	wheel-made	unknown
3	fen3	amorphic	Tumulus A, unknown context	wheel-made	unknown
4	fen4	amorphic	Tumulus A, fill	wheel-made	unknown
5	loc5	amorphic	Tumulus A, fill	hand-made	*à chardón*
6	loc6	amorphic	Tumulus B, urn 32	hand-made	biconical
7	loc7	amorphic	Tumulus B, urn 23	hand-made	*à chardón*?
8	loc8	amorphic	Tumulus B, fill	hand-made	unknown
9	loc9	amorphic	Tumulus B, urn 20	hand-made	bowl
10	loc10	amorphic	Tumulus B, urn 32	hand-made	biconical
11	loc11	amorphic	Tumulus B, urn 23	hand-made	*à chardón*?
12	fen12	amorphic	Tumulus A, fill	wheel-made	unknown
13	fen13	amorphic	Tumulus A, fill	wheel-made	unknown
14	fen14	amorphic	Tumulus A, fill	wheel-made	unknown
15	fen15	amorphic	Tumulus A, fill	wheel-made	unknown
16	fen16	amorphic	Tumulus B, urn 28	wheel-made	unknown
17	loc17	amorphic	Tumulus B, urn 27	hand-made	bowl
18	loc18	amorphic	Tumulus B, urn 27	hand-made	glob. vase
19	loc19	amorphic	Tumulus B, urn 27	hand-made	unknown
20	loc20	amorphic	Tumulus B, urn 24	hand-made	biconical
21	loc21	amorphic	Tumulus A, urn 3	hand-made	unknown
22	loc22	amorphic	Tumulus A, urn 1	hand-made	unknown
23	fen23	amorphic	Tumulus A, fill	wheel-made	unknown
24	fen24	amorphic	Tumulus A, urn 14	wheel-made	*à chardón*?
25	fen25	amorphic	Tumulus A, urn 8	wheel-made	plate
26	fen26	amorphic	Tumulus A, urn 21	wheel-made	*à chardón*
27	loc27	rim	Tumulus A, unknown context	hand-made	unknown
28	loc28	amorphic	Tumulus A, urn 26	hand-made	*à chardón*?
29	fen29	amorphic	Tumulus A, urn 26	wheel-made	*à chardón*?
30	loc30	amorphic	Tumulus A, urn 27	hand-made	*à chardón*
31	fen31	amorphic	Tumulus A, urn 41	wheel-made	umknown
32	fen32	amorphic	Tumulus A, urn 42	wheel-made	bowl
33	loc33	amorphic	Tumulus A, urn 39	hand-made	biconical?
34	loc34	amorphic	Tumulus A, urn 34	hand-made	bowl
35	loc35	amorphic	Tumulus A, urn 29	hand-made	plate
36	fen36	amorphic	Tumulus A, unknown context	wheel-made	unknown
37	fen37	amorphic	Tumulus A, unknown context	wheel-made	unknown
38	fen38	amorphic	Tumulus A, urn 31	wheel-made	unknown
39	fen39	amorphic	Tumulus A, unknown context	wheel-made	unknown
40	fen40	amorphic	Tumulus A, urn 10	wheel-made	plate?
41	loc41	amorphic	Tumulus A, urn 8	hand-made	unknown
42	fen42	amorphic	Tumulus A, fill	wheel-made	unknown
43	fen43	amorphic	Tumulus B, fill	wheel-made	unknown
44	loc44	amorphic	Tumulus B, urn 20	hand-made	bowl
45	loc45	amorphic	Tumulus B, urn 31 (?)	hand-made	unknown
46	loc46	amorphic	Tumulus A, fill	hand-made	unknown
47	fen47	amorphic	Tumulus A, fill	wheel-made	unknown
48	loc48	amorphic	Tumulus A, fill	hand-made	unknown
49	loc49	amorphic	Tumulus B, urn 29	hand-made	bowl

3. X-RAY FLUORESCENCE ANALYSIS

The chemical composition of the 49 samples from Setefilla was studied by means of a portable X-ray fluorescence spectrometer (Bruker Tracer III SD). The settings used for the measurements were as follows: energy 15 kV, current 25 µA, no filter, 15 s per analysis. All measurements were undertaken with the help of a vacuum pump. Their accuracy has been verified by means of comparison with a key ceramic sample (part of a modern ceramic vessel) with known chemical composition. All specimens were measured at least three times on a flat, external surface of the sherd. The spectrometer was set up in laboratory position, so the distance between the detector and a sample was always the same. During the analyses, MajMudRock software calibration, provided by the manufacturer of the XRF device, was used.

The spectrometer detected 12 elements (Mg, Al, Si, K, Ca, Ti, Mn, Fe, Co, Cu, Zn, Ba). It is well known that the main chemical components of the clay are always present in similar, high concentrations. That is why for the purposes of our research it was crucial to find a suitable way to differentiate between samples.

One of the existing methods to categorise pottery due to differences in its chemical composition is the potassium-titanium test. This approach has been established in the provenance determination of clay cuneiform tablets by Y. Goren et al. (2011) and is normally used prior to more detailed statistical analysis. It is especially useful for the initial attribution of an artefact of unknown provenance to a possible provenance cluster of a reference group (Goren et al., 2011: 689). This method is universally applicable and is also suitable for analysing ceramics from other parts of the Mediterranean world. In the results obtained with this approach, differences between wheel-thrown and hand-made pottery from Setefilla are clearly visible.

Unfortunately, among the studied material there were no remains from pottery kilns or misfired ceramics which could have provided a benchmark for establishing criteria to identify local production. However, this does not constitute an insurmountable obstacle. A reliable and tested procedure used in previous studies by other teams consists in observing whether the majority of samples from the same site show the same chemical pattern. If this is the case, local production may tentatively be assumed (Behrendt and Mielke, 2014: 636). During the Late Bronze Age in western Andalusia, connections of indigenous communities with the outside world appear limited to a narrow range of metalwork items for élite consumption (Brandherm, 2016), and it is difficult to think that indigenous societies from the Iberian interior imported all hand-made pottery.

The results of our analysis show two groups of pottery sherds which, on the basis of archaeological considerations, can be equated with what in the literature has been conventionally referred to as local (hand-made) and so-called "foreign" (wheel-thrown) productions. The local group is characterised by low concentrations of potassium and average to high concentrations of titanium. Five samples initially considered as local: loc 8, loc 34, loc 41, loc 45 and loc 46 are among the "foreign" group, which is characterised by high concentrations of potassium and not very high concentrations of titanium (Fig. 4).

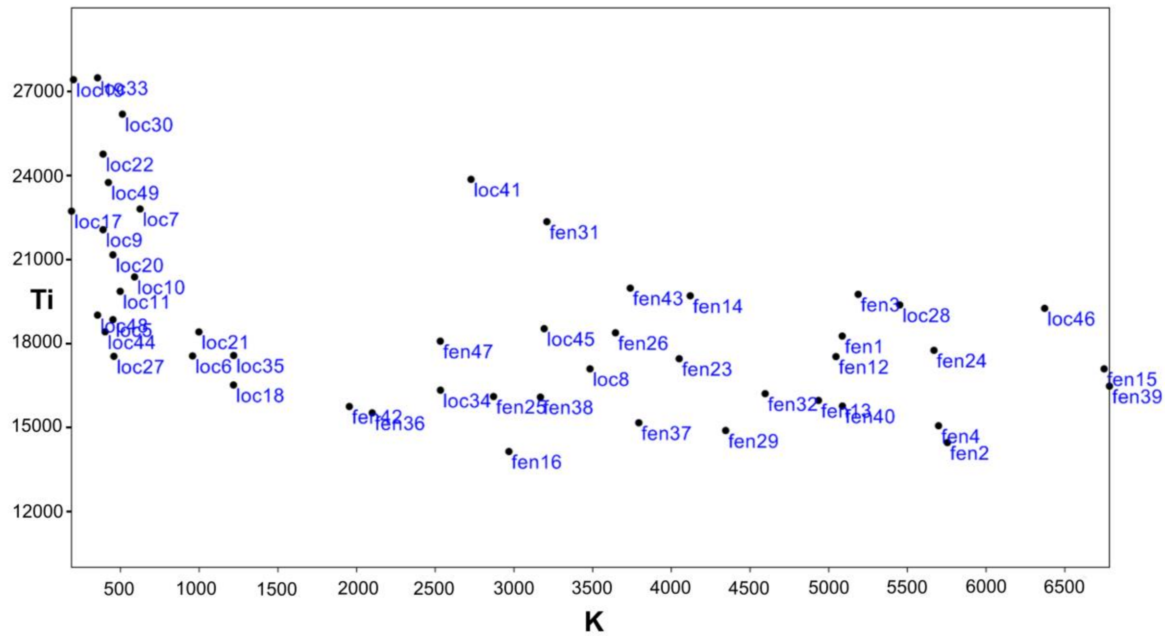

Figure 4. K-Ti test of samples from Setefilla, the axes are plotted in ppm (mg/kg).

Table 2. Elemental analysis of samples from Setefilla in ppm (mg/kg).

sample	Al	Ba	Ca	Co	Cu	Fe	K	Mg	Mn	Si	Ti	Zn
1	27588	4148	21216	13	48	32940	5086	15722	473	97040	18275	113
2	27588	7174	19054	13	48	32940	5754	15722	1083	97040	14465	104
3	27588	2125	20034	13	48	32940	5187	15722	720	97040	19766	111
4	27588	9199	15108	13	48	32940	5698	15722	516	97040	15066	106
5	36722	4607	16844	15	50	34222	452	14179	645	94852	18860	101
6	38554	4287	16632	14	50	32326	958	14808	572	85589	17563	112
7	25949	5675	30333	13	45	28363	624	17703	306	78143	22817	55
8	24217	6483	50723	9	42	22994	3483	18917	519	71315	17100	88
9	34770	6970	16338	16	44	34922	389	14044	1158	78620	22076	98
10	34410	3145	17917	12	62	27814	589	14183	655	89680	20386	140
11	39584	4043	16366	15	56	34722	498	13730	806	90674	19870	83
12	31298	4552	32244	12	47	28195	5046	18728	1163	75239	17538	99
13	25971	6214	50218	9	41	24855	4935	18392	539	76445	15972	93
14	31224	5249	30983	12	51	29547	4120	16038	704	81761	19712	165
15	30648	3136	36547	9	45	25431	6750	19246	521	75705	17101	132
16	18154	8529	87749	7	33	20474	2968	14580	441	51860	14148	94
17	34981	4953	13333	16	50	34022	189	13739	511	89754	22738	84
18	41637	2228	15331	14	55	31432	1218	12742	2318	96008	16526	104
19	29913	732	9429	19	41	36060	201	14850	342	77567	27442	55
20	39405	3730	18035	15	47	32161	452	16513	1492	80239	21176	128
21	36153	4272	19067	14	27	31450	998	16698	1671	73024	18420	78
22	25747	4024	11914	18	51	39343	389	17218	560	65892	24779	87
23	29134	4658	46170	12	52	31847	4050	16227	1244	60119	17463	196
24	33380	1796	30257	10	46	24539	5669	18790	1143	76259	17763	87
25	27052	8775	45834	6	40	19733	2870	22279	573	55877	16113	94
26	38111	739	8904	11	46	28239	3645	22063	610	91646	18389	91
27	12440	7564	24519	9	55	25577	458	24893	591	41827	17549	74
28	40438	4364	8364	14	48	31178	5451	16986	503	83475	19386	84
29	36087	8671	39426	9	39	22643	4345	19005	877	75743	14895	92
30	24955	5577	12860	16	45	32864	512	17204	761	71253	26205	116
31	27348	5086	12576	12	47	30834	3209	20557	519	77966	22362	125
32	31307	6944	24672	12	40	29624	4596	17179	1121	66306	16213	136
33	27682	2749	10233	18	52	33182	354	14012	679	86947	27505	50
34	31606	4424	23120	10	49	26443	2533	20158	581	86484	16339	63
35	26284	1065	25047	13	59	30886	1219	13539	1281	73114	17579	182
36	21633	6581	58155	4	42	15766	2099	22435	478	58195	15527	105
37	31788	3464	33312	10	49	26745	3793	19581	1043	74826	15175	171
38	32446	5358	48861	9	60	23583	3168	17043	1166	64344	16093	268
39	33825	3113	35401	9	48	23559	6784	17447	765	91235	16484	121
40	28739	4786	37935	8	53	21771	5087	19067	493	78366	15771	96
41	29453	3400	6891	18	49	37539	2727	18868	826	71341	23875	60
42	14281	4636	71281	12	44	34024	1954	15292	427	49009	15754	164
43	32805	436	55690	7	40	19812	3739	15530	347	82189	19987	102
44	38088	1708	15256	13	45	30887	402	17882	490	84449	18425	46
45	44252	5982	11234	12	46	29951	3192	16456	533	105357	18538	82
46	37790	4054	25235	11	47	26847	6372	15971	571	101322	19265	87
47	30068	2875	25238	8	46	22151	2532	16156	571	108987	18090	94
48	31404	7035	15166	12	51	28786	354	19124	641	73997	19021	99
49	38098	3510	10794	14	44	30722	423	13008	447	100572	23764	55

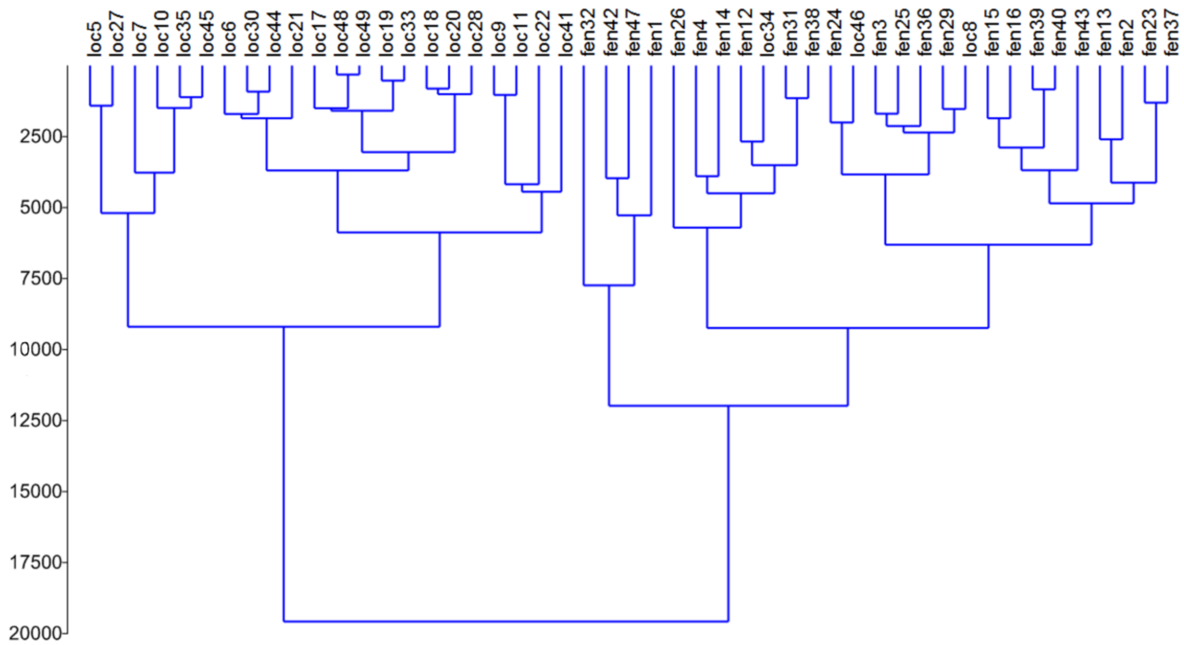

Figure 5. Exploratory data analysis of 49 samples from Setefilla, analysed by microwave-induced plasma optical emission spectrometry ('fen' – wheel-made pottery, 'loc' – hand-made pottery).

In addition to the XRF measurements taken on the external surface of the sherd, the samples subsequently were ground into powder in order to analyse them by means of microwave-induced plasma atomic emission spectrometry (see next section).

4. OPTICAL EMISSION SPRECTROMETRY

The elemental composition of 49 pottery samples from Setefilla has been determined by microwave-induced plasma optical emission spectrometry (4100 MP-AES, Agilent, USA), after melted-samples extraction by hydrochloric acid. Additionally, the selected samples have been digested by hydrofluoric acid. This part of the investigation was important for cross-checking the results with the data obtained from the portable X-Ray Fluorescence spectrometer. Using XRF to analyse ceramic samples with already known composition is the standard approach in this type of research.

Through multivariate data analysis it was possible to establish two big groups of pottery samples which are in good agreement with the previously observed technological differences between them (Fig. 5). Within the group visible on the right (marked as 'fen') of the dendrogram, other subgroups can be discerned and they correspond to petrographic Class Vb and Class VI. This was clearly visible, especially in the exploratory data analysis for samples after the grinding process. However, the correlation analysis showed that the chemical composition of the clay (as the matrix of pottery raw material) was very similar in all examined samples. The differences in the chemical composition of the pottery were based on the additives to the clay matrix.

It is important to stress that the pattern described above is coherent with the results from destructive chemical analyses of the same samples. The two methods have produced results that are highly consistent with each other. At this stage it is not possible to determine the geographical provenance of the group conventionally classified as "foreign". However, there are petrographic as well as typological arguments to assign it a local origin also. Several of the types of wheel-thrown vessels identified in Setefilla have no direct parallels among the eastern Phoenician repertoire.

5. PETROGRAPHIC ANALYSIS

Petrographic analysis was undertaken on 38 selected sherds from Setefilla and includes the complex examination of the clay matrix and non-plastic inclusions (Bartkowiak and Krueger, 2015). The analysis was carried out adopting a low-tech approach, derived from the so-called "Leiden approach", developed in the Laboratory for Ceramic Studies in Leiden during the 1960s (Franken, 1969; Jacobs, 1983; Stienstra, 1983; Van As, 1984; Franken, 1985; Van As, 2004) (see Fig. 6).

This holistic approach aims to investigate various aspects of pottery production, technology, usage, trade and distribution, etc. Experimental archaeology and ethnoarchaeology also form an integral part of this line of study (e.g. Annis and Jacobs, 1986). The low-tech analysis itself focuses mostly on the composition of the paste. It encompasses microscopic examination of temper materials, clay matrix, sorting and pore structure of each ceramic fragment, as well as the determination of size, texture, shapes, distributions, colour of the grains and matrix. The physicochemical properties of particular fractions such as hardness, colour, transparency, fracture, cleavage, lustre, crystal habit, magnetism and solubility in hydrochloric acid enable their identification and description. These low-tech methods are relatively inexpensive, do not require any specialist equipment, and provide an opportunity to process a large number of sherds. The advocated analytical procedure consists of three main steps, starting from the selection of sherds, through the sampling of the selected specimens and their preparation, leading to the microscopic examination and interpretation of the results. First, a small fragment of each sherd is mechanically cut off and cleaned. Subsequently, each fresh cross-section is polished, using wet abrasion papers in order to obtain a flat and smooth surface for examination, which is then performed under a binocular optical microscope (Bresser) using 10 and 20×, and in special cases also higher 40× magnifications. (Jacobs, 1983; Van As, 1984, 2010).

5.1. Main fabric groups

Eight fabric groups (I-VIII) could be discerned, based on their similarity in terms of composition of paste, added tempers and basic properties such as colour, texture, firing conditions, etc. These groups were subsequently collated into broader categories – Classes 1-3 – based on the resemblance of the clay matrix, and they reflect potential clay sources (Fig. 6).

5.1.1 Class 1

The first class is characterised by an intensely reddish ferruginous clay containing numerous iron oxide concretions, igneous and ferruginous rock fragments. It encompasses Groups I-IV. Previously undertaken experimental work demonstrates that the pots made from this type of clay were fired under oxidizing conditions at a temperature of around 650-700°C (Krueger et al., 2018). When compared with the results from the chemical analysis, Class 1 corresponds to the local group as defined by XRF, which is characterised by low concentrations of potassium and average to high concentrations of titanium.

5.1.1.1. Group I

Group I consists of eight sherds recorded as loc 7, loc 17, loc 18, loc 19, loc 22, loc 30, loc 33 and loc 41 (see Fig. 6). This group is very homogeneous in terms of clay composition and contains mostly iron oxide concretions, micaceous schist and dark igneous rock fragments (gabbro or diabase or basalt). The dominant type of grain is quartz, although feldspar, albite, shale, hornblende, some pyroxenes, biotite, and muscovite occur as well. The matrix, which is very rich in non-plastic elements (40-45 per cent), has a rough, porous structure and dark red colour (2.5 YR 4/6 and 4/8). Sorting is mostly moderate to poor and the size of grains differs from 0.1 to even 2 millimetres in length. Their shape is sub-angular and angular. It is assumed that the clay paste was rather poorly prepared and has not been levigated at all. All samples in this group are from hand-made pots.

5.1.1.2. Group II

Group II contains three potsherds: loc 11, loc 20 and loc 21 (see Fig. 6). This group strongly resembles Group I; however, while the quantity of quartz and feldspar increases significantly, the other components such as iron oxide concretions, micaceous schist and dark igneous rock fragments decrease. The total quantity of grains was established at 30-35 per cent. Grain shapes are usually sub-angular and sub-rounded, and their size is diversified, but does not exceed 2 millimetres. The colour of the matrix is red (2.5 YR 4/6 and 2.5 YR 4/8) with a sporadically visible reddish-grey core (5 YR 3/3). Moreover, a limited amount of organic fibres (5 per cent) was present. All the sherds are hand-made.

5.1.1.3. Group III

This group, which consists of three samples (loc 5, fen 24, loc 27), is also characterised by the occurrence of various iron oxide concretions in higher quantity, but lighter inclusions such as quartz (milky and transparent) and feldspar dominate over some darker grains (see Fig. 6). Beside these grains, calcite and probably also dolomite occur in the paste. Sporadically biotite, muscovite, hornblende and some pyroxenes were also observed. The total quantity of non-plastics is around 35 per cent, and their shapes are sub-angular and sub-rounded. Sorting is poor, and the size of particular tempers varies from 0.1 to even 3 millimetres. The colour is less homogeneous than in the previously mentioned groups, and there were distinct reddish-grey cores (5 YR 3/2 and 5 YR 4/2) and reddish margins (2.5 YR 4/8 and 4/6). Additionally, some amount of organic matter was used as temper, but its quantity does not reach 7 per cent. The examined sherds are all hand-made as well.

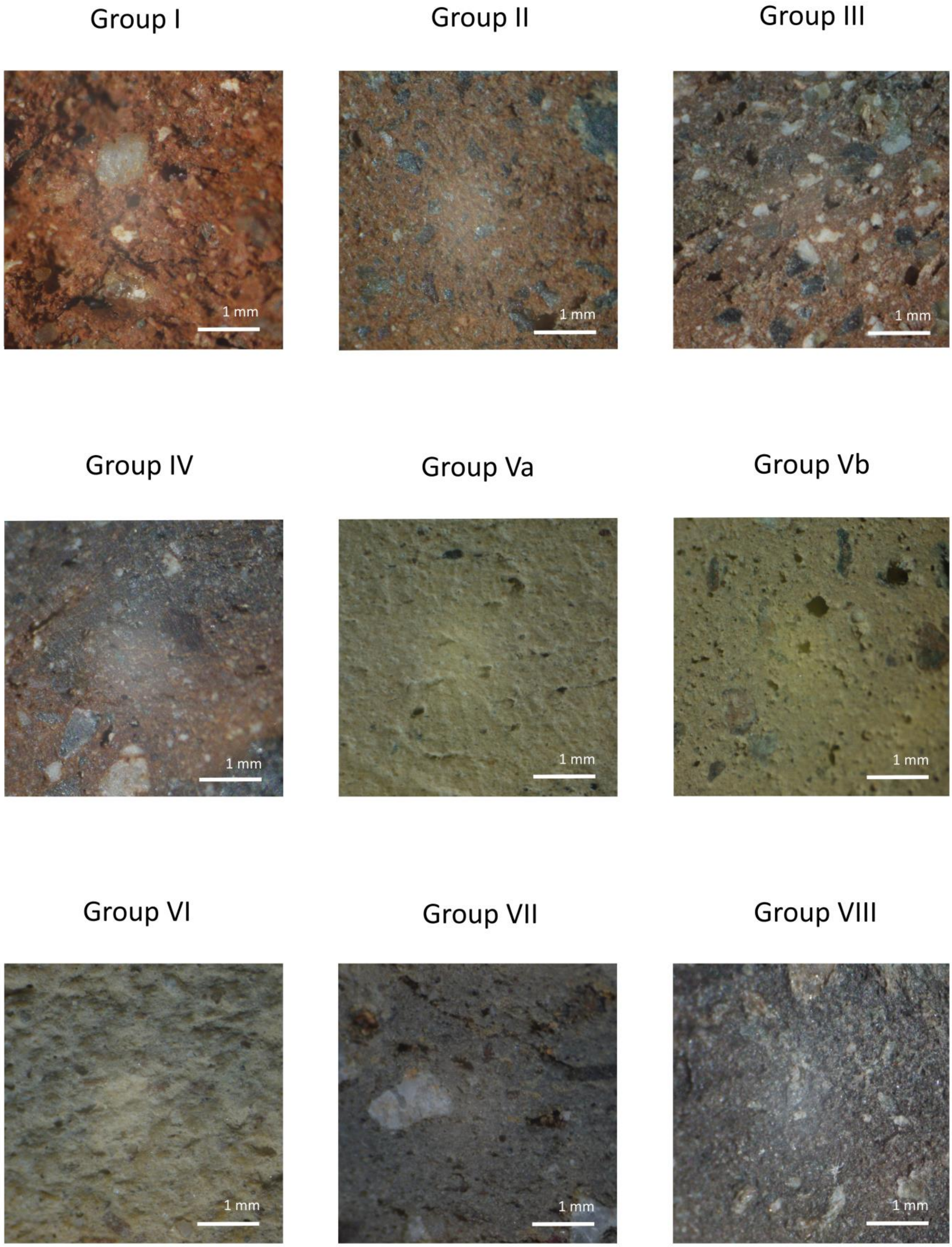

Figure 6. Microphotographs of the main fabric groups from Setefilla (Photo: Michal Krueger).

5.1.1.4. Group IV

This group, consisting of two potsherds (loc 6, loc 10), is characterised by a relatively low quantity of mineral inclusions (15-20 per cent). Quartz, feldspar, hornblende and some dark, probably igneous rock fragments are the dominant non-plastics, but occasionally iron oxide concretions, muscovite and biotite are present (see Fig. 6). Plant temper occurs in higher quantities than in other groups, varying between 7-15 volume per cent in particular sherds, and was probably deliberately added to increase the plasticity of the clay paste. The holes left by burned-out organic fibres range in size from 0.1 to 4 millimetres. Size of mineral particles is also varied, suggesting moderate sorting, and oscillates between 0.1 and 1.2 millimetres. The shape of the grains is mostly sub-angular and sub-rounded. The structure of the matrix itself is compact and hard; however, there are some voids visible in the paste as a result of spent organic matter. The colour of the matrix is reddish-brown (2.5 YR 4/4) and dark grey (5 YR 3/1). Both specimens in this group are hand-made.

5.1.2. Class 2

This class includes four fabric groups (Va, Vb, VI, VII) and is characterised by calcareous clay, rich in grains of limestone and calcite, with sporadically occurring iron oxide concretions, quartz, feldspar and biotite. Moreover, the experimental examination of these sherds revealed that there were fired under oxidizing conditions, at a temperature slightly higher than pots belonging to Class 1 (around 750-800°C) (Krueger et al., 2018). In terms of the chemical analysis, Class 2 corresponds to the so-called "foreign" group, which is characterised by high concentrations of potassium and not very high concentrations of titanium.

5.1.2.1. Group Va

Group Va encompasses ten samples (fen 2, fen 12, fen 13, fen 15, fen 23, fen 25, fen 29, fen 36, fen 37). The clay paste of Group Va is calcareous and light yellowish-red in colour (7.5 YR 7/4; 10 YR 7/4) with a sporadically present yellowish-grey core (7.5 YR 6/2, 10 YR 5/2) (see Fig. 6). Calcite is the dominant grain, but limestone, iron oxide concretions, feldspar, biotite occur as well. Rarely, lime nodules, quartz, mudstone, muscovite, some unidentified rock fragments and tiny organic fibres were recorded. The total quantity of both mineral and organic temper materials is considered as low and does not exceed 5-10 per cent. The shape of the dominant grains is mostly sub-rounded. Sorting was good, and some standardisation in the size of added fractions is observed. While the mineral grains vary from 0.1-0.5 millimetres in size, the organic matter ranges between 0.1-0.4 millimetres. It is assumed that the clay used was carefully levigated and that mineral fractions have not been intentionally added but were already present in the clay matrix. All studied potsherds are from wheel-thrown vessels.

5.1.2.2. Group Vb

Group Vb bears strong resemblance to Group Va, but it is visibly less compact and much richer in mineral inclusions. This group consists of six potsherds (fen 1, fen 14, fen 24, fen 31, fen 38, fen 39). The calcareous clay contains calcite, limestone, quartz, biotite and iron oxide concretions (see Fig. 6). Moreover, lime nodules, feldspar, albite, hornblende, pyroxenes, as well as igneous rock fragments (basalt or gabbro?) occur, but in smaller quantities. The matrix is more porous than that of Group Va, due to a more common presence of organic matter (10-15 per cent) and its poorer sorting (from 0.1 to 1.5 millimetres in length). The shape of the grains is sub-angular, and their quantity was estimated at 15-20 per cent, with moderate sorting and grain size ranges from 0.1 to 1.5 millimetres. The colour of the matrix is light red (7.5 YR 7/4; 10 YR 7/4). All the analysed potsherds seem to be wheel-thrown.

5.1.2.3. Group VI

Group VI comprises two samples (fen 16, fen 40). This is another calcareous clay with a strongly compact, firm structure and an abundance of non-plastics (15-20 per cent) (see Fig. 6). Quartz and iron oxide concretions dominate, but feldspar, calcite, muscovite, lime nodules, as well as organic fibres are also present. Mineral inclusions, despite their significant quantity, are well sorted and of fine size. Their grain size oscillates between 0.05 and 0.2 millimetres and their shape is sub-rounded. Plant tempers occur in small amounts (5-7 per cent) and were relatively tiny, with lengths between 0.3-0.5 millimetres. The colour of the matrix is yellowish-red (5 YR 7/4). Both sherds are wheel-thrown.

5.1.2.4. Group VII

This group, which includes two potsherds (fen 3, fen 26), is characterised by the predominant presence of calcite, iron oxide concretions, feldspar, and quartz, over other inclusions such as muscovite, biotite, lime nodules, limestone, hornblende, quartzite and dark igneous rock fragments. The quantity of grains is 15 per cent and their shape is sub-angular. Sorting is poor, with grain sizes including both very small particles of 0.1 millimetres and bigger ones reaching 1 millimetre (see Fig. 6). Besides mineral inclusions, there is also an added limited amount of organic fibres, in a quantity of 7 volume per cent and with lengths of 0.1 to 2 millimetres. The matrix was normal with a porous structure and dark grey colour (7.5 YR 4/1, 5/2), sporadically with distinct reddish margins (5 YR 6/6). The sample recorded as fen 26 is wheel-thrown, while sample fen 3 is hand-made.

5.1.3. Class 3

This class only consists of a single fabric group (VIII). Future work will have to broaden the very narrow sample base for this class. It falls into the local group as defined by XRF.

5.1.3.1. Group VIII

Group VIII is based on only a single sherd (loc 35). However, it is clearly different from all previous mentioned fabric groups and cannot be assigned to any other category. Its detailed characterisation will require scrutiny of more sherds from Setefilla in the future. It contains mostly grains of quartz and feldspar; however, iron oxide concretions frequently occur also (see Fig. 6). Sporadically, muscovite, biotite, hornblende calcite, and very rarely limestone were observed. The size of these sub-angular and sub-rounded grains varies from 0.1 to 2 millimetres. The clay matrix, containing mineral inclusions in a quantity of 15 per cent, has a very compact, hard and dense structure. Its colour is dark grey (5 YR 4/1). This potsherd was hand-made and fired under oxidizing conditions, presumably at a temperature not exceeding 650°C (Krueger et al., 2018).

6. CHRONOLOGICAL CONTEXT

The absolute chronology of the Early Iron Age in SW Iberia has conventionally depended on historical dates ultimately derived from Near Eastern chronologies. Traditionally, imports of Greek and Phoenician pottery found in association with indigenous material culture have been the main vehicle for the "transfer" of dates from the eastern to the western end of the Mediterranean (Brandherm, 2008a: 149-150; Brandherm, 2008b: 93). While the problems that come with this approach have been obvious for a long time, the so-called "Hallstatt plateau" in the calibration curve, and the adverse effects it has on any attempt to establish a precise ^{14}C chronology for the period between c. 760-400 cal BC, have severely hampered the use of radiocarbon determinations as an alternative to traditional cross-dating (Hajdas, 2008: 16).

To overcome the difficulties caused by the "Hallstatt plateau", a large series of radiocarbon dates from closed assemblages containing diagnostic material-culture items was required, preferably from a stratigraphic sequence or offering other constraints that would allow chronological modelling. Most samples from settlement contexts – even short-lived ones – do come with a number of caveats in terms of meeting these criteria, as redeposition and mixing with material from adjoining contexts can rarely be ruled out. Cemeteries with individual burials, such as the Setefilla necropolis, in this respect offer much better conditions, as long as both the relevant ^{14}C samples and any associated grave goods can be securely linked to a specific burial.

The development over the last two decades of radiocarbon dating techniques also for cremated bone – where carbonate from the crystal lattice (bio-apatite) rather than the collagen fraction is used to obtain ^{14}C determinations – has opened up significant new possibilities, even though a number of potential problems still persist with this approach (Lanting and Brindley, 1998; Van Strydonck et al., 2010; Ohlsen et al., 2013). Our project represents the first large-scale attempt of applying ^{14}C determinations from cremated human bone to establish a radiocarbon-based chronology for the Early Iron Age in SW Iberia.

A total of 65 samples from different burials excavated at Setefilla were initially submitted for dating, 36 from Tumulus A and 29 from Tumulus B. The choice of available samples was limited by both the quantity and quality of available bone material. Cremation graves at Setefilla, as at most funerary sites of the Late Bronze and Early Iron Ages in SW Iberia, generally contain token burials only. In some instances, the mass of bone material from a grave was less than 10 g. Also, charred bone fragments showing little evidence of calcination were excluded as samples for dating purposes from the outset. As a further measure to prevent the processing of potentially unreliable samples, after pre-treatment tests to determine the crystallinity index (CI), all cremated bone samples with a CI value below 5.0 were excluded from the dating programme. This left a total of 27 samples considered suitable for obtaining reliable ^{14}C determinations, of which 17 came from Tumulus A, including one from an uncremated animal bone (UBA-27571), and 10 from Tumulus B. Notwithstanding this much winnowed-down number of suitable samples that could be obtained from the Setefilla necropolis, some important results have emerged from our dating programme (Fig. 7, Table 3).

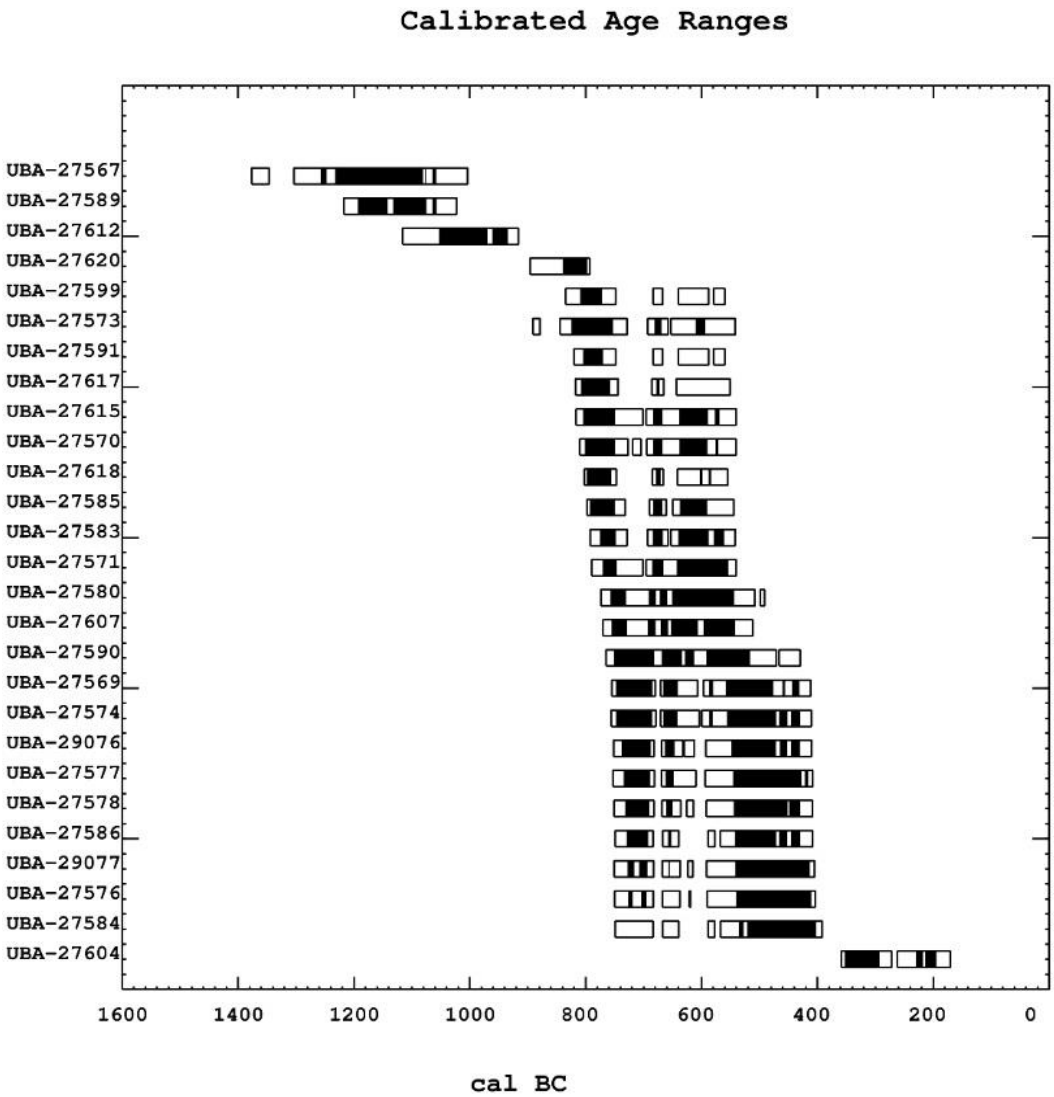

Figure 7. Distribution of calibrated radiocarbon dates from Setefilla (solid fill – 1 σ, open boxes – 2 σ). Calibration was undertaken based on the IntCal13 calibration curve (Reimer et al., 2013), using the CALIB 7.1 software (Stuiver et al., 2015).

Table 3. Radiocarbon determinations from Setefilla. Calibration was undertaken based on the IntCal13 calibration curve (Reimer et al., 2013), using the CALIB 7.1 software (Stuiver et al., 2015).

Laboratory code	Grave number	CI	^{14}C age BP	±	F^{14}C	±	cal BC (1 σ)	Relative area under probability distribution	cal BC (2 σ)	Relative area under probability distribution
UBA-27567	A05	5.9	2953	55	0.6924	0.0047	1257–1247	0.045930	1377–1347	0.027108
							1233–1081	0.913963	1303–1004	0.972892
							1077–1076	0.008812		
							1064–1058	0.031295		
UBA-27569	A08	6.1	2452	33	0.7369	0.0030	748–685	0.352457	755–680	0.277002
							667–641	0.135589	670–607	0.176286
							587–580	0.030385	596–412	0.546712
							559–476	0.408564		
							461–456	0.018447		
							444–431	0.054558		
UBA-27570	A10	5.5	2557	45	0.7273	0.0040	802–750	0.561666	810–727	0.466953
							683–668	0.113483	719–704	0.013862
							638–590	0.293982	695–541	0.519185
							576–571	0.030869		
UBA-27571	A11	n/a	2509	31	0.7318	0.0028	771–746	0.192333	789–701	0.290661
							686–666	0.156470	696–540	0.709339
							643–554	0.651197		
UBA-27573	A13	5.5	2592	50	0.7242	0.0044	825–753	0.858385	891–879	0.007719
							681–669	0.061808	844–729	0.676557
							610–594	0.079807	693–658	0.076311
									653–542	0.239413
UBA-27574	A14	5.6	2451	39	0.7370	0.0035	747–685	0.330212	756–679	0.262394

							666–641	0.124821	671–604	0.180912
							587–581	0.019610	599–411	0.556693
							556–471	0.404797		
							466–451	0.055074		
							446–430	0.065486		
UBA-27576	A17	5.2	2427	33	0.7392	0.0030	727–719	0.043991	750–683	0.198385
							704–695	0.055455	668–638	0.068419
							541–411	0.900555	621–619	0.002708
									591–404	0.730489
UBA-27577	A19	5.9	2442	35	0.7379	0.0032	734–689	0.259301	753–681	753–681
							662–648	0.074268	669–610	669–610
							546–427	0.634298	594–408	594–408
							422–416	0.032133		
UBA-27578	A20	5.2	2441	29	0.7380	0.0027	732–690	0.262238	751–682	0.251599
							661–650	0.064561	668–636	0.093022
							545–451	0.566102	626–614	0.015120
							449–430	0.107099	592–408	0.640259
UBA-27580	A22	5.5	2484	28	0.7340	0.0026	757–730	0.169027	774–508	0.994262
							691–678	0.080663	499–491	0.005738
							672–659	0.075059		
							651–544	0.675252		
UBA-27583	A30	5.4	2517	27	0.7310	0.0025	776–748	0.254835	792–729	0.294467
							684–667	0.166191	693–658	0.161322
							640–588	0.445456	653–542	0.544211
							579–561	0.133518		
UBA-27584	A31	5.3	2396	42	0.7421	0.0039	536–527	0.047181	749–684	0.136900
							521–402	0.952819	667–639	0.043543
									589–577	0.008557
									567–392	0.811000
UBA-27585	A32	6.3	2535	31	0.7294	0.0028	793–750	0.497759	798–732	0.410619
							683–668	0.144980	690–661	0.137247
							638–590	0.357261	650–544	0.452133
UBA-27586	A43	6.1	2438	24	0.7382	0.0022	729–692	0.248471	749–684	0.239688
							658–652	0.037685	667–639	0.076796
							543–471	0.529542	589–577	0.014020
							466–452	0.083462	568–408	0.669496
							446–430	0.100839		
UBA-27589	A47	5.4	2928	31	0.6946	0.0027	1194–1142	0.455366	1217–1023	1.000000
							1133–1075	0.491325		
							1065–1057	0.053309		
UBA-27590	A51	5.8	2466	33	0.7356	0.0030	751–682	0.381996	765–471	0.944561
							669–634	0.188355	466–430	0.055439
							628–613	0.065857		
							592–516	0.363793		
UBA-27591	A52	5.6	2584	35	0.7250	0.0031	805–770	1.000000	820–748	0.846177
									684–667	0.040621
									640–588	0.091194
									579–560	0.022008
UBA-27599	B02	5.8	2597	39	0.7237	0.0035	810–772	1.000000	835–748	0.880150
									684–667	0.031259
									640–588	0.071632
									579–560	0.016958
UBA-27604	B08	5.3	2180	27	0.7623	0.0026	353–293	0.690218	359–272	0.574251
							230–218	0.107735	262–171	0.425749
							214–195	0.202047		
UBA-29076	B11	5.1	2446	28	0.7375	0.0025	738–688	0.321734	752–682	0.271656
							663–646	0.099562	669–632	0.109386
							548–472	0.451591	630–612	0.024824
							465–452	0.057044	593–410	0.594133
							446–430	0.070069		
UBA-27607	B12	5.1	2481	25	0.7342	0.0023	755–729	0.175459	770–512	1.000000
							693–679	0.083244		
							671–658	0.083302		
							653–606	0.299527		
							597–542	0.358469		
UBA-27612	B18	5.5	2848	36	0.7015	0.0031	1053–970	0.797416	1116–916	1.000000
							961–934	0.202584		
UBA-29077	B20	5.0	2431	33	0.7389	0.0030	728–716	0.062314	751–683	0.212797
							708–694	0.079539	668–637	0.076930
							657–654	0.010916	623–615	0.008440
							542–413	0.847231	591–405	0.701833
UBA-27615	B23	5.0	2564	49	0.7267	0.0044	805–749	0.573353	817–701	0.503091
							684–667	0.106127	696–540	0.496909
							639–589	0.281433		
							577–569	0.039087		
UBA-27617	B26	5.7	2579	38	0.7254	0.0034	808–758	0.967888	818–744	0.739115
							678–673	0.032112	686–665	0.062046
									644–551	0.198839
UBA-27618	B27	5.2	2555	28	0.7276	0.0025	798–756	0.900686	802–747	0.681341
							679–671	0.061763	685–666	0.081161
							604–599	0.037551	642–586	0.178649
									585–555	0.058849
UBA-27620	B29	5.1	2658	38	0.7183	0.0034	840–797	1.000000	896–793	1.000000

We were able to establish that the cremation burial rite at the site was introduced already in the late 2nd millennium cal BC, about two centuries earlier than hitherto accepted (Brandherm and Krueger, 2017). This has far-reaching implications for our understanding of the Late Bronze Age / Early Iron Age transition in SW Iberia more widely. Also, with the caveat that most Late Bronze Age graves from Setefilla at this point have no ^{14}C determinations attached to them, the available data appear to suggest that we might be looking at a potential hiatus in the occupation of the Setefilla necropolis during the 9th century cal BC, at least as regards the sector of the cemetery explored by the 1970s excavations. While unsuspected, this should not come as a real surprise, given that Tumuli A and B have also yielded a small number of Mid/Late Iron Age and Early Roman cremation burials, which are clearly separated from each other and from the Early Iron Age occupation by substantial periods without any evidence for funerary activity.

Another significant result is that the Early Iron Age occupation of the Setefilla cemetery begins no later than the early 8th century cal BC, which again is considerably earlier than the conventional chronology assigned to both "foreign" and indigenous material-culture items from the site. While for the time being the effects of the "Hallstatt plateau" prevent an exact determination of an end date for the sequence of grave assemblages under study here, stratigraphic considerations – the truncation of the cremation cemetery by the building of monumental tumuli (Beba, 2008: 132-133) – as well as the homogeneous nature of the overall assemblage seem to indicate that the funerary occupation of the Early Iron Age cremation cemetery might have come to an end as early as the beginning of the 7th century BC, prior to the monumentalisation of the funerary landscape at Setefilla, and certainly no later than the second half of the 7th century BC.

Despite the new insights from our dating programme, difficulties persist in establishing a secure chronological framework for the various fabric groups identified in the pottery study. This is partially due to the effects of the "Hallstatt plateau", but also to the fact that unfortunately most of the bone samples that proved suitable for ^{14}C analysis come from different contexts than the pottery samples available for petrographic analysis. The only potential exception may be Group VIII (Class 3), which based on a cursory naked-eye survey of the overall assemblage appears to align with pottery only from the Late Bronze Age phase of the cemetery. However, additional petrographic analyses will be required to verify this.

7. DISCUSSION AND CONCLUSION

The three pottery classes described above seem to represent three different clay sources. However, for the moment it has not been possible to identify the particular clay sources which were exploited by the Late Bronze Age and Early Iron Age community of Setefilla with any degree of certainty. Likewise, it remains highly problematic to establish the provenance of the pottery and distinguish unambiguously between locally manufactured and "foreign" vessels. Resolving those issues will require more detailed studies, including both careful geological examination of the immediate vicinity of the site and a comparative study of bulk local and non-local (Phoenician) pottery dated to this period.

The same holds true for identifying a potential chronological gradient in our data set. Based on the results of the dating programme conducted in parallel to the chemical and petrographic analyses, Class 3 fabrics may be tentatively associated with the Late Bronze Age occupation of the Setefilla necropolis. A cursory survey of the overall ceramic assemblage suggests that other fabrics correspond to productions more characteristic of the Early Iron Age. However, it must be stressed that hardly any of the samples analysed for the present study come from directly dated contexts, and further work will be needed to establish if particular fabric groups can indeed be correlated with specific chronological phases. What can be said at this point is that there does not seem to be a chronological dimension to the use of either calcareous or ferruginous clay sources at the site.

What we have been able to establish is that there is no definitive and unambiguous evidence for a foreign origin of any type of clay paste used for pottery production at Setefilla. All identified minerals and fragments of rocks present in these pastes were common materials available to prehistoric communities in the area between the mountain ranges of the Sierra Morena and the valley of the Guadalquivir river, as geological surveys suggest (Delgado, 1983: 11-12). Furthermore, the initial experimental studies confirmed that all the minerals and rock fragments detected in the three main classes of clay paste which we distinguished could have been easily acquired in the vicinity of the site (Krueger et al., 2018). Consequently, what has conventionally been depicted as Phoenician might rather be a result of intentional imitation and thus reflect a complex process of cultural hybridisation (Krueger et al., 2018). Moreover, recent thin-section analysis of wheel-thrown pottery from the three sites of El Carambolo, Setefilla and La Joya suggests that the sherds conventionally perceived as foreign imports may in fact have been locally produced (Moreno and Krueger, 2019).

The compositional data from our pottery analyses indicate a significant correlation between techniques of manufacture and type of clay paste used. On the basis of XRF results, optical emission spectrometry and macroscopic observations, in the necropolis of Setefilla two groups of pottery can be established: local (hand-made) and foreign (wheel-thrown). All analysed vessels made of fine calcareous clays (Class 2) are wheel-thrown with high concentrations of potassium. They are fine-ware vases, well fired and generally covered by a red slip. On the other hand, hand-made pots were manufactured mostly from red ferruginous clay (Class 1) with low concentrations of potassium and average to high concentrations of titanium. These are coarser, more porous, and more poorly fired than wheel-thrown pots. Occasional use of ferruginous clay to make wheel-thrown ceramics was also recorded. We see this as strong indication that even wheel-thrown pots made of light yellowish clay (Class 2), conventionally perceived as Phoenician products, might in fact be related to local pottery workshops and reflect a process of imitation and emulation rather than being just simple imports.

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