

Archaeometric Characterization of Iron Age Indigenous Pottery from the Staggered Turriform of Son Ferrer, Mallorca, Spain

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Abstract

The paper explores indigenous ceramic production found at the Iron Age ceremonial center of Son Ferrer in Western Mallorca in the Balearic Islands (Western Mediterranean). The archaeometric characterization, which combines chemical and minero-petrographic techniques facilitates study of the evolution of ceramic traditions.

The results show an important shift in ceramic production. The Late Iron Age (Post-Talaiotic) pottery found at the site reflect the coexistence of various technological recipes for making pots, in comparison with a more homogeneous ceramic tradition during the Talaiotic period (*c.* 850-550 BC). This diversified and poorly standardized production is interpreted in association with changes in the system of knowledge transmission among artisans, restricted in the Post-Talaiotic period (*c.* 550-50 BC) to a household low-scale production. The observed variability demonstrates a differential use of natural resources for pottery making at a regional scale, as well as the interaction among various social groups in the area. In this sense, the increased variability observed in diachronic terms in the pottery deposited in the staggered turriform of Son Ferrer points to a change in the social role played by this archaeological site in the Post-Talaiotic period.

Key words: petrography, chemistry, ceramics, Iron Age, indigenous

1. Introduction

The study of Iron Age indigenous handmade pottery from the Balearic Islands has been addressed by many scholars. The focus of interest and the analytical approaches have varied significantly over time since M. Murray (1932) published the first research on the pottery from the archaeological site of Trepucó in Menorca. Since then, many typological studies of native pottery have been carried out in the islands in order to use this kind of material as a relative dating method (e.g. Camps et al., 1969, Rosselló 1972, 1974, Fernandez-Miranda 1978 and Mayoral 1983). To a lesser extent, some authors (e.g. Waldren 1982; Gasull et al., 1984) also undertook the study of ceramics in the 1980's with the aim to address certain social, economic, or environmental issues. There was also some interest in addressing the connections existing between the Late Iron Age (Post-Talaiotic period) indigenous pottery and the Punic world (Plantalamor and Rita 1986; Pons 1991; Guerrero 1985). The study of the relationship between local and imported ceramics has recently been taken up by Calvo et al. (2014a), though using postcolonial perspectives.

There has been a growing interest from the beginning of the 21st century in the implementation of multiple methodological strategies (e.g. archaeometric approaches, trace analysis, typological studies) in the Balearic Islands with the aim of carrying out the technological characterization of indigenous pottery. This technological paradigm in the analysis and interpretation of pottery has been used to tackle new problems related to the social organization of the Iron Age communities from the archipelago, as demonstrated by research at Son Ferragut (Risch and Gómez-Gras 2003) and Son Fornés (Palomar 2005, Lull et al., 2008), and in particular the southwest area of Mallorca (Garcia Rosselló, 2010, 2013, Albero 2011, Albero and Mateu 2012, Albero et al., 2012, Garcia Rosselló et al., 2012, Albero et al., 2014, Albero and Cau 2017). Some research has also been carried out with Iron Age ceramic assemblages from diverse sites of Menorca (Andreu *et al.* 2007). As a whole, all these works have provided important information regarding the diverse technical processes involved in the *chaîne opératoire*, including raw materials procurement, paste recipes, forming methods, surface treatments, and firing strategies.

Technological studies of indigenous pottery have significantly increased our understanding of the Iron Age societies from the Balearic Islands. However, such analyses remain limited to the ceramic assemblages of very few archaeological sites, which are

usually related to habitation or domestic contexts. It is crucial, therefore, to conduct the analysis of vessels recovered from archeological contexts associated with other functions (e.g. ritual, funerary) in order to properly address the complexity underlying the production, distribution, consumption and deposition of such handmade native pottery.

The aim of this paper is to gain information about the provenance and the production technology of the ceramic assemblage recovered in the staggered turriform of Son Ferrer (Figure 1), by means of an integrated archaeometric approach including chemical, petrographic and mineralogical analysis. The analysis of these materials, dating predominantly to the Iron Age (*c.* 850-50 BC) and also the Bronze Age (*c.* 1700-850 BC), is a pioneering study as it marks the first time pottery from this kind of turriform structures has been characterized in the Balearic Islands. This study is significant not only for increasing our knowledge about the pottery technology of this period, but also for advancing an understanding of the role these kind of massive structures could have played within the indigenous communities of Mallorca during the Iron Age.

2. The staggered turriform of Son Ferrer: archaeological context

The staggered turriforms are monumental structures that emerge in Mallorca during the Early Iron Age (Talaiotic period, *c.* 850-550 BC). This kind of structure was traditionally thought to be used mainly as a landmark in the territory of the indigenous communities and as a ceremonial area (Aramburu 1998). Authors such as J. Coll (1989) have argued that these could also be ritual places linked to funerary rites. However, the data obtained in the archaeological excavations carried out in the staggered turriform of Son Ferrer (Santa Ponça, Mallorca) allow us to surmise much more information. In addition to its basic role as a landmark (Calvo et al., 2005), the life cycle of these kind of structures and significance thereof were quite complex. Son Ferrer is currently the only staggered turriform fully excavated in the Balearic Islands. The excavation and the availability of a significant number of radiocarbon dates (see in detail in Calvo et al., 2014b; Garcia Rosselló et al., 2015) suggest an extended and uninterrupted occupation of the site over time associated with different chronological phases and uses. Thus, this archaeological site can be defined as a *persistent place* due to its long-lasting nature of more than two-thousand years. In this sense, Son Ferrer would have played a key mnemonic role for the

people who inhabited the area by connecting them with their ancestors (Garcia Rosselló et al., 2015).

The first phase of use of the site is related to the construction of a funerary hypogeum between *c.* 1800-1450 BC. Afterwards, a stepped structure was erected over this hypogeum during the Late Bronze Age (*c.* 1100-800 cal. BC) that was subsequently modified in the Early Iron Age or Talaiotic period by the construction of the current staggered turriform around *c.* 800 BC (Garcia Rosselló et al., 2015). An area was also documented that linked the stratigraphic unit (SU) 17 to ritual activities that had been used during the Talaiotic phase, between *c.* 850 to 600 BC; nevertheless, the possibility of later sporadic reoccupations of this area cannot be dismissed.

During the Late Iron Age, or Post-Talaiotic period, the Bronze Age funerary hypogeum was reused to bury adults and children, with the latter dominating the assemblage. A single stratigraphic unit, SU-9, dating between 522-386 cal. BC was documented and composed of disaggregated sediments where all the inhumations and ceramic materials were found. Once the hypogeum was filled, these burials continued to be performed in the corridor access of the structure (SU-101) between *c.* 200-75 BC, where children were buried in both ceramic containers and sandstone urns (Calvo et al., 2014b). Around the 1st century BC the northeastern walls of the monument were dismantled, continuing this funeral ritual until the beginning of the 3rd century AD. Finally, we should note that alongside with these funerary spaces there was also an area, SU-62, located attached to the access corridor of the hypogeum used in the Post-Talaiotic period for carrying out ritual practices linked to the burials (García Rosselló et al., 2015).

3. Local geology

The site of Son Ferrer is located in the municipality of Calvià, in the western side of Mallorca. It is a site situated on Quaternary (Holocene) sediments characterized by siltstones and red clays with limestone pebbles (Figure 2). To the west, outcrops of eolianites or *marès* are present, while aeolian sand deposits are found to the north and south of the site. The Puig d'en Saragossa, a hill located to the northeast of the site, comprises Jurassic (Lias) laminated dolomite rocks and limestones, as well as marls and sandstones.

At some areas to the northwest of the site there are Tertiary deposits of conglomerates, clays, silts and limestones (ITGE 1992a).

The southern coastal area is formed by Pliocene calcarenites. The lower layers consist of bioclastic calcarenites interbedded with siltstones. These calcarenites contain abundant foraminifera and mollusc remains, and can be classified as intrabiomicrites and biopelmicrites, with gravel and sand, and including some quartz. Over these layers there are bioclastic calcarenites and some levels of gravels and red clays. In petrographic terms, they correspond to sandstones enclosing fossil fragments and quartz, with a scarce carbonate cement and high porosity (ITGE 1992a).

In summary, the local geology is mainly sedimentary. Therefore, the local/regional ceramic products from the site are expected to contain sedimentary rock fragments and minerals as the predominant components.

4. Materials and methods

Forty-six ceramic individuals were selected for archaeometric characterization originating from various archaeological contexts at the site of Son Ferrer (Table 1). The materials are native pottery fragments mainly from the Post-Talaiotic period found in a number of stratigraphic units (SU) of the cave. A total of 28 samples come from the SU-9 (Post-Talaiotic I, c. 525-375 BC), while 10 samples were selected from the SU-62 (Post-Talaiotic II, 200-50 BC). Two of the samples from the SU-9 show a macroscopic fabric that is similar to the typical Late Bronze Age pottery, possibly representing residual materials in this context. In addition, eight samples from the SU-17 (Talaiotic, 850-600 BC) were also included in the analysis. This could help to compare indigenous products from different periods at the site and to identify any possible diachronic variation in the role that the site played within the hinterland of the communities settled in the region. The sampling comprises pottery vessels related to different shapes, sizes, and functions, such as utilitarian pottery and funerary urns.

The ceramic samples were studied using a combined archaeometric approach that includes chemical, mineralogical and petrographic analysis. Such approach is crucial for obtaining complementary information for the characterization of the materials, as well as

for shedding light on their provenance and technology. Chemical analysis is essential for the identification of different ceramic products related to various production centers and/or different recipes for paste preparation. It is also useful for assessing the geochemical compatibility between the ceramic materials and a specific geological zone. Optical microscopy by thin section analysis (OM) is essential for identifying minerals and rock fragments included in the ceramic fabric, and therefore it provides evidence for suggesting a geological origin for the fabrics and investigating the provenance of the ceramics. In addition, it is useful for gaining information on technological features such as raw materials selection, paste preparation and tempering, among others. X-Ray Diffraction (XRD) is particularly important for the identification of firing phases, as well as secondary phases formed during use and/or burial. The mineral phases identified in each diffractogram enabled an estimation of equivalent firing temperatures or EFT (Roberts 1963; Maggetti 1982; Cultrone et al. 2001; Buxeda and Cau 2004; Maggetti et al. 2011).

Following this approach, all the samples were analyzed by means of Wavelength Dispersive X-ray fluorescence (WD-XRF), XRD, and OM through thin section analysis, except for three samples (TSF016, 045, 046) that were analyzed only by OM. One sample, TSF027, was analyzed by OM and XRD due to inadequate weight for XRF.

The WD-XRF chemical analysis was performed using a Phillips PW 2400 spectrometer with a Rh excitation source. A sample of each specimen was powdered and homogenized in a tungsten carbide mill, and dried at 100°C for 24 h. Major and minor elements were determined by preparing duplicate glass beads, using 0.3 g of powdered specimens in an alkaline fusion with lithium tetraborate at a 1/20 dilution. Trace elements and Na₂O were determined using powdered pellets made from 5 g of a specimen mixed with Elvacite agglutinating agent, placed over boric acid in an aluminum capsule, and pressed for 60 s at 200 kN. The quantification of the concentrations was obtained by using a calibration line performed with 60 International Geological Standards (Hein *et al.* 2002). The identified elements are: Fe₂O₃ (as total Fe), Al₂O₃, MnO, P₂O₅, TiO₂, MgO, CaO, Na₂O, K₂O, SiO₂, Ba, Rb, Th, Nb, Pb, Zr, Y, Sr, Ce, Ga, V, Zn, Cu, Ni and Cr. The loss on ignition (LOI) was determined by heating 0.3 g of dried specimen at 950°C for 3 h.

Mineralogical analysis by XRD was carried out by using the same powdered specimens prepared for XRF. Measurements were taken using a Siemens D-500

diffractometer, working with Cu-K α radiation ($\lambda=1.5406 \text{ \AA}$) and a graphite monochromator in the diffracted beam at 1.2 kW, 40 kV, 30 mA. Spectra were taken from 4 to 70° 2 θ with a step-size of 0.05°2 θ and a step-time of 3 s. The evaluation of crystalline phases was carried out using the DIFFRACT/AT program by Siemens, which includes the Joint Committee of Powder Diffraction Standards (JCPDS) data bank.

Finally, OM petrographic-mineralogical analysis of thin sections was carried out using an Olympus BX41 polarizing microscope, 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 ceramic fabrics were described following the system proposed by Whitbread (1989, 1995) and Quinn (2013). Grain-size classification for the inclusions in petrographic descriptions is based on the Udden-Wentworth scale.

5. Results

Petrographic-mineralogical analysis

The OM thin section analysis allows for the differentiation of seven fabric groups, although only three, Fabric Groups 1 to 3, are well represented in the ceramic assemblage. These groups are distinguished according to the type of inclusions used for tempering. Nevertheless, a certain variability can be found within these groups with regard to other compositional and textural characteristics, and thus several fabrics can be differentiated. The variations observed between the different Fabric Groups are related to differences in the *chaîne opératoire* that are significant in terms of technological traditions and production organization.

The majority of the assemblage can be included in a large Fabric Group 1, comprising diverse fabrics with a combined calcareous and vegetal temper. In these fabrics,

iron oxides and clay pellets are common, while quartz is frequent but only in the fine fraction. Other fine inclusions, such as muscovite, polycrystalline quartz and chert, can be present but normally as accessory components in some of the samples. The fabrics with abundant vegetal temper normally present a highly porous microstructure, with large elongated and curved voids containing partially burnt organic matter. These voids, which in many cases show a parallel or sub-parallel orientation to the vessel walls in thin section, retain the form of the original plant remains that were added as temper and carbonized during the firing process.

A certain variability of fabrics can be differentiated in Fabric Group 1 on the basis of the relative abundance of these components, the characteristics of the calcareous inclusions, and the fine fraction (Figure 3a-e). In particular, six fabrics, 1.1 to 1.6, can be identified in this group.

Fabric 1.1, with crushed calcite and vegetal temper (Figure 3a), is found in eight individuals (TSF002, TSF005, TSF006, TSF008, TSF010, TSF019, TSF042, TSF044). It is characterized by a coarse fraction (>0.10 mm) of angular calcitic inclusions, mainly sparry calcite, with predominant fine to medium sand, few coarse sand and rare very coarse sand. There are also frequent remains of vegetal temper. The fine fraction (silt to very fine sand) is composed of dominant angular calcite, as well as few quartz and very few to rare calcareous microfossils, mostly foraminifera. The matrix has a brown to orange color under plane polarized light (PPL), with partial to total darkening of the section due to the firing process; it displays low to high optical activity under crossed polarized light (XPL), except in TSF042 where it is optically inactive. The sample TSF044 shows a finer texture, due to a lower mode of the coarse calcitic fraction (>0.10 mm), formed by predominant fine sand; the fine fraction here is composed of dominant calcite and frequent quartz.

Fabric 1.2, with crushed calcite and subordinated vegetal temper, is observed in six individuals (TSF011, TSF021, TSF028, TSF035, TSF038, TSF039). In this fabric, the coarse fraction (>0.10 mm) comprises predominant angular inclusions of sparry calcite, with similar grain sizes to Fabric 1.1. Vegetal temper is few to common, clearly less frequent than in Fabric 1.1. The fine fraction (<0.10 mm) consists of dominant calcite, frequent to common quartz and very few to rare microfossils. The matrix shows a brown to orange color (PPL), with a darkened core; it displays low to high optical activity.

Fabric 1.3, with angular and rounded calcite, and vegetal temper (Figure 3b), includes four individuals (TSF003, TSF012, TSF040, TSF043). The coarse fraction in this fabric (>0.10 mm) contains frequent calcite (less than in fabrics 1.1 and 1.2), from angular to rounded, and including both sparry and micritic calcite. Remains of vegetal temper are frequent. An abundant fine fraction of dominant calcite and frequent to common quartz inclusions is observed. Small iron-rich nodules are frequent, in particular in samples TSF012, TSF040, and TSF043. Despite these similarities, the four samples are somewhat heterogeneous and probably correspond to more than one fabric.

Fabric 1.4, with calcite and vegetal temper, and very fine calcareous clay (Figure 3c), is found in one individual (TSF026). This fabric is clearly differentiated due to a very calcareous clay matrix comprising less silt or very fine sand than the clay matrix in the other samples analyzed, and therefore shows a 'cleaner' aspect. It presents a brown to light brown color in PPL, and low optical activity in XPL. The coarse fraction (>0.10 mm) is poorly sorted and consists of subangular to rounded fragments of micritic calcite and limestone, from fine sand to very coarse sand; vegetal remains are also frequent.

Fabric 1.5, with vegetal and calcite temper, and abundant fine quartz (Figure 3d), includes two individuals (TSF001, TSF009). Here the fine fraction (<0.15 mm) consists of predominant quartz, mostly silt and very fine sand. This suggests the use of a siliceous clayey raw material. There is a coarse fraction (>0.15 mm) of frequent angular calcitic inclusions, mostly fine and medium sand and a few coarser grains. However in this fabric the remains of vegetal matter are dominant and can be interpreted as the main component of the temper. The matrix displays optical activity and is orange-brown (PPL) in color with various darkened parts.

Fabric 1.6, with rounded micrite and biocalcarenite, and few vegetal temper (Figure 3e), is observed in two individuals (TSF024, TSF030). The coarse fraction (>0.10 mm) is dominated by rounded micritic calcite and fragments of biocalcarenite or fossiliferous limestone, as well as fossils derived from the latter; this coarse fraction is moderately to well sorted and contains mostly fine to medium sand. Few traces of vegetal tempering are also present. The fine fraction comprises dominant calcite, frequent quartz and common microfossils (foraminifera mainly) suggesting the use of a clayey raw material of marine origin. The clay matrix is slightly different in the two samples, more darkened in TSF024

probably due to variations in the firing conditions.

For the majority of the samples in Fabric Group 1, XRD results indicate the absence of firing phases. In general, only primary phases are observed, such as phyllosilicates, quartz and calcite, that suggest equivalent firing temperatures (EFT) under 800/850°C. In one individual, TSF042, small peaks of gehlenite point to a slightly higher EFT ranging between 850-900°C (Table 2). The presence of alkali feldspar or plagioclase peaks as primary phases in a few samples does not show any clear correspondence to the petrographic fabrics defined from the thin section analysis. Peaks of dolomite are found in the sample TSF003; the thin section analysis has not enabled us to observe clear dolomite inclusions, but their presence should not be excluded for this sample.

Fabric Group 2 is characterized by a predominant vegetal temper; unlike Fabric Group 1, vegetal remains are the only constituent of the temper. It includes eight individuals that can be associated with two different fabrics, 2.1 and 2.2.

Fabric 2.1, with vegetal temper and abundant fine calcite (Figure 3f), is found in four individuals (TSF013, TSF031, TSF032, TSF036). The fine fraction (<0.15 mm) comprises dominant sparry calcite, frequent to common quartz and very few calcareous microfossils. The matrix is brown to orange-brown in PPL, heterogeneous, with darkened sectors due to the firing atmosphere. Apart from the predominant remains of vegetal temper, few coarse calcareous inclusions (angular to rounded calcite and limestone) can be found, although this material was possibly already present in the natural clay.

Fabric 2.2, with vegetal temper and abundant fine quartz (Figure 4a), is observed in four individuals (TSF007, TSF033, TSF034, TSF041). These samples present abundant, elongated vegetal remains as the main component of the temper. Few to rare coarse calcareous inclusions (angular to rounded micrite) are observed; these probably correspond to natural inclusions in the clayey raw material. The fine fraction (<0.15 mm) is dominated by quartz, especially in TSF033 and TSF041 where it is more abundant. Fine calcitic inclusions are few, suggesting the use of a less calcareous clay than in Fabric 2.1. Abundant secondary calcite is seen in TSF007, mainly as infilling of voids. The clay matrix is dark colored except in sample TSF034, which has a light brown color and high optical activity.

These pottery samples in Fabric Group 2 are low fired, with an EFT under 800-850°C as indicated by the absence of firing phases in the XRD patterns (Table 2). Only for

the individual TSF036 (Fabric 2.1) a slightly higher EFT, 850-900°C, can be estimated, based on the presence of small peaks of gehlenite in the XRD patterns.

Fabric Group 3 (Figure 4b) is characterized by the presence of crushed calcite as the only component of the added temper; it is observed in 10 individuals (TSF014, TSF015, TSF016, TSF017, TSF018, TSF020, TSF023, TSF027, TSF029, TSF037). The coarse fraction (>0.10 mm) is clearly dominated by angular fragments of sparry calcite. The calcitic temper is normally abundant, especially in TSF016 and TSF029 where the packing is clearly higher than in other samples. Unlike all previous fabrics, no organic temper is observed here. The fine fraction (<0.10 mm) is also abundant and contains predominant calcite, common to few quartz and very few to rare calcareous microfossils, suggesting the use of a calcareous clay. The color of the matrix ranges from orange to reddish-brown or brown (PPL), with darkened sectors related to the firing conditions, and variations in the optical activity in XPL likely due to slight differences in the firing temperature and/or atmosphere. The XRD patterns indicate for all the samples analyzed in this group an EFT no higher than 800/850°C (Table 2).

A few samples of the analyzed assemblage reveal particular fabrics in thin section due to the presence of other elements added as temper, such as grog or sedimentary rock fragments, sometimes combined with calcite or vegetal inclusions. In fact, TSF022 shows a fabric with crushed calcite and grog temper, along with an abundant fine fraction (<0.10 mm) of dominant calcite and frequent quartz (Fabric 4; Figure 4c). In TSF004, a fabric tempered with vegetal matter and grog is observed (Fabric 5), while in TSF025 grog is the only component of the temper (Fabric 6; Figure 4d). Both fabrics also contain other argillaceous fragments, which are more rounded in shape and may be interpreted as clay pellets (Whitbread 1986), as well as a fine fraction (<0.10 mm) dominated by both quartz and calcite.

On the other hand, samples TSF045 and TSF046 show a temper composed of calcitic inclusions and fine-grained sedimentary rock fragments (Figure 4e-f). However, each sample probably represents a different fabric (Fabrics 7.1 and 7.2, respectively), due to differences in the nature of these sedimentary rocks (mainly argillites in TSF045 and mudstones in TSF046) and in the abundance of fine quartz (silt to very fine sand), which is frequent in TSF046 and few in TSF045. The clay matrix is similar in these two samples,

with a light orange-brown color (PPL) and very high optical activity.

Chemical analysis

The normalized chemical composition for each sample, obtained through XRF analysis, is provided in Table 3. A first exploration of the chemical variability in the dataset can be obtained through calculation of the compositional variation matrix or CVM (Aitchison 1986, 1992; Buxeda and Kilikoglou 2003), which includes the total variation (vt) value and the degree of variability introduced by each element (vt/τ_i) in the dataset. The high vt value obtained is equal to 3.03, which indicates a polygenic sample. According to Buxeda and Kilikoglou (2003), vt values lower than 0.3, after excluding elements possibly related to post-depositional alteration and/or contamination processes, would represent, in practical terms, a highly standardized pottery production. However, this is not necessarily the case for handmade calcareous pre- and proto-historic coarse wares, for which vt values of around 0.6/0.7 might represent geochemically related pottery and or a common origin (Buxeda *et al.* 2001). In any case, the vt value for the present dataset is much higher and clearly excludes a monogenic origin. The elements that introduce more than 50% of the variability in the dataset according to the vt/τ_i values are CaO ($\tau_i = 17.54$), MnO ($\tau_i = 14.39$), Ba ($\tau_i = 10.02$), P₂O₅ ($\tau_i = 9.20$), Sr ($\tau_i = 7.23$), Na₂O ($\tau_i = 6.97$) and Ni ($\tau_i = 6.76$). It is evident that the high variations in CaO and Sr must be affected to a certain degree by the very frequent presence of intentionally added calcareous temper, mainly as crushed calcite, in most of the samples, as suggested by the petrographic analysis. If we recalculate the CVM excluding these two elements, as well as others that usually show alteration and/or contamination problems, such as P₂O₅, Na₂O and Pb, the vt value (1.77) remains very high. This suggests that more than one compositional group is represented in the assemblage.

The majority of the analyzed individuals present a high calcareous composition, with CaO percentages above 20%, and in some cases even higher than 40%. Only two samples, TSF033 and TSF041, are low calcareous (CaO <5%), and in six samples the CaO percentages are between 5-10%, while the remainder of the assemblage contains compositions consistently higher than 15%. In contrast, the SiO₂ percentages are usually below 50%. These variations in the CaO content show a broad relationship to the

petrographic fabrics (Figure 5), since the lowest calcareous samples ($\text{CaO} < 10\%$) correspond well with four fabrics in which the calcareous inclusions are present but clearly subordinated to other components (Fabrics 1.5, 2.2, 5, 6); of these, the fabrics with higher content of quartz, mainly Fabrics 1.5 and 2.2, present higher SiO_2 and Zr, while the grog-tempered Fabrics 5 and 6 are well differentiated by their higher Al_2O_3 percentages (Figure 5a-b; Table 3). The more calcareous samples ($\text{CaO} > 15\%$), conversely, correspond with the remaining fabrics, which are mostly associated with the use of some type of calcareous temper, either crushed calcite (Fabrics 1.1, 1.2, 3, 4) or others (Fabrics 1.3, 1.4, 1.6). An exception is given by the samples in Fabric 2.1 (TSF013, TSF031, TSF032, TSF036), whose calcareous composition is explained by the abundant fine calcitic inclusions, most probably related to the use of a calcareous clayey raw material, whereas the added temper consists of vegetal remains; these samples show quite heterogeneous chemical compositions (Table 3). The bivariate plot $\text{Fe}_2\text{O}_3/\text{TiO}_2$ (Figure 5c) shows a linear correlation (r Pearson = 0.887) between these elements and a certain variability related to the use of more ferruginous pastes in some cases (in particular Fabric 1.3) than in others; the less ferruginous paste is associated with Fabric 1.4, in agreement with the very calcareous clay matrix observed in thin section.

A further exploration of the chemical variability in the dataset is provided by multivariate statistical treatment for which the raw chemical concentrations were transformed into additive log-ratios (alr), following the considerations by Aitchison (1986) and Buxeda (1999). A cluster analysis was performed using the centroid agglomerative method and squared Euclidean distance on the following sub-composition: Fe_2O_3 , Al_2O_3 , TiO_2 , MgO , CaO , K_2O , SiO_2 , Ba, Rb, Th, Nb, Zr, Y, Sr, Ce, V, Zn, Cu, Ni and Cr; Ga was used as a divisor in the additive log-ratio transformation of the concentrations. P_2O_5 , Na_2O and Pb were excluded from the cluster analysis to avoid any possible contamination problem related to these elements, while MnO was also removed due to possible analytical imprecision. Four major clusters, A to D, can be observed in the resulting cluster tree (Figure 6; Table 4). The samples in cluster D are the most clearly differentiated due to a lower calcareous composition ($\text{CaO} < 10\%$ in almost all the cases) when compared to the rest of the assemblage ($\text{CaO} 15.1\text{-}47.4\%$), as well as relatively high percentages of Al_2O_3 and SiO_2 . Cluster C is also well differentiated from clusters A-B on the basis of its lower

Ba concentrations (73-137 ppm). Clusters A and B, on the other hand, separate each other in the analysis due mainly to the higher concentrations of Fe₂O₃, TiO₂, Nb, Ni, and Cr in cluster B. In any case, the examination of the chemical data for the samples in each cluster (Table 3) suggests that a significant internal variability exists, as can be inferred also from the dissimilarity levels in the cluster tree (Figure 6), where only a few samples seem to present strong similarities in the bulk chemical composition.

A number of chemical groups can be defined (A1, A2, B1, C1, D1, see Table 5), based on lower dissimilarity levels found in cluster analysis (Figure 6) and *vt* values, which do not exceed 0.60 in each case (0.50, 0.49, 0.27, 0.38 and 0.22, respectively). Even if a clear correspondence between the clusters in Figure 6 and the petrographic fabrics cannot be established, the few chemical groups defined tend to be associated with specific fabrics, *e.g.* group A1/Fabric 1.2, group B1/Fabric 1.3, group C1/Fabric 1.1 and group D1/Fabric 2.2 (Figure 6). However, not all the samples in these fabrics belong to these chemical groups. The group A2, for instance, comprises 13 samples of various fabrics, 11 of them with a calcareous temper composed of crushed calcite (Fabrics 1.1, 1.2, 3 and 4) or biocalcarene and micrite (Fabric 1.6).

Nonetheless, it is evident that the presence, and abundance in some cases, of a calcareous temper in the Fabric Groups 1, 3, and 4 must be clearly affecting the results of multivariate analysis by enriching the concentrations of CaO and diluting others (Neff *et al.* 1988, 1989). A consequent enrichment of Sr is not evident, since no correlation is observed between CaO and Sr (*r* Pearson = 0.192; Figure 7). However, a certain enrichment cannot be excluded for some of the samples tempered with calcareous inclusions. In order to gain further information on the clay sources for these fabric groups while avoiding the distortion caused by the calcareous tempering on the bulk chemical composition, another cluster analysis was performed that used the *alr* transformed elemental concentrations but excluded CaO, Sr, and Ba, which in some cases may be related to CaO (Figure 8). Fabric 4, with crushed calcite and grog temper, is a special case, since the effect of grog tempering on the elemental composition is more serious and the characterization of clay sources is much more difficult in these cases (Neff *et al.* 1989). In any case, the addition of grog has been observed only in three individuals analyzed (Fabrics 4, 5 and 6).

The cluster tree in Figure 8 reveals the presence of five main clusters, Cl-1 to Cl-5,

which are also confirmed by the PCA in Figure 9, based on the same sub-composition as in the cluster analysis. Cl-1 is characterized by a higher content of Fe_2O_3 , TiO_2 , and Ni (see Figure 5c), indicating the use of an iron-rich clay paste previously observed for some of these samples through the thin section analysis (Fabric 1.3); a few samples of Fabrics 1.1 and 3 are also included in this cluster. For all these samples, the combination of these results with the petrographic study points to the use of a calcareous and ferruginous clayey raw material (the same clay or possibly a clay mixing). Cl-2 is defined by a low content of MgO and K_2O , and a high content of SiO_2 and Zr; it includes the samples in Fabric 1.5 (Figures 5a and 9), for which the use of a quartz-rich clayey raw material was evidenced from petrographic analysis. The main aspect that differentiates Cl-3 from the other clusters is the relatively high content of MgO and, in some cases, K_2O ; this cluster is entirely formed by samples of the Fabric 1.2 (Figure 8), for which a certain association with a calcareous clay was observed under the optical microscope. Further investigation is needed in order to propose a precise interpretation for the higher levels of MgO in these samples. A particular case is given by the individual TSF003 (Fabric 1.3), with similar levels of Fe_2O_3 , TiO_2 , and Ni to those of Cl-1 but also high MgO as in Cl-3; it can be interpreted as a loner (Figure 9), certainly related to the use of a ferruginous and calcareous clay, while the MgO content should be associated with the peaks of dolomite documented through XRD. Cl-4 and Cl-5 are slightly related to each other, with minor differences in some major and minor elements (Fe_2O_3 , TiO_2) and traces (Ni, Cr, Zn, V), which are higher in Cl-5 and probably indicate a more ferruginous content of the clay matrix in the latter group. Nevertheless, in both cases the clayey raw material is predominantly of a calcareous nature, according to the petrographic evidence. Cl-5 relates to Fabric 1.1 mainly (also to Fabric 3), while Cl-4 comprises individuals of the Fabric 3 and, to a lesser degree, Fabrics 1.6, 1.1, and 1.2 (Figure 8).

6. Discussion

According to the archaeological evidence, the site of Son Ferrer must be interpreted as a ritual center during the Late Bronze Age and Talaiotic period, and a cemetery during the Post-Talaiotic period, rather than a village or inhabited site. It is therefore expected that

the pottery production did not take place *in situ* but, instead, at other sites from the periphery, such as Puig de Sa Morisca or Turó de les Abelles, which are both located near (< 2.5 km) Son Ferrer (Figure 2). The archaeometric results of this study, in particular those derived from the petrographic analysis, are compatible with a regional provenance as there are no petrographic-mineralogical components indicating any fabric clearly imported from outside the region. There are several outcrops of carbonatic deposits (limestone, biocalcarenite, marl, dolomite, etc.) in the surroundings of the mentioned sites that could have been the source of the calcareous tempers and/or clays found in the majority of the samples. The general geological background includes deposits of other sedimentary rocks as well as of clayey raw materials that were suitable for pottery production (García Rosselló and Albero 2011; Albero and Mateu 2012).

Concerning the fabrics defined in this study, further considerations can be obtained by comparing the obtained analytical results with the archaeological information for each sample, including typological and chronological data (Figure 6 and Figure 10).

From a diachronic point of view, almost all the samples from the Talaiotic context (SU-17) present a similar chemical composition and more or less similar fabrics (Figure 6). These are all related to crushed calcite tempering, normally without any other temper (Fabric 3) except in TSF019 (Fabric 1.1) and, to a lesser degree, TSF021 (Fabric 1.2), where vegetal remains are also found. A similar technological tradition has also been reported for pottery from the nearby site of Puig de Sa Morisca (Albero 2011; Albero and Mateu 2012; Albero *et al.* 2014; Albero and Cau 2017), as well as other sites from Mallorca (Albero 2011, in press) and Menorca (García Orellana *et al.* 2001) dating to the same period. The fabric and chemical composition of the Talaiotic individuals from Son Ferrer show strong similarities with the ‘petro-group 1’ of Puig de Sa Morisca (Albero and Mateu 2012; Albero *et al.* 2014), related to the use of Tertiary calcareous clays that are very suitable for pottery manufacture (García Rosselló and Albero 2011).

Conversely, the vast majority of the samples from the Post-Talaiotic phases, both Post-Talaiotic I (SU-9) and II (SU-62), are associated with the use of vegetal temper in the ceramic production. However, in a wide variety of fabrics many cases imply also tempering with crushed calcite (Fabrics 1.1, 1.2, 1.5) or other calcareous inclusions (Fabrics 1.3, 1.4, 1.6). In other cases (Fabrics 2.1, 2.2), the vegetal remains are the only component of the

added temper. It must be pointed out that no significant differences in fabric and chemical composition can be observed between the analyzed pottery of the two Post-Talaiotic phases, this implies a high degree of continuity in the pottery manufacturing strategies over this entire period.

These results indicate a shift in the technology of pottery production took place between the Talaiotic and the Post-Talaiotic periods, concerning the type of materials used in tempering. This involves, on one hand, the systematic use of organic matter as a main component of the temper in the Post-Talaiotic samples, an aspect already reported by other authors for pottery from the same period in Mallorca (Waldren 1982, 1991; Palomar 2005; Albero 2011). On the other hand, the shift documented in this study is related to an increased diversification of the tempers and, thus, of the technological choices followed by the potters, as suggested by the appearance of some less represented fabrics associated with the use of other types of temper, such as biocalcarenite (Fabric 1.6) and grog by itself (Fabric 6) or combined with crushed calcite (Fabric 4) or vegetal temper (Fabric 5). Interestingly, a similar diversification pattern has been reported by recent studies on the nearby sites of Puig de Sa Morisca and Turó de les Abelles, both dated to the same periods (see Albero 2011; Albero *et al.* 2014; Albero and Cau, 2017). Indeed, Fabric 1.6 is the same fabric defined as ‘petro-group 3’ for Puig de Sa Morisca (Albero *et al.* 2014), while the grog-tempered fabrics, in particular Fabric 5, might be associated with a similar fabric found in Puig de Sa Morisca (Albero 2011).

Furthermore, the clays used in pottery production are more diversified in the samples from the Post-Talaiotic period. A similar Ca-rich clay documented for the Talaiotic pottery found in Son Ferrer seems to have been used also in some of the Post-Talaiotic fabrics; consistent with the evidence found by Albero and Mateu (2012) for Puig de Sa Morisca concerning the Tertiary calcareous clays, which continued to be used from the Late Bronze to the Post-Talaiotic periods. However, other fabrics reveal a higher diversification in the used clayey raw materials for this period, including siliceous quartz-rich clays (Fabric 1.5 and 2.2) and ferruginous or ferruginous-calcareous clays (Fabric 1.3 mainly), as well as a very calcareous, finer-grained clay in Fabric 1.4. Fabrics associated with the use of ferruginous clays, probably *terra rossa*, as well as a fabric with siliceous clay and optionally vegetal temper, have been documented in Turó de les Abelles (Albero 2011;

Albero *et al.* 2014; Albero and Cau 2017). This could provide a possible provenance hypothesis for similar fabrics found in Son Ferrer (*e.g.* Fabrics 1.3 and 2.2, respectively), although it must be pointed out that the existing evidence so far for Turó de les Abelles dates to the Post-Talaiotic II, whereas the mentioned fabrics from Son Ferrer are attested in both Post-Talaiotic I and II contexts. For other fabrics identified in our study we could not find any clear parallel in the fabrics defined for Puig de Sa Morisca or Turó de les Abelles, a possible interpretation being that production occurred in other Post-Talaiotic sites located in the territory of Son Ferrer. This is the case, for example, of Fabric 1.2, with a calcareous clay tempered with sparry calcite and vegetal matter that shows a higher MgO content than other fabrics, possibly suggesting the use of slightly more dolomitic raw materials.

Such increase in the number of fabrics and chemical groups observed in the staggered turriform of Son Ferrer during the Post-Talaiotic period is in agreement with a broader regional phenomenon. Thus, when Bronze and Early Iron Age pottery productions are compared with Late Iron Age ceramic assemblages it becomes evident that the former had a higher degree of standardization. This increment in the technological diversity during the Post-Talaiotic period has been associated with deep changes in the ways of organizing pottery production, the learning contexts and the development of new cultural contacts (Albero 2017). However, this shift in the technological variability observed in this archaeological site can be also explained, at least in part, by considering the function of this site and its role within the territory (Albero 2011: 1201). On the one hand, it should be remembered that Son Ferrer shifted from a ceremonial center in the Early Iron Age to a collective necropolis in the Post-Talaiotic period. On the other hand, a change in the settlement pattern in the study area is also observed which is in agreement with this new function of the site. Both aspects could greatly affect the way pottery was produced and distributed through the territory and, in the case under study, the way it was deposited in Son Ferrer, thus explaining the features observed in the record.

As noted by several authors (Arnold 2000; Livingstone-Smith 2007) the spatial distribution of the settlements can determine the way in which the ceramics are deposited and distributed through the territory, as well as their features and degree of variability. We already mentioned that the staggered turriforms —a kind of structure strategically located in the territory— were loaded with a high social meaning and symbolically organized the

landscape of the Iron Age communities (Calvo 2009). This is also the case for the prehistoric communities that inhabited the area of Santa Ponça (Calvo *et al.* 2005), for whom this site played a key social role as a *persistent place* with a strong symbolic load during the Iron Age, first as a ritual area and subsequently as a necropolis (Garcia Rosselló *et al.* 2015). In this sense, it is necessary to point out that the area of Santa Ponça underwent a significant change in the settlement pattern in the transition between the Talaiotic and the Post-Talaiotic period. This change implied a more decentralized settlement pattern habitat and the foundation of new archaeological sites (Calvo *et al.* 2005, 2009; Galmés 2015).

During the Post-Talaiotic period the communities settled in the Santa Ponça area did not only inhabit the site of Puig de Sa Morisca, which was the main nucleus of population documented in the region, but also many others recorded in this area. The deposition of funerary ceramics in the necropolis of Son Ferrer deriving from the diverse archaeological sites of this hinterland (e.g. Puig de Sa Morica, Puig des Rei, Turó de les Abelles, Santa Ponça 5, Santa Ponça 20, Ses Penyes Rotges, King's Park), accounts for the high variability observed in the Post-Talaiotic ceramic assemblage of Son Ferrer. Such sites would have provided the necropolis with pottery produced using particular raw materials and tempers. Although this hypothesis requires further confirmation, since the vessels from these locations have not been characterized yet, it allows us to pragmatically explain the high variability observed in the pottery from Son Ferrer necropolis at this phase.

Two possible Bronze Age pottery samples (TSF045, TSF046) have particular fabrics (7.1 and 7.2) which are quite different from the rest of the assemblage. When compared to the Talaiotic and Post-Talaiotic samples, these two seem to indicate the use of different temper and clayey raw materials for pottery production. In any case, further sampling from Bronze Age ceramics is needed for a better examination of these technological differences.

Concerning the class or type of vessels, results reveal that the same fabric and/or chemical composition is normally associated with different ceramic forms. Conversely, similar forms are related to more than one fabric or chemical composition (Figure 10). Few exceptions can be mentioned, such as Fabric 1.6 observed in two bowls (TSF024, TSF030) with similar bulk chemical composition. Other examples include the lower calcareous

fabrics (1.5, 2.2, 5, 6) in the chemical group D, which is almost entirely formed by funerary urns, except for the bowl TSF034. However, many different recipes were used for the manufacture of funerary urns (Fabrics 1.1, 1.2, 1.3, 1.5, 2.1, 2.2, 5, 6), while others were applied to ceramics intended for different functions. Fabric 3 for instance, which is well represented in the assemblage analyzed, was used for a variety of ceramic forms instead of urns (Figure 10).

The analytical results also show that crushed calcite tempering and a calcareous clay (Fabric 3) were used both in Talaiotic samples (TSF015, TSF018, TSF019, TSF020) and in one Post-Talaiotic sample (TSF027). During the Post-Talaiotic period, additional distinct recipes were used, including tempering with crushed calcite and few vegetal remains (Fabric 1.2: TSF035), with vegetal remains only (Fabric 2.1: TSF036), and with calcite and vegetal inclusions but using a different calcareous clay from the other fabrics (Fabric 1.4: TSF026).

7. Conclusions

The archaeometric characterization of the pottery recovered at the sanctuary of Son Ferrer combining OM, XRF, and XRD analysis has enabled the definition and characterization of a variety of fabrics, as well as the identification of changes in pottery-making traditions between the Talaiotic and Post-Talaiotic periods, or between Early and Late Iron Age, in this area of Mallorca.

In general, the pots sampled from the ritual area of the site, dating to the Talaiotic period, which employ manufacturing techniques of crushed calcite-temper, low firing regimes, and a calcareous clay correspond to ceramics produced in the same period in Puig de Sa Morisca (Albero 2011; Albero and Mateu 2012; Albero *et al.* 2014), a fortified site located 2.2 km to the northwest. Given these similarities, Puig de Sa Morisca serves as the most probable provenance hypothesis for the materials found in Son Ferrer. Ceramics dating to the Post-Talaiotic I and II periods from funerary contexts of Son Ferrer, on the other hand, demonstrate a higher diversification of technological strategies, concerning both the tempers and the clays used for making pots. Even if crushed calcite continued to be used in some cases, the main technological choice for tempering in this period is the use

of vegetal matter or a combined vegetal and calcareous temper. This includes either crushed calcite or other calcareous materials, *e.g.* biocalcarenite. Less represented technological choices in the analyzed assemblage involve the addition of grog, sometimes combined with crushed calcite or with vegetal temper. Calcareous clays, combined with a variety of tempers, continued to be used as raw materials, but the use of ferruginous clays (with calcitic and vegetal temper), and siliceous clays (either with calcitic and vegetal temper, or with vegetal temper only) is also attested. For some of these fabrics, it is possible to find parallels in the nearby sites of Puig de Sa Morisca and Turó de les Abelles (Albero 2011; Albero *et al.* 2014; Albero and Cau 2017). For other fabrics, the lack of any known similar cases in these sites does not lend to interpretations about provenance. That said, association with any other possible Post-Talaiotic sites from this area, whose pottery record has not yet been characterized cannot be excluded from these cases.

An interesting conclusion derived from the results is that the pottery found in Son Ferrer seems to reflect a diversified and poorly standardized production process during the Post-Talaiotic period. This limited standardization is evidenced by the coexistence of various technological recipes for making pots, which meaningfully contrasts a more homogeneous ceramic tradition during the Talaiotic period. Similar patterns have been found for pottery assemblages from Puig de Sa Morisca and Turó de les Abelles. These have been interpreted in association with changes in the system of knowledge transmission among artisans, which was restricted in the Post-Talaiotic period to a household level-scale production (see Albero *et al.* 2014, in press). In this case, every family or domestic unit produced pottery according to its own manufacturing knowledge and strategies for raw material procurement and modification. This would explain the great compositional variability found in the pottery assemblages from this period. Of course, in some cases other plausible interpretations (*e.g.* existence of micro-regional scale exchanges) cannot be ruled out, however, further research is required to resolve these important questions.

Despite the multiplicity of fabrics and compositions documented in the handmade ceramics from Son Ferrer, all wares are compatible with a regional provenance, while local production seems unlikely due to both the nature of the site (ritual center and cemetery) and existing archaeological evidence thus far. Nevertheless, the observed variability indicates a differential use of natural resources for pottery making at a regional scale, which suggests

interaction among various social groups in the area. In this sense, the increased variability observed in diachronic terms in the pottery deposited in the staggered turriform of Son Ferrer can be also related to two phenomena co-occurring in the Post-Talaiotic period: 1) a change in the function of the site, from ritual to funerary; 2) a new settlement pattern suggestive of emergent habitat sites in the territory used for providing the necropolis with funerary ceramics. A prolonged systematic research project is needed. This should include a broader pottery sampling at both Son Ferrer and other contemporary sites in the area. In addition, a further survey and analysis of the raw materials available in the regional geology needs to be completed. The analysis of more ceramics and regional raw materials, will allow for a better understanding of the social interactions and the diachronic and local/regional variability of pottery production technology in western Mallorca between the Late Bronze and Post-Talaiotic periods.

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Figure captions

Figure 1. Location of the staggered turriform of Son Ferrer within the context of the Balearic Islands and plan of the site including the stratigraphic units considered in this study.

Figure 2. Geological map of the Calvià peninsula, with the location of Son Ferrer and other sites mentioned in the text (based on ITGE 1992a, 1992b)

Figure 3. Photomicrographs of ceramic thin sections, taken under crossed polars (c, e-f) or plane polarized light (a-b, d) at the same magnification (40x). (a) TSF002, Fabric 1.1, crushed calcite and vegetal temper. (b) TSF012, Fabric 1.3, angular and rounded calcite, and vegetal temper. (c) TSF026, Fabric 1.4, calcite and vegetal temper, very fine calcareous clay. (d) TSF001, Fabric 1.5, vegetal and calcite temper, with abundant fine quartz. (e) TSF024, Fabric 1.6, rounded micrite and biocalcarenite temper, with few vegetal remains. (f) TSF013, Fabric 2.1, vegetal temper, with abundant fine calcite

Figure 4. Photomicrographs of ceramic thin sections, taken under plane polarized light (a) or crossed polars (b-f) at the same magnification (40x). (a) TSF034, Fabric 2.2, vegetal temper, with abundant fine quartz. (b) TSF016, Fabric 3, crushed calcite temper. (c) TSF022, Fabric 4, crushed calcite and grog temper. (d) TSF025, Fabric 6, grog temper. (e) TSF045, Fabric 7.1, calcite and argillite/mudstone temper. (f) TSF046, Fabric 7.2, calcite and mudstone/argillite temper

Figure 5. Binary diagrams (using normalized data) of: (a) SiO_2 vs Zr, (b) Al_2O_3 vs CaO, (c) Fe_2O_3 vs TiO_2 , for the samples from Son Ferrer, with an indication of the petrographic fabrics according to the results of thin section analysis

Figure 6. Dendrogram resulting from a cluster analysis (using the centroid agglomerative method and the squared Euclidean distance) on 42 samples, based on the alr transformed concentrations of Fe_2O_3 , Al_2O_3 , TiO_2 , MgO, CaO, K_2O , SiO_2 , Ba, Rb, Th, Nb, Zr, Y, Sr, Ce, V, Zn, Cu, Ni and Cr, using Ga as divisor in the log-ratio transformation of the data. Main clusters (A to D) and chemical groups (A1, A2, B1, C1, D1) are indicated. Petrographic and chronological data for each sample are given (TAL = Talaiotic; PTAL = Post-Talaiotic). Funerary urns are labeled with a black circle

Figure 7. Binary diagram (using normalized data) of CaO vs Sr, for the samples from Son Ferrer. An indication of the petrographic fabrics, according to the results of thin section analysis, is given

Figure 8. Dendrogram resulting from cluster analysis on 31 samples with calcareous temper (Fabric Groups 1 and 3), based on the alr transformed concentrations of Fe_2O_3 , TiO_2 , MgO, K_2O , SiO_2 , Rb, Th, Nb, Zr, Y, Ce, Ga, V, Zn, Cu, Ni and Cr; Al_2O_3 was used

as divisor in the log-ratio transformation of the data. Main clusters are labeled as Cl-1 to Cl-5. Petrographic fabrics for each sample are also indicated

Figure 9. PCA of the alr-transformed chemical data of 31 samples (Fabric Groups 1 and 3), based on the same alr transformed subcomposition as the cluster analysis in Figure 8. Bivariate plot with the first two principal components, PC1 and PC2. PCA was performed on the covariance matrix. For each sample the TSF0 prefix was removed in order to simplify the reading.

Figure 10. Illustrations of the samples analyzed from Son Ferrer, organized by petrographic fabric, according to the analytical results. TAL = Talaiotic; PTAL = Post-Talaiotic

Table captions

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

Table 2. Mineralogical composition and equivalent firing temperature (EFT) of the samples analyzed, determined from XRD results. Abbreviations for minerals, based on Kretz (1983): Qtz, quartz; Pl, plagioclase; Kfs, K-feldspar; Cal, calcite; Gh, gehlenite; Px, pyroxene; Hem, hematite; Ill-Ms, illite-muscovite; Dol, dolomite. The samples are organized by fabric, according to the results of the OM analysis

Table 3. Normalized chemical results of the 42 samples that were subjected to chemical analysis (XRF). Concentrations of major and minor oxides are in %, other minor and trace elements are in ppm

Table 4. Normalized chemical composition of the clusters A to D defined from the multivariate statistical analysis of the data. Mean (m) and standard deviation (sd) values are presented for each element

Table 5. Normalized composition of the five chemical groups (A1, A2, B1, C1, D1) defined from the cluster analysis. Mean (m) and standard deviation (sd) values are presented for each element