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The Hidden Record at Torre d'en Galmés, Menorca. Accounts from Soil Micromorphological Analysis

El registro arqueológico escondido en Torre d'en Galmés, Menorca. Historias de micromorfología de suelos

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Menorca contains a wealth of archaeological sites dating to the Talayotic period (1st millennium BC) and occupied throughout the late Middle Ages. These sites have been the object of a number of excavations in the past decades. Most excavations have concentrated on revealing the architecture and traditional aspects of the archaeological record. Many facets of site formation and the stratigraphic record, however, are often not visible, go unnoticed, or are largely under the radar. The main goal of this paper is to show how archaeological soil micromorphology can reveal information about human activities and site use within and between structures at Torre d'en Galmés that are virtually unseen in the field. As such, it more than supplements information derived from the 'traditional' archaeological record, which can be deficient in revealing what people were actually doing at the site, and should be viewed as part of the archaeological record.

KEYWORDS
STRATIGRAPHY, SOIL MICROMORPHOLOGY, TALAYOTIC, MENORCA, SPHERULITES, COPROLITES, DUNG

Menorca es rica en yacimientos arqueológicos construidos durante el primer milenio a.C. —cultura talayótica— y ocupados de manera intermitente hasta la Baja Edad Media. En las últimas décadas, varios de estos yacimientos han sido objeto de intervenciones arqueológicas con proyectos de investigación centrados en el estudio de la arquitectura, cerámica, fauna y otros materiales recuperados

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durante la excavación. Sin embargo, algunos aspectos del registro arqueológico no son visibles en el yacimiento. El objetivo principal de este trabajo es mostrar cómo la micromorfología de suelos puede revelar información sobre actividades humanas y el uso del espacio en el yacimiento de Torre d'en Galmés, aunque sean invisibles durante los trabajos de campo. De esta manera, la micromorfología complementa la información que se obtiene del registro arqueológico «tradicional», que puede ser deficiente en el estudio de actividades humanas y estudio del pasado.

PALABRAS CLAVE
ESTRATIGRAFÍA, MICROMORFOLOGÍA DE SUELOS, CULTURA TALAYÓTICA, MENORCA, ESFERULITOS, COPROLITOS, ESTIÉRCOL

1. Introduction

This note comes about in a curious way, mainly as a need to explain to our colleagues an aspect of the research that we have conducted in Menorca for over a decade: micromorphological analysis. Both of us have worked at the site of Torre d'en Galmés since 2002, a complex one that spans from about the 9th century BCE to the 13th century CE, i.e., during the Talayotic, post-Talayotic, Roman, and Muslim periods (fig. 1). The site sticks up above the sloping landscape because of the striking presence of megalithic structures, including public buildings—watchtowers and sanctuaries—as well as domestic constructions, storage areas and open spaces, probably for gathering and circulation, between buildings (Pérez-Juez *et al.*, 2011; Pérez-Juez, 2013). We initially spent seven years excavating one of the residential complexes—Casa 2—(Pérez-Juez, 2012), and we finished our research by excavating a number of test trenches that were aimed at understanding the three-dimensional fabric of the architectural space and its articulation with what appeared to be open areas: how did the site's inhabitants utilize non-architectural space? (See Pérez-Juez and Goldberg, in press, for consideration of quarrying activities at the site.)

The main structure, Casa 2 (figs. 1 and 2), is a complex of constructions that was built during the post-Talayotic period and intermittently used until the 13th century CE. The deposits in the building clearly indicate some temporal gaps in the archaeological record, showing use, abandonment, and reuse of the building. In addition to revealing the architecture, site plan, and the sequence of occupation of the structures, we recovered relatively characteristic types of materials from the three main phases of occupation: post-Talayotic, Roman, and Medieval. These objects revealed local production as well as imported material, which confirmed trade patterns and commercial influence throughout the Mediterranean for each time period. So up to here, the excavation process, archaeological research, and historical background represent a common thread that attempts to look at the entire record visible at the site: architecture, objects, fauna, charcoal, seeds, etc., except one: the deposits themselves and their study through archaeological soil micromorphology (henceforth, simply micromorphology; see for example, Goldberg and Aldeias, 2016).

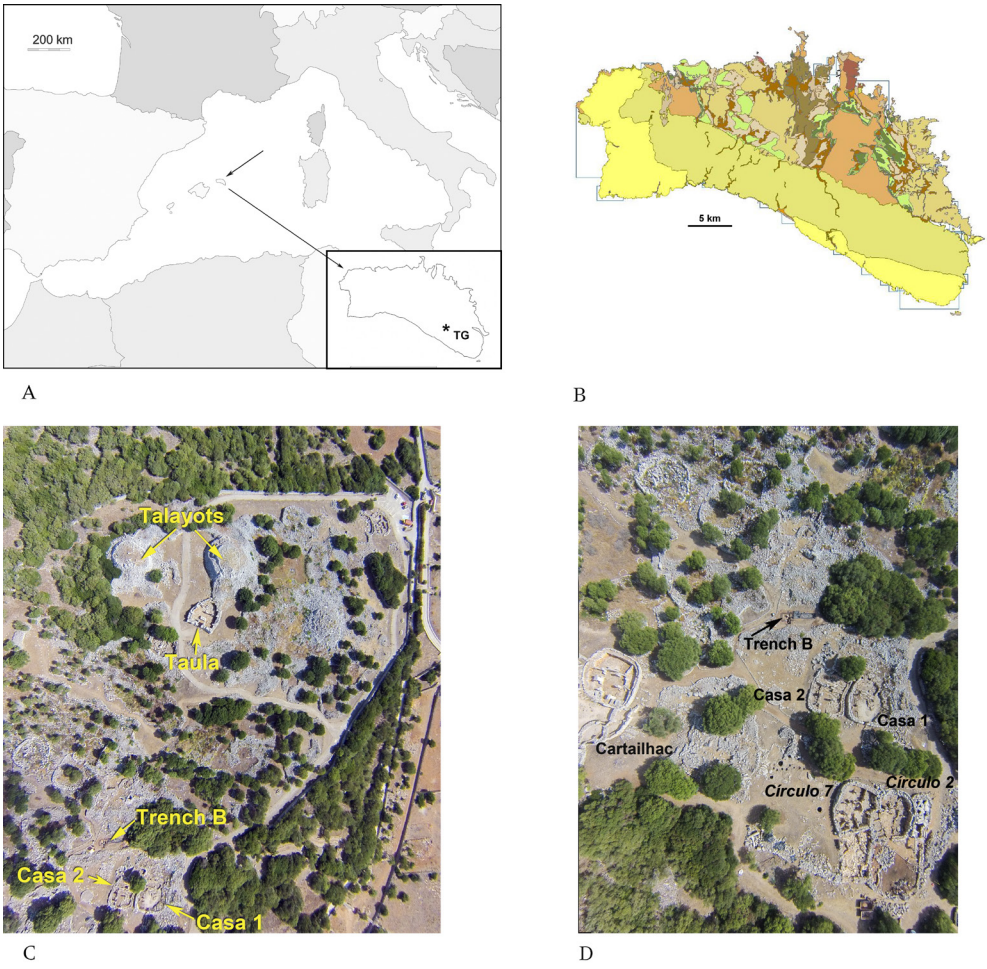

Figure 1. The site of Torre d'en Galmés. *A*) Location map showing the position of Menorca in the Western Mediterranean; *B*) Generalized geological map of Menorca. Note the extensive cover of Miocene limestone (yellow) in the S and W part of the Island and the variety of clastic rocks on the northern side (brownish colors) – map from (IDE, 2016); *C*) Aerial view of site of Torre d'en Galmés showing northern and eastern areas, including Talayots, Taula, Casa 1 and Casa 2, and excavation trench (Trench B) just NW of Casa 2; *D*) Close-up and slightly expanded view of 1 *C*, showing additional houses (Círculo 2 and 7, and Cartailhac) to the south and west of Casa 2, respectively; Trench B occupies an open area between architectural space.

Nonetheless, many of the important and interpretable aspects of the deposits are only partially visible in the field. In other words, latent properties of the deposits are simply waiting to be analyzed with a different approach. And here is where this paper comes about in a curious way: one of the best and most exciting things about archaeological projects is the challenging conversations that members of the team can have among them-

selves or with other teams. Engaging discussions commonly lead to understanding better what one is dealing with, and they provide a much fuller picture of the situation: the sum of the parts is almost always greater than the whole.

Most of the conversations with colleagues and friends over the years have dealt with the interpretation of the archaeological record, including different ways of looking at what we unearth and how we solve the puzzle with the information we have. From the very beginning of the BU project in Menorca, micromorphology was part of the data recovered and it yielded some enlightening results at Torre d'en Galmés that will be highlighted below. The interest about what we were doing has grown among other teams on the Island, but not to the point where it has become standard or even common practice.

These are the reasons that prompted us to put down some of our results after many chats, discussions, and invitations to join other projects on the Island. We are hopeful that colleagues working on similar types of sites and issues will benefit from these experiences and, perhaps, we can finally get the word out about the importance of looking at the hidden aspects of the archaeological record. We think that some of our conclusions and inferences will help broaden all of our perspectives for these sites, which dot the Menorcan (and Mallorcan) landscape.

Torre d'en Galmés: the site and its nature

Torre d'en Galmés is one of the largest Talayotic settlements on the island of Menorca (fig. 1). The site became a major urban center at the beginning of the 1st millennium BCE, with the construction of three talayots at the top of the hill, along with a taula precinct. Around these first constructions, the site grew downhill (southward) where houses, storage areas, cisterns etc. were built. The good state of preservation makes it ideal to study the layout of an Iron Age site as a whole, and later time periods are also well represented: Roman and Medieval structures were constructed on top of the post-Talayotic buildings providing an entire sequence of the use, abandonment, and reuse of the site for over two thousand years.

The area we excavated—Casa 2—is located in the southern part of the site, an urban expansion that took place from the 4th century BCE, revealing the commercial, military –and most likely political– influence of the Punic world. The main building was completed with a rectangular structure, SPU 8—a Muslim medieval kitchen—as we moved north of the original circle. It all forms a domestic complex produced by different superimposed structures dating from the 4th century BCE to the specific year of 1287, when Alfonso III conquered the island from the Muslims (Pérez-Juez, 2012). The original post-Talayotic building had been modified over the course of these centuries and only some of the original construction remained: outer walls, some of the internal divisions and the bottom layers of quarrying and construction. The successive modifications of the house had to do with the construction of interior divisions used to partition the house and reutilize the space for different purposes.

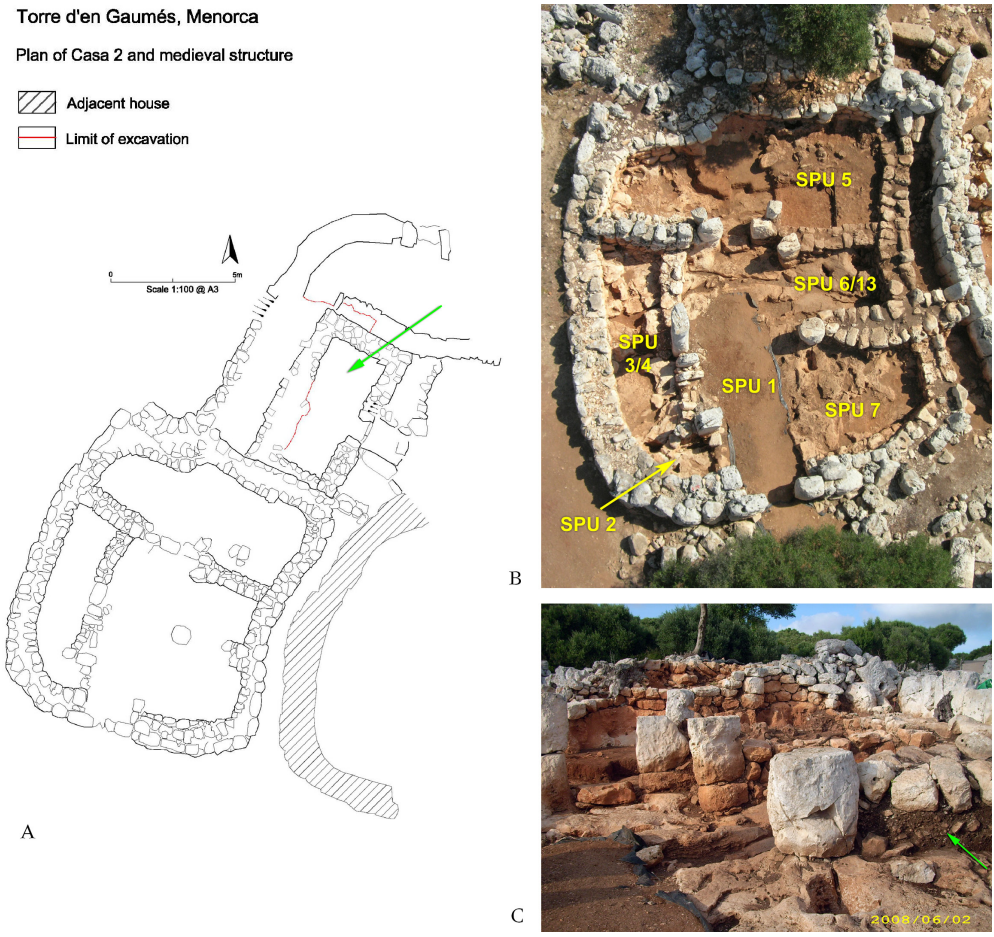

Figure 2. Casa 2. *A*) Map of excavated area with arrow pointing to medieval construction of SPU 8 (map by Planas & Wilson); *B*) Different spatial units (SPUs) in the structure; *C*) View from the entrance showing the dark medieval deposit at the front (green arrow) and, in the background, the remains of red deposits that filled the house; note the red staining on the pillars and walls that the denote the height of the red fill.

The period of abandonment from the 2nd to the 12th centuries CE is also clearly represented by a meter-thick accumulation of mostly reddish sandy silty clay mixed with stones and cultural debris (see below). It is not until the 12th century that we can see renewed activity within the site: new constructions on top of the abandonment debris, as well as the removal of sediments of some areas that were filled with midden material (broken pottery, bones of consumed animals, construction materials—plaster) by the inhabitants during the Muslim period. These medieval deposits are unconformably draped over the decayed architecture (stone walls) and are composed of dark brown, organic-rich clays.

Soil Micromorphology

A few words are needed about soil micromorphology, a technique essentially borrowed from petrography in geology, adapted by soil scientists in the 1930s (Kubiëna, 1938), and ultimately by archaeologists and geoarchaeologists at the end of the 1970s (Courty *et al.*, 1989; Macphail *et al.*, 1990; Goldberg, 1979, 1980). Micromorphology is chiefly the study of intact blocks of soil, sediment, or archaeological materials (e.g., ceramic, plaster, daub, etc.) using petrographic thin sections. In the thin section, it is possible to observe the organic and inorganic components of the material and the void spaces among them, all preserved in their original geometric positions, along with minerals that might have been precipitated or altered after original deposition.

Samples are collected in the field as intact blocks using different strategies (Goldberg and Macphail, 2003). If the sediment, for example, is compact, a block can be removed with a knife and simply wrapped tightly with toilet paper and plastic packaging tape. For loose, crumbly deposits, it can be jacketed with plaster of Paris bandages. The blocks are then transported to the laboratory where they are embedded with epoxy or polyester resin, sliced, and mounted on a glass slide (typically 50 × 75 mm, 60 × 90 mm, or 75 × 137 mm) and finally ground to a thickness of 30 µm, roughly that of a piece of paper (Murphy, 1986) (http://www.earthslides.com/).

After fabrication, the entire thin section is photographed or scanned on a flatbed scanner at 1200 or 2400 dpi (Arpin *et al.*, 2002; Goldberg and Aldeias, 2016), and in tandem examined at lower magnifications (~6x to 20x) with the stereo microscope in order to document and understand the overall organization of the materials and their porosity (e.g., bedding, burrowing). We stress that such low-magnification observation also serves as a transition from field-based observations to those obtained with a petrographic microscope. The latter uses plane-polarized (PPL) and cross-polarized light (XPL), and in some cases, oblique incident (OIL), ultraviolet (UV), and dark field illuminations. These illumination techniques are used to highlight certain aspects of the slide, such as composition, texture (size and shape of grains) fabric (the arrangement of the solid components and voids), and post-depositional precipitates—e.g. calcite—(Bullock *et al.*, 1985; Courty *et al.*, 1989; Stoops, 2003; Stoops *et al.*, 2010; FitzPatrick, 1984); magnifications with the petrographic scope commonly range from 20x up to 200x.

Case Studies

Below we present from the site a number of examples of hidden information that was more clearly evident when seen in thin section. They include types of materials associated with building construction, the use and nature of fire throughout the house, fauna remains and quarrying activities.

A

B

C

Figure 3. Micromorphology at Torre d'en Galmés. *A*) Preparing to collect two micromorphological samples from the wall between SPUs 3 and 4. Because of the stone- and clay-rich nature of the deposits, blocks were stabilized with plaster of Paris jackets before being removed; *B*) Jacketed samples ready to be removed from wall between SPUs 3 and 4; *C*) Plaster-jacketed sample (from Trench B) showing face of sample that was attached to the wall. This face is also covered with plaster and the entire block is transported back to the laboratory.

Case #1. SPU 5: Red deposits

SPU 5 is the back room in Casa 2 and shares a similar position of other rooms in post-Talayotic houses (Figs. 2 and 4). It is a wide space that is accessed through a door clearly framed. It has been interpreted as the bedroom for different reasons: a) it is at the rear of the building; b) in some cases it has a large bench that might have functioned as a bed—c.f. Círculo Cartailhac—(Sintes and Isbert, 2009); and c) in one of the other houses at Torre d'en Galmés, Círculo 7, a brazier was found and interpreted as a means to warm the place

(Lara, 2012). The archaeological materials, in fact, do not and cannot yield more information: almost all the houses were emptied out before abandonment, which makes it difficult to interpret them through the few, non-diagnostic objects found during excavation.

The amount of this red silty clay deposits that filled some of these rooms is substantial (~1-1.2 m^3). This fill is widespread in other closed spaces throughout Torre d'en Galmés, and its vertical extent is readily apparent in excavated houses where it has stained the inner walls with a red color (figs. 2, 5). In addition, and as we show below in example #2, it is clear that the sediments within SPU 5 are substantially different from those in other rooms of the house. Micromorphologically, they consist of non-calcareous massive red silty clay with inclusions of quartz sand and silt and some rare clasts of limestone bedrock. They exhibit some channel and vugh porosity, as well as speckled and granostriated b-fabrics. Importantly, they have micromorphological characteristics similar to what one observes in a local *terra rossa* profile in this area (fig. 4 f, g).

So, what is all this red filling? Does it have to do with construction materials? Floors? Plaster from the walls? Roofing? Different researchers have noticed these red deposits at this and other sites, and have entertained the idea that they have to be part of something anthropogenic, probably roofing or wall plaster (Sintes and Isbert, 2009; Pons, 2016; Ferrer *et al.*, 2011). We see images of the reconstruction of these houses with adobe walls or clay roofs, in published catalogs, books or exhibitions (Sintes, 2014).

Some deductions can be made directly at the site. For instance, in trying to figure out the nature, origin and use of these red deposits, we have to take into account not only the composition of the material and how it varies vertically but also the geometry of the infilling within SPU 5. Whatever the interpretation, we are constrained by the fact that the red fill appears to be thickest at the rear wall and sides of the house, and thin in the direction of the doorway. Following geological principles, deposits are thickest in the source area and thin away from it. Thus, it is quite reasonable to conclude that the material originated from the wall. Moreover, as mentioned above, the material itself is quite similar to *terra rossa* soil. Thus, a realistic hypothesis is that the deposits denote decomposed "terra rossa" mud plaster, and may represent successive accumulations of multiple episodes of plastering and replastering of the walls.

Since all buildings at the site are filled with these red deposits (see for example, fig. 2 c, 4 b; 5), it is imperative that *during excavation* closer examination of the microstratigraphy of these deposits be made and more samples be taken. Whether they constitute materials derived from walls (or roofing), they should be excavated as if they were objects, preserving part of them as baulks, and analyzing them from the inside out: micromorphology, phytoliths, charcoal, etc.

Case #2. SPU 3-4: Small fireplaces

Almost all of the houses excavated in Menorca for this time period—4th through 2nd centuries CE—show a hearth in the central courtyard where food preparation and cooking

Figure 4. Field and microscopic views of sediments from SPU5 in Casa 2 (see figure 2). *A*) SPU 5 as seen from SPU 1 looking north into the area. Note the mass of red silty clay in the course of being excavated. Width of doorway is about 1 m; *b*) Location of micromorphology sample TG-105 taken from baulk within the fill of SPU 5. The length of the rectangular sample is ~20 cm. The stratigraphy consists of three major levels: 1) The basal one resting on bedrock is grey brown charcoal-rich sandy clay with bones, pieces of charcoal, and trampled pottery; 2) A sterile, sandy silty clay; and 3) Loose, stony, dark brown, crumbly organic-rich clay; *C*) Scan of thin section of sample TG-105A (50 × 75 mm) from the middle layer (#2) above; note the generally homogeneous nature of the material with a cm-sized rounded clast of sandstone at the left; *D*) Photomicrograph of sample TG-105B showing quartz grains within a non-calcareous silty clay matrix. Plane polarized light (PPL); *E*) Same as *d* but in cross-polarized light (XPL). The quartz sand is the coarser grey and white grains, whereas the silt is denoted by finer grey/white dots; *F*) Thin section of natural terra rossa soil collected from the surface about 150 m south of Casa 2; although the photo is at a slightly different scale from that of D and E, the similarity in composition of quartz sand and silt in a red clay is notable and comparable to that in d from SPU 5; *G*) Same as in *f* but in XPL.

might have been done (Sintes and Isbert, 2009; Pons, 2016). Casa 2, however, did not yield any evidence of a hearth in the patio area. Modifications of the architecture of the house after the Roman conquest, and later use of the area as a dump by the Muslims might have erased the evidence of the existence of any hearths. Fire, however, was produced and used in the house. The following case study shows a particular use of fire at Casa 2 in SPU3-4 (fig. 2 b) on the western side of the building.

SPU 3-4 consists of an elongated room that opens east to the patio. Similar spaces exist in other post-Talayotic houses and have been interpreted as working areas due to the recovery of loom weights (Pons, 2016). The excavation did not yield information about its original use. Like in the rest of the building, the space had been emptied out and abandoned, and then used for other purposes different from the first household. Some modifications of the original architecture were also noted, such as a layer of stones above the Talayotic levels and the blocking of the entrance to the room. In the center of this room we identified a number of combustion features that were not related to any architectural feature, nor did they appear to be associated with a permanent fireplace.

Sample TG-107 was taken from a dark grey ashy combustion feature. This has a loose, aggregated microstructure with a variety of compositions (fig. 6 a, b-h): fire reddened clay aggregates, bone fragments, weathered and fresh limestone fragments, shell fragments, pottery, some of which is possibly vitrified. Charcoal is fine-grained (silt-sized) and is well mixed into the matrix. Most significantly however, is the presence of aggregates of calcareous ash, phytoliths (some melted) and calcareous spherulites (some also showing signs of having been heated from dung (Canti, 1997, 1998, 1999; Shahack-Gross *et al.*, 2003). No large pieces of what appeared to be wood charcoal were observed. The implication of this composition is that the feature represents burning of grassy material derived from dung (phytoliths and spherulites).

Sample TG-106 comes from the margins of the burning features associated with sample TG-107 described above (fig. 6 a, b, d, i-l). It contains overall a higher proportion of sandy silty clay than does sample TG-107 and is granular. It also has a wide range of components that include grains of fresh and weathered limestone, aggregates/granular grains of fire reddened reddish clay, sand-sized grains comprised of spherulites (some heated, fig. 6 l) and phytoliths (some melted) as in sample TG-107; phosphatic carnivore coprolites, and bone (some burned). In addition, charcoal occurs typically as fine, silt-sized grains that appear to be incorporated into the matrix by trampling or biological activity. Clumps of calcareous ash occur, but these are also scattered throughout the matrix. Phytoliths are quite abundant and occur throughout much of the matrix. In sum, this sample displays the partially mixed remains of combusted components of dung that have been worked into the sandy silty clay matrix by biological activity (burrowing), as well as trampling (Miller *et al.*, 2010).

The two samples of 107 are from one of three superposed combustion features, and sample 106 is from the margin of this feature. Although only one combustion feature is presented here (TG-107), it is presumed to be representative of all the features. Nevertheless,

A

B

C

Figure 5. Red staining of walls in structures from Torre d'en Galmés showing the level of red silty clay that filled them before they were excavated. What is this red material, where did it come from, and how? *A*) Ground view of Cartailhac house with arrow pointing the pre-excavation level of red fill; *B*) Southeastern part of Círculo 7 – a domestic complex south of Casa 2 – during excavation; *C*) Back room of Cartailhac House. Note the quantity of red fill that was in the process of being removed at that time (2008).

it is clear that in the field there were different superposed or stacked episodes of combustion and not an individual feature that would indicate a single fire. What is not clear in the field, however, is the nature of the combustion features—i.e., what was being burnt-information that is visible only through microstratigraphic techniques such as micromorphological analysis. Thin section observations showed that the dark material within the feature (fig. 6 c, e, f, g, h) is fine, silt-sized charcoal and primarily dung as shown by the abundance of spherulites and associated phytoliths.

The stacked nature of combustion features—a series of successive actions—and the fuel used suggest that fire was made at specific moments. In other words, these fires were produced sporadically for some reason, possibly for heating or for light using the dung fuel that could be found around them. It is also possible that they represent the simple act of burning waste, which would include dung. In any case, the small size of these combustion features and the absence of other archaeological elements (e.g., stone lining to contain the fire, for example) suggest more of an expedient use and exclude an industrial one.

Case #3. Dogs and other animals

Subtle remains of animals associated with structures at Torre d'en Galmés appear in thin sections from Círculo Cartailhac and Casa 2 (figs. 5, 7, 8); the former is the largest domestic structure at the site of Torre d'en Galmés. In 2008, the structure was excavated and restored (Sintes and Isbert, 2009), becoming one of the site's landmarks because of its size and complexity; it dominates the entire southern part of Torre d'en Galmés. This post-Talayotic complex is a compound of structures that include the so-called "circle"—which is comparable in morphology to the structure of Casa 2—and a series of other, smaller structures of different shapes and heights. All the structures were enclosed by a wall, which had a principal entry on the east side (fig. 7a, b). These spaces were used for domestic/industrial activities; they were built in the 3rd century BCE and used for a short period of time, around 150 years (Sintes and Isbert, 2009).

One intriguing aspects of Círculo Cartailhac is the nature of a small (~50 cm wide) room immediately to the left as one enters the main building (fig. 7 a-d). The entrance is about 80 cm high and roughly 50 cm wide. It was covered, so it has always been interpreted as being unsuitable for human activities. So… what was this space used for? Some of the hypotheses that have been raised are storage of tools and grains, or an enclosure for small animals, including sheep/goat and dogs (Salvà and Hernández-Gasch, 2009; Pons, 2016)

This issue can be elucidated from thin section observation of a sample (ME-7) collected by E. Sintes from the deposits in the structure (fig. 7) (Goldberg and Pérez-Juez, 2012). Notable in this sample is the amount of anthropogenic material, including charcoal, pottery, bones (some of which are burnt), as well as some exotic grains (e.g., clasts of quartzite) and pieces of rubefied (reddened) aggregates of sandy silty clay, the

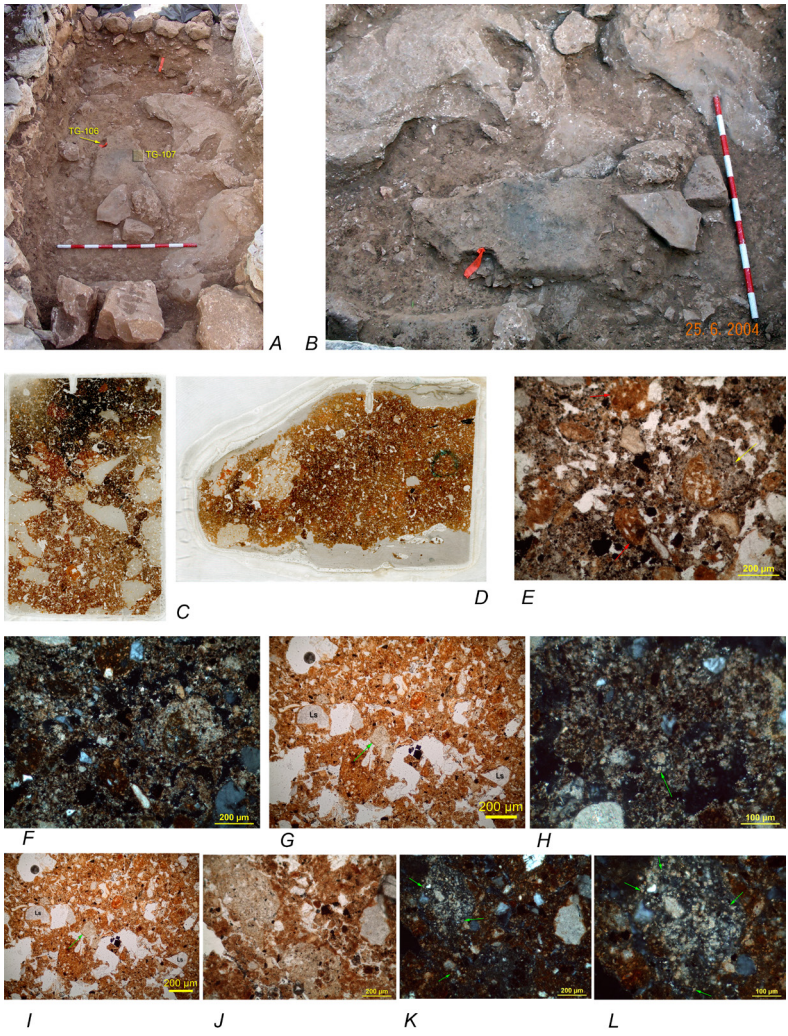

Figure 6. *A*) SPU3/4 with surface of darker stained patches representing small burning features about 10-15 cm in diameter; locations of micromorphology samples are shown; *B*) Close-up view of combustion features, showing that some are stratigraphically isolated and stacked; *C*) Thin section scan from one of these features. Sample TG107L mirrors the dark organic-rich stain shown in *A* and *B*. Thin section measures 50 × 75 mm; *D*) Thin section scan of sample TG-106 from the edge of one of the features, which is less rich in organic matter but contains numerous phytoliths and spherulites (see *I-L*); *E*) Photomicrograph of sample TG 107L showing mixed grains and clumps of terra rossa (red arrows) and calcareous ash (yellow arrow), PPL; *F*) Sample TG 107L; same as *E* but in XPL. The bright areas are rich in ash and spherulites; *G*) Detailed view of sample TG 107L; note the fine charcoal mixed with the calcareous ashes and spherulites, PPL; *H*) Sample TG 107L; spherulites, with green arrows pointing to darker ones that are burned; *I*) Sample TG 106, consisting mostly of silty clay and limestone clasts (Ls) along with distinct grains composed of spherulites (green arrow), PPL; *J*) Sample TG 106 with detailed view of lighter coloured spherulite-rich grains shown in *I*, *PPL*; *K*) Sample TG 106; same as *J* but in XPL. The spherulites (green arrows) are more evident in this XPL view; *L*) Detail of *K* with green arrows pointing to some of the spherulites, XPL.

same material that makes up the matrix of the sediment that fills this structure (fig. 7 f). Particularly striking, however, is the relative number of carnivore coprolites (fig. 7 d, e, f), which appear as phosphatic (apatite–carbonate calcium phosphate), yellow, sand- to granule-sized grains that are black in cross-polarized light. They have a dusty appearance and display irregular voids and vesicles (representing intestinal gas in the animal's gut during formation (Horwitz and Goldberg, 1989). In addition, we observed grains of limestone that are partially replaced by apatite (fig. 7 g, h). Finally, some phytoliths were observed in one of the coprolite fragments (fig. 7 e, f), as well as weathered calcareous spherulites derived from herbivore dung (Canti, 1998, 1999; Shahack-Gross, 2011). It seems unlikely that these phosphatic grains are human coprolites associated with cess or latrine waste, since the architecture and context of the room fill here is not compatible. Furthermore, the absence of inclusions of nematode eggs (or other parasites), and seed testa does not argue for its being of human origin. Finally, large vesicle like voids observed here are more compatible with vesicles from carnivores (Horwitz and Goldberg, 1989).

The phosphatic components (carnivore and herbivore coprolites and weathered limestone), as well as the spherulites, are all indications of animal waste (see also #2 above). The coprolite fragments illustrated in fig. 7 e, f are produced by carnivores (here, likely dogs; see below) whereas the spherulites are associated with herbivore dung. The partially phosphatized limestone grains—although weakly developed—are similar to those recorded in areas interpreted as stabling (here, more likely small-scale penning) in which the phosphate-rich liquid excrements react with the limestone (see, for example Goldberg and Macphail, 2006; Macphail and Goldberg, 1995). Thus, it is reasonable to interpret that this structure was used to enclose animals, including dogs or one or two sheep (coprolites and phytoliths, respectively). In addition, we cannot rule out the possibility that the structure was used for (a sometime?) storage or dumping of dung, as shown by the relative abundance of spherulites and phytoliths. Although, this structure is too small to fit more than one or two sheep, a dog would fit comfortably inside it. On the other hand, the presence of phosphatized limestone in association with penned animals has been documented both by experiments and at archaeological sites (Macphail and Goldberg, 1995; Macphail *et al.*, 2004).

The results from the Cartailhac house should not be considered as being unique. Similar micromorphological observations and results can also be seen in SPU 2 in Casa 2, which occupies the same architectural position as the above sample from Cartailhac (fig. 2, 8), although no roof was observed during excavation. Excavation of SPU 2 revealed a basal deposit of light-colored, powdery ashy clay that was locally dug into dense reddish clay containing charcoal and ash filling an irregular depression in the bedrock; in turn this was overlain with gradual contact by dense, compact, brown silty sand with few snail shells.

A thin section from the basal sediments of SPU 2 (TG-7C) is notable for the occurrence of a ~500 µm-sized isotropic phosphatic grain within a sandy silty clay matrix similar to

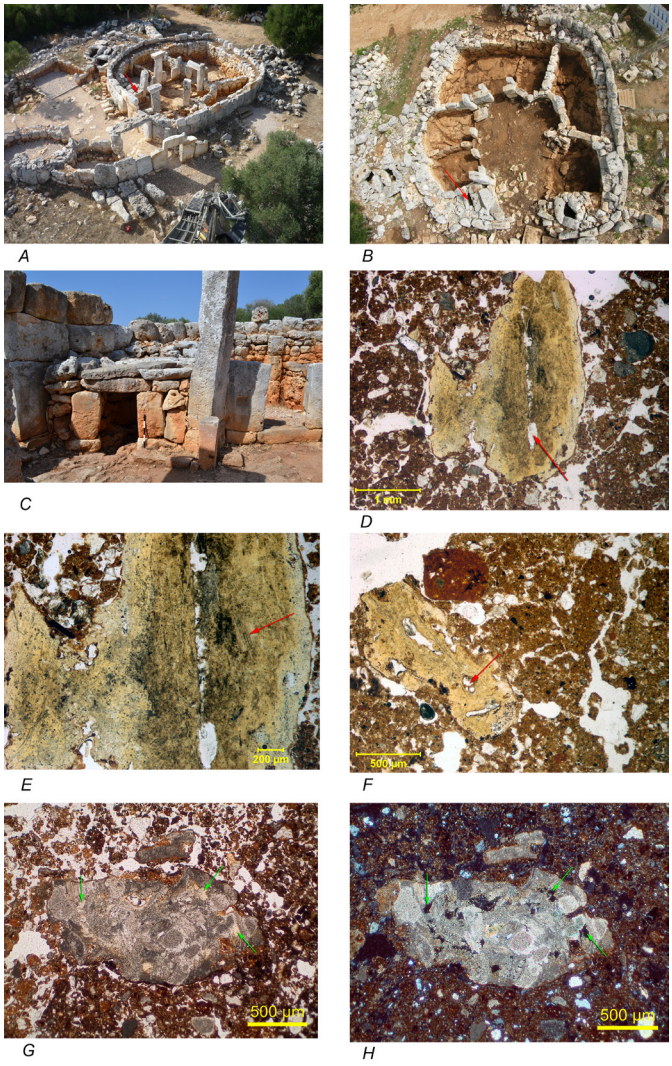

Figure 7. Recinto Círculo Cartailhac. *A*) Oblique aerial view of structures with red arrow pointing to small room just inside the main building that is studied here; *B*) Vertical view of *Recinto* Cartailhac with partitioned rooms. Red arrow indicates covered small structure just left of the entrance. Photo Credit: Elena Sintes-PAC; *C*) Frontal view of the room near the entrance from which sample ME-7 was taken. Note the red staining at the doorway and elsewhere on the walls, indicating the height of the red fill before the structure was excavated; *D*) Dusty, yellow carnivore coprolite in a matrix of brown sandy silty clay. Note the elliptical void in the lower part of the sample (arrow) reflecting gastric gas during the formation of the coprolite, PPL; *E*) Detail of coprolite with arrow pointing to phytolith inclusion, PPL; *F*) Rounded coprolite fragment from the same deposit as in *E*; notice the irregular void shapes as well as a circular one (vesicle-arrow) that is typical of a carnivore coprolite, but note the brighter red aggregate of silty clay similar in composition to the surrounding matrix, which is the same as in *D*; this grain likely has been heated, PPL; *G*) Grain of limestone that shows yellow phosphatized areas (arrows) that are likely the result of phosphatic liquid excrements of animals reacting with the limestone, PPL; *H*) Same grain as in *G*, showing yellow areas are black (isotropic) here in XPL;

the carnivore coprolites from Cartailhac. Sediment from the overlying thin section TG-7B is relatively rich in finely divided charcoal, and an abundance of spherulites (fig. 8 c, d) and phytoliths. Thin section TG-7A at the top is similar: poorly sorted mixture of rock fragments and some bone and pottery mixed with grains of *terra rossa* (some heated). As with thin section TG-7B, charred material and abundant spherulites occur, the latter being locally concentrated with the thin section. Finally, a few rounded mm-sized grains of phosphatic carnivore coprolites were observed (fig. 8 f).

Thin sections from SPU 2 demonstrate the presence of spherulites and phytoliths, and coprolites, all of which match their occurrence in the corner room of Cartailhac described above. Moreover, both architectural features are generally similar in overall shape and dimensions. We hence tentatively conclude that both rooms served the same function for keeping herbivores or herbivore dung (i.e., spherulites), as well as dogs (i.e., carnivore coprolites). Furthermore, the remains of burnt materials in SPU 2 (burnt *terra rossa* aggregates, and finely comminuted charcoal and charred materials) mixed with the spherulites and phytoliths suggest that the fuel associated with the burning was likely dung and not wood, particularly since calcareous ash rhombs were not observed. Finally, we raise the possibility that the co-occurrence of dung and carnivore coprolites (dog; see below), is tied to the use of dogs for looking after the flocks of sheep/goat, as suggested by other researchers (Ramis, 2006). Accordingly, since the fauna found at Talayotic sites is all herbivore (sheep, goat, cow, or omnivore—pig) we can infer that the carnivore coprolites found at Casa 2 and Círculo Cartailhac come from domestic dogs, which serves as additional evidence to substantiate the existence and use of this animal during Talayotic times.

Case #4. Open area in Torre d'en Galmés: the "white powdery ashes" infilling parts of Trench B

Open spaces within the Talayotic site of Torre d'en Galmés, have been traditionally left out of research projects for their lack of architecture. They have been interpreted as "empty areas" for farming, keeping animals, or circulation. The excavation of one of these spaces, located on a terrace above the post-Talayotic group of houses at the southern end of the site (fig. 1), gives another good example of what is not actually seen during the excavation.

We excavated a 10 × 1.5 m trench through the middle of this space, just northwest of Casa 2 (fig. 9). Although not all parts of the trench were excavated to the same depth, the westernmost part locally reached ~120 cm below the surface, where deposits rested upon an undulating, surface of the basal bedrock. The surface of the bedrock exhibits strong micro-relief because of quarrying activities, which also produced abundant trimming flakes (Pérez-Juez and Goldberg, in press). In any case, the deposits exposed on the southern part of the trench can be described from bottom to top as follows:

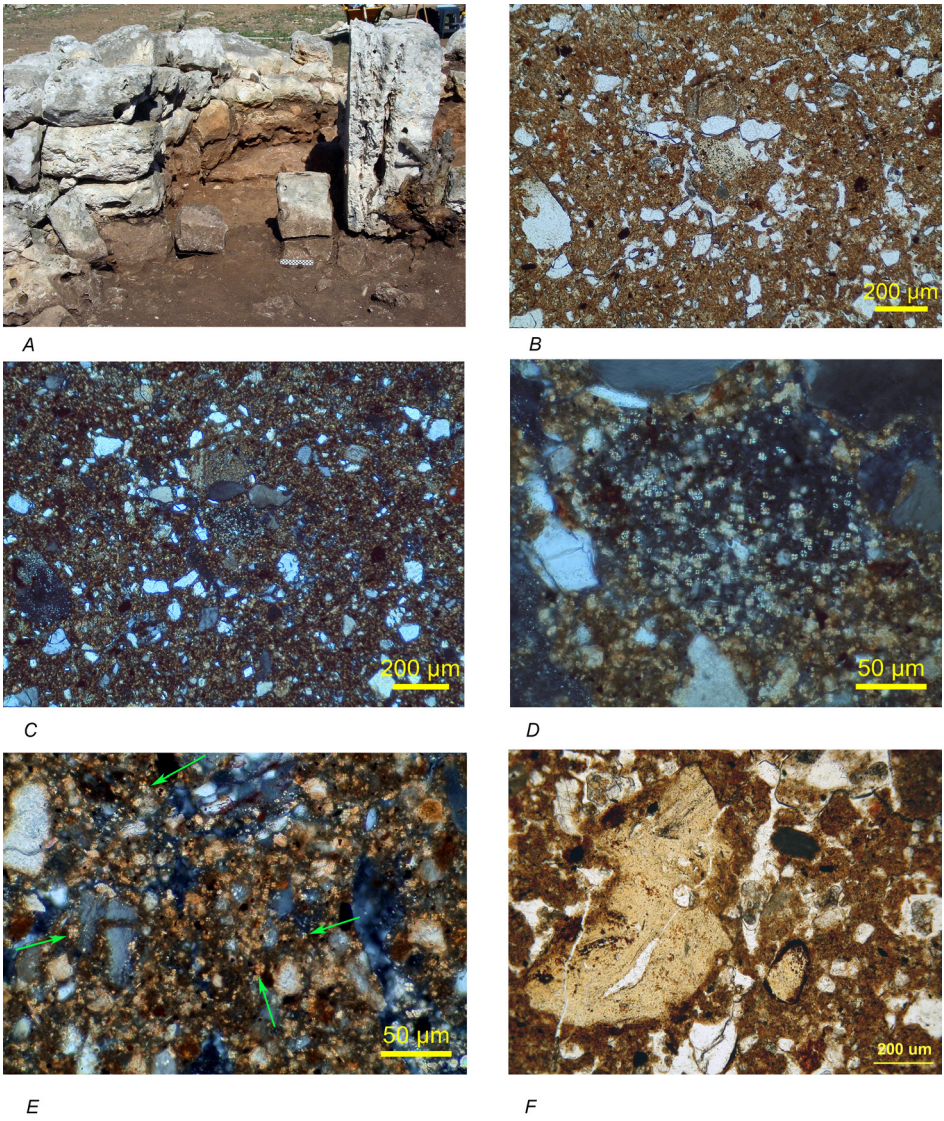

Figure 8. Casa 2, SPU2 micromorphology (see also figure 2). *A*) Entrance to SPU2 looking west from SPU1, the Central Patio. Although more decayed than the equivalent structure in Círculo Cartailhac, the similarities in size and shape are evident; *B*) File: Thin section photo of sample TG-7A showing a densely packed calcareous sandy silty clay. The yellow grain in the center is composed mostly of spherulites, PPL; *C*) Same as in b but in XPL. The fine speckled appearance relates to the abundance of spherulites; *D*) Detailed view of grain in the center of *B* and *C*. Not the abundance of spherulites within the grain; *E*) Detailed view of thin section TG-7A from a slightly higher part of the sampled block from which three thin sections were made. Many of the areas with a crystallitic b-fabric (brighter speckled patches) are spherulites and particularly coarse ones are indicated with arrows point; note their radial cross-like extinction. XPL; *F*) Carnivore coprolite from TG-7B; note the similarity with the one from Cartailhac (figure 7 *F*), including the vesicle and dusty yellow color. PPL.

1. The basal ~ 50 cm overall consists of pinkish white powdery silt, although the lower ~30 cm are rich in angular and rounded, fist-sized clasts of limestone. A bone from these deposits yielded an uncalibrated radiocarbon date of 2540 ± 30 a BP (BETA #356718)(2 sigma calibrated range: 800 to 550 BCE) (fig. 9 c).
2. These deposits are overlain with a distinct erosional contact by a ~10 cm thick stony and pottery-rich crumbly reddish brown clayey silt.
3. The upper 10-15 cm is dark grey brown organic-rich crumbly silty clay; it contains many roots and overlies a Muslim wall [not shown here].

The interesting issue, which was somewhat striking to us in the field for its color and texture, was the basal "pinkish white powdery silt" (no. 1 above): we had somewhat tacitly assumed, based on (Kopper and Rosselló-Bordoy, 1974) that it represented dumped ashes resulting from fires produced to exploit the stone and discarded there in order to fill up the relief created by the quarrying.

It turned out that we were very wrong. Visible in thin sections of this sediment from the lower part of Trench B (fig. 9 d, e) is a matrix of brown and yellowish brown calcareous clay that contained only a very few rhombs of calcitic ash (the white ash residues of fires are composed of calcite—Canti, 2003; Courty *et al.*, 1989). On the other hand, we did observe abundant grains of limestone sand and silt—and some quartz sand and silt—that were derived from the surrounding limestone. It became apparent to us that the whitish powdery and "ashy" aspects of these lowermost deposits in Trench B were due to the limestone grains and fine (clay-sized) calcite mixed into the clayey matrix. Furthermore, we surmise that calcitic grains have an anthropogenic source and most reasonably are a by-product of the quarrying activity, since natural soils in most parts of the site are less rich in fine calcite (especially this amount) or are devoid of it (cf. natural terra rossa soil shown in fig. 4 f, g).

So instead of this massive deposit being a substantial accumulation of ashes, it is a remnant of ancient quarrying. This inference not only fits well with the fact that the deposits fill in irregular surface depressions in the bedrock, thus smoothing out the relief that was created by quarrying of the bedrock—as noted above—but also that the sediments contain dozens of angular trimming flakes of limestone produced by such quarrying activity. Ultimately, it is important to note that this filled-in and irregular quarried bedrock substrate ultimately became a public or circulation space surrounded by different domestic complexes.

Moreover, the radiocarbon date for the trench shows a period between 800 and 550 BCE. This in turn means that the quarrying in trench B was supplying construction material for buildings in the northern part of the site – the taula and talayots area—and not the southern part of the site, which post-dates the 4th century BCE. There is a temporal gap of what was happening at the site between the construction of the taula and the expansion of the southern south, which should be looked at maybe through more test pits from the top of the hill.

Figure 9. Trench B in the open area NW of Casa 2 (see figure 1 *C*, *D*). *A*) Trench B looking southwest. Part of Casa 2 is visible in the very upper left-hand part of the photograph. The arrow points to a deeper excavated part of the trench and is shown in more detail in *B* and *C*; scale is 1 m. *B*) Western end of Trench B looking east. The "X" marks a protrusion of limestone bedrock that has been quarried on the south side, resulting in a much deeper sedimentary fill on the right-hand side of the photograph; the excavated profile is illustrated in *C*. *C*) The deep profile shown in *B*, showing location of micromorphology sample at right that includes the pinkish white powdery silt discussed in the text and shown in *D*. The numbers refer to the stratigraphic units discussed in the text. At left is a sedimentary peel made by draping gauze on the profile and painting it with white glue (Goldberg, 1975). The radiocarbon date on bone is significantly older than the age of any of the houses excavated in the site, which were all built in the 4th c BCE. *D*) Photomicrograph of sediment from the base of the block in *C* showing brown calcareous silty clay with coarser grains of limestone and quartz. PPL; *E*) Same as in d but in XPL. Red arrows point to quartz grains whereas yellow ones indicate sand-sized grains of limestone; the very fine calcite within the matrix (bright colored here in XPL) provides the light color of the sediment and its powdery aspect in the field; black areas are voids. Note the striking contrast with the non-calcareous reddish material found in SPU5 (figure 4 *C*, *D*, *E*).

Comments and Implications

The cases presented here have important implications in the way we interpret the site of Torre d'en Galmés, and in fact, all the Talayotic and post-Talayotic archaeological sites on the island. As we have discussed throughout the paper, some of the results do chan-

ge what is known about questions like construction techniques or daily activities in the 1st millennium BCE. In sum, they provide essential information required to understand the whole picture.

1) Building materials

Post-Talayotic houses have been excavated everywhere throughout the Island. Construction techniques follow a very similar pattern that has been extensively researched and published. The truth is that the architecture that has been studied is restricted to stone remains: the exterior walls, inner partitions, lintels; the structures still standing have been considered independent units that are examined with no relationship to the rest of the architecture at the site. There are still many unanswered questions in order to understand the full history of a Talayotic settlement: where does all that construction material come from and how were the houses completed and maintained (roofed, plastered, or modified).

We have demonstrated through case 4—and other publications—that quarrying was ubiquitous throughout the site (Pérez-Juez and Goldberg, in press): inside the buildings, in open spaces, and wherever the inhabitants of Torre d'en Galmés could extract an orthostat for their buildings. However, without micromorphology, it is difficult to see that the infilling of spaces left after blocks were quarried are remnants of the quarrying itself. At other sites like Son Catlar (Kopper and Rosselló-Bordoy, 1974), these ashy deposits have been interpreted as the remains of fire made to extract the stone. This is understandable because the powdery accumulations look very similar to ashes with the naked eye. However, it is incorrect, and we need to be aware that these sediments should not be excavated and discarded, with the goal of reaching bedrock or discovering cultural material. The key is precisely in those deposits, just hidden.

The same applies to the actual architecture, as it is shown in Case 1. None—or almost none—of the structures have kept their roofing and upper layer materials, at least, the ones excavated until now. Some show the existence of two stories—Círculo Cartailhac—and all show a back room, and different spaces arranged around a courtyard. Moreover, in the field, it is not evident how they were covered or with what materials. Yet, the information is once again still there but hidden in the deposits that filled the houses after abandonment. Some things are obvious in the field: for example, all the structures excavated at Torre d'en Galmés show deposits that are thicker towards the main enclosing walls of the structure and thinner towards the inner courtyard. It is also evident that these deposits are sterile and, contain very little and poorly preserved cultural material. Accordingly, this is the reason why we need to take a different approach to their study: thanks to the results obtained through micromorphological analysis, these deposits can be interpreted as essentially building materials accumulated from the walls (possibly mud plaster) and redistributed toward the center of the building as colluvium resulting from decay after abandonment. Again, the fact that they are sterile and do not content any cultural material

should not make us think that they contain no information. Because these deposits are the actual artifacts that we are looking for.

2) Fire: heating and light

One of the most evident implications of the cases studied affects our interpretation of everyday life. Despite the large number of excavations of domestic spaces on the island, our knowledge of daily activities remains scarce. As we said earlier, excavations have provided the fundamentals of the architecture, the general plan and layout of the sites, and basic constructions techniques. They have also yielded information on the kind of pottery they were using and whether this was made locally or imported. Nevertheless, at least in Torre d'en Galmés, the majority of the buildings were abandoned peacefully after the Roman conquest,[1] which results in little or no archaeological material being left behind: the inhabitants took their cooking and small storage vessels as well as personal objects, and probably some larger objects such as mortars or stone vessels. The place was obviously not abandoned in a rush. This lack of archaeological material makes it difficult to interpret the exact use of different built areas, and other pieces of daily life: activities, distribution of work, use of the space, etc. Since most of the houses follow a very similar constructive pattern and, probably each room had a specific function, can we be sure that interpretations based mostly on the application of ethnographic models are the correct ones (e.g., SPU5 at the back of the structure was quiet and used for sleeping)? Or, do we need to contrast them with other techniques such as soil micromorphology among others?

The use of fire, for example, has been documented in Talayotic sites, primarily related to the existence of a hearth in the center of the buildings. This hearth, constrained by a semicircular architectural feature bounded by the so-called *amolons*, would be primarily used for food preparation, and maybe even the place for food consumption. However, it is obvious that other fires were being produced and managed at the sites: for kilns, smelting, ovens, or just for heat or light. Fire would have been used for personal purposes and for industrial ones. Micromorphology can provide the information to understand these episodes, and identify different burning events and types of fuels. As we documented throughout Casa 2, inhabitants of these buildings made fires in the house, outside of the house, using wood (SPU 5) and also dung (SPU 3-4). They produced fire for filling the solution holes of the house but also for expedient heating, or cleaning (Pérez-Juez *et al*., 2011).

These results have archaeological and historical implications. We know now that the fires that we documented in SPU 3-4 were punctual events, possibly for heating the space, and only occasionally, once the household lost its domestic use. Moreover, we have demonstrated that the fuel used was herbivore dung. In other words, the archaeological

1 Only Círculo 7 shows a different story with a layer of fire and destruction that dates to the Second Punic War (Ferrer *et al.*, 2011).

evidence shows that the area might have been used to store sheep and goats, probably after the Roman conquest, and employed as occasional human shelter. In this regard, it is also possible that the fires here are the result of successive sporadic cleaning events that would have entailed the burning of waste, including dung.

This relates to the transition of the place from a major urban settlement to a rural pastoral one. The Roman reorganization of the island included a shift of population from the major Talayotic communities to the coast and cities of Mago and Iammo. Torre d'en Galmés lost its major role as an urban settlement, houses were abandoned, and the material culture left behind was useless or too big to transport. Some inhabitants might have remained at the site, and used the space for agro-pastoral activities.

As demonstrated through this and other publications, fire in Talayotic houses can be found in primary and secondary position (either in hearths, filling solution holes, or expedient fires). We would like to point out another combustion feature discovered and studied by the team of Amics del Museu de Menorca in Círculo 7. This structure, found in the back room of the household, has been interpreted as a brazier that would contain the charcoals from the hearth located in the patio of the building (Lara, 2012). Therefore, whatever was being burned would be there in secondary position, and would have been produced outside. In light of the results presented above, however, what if the fires in Círculo 7 were produced *in situ*, using dung for fuel and not wood? This option would change the interpretation of this combustion feature, which then would be in primary position. In order to answer this question, we would need to determine the nature of the fire through micromorphological analysis.

3) Domestic animals: dogs

The combustion features documented in SPU 3-4 are linked also to the evidence of dogs in Talayotic households, and the difficulty of documenting its remains in archaeological excavations. Although dogs have been found in some excavations, its presence is scarce in the archaeological record of Menorca or Mallorca, primarily because it does not show in the remains where we can study diet: garbage pits with bones showing cut marks or other evidence of consumption. In other words, probably dogs were not generally eaten and do not reflect consumption patterns. More typically, fauna recovered from excavations for this period is primarily sheep and goat with other species complementing the diet, such as pigs, cows, fish, and chicken (Hernández-Gasch *et al*., 2011; Ramis, 2006). At Casa 2, the analysis of fauna also provided information about the existence and/or consumption of rabbit, horse, cat, and shark, but only marginally (Morales, 2005). In some cases such as at Talatí de Dalt (Juan and Pons, 2005), evidence of the consumption of dog has been found whereby a number of dog bones show cut marks. However, according to the researchers, this consumption was punctual, probably related to the Second Punic War, during which a limited amount of resources was available (Morales, 2005).

In any case, whereas there have been some dog bones recovered, their frequency is much lower in comparison to other species (Fernández-Miranda, 2009; Gornés, 2003; Guerrero *et al.*, 2007; Herranz and León, 2007; Anglada *et al.*, 2017).[2] As Ramis (2006) noted, dogs served another purpose, and although it is difficult to recover dog bones in the excavation of Talayotic sites, there is no doubt that domestic dogs played an important role during this time period in the Balearic Islands. Dogs were probably used for other functions, most likely, in herding of flocks of sheep and goat, which were the main source of meat for Talayotic people. Since the archaeological record is poor in dog bones, we have to turn to other types of evidence to document it, such as dog gnaw marks on other animal bones, but also the remains of its presence in the sediments of Talayotic sites, i.e. micromorphology.

The actual use of dogs for herding other animals can be also inferred with micromorphology by the coexistence of herbivores and carnivores, i.e. dogs and ovicaprids. Both spherulites and coprolites were found in relatively large amounts in the thin sections of SPU 2 and, although we could infer that this space was used for animals and other domesticated fauna, it is thanks to micromorphology that this can be demonstrated.

Finally, although the dimension of these spaces—SPU 2—can seem small for animals, we should note that the size of local fauna on the island, at that time, was smaller than it is today. The fauna studied at other sites like Cornia Nou (Anglada *et al.*, 2017) or Talatí de Dalt (Morales, 2005) points to this small size. Given the fact that the two houses sampled—Círculo Cartailhac and Casa 2—show the evidence of the use of this space for a dog, it would be essential to collect samples from other domestic spaces and contrast these results.

Conclusions

From the micromorphological analysis of the samples, we are able to obtain information related to construction techniques, daily life activities and behavior of the Talayotic peoples residing in Torre d'en Galmés. This statement becomes even more important because most of the deposits that we all excavate at Torre d'en Galmés are object free. In most cases, they have been considered as sterile deposits with no information, while this is precisely the opposite. The fact that they are "sterile"—although anthropogenic—and that they fill up every single structure at the site, make them a perfect example of the point we are trying to make: they are full of information, but it is hidden. We need to study them differently to understand their nature and purpose: by combining field observation with soil micromorphology.

2. The most recent excavations at Cornia Nou have recovered 47 remains of dog but only for the last part of occupation of the talayot (400-200 BCE). This small number, compared to the rest of the species recovered, prove the occasional consumption of dog in post-Talayotic times. On the other hand, dog gnaw marks have been documented for the earlier period.

However, if we want to have the full picture, we have to add one other thing to the importance of the microscale, which is the urgency of looking at the macroscale. Although there have been very serious efforts to investigate the architecture of Torre d'en Galmés, and trace its use throughout history, there is one pending subject that requires our attention: the understanding of the site as a whole, looking at its evolution throughout time. We need to have a diachronic picture of how the settlement was formed, used, and abandoned. This is possible only through a global project that would investigate the built and non-built spaces and their interrelation, and the combination of different scales when studying the site.

Although this has yet to be done, at this point, small sampling of open areas has proven to be rewarding. At Trench B, the thin sections show how the site was used before even the *círculos* in the south of the settlement were built. But again, unless we understand the need of a holistic approach to the site, and the urgency of looking at the micro and macro scale, we will have only pockets of information with no interconnection.

In 2008 we gave a paper that raised concerns about this final point that we are trying to make: the isolated excavation of what is known as "círculos", understood as individual domestic units that were being studied without relation to the rest of the structures at the site (Pérez-Juez, 2011). Since Maria Lluísa Serra started the excavation of these structures at Alcaidús in 1959 and synthetized the prototype of prehistoric houses in Menorca – the so-called "círculos" – the study of domestic architecture has been almost limited to the interior of these circular structures (e.g., Trepucó, Torre d'en Galmés, Son Catlar, Talatí de d'alt, Montefí). This prescient and methodical archaeologist set the basis for much of the archaeology that we do today on the island. . Maria Lluísa Serra already noted the existence of different structures attached to the círculos, discussed the roofing of the houses, and suggested the need of locating the quarries. The technological advances of the past decades have made it possible for us to progress in some of the areas she noted in the field.

In the same paper mentioned above (Pérez-Juez, 2011), we demonstrated that these domestic structures were formed by different spaces, enclosures, patios, cisterns, storage areas, working and industrial zones, and pits. We proposed the name "domestic complex" for post-Talayotic domestic architecture and to replace the word "círculo" when talking of post-Talayotic households. Part of this study was done thanks to a grant from the Institut Menorquí d'Estudis to make a virtual reconstruction of a house that allowed us to document photogrammetrically Casa 2 and photograph some of the major structures in Torre den Galmés. The subsequent excavations of Círculo Cartailhac, Círculo 7, and Casa 2 have supported the hypotheses that we already proposed in September of 2008 and published in 2011.

In 2012 we went back to this original idea of studying the interconnection of buildings and open spaces at Torre d'en Galmés by presenting a new research project to the Consell Insular of Menorca. This project aimed to study the site as a whole, with the idea of understanding constructed and non-constructed spaces at the site of Torre d'en Galmés, open and built spaces, urbanism and proto urbanism. We approached this new research

by proposing different test pits in open spaces and conduct specific sampling, which goes back to our case study 4. And this leads us to our final thoughts. The excavation of these open spaces has proven to be essential to understand the story of Torre d'en Galmés. We need to look at the site from a holistic perspective, going from the micro to the macroscale, combining all the data we have, gathering records from different parts of the site, and exchanging the results of our partial analyses. Only by looking at these different scales we will be able to see the big picture, and understand the real history of Torre d'en Galmés and all the hidden information that it still preserves.

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