



Site formation processes and settlement reorganisation during the late iron age–roman transition in the eastern Pyrenees: A case study of serrat del castellar (La Cerdanya, Spain)[☆]

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ABSTRACT

Despite the growing body of archaeobiological data from Iron Age and Roman sites in the Iberian Peninsula, the interpretative potential of micro-contextual evidence remains insufficiently explored. This study investigates plant use, combustion technologies, and depositional processes at the Late Iron Age and Roman Republican settlement of Serrat del Castellar (Bellver de Cerdanya, eastern Pyrenees), a fortified hilltop site strategically positioned along a major *trans*-Pyrenean corridor and occupied between the fourth and second centuries BC. An integrated biogeographical approach combining micromorphology and phytolith analysis is employed to explore construction practices, spatial organisation, and plant management strategies across the Iberian–Roman transition. Microstratigraphic evidence provides high-resolution insights into site formation processes and the evolving biography of the site, while contextual associations of charred plant remains and microscopic residues shed light on food processing, fuel use, and waste management practices within domestic contexts. By examining these micro-scale signatures within their broader stratigraphic and architectural framework, the study contributes to ongoing discussions of continuity and transformation during the Late Iron Age–Roman transition, demonstrating the value of integrated micro-contextual approaches for reconstructing site biographies and everyday practices in high-mountain contexts.

1. Introduction

This study examines plant-use practices, combustion technologies, and site formation processes at the Late Iron Age and Roman Republican settlement of Serrat del Castellar, located in the high-mountain basin of La Cerdanya in the eastern Pyrenees (Catalonia, northeastern Iberian Peninsula). Stratigraphic and archaeological evidence indicate that the site was occupied from at least the 4th century BCE during the Iberian (Cerretan) period and was subsequently reconfigured during the Roman Republican phase (Morera et al. 2020a; Oller et al. 2021, 2022; Olesti et al. 2023; Oller et al. 2024a, 2024b). Serrat del Castellar is a fortified

hilltop settlement strategically located above the main terrestrial corridor connecting the Cerdanya basin with the interior of Catalonia, thereby facilitating communication between *trans*-Pyrenean communities. Archaeological research over the past decade has revealed a multi-phase occupation sequence characterised by defensive architecture, reorganised domestic spaces, fire installations, and evidence of agricultural processing and storage activities.

The present study employs an integrated micromorphological and phytolith approach to reconstruct space use, construction practices, and depositional dynamics across the Iberian–Roman transition in the eastern Pyrenees with the aim to elucidate how broader social, political,

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and economic transformations materialised in everyday life at most suitable time-scales (Foxhall 2000). Microstratigraphic approaches have proven essential in providing information about architecture and domestic life preserved within the sedimentary matrix of domestic buildings and associated features in a wide range of contexts (Matthews 2005, 2012; Karkanas and Van de Moortel 2014; Banerjee et al. 2015; Amadio 2018; Mylona and Pomadère 2021; Kovács et al. 2024; Sisa-López de Pablo et al. 2024; García-Suárez, 2025; Marras et al. 2026). When combined with targeted phytolith analysis, these methods allow for the direct observation of microscopic plant remains within their precise stratigraphic context (Matthews 2005; Shillito and Ryan 2013; Portillo et al. 2019), thereby enhancing interpretations of plant use, construction materials, and activity areas.

While high-resolution approaches have recently been applied to some Iron Age and Roman sites in Iberia, with a focus on architecture, floor construction, midden deposits, and occupation layers (e.g., Mateu et al. 2019; Gutiérrez-Rodríguez et al. 2022; Belarte et al. 2023a; Cutillas-Victoria et al. 2023; Portillo et al. 2023; Grau et al. 2024; Tomé et al. 2024; Carbonell-Roca et al. 2025; García Sánchez et al. 2025; González-Reyero et al., 2026), few studies have examined site biographies across major cultural transitions using an integrated microstratigraphic perspective. This is particularly evident in high-mountain contexts, which remain insufficiently understood.

By applying an integrated micromorphological and phytolith approach to selected buildings at Serrat del Castellar, this study contributes to ongoing discussions of social interactions during the late first millennium BC and significantly expands the limited availability of high-resolution, microcontextual data sets concerning the Iberian–Roman transition in the Iberian Peninsula.

2. Archaeological context

Serrat del Castellar (Fontanals de Cerdanya, Girona) is an Iberian hillfort situated at 1368 m a.s.l. in the central Cerdanya basin (Oriental Pyrenees) (Fig. 1.). The site occupies a strategic promontory overlooking the Cerdanya plain and maintains direct visual control over the Molina corridor, a major natural passage connecting the basin with the interior of Catalonia. The hill forms part of the foothills of the Serra de la Molina and is connected to the main ridge by an elongated eastern spur. This spur likely constituted the principal access route to the settlement, as the

remaining slopes exhibit steep gradients that would have limited direct approach. The occupied promontory rises approximately 15 m above the spur, creating a naturally defensible elevated platform.

After eight fieldwork seasons, the main structural features and chronological framework of the site are well established (Morera et al. 2020a; Oller et al. 2021; Oller et al. 2022, 2024a, 2024b). The settlement likely extended across the entire hilltop, covering approximately 0.5 ha (Fig. 2.), and is comparable to other major settlements in the region, such as El Castellot de Bolvir, suggesting a substantial, permanently inhabited site rather than a simple surveillance outpost (Oller et al. 2018a).

The presence of a perimeter rampart enclosing most of the hill further supports its interpretation as an Iberian oppidum. Three main occupation phases have been identified: a Preiberian phase (prior to the 4th c. BCE), an Iberian phase (4th–3rd c. BCE), and a Roman Republican phase (2nd–1st c. BCE). This sequence is consistent with the chronological patterns documented at other excavated sites in the Cerdanya region, particularly El Castellot de Bolvir and Tossal de Baltarga (Oller et al. 2018a, 2018b; Olesi et al. 2024).

2.1. The Late Iron Age phase

The available data for the earliest occupation, conventionally termed the “Preiberian phase”, remains limited and fragmentary. The primary feature attributed to this phase is an early rampart located along the natural eastern access to the hilltop. This structure consists of a substantial wall documented exclusively on the eastern sector of the settlement, with a preserved width of 1.65 m and a recorded length of approximately 12 m. Only the basal course is preserved. The poor state of conservation appears to result from deliberate dismantling during the subsequent Iberian phase, preventing reconstruction of its original elevation and total extent.

The absence of associated diagnostic materials precludes precise chronological attribution. However, stratigraphic relationships indicate that the structure was clearly cut and overlain by Iberian-phase constructions, allowing its provisional placement prior to the 4th c. BCE. A wall segment, running parallel to the southern stretch of the Iberian rampart and located only a few meters from the previously documented structure, may represent an additional component of this early defensive system.

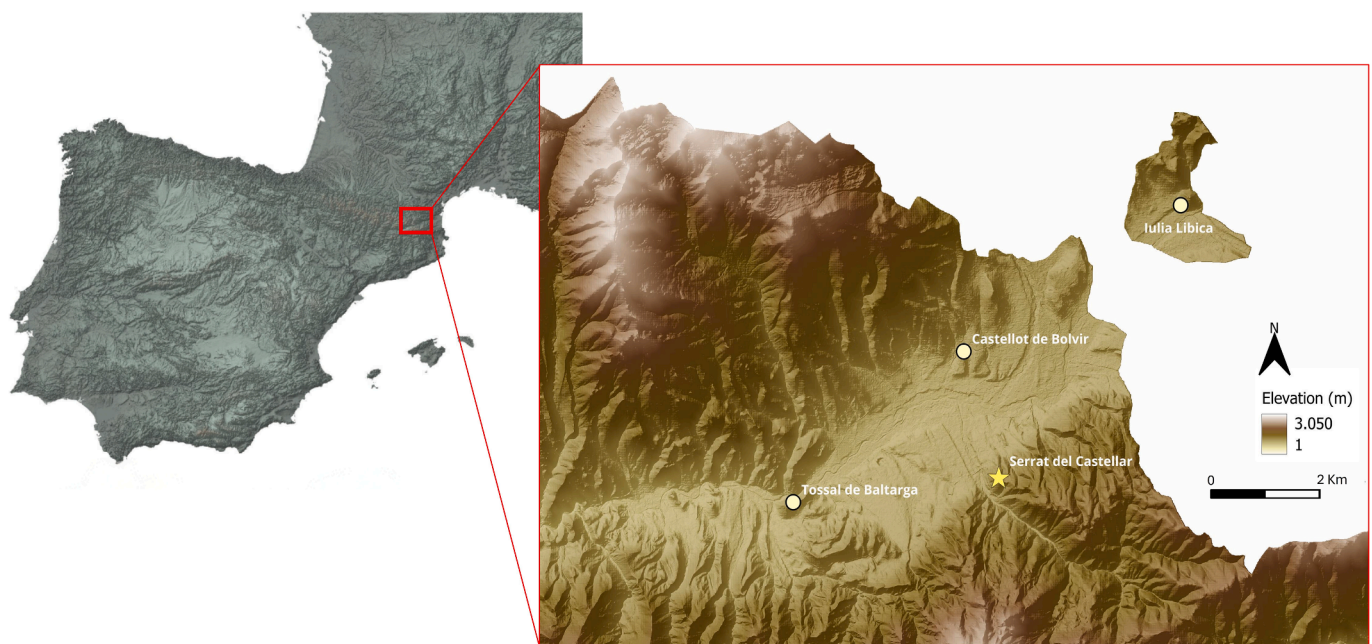


Fig. 1. Location of Serrat del Castellar and main sites mentioned in the text within La Cerdanya region in the north-east of the Iberian Peninsula.



Fig. 2. Plan of Serrat del Castellar.

Preiberian structural levels have been documented at other regional sites, including El Castellot de Bolvir, Tossal de Baltarga, and Sant Feliu de Llo (Oller et al. 2018a). However, the dimensions of the Serrat del Castellar rampart suggest a more substantial defensive investment than currently attested elsewhere in the region. At present, the absence of secure chronological markers prevents assigning this structure to a specific historical horizon, whether the Late Bronze/Early Iron Age or an early Iberian occupation phase.

2.2. The Iberian phase

The second occupational phase corresponds to the Iberian (Cerretan) period, dated to the 4th–3rd centuries BCE. During this phase, the settlement consolidated its primary spatial and defensive configuration, likely extending across the entire hilltop and incorporating a fortification system composed of a rampart and an associated moat. The perimeter wall has been archaeologically documented along the southern and eastern sectors of the hill, although topographic continuity indicates its extension toward the southwest and northwest. The structure follows an *emplekton* construction technique, consisting of two parallel external faces filled with locally sourced stones and compacted earth. No evidence of mortar use has been identified. The rampart reaches a maximum recorded width of 1.40 m and a preserved height of up to 1 m. Notably, in the southeastern corner the rampart does not strictly follow the natural contour of the hill. Instead, it deviates sharply, forming an approximately 90-degree turn toward the northwest. This deviation suggests that, during the Iberian phase, the settlement boundary at this point was set slightly further inland compared to its later expansion during the Roman Republican phase.

The moat has been documented exclusively at the natural eastern entrance to the settlement, although its alignment suggests that it likely followed the course of the rampart along this sector of the fortification system. Immediately in front of the moat, a feature consisting of a cut with comparable morphology and orientation, potentially indicating the presence of an additional defensive ditch. Taken together, the rampart and moat system indicate a substantial investment in defensive infrastructure during the Iberian phase. These elements are consistent with the characteristics of fortified “oppidum-type” settlements documented in northeastern Iberia from at least the 4th c. BC onward (Oller et al. 2018a).

This defensive system appears to have been complemented by an additional structure projecting outward from the southeastern corner of the Iberian rampart. In this area, beneath later Roman constructions, two elongated parallel walls were documented, oriented toward the eastern spur that constitutes the principal access route to the settlement. The structure is only partially preserved. The outer closing wall has been lost due to slope erosion, while much of the internal area was disturbed or destroyed by subsequent Roman-phase activity. Stratigraphic relationships confirm that the feature belongs to the Iberian occupation and was located outside the main perimeter wall. Given its position adjacent to the primary access corridor and its projected configuration beyond the rampart line, this structure may have functioned as a defensive outwork, possibly a tower controlling entry to the settlement.

Reconstruction of the Iberian urban layout is limited by the stratigraphic impact of a destructive event marking the end of this phase, followed by substantial reorganisation during the Roman Republican occupation. Consequently, the majority of preserved architectural features correspond to the later phase, restricting direct observation of the earlier spatial arrangement. For analytical consistency, the term “buildings” is used to designate excavated architectural units, although their preserved structural boundaries primarily reflect Roman Republican constructions. Iberian stratigraphic units have nonetheless been documented in nearly all excavated sectors.

In the southern sector, particularly within the area designated as “Building 2”, localised zones of compacted and thermally altered clay were identified and provisionally interpreted as fire installations.

Associated with them is a small basin cut into the bedrock, containing burnt residues and fragments of handmade pottery (Fig. 3.).

The most substantial evidence for the Iberian urban layout derives from the sector designated as “Building 3”. Beneath the Roman Republican levels, a substantial wall oriented northward was documented, connected to a secondary perpendicular wall partially truncated by later Roman constructions. The original extent and overall ground plan of this building cannot be reconstructed due to later disturbances and incomplete preservation. However, associated occupation layers were excavated, along with two combustion features and four small silo-like structures cut into the bedrock.

The material assemblage is dominated by ceramic remains, with handmade pottery accounting for approximately 95 % of the total ceramic corpus. Faunal remains are also well represented. The most frequently documented vessel forms include pots, jars, bowls, and lids, consistent with assemblages identified at other contemporary sites in the region (e.g. Oller et al. 2018b). Additional finds include granite grinding stones, spindle whorls, and metal artefacts such as iron nails, small bronze plaques, and a limited number of bronze Iberian coins. A bronze sieve was recovered from a small, concealed deposit within a rock outcrop. Overall, the composition of the assemblage is consistent with a settlement characterised predominantly by domestic activities during this period.

2.3. The Roman Republican phase

The last occupation at Serrat del Castellar corresponds to the Roman Republican period (2nd–1st c. BCE). This phase is associated with broader patterns of settlement transformation documented in the Cerdanya region following the Second Punic War. Classical literary sources refer to the involvement of Pyrenean Iberian groups in this conflict, while archaeological evidence indicates significant regional disruption during this period. In several cases, this disruption resulted in site abandonment or destruction, as documented at Tossal de Baltarga, whereas other settlements, such as El Castellot de Bolvir, underwent substantial reorganisation of their urban layout (Oller et al. 2018a; Oller et al. 2018b; Morera et al. 2020b).

Within this regional framework, the Roman Republican phase at Serrat del Castellar is defined by substantial architectural reorganisation and spatial reconfiguration of the preceding Iberian occupation. Stratigraphic evidence indicates that the Iberian phase terminated with a widespread fire event. Then, the settlement underwent a reorganisation marked by the establishment of a new architectural layout. This reconfiguration included the construction of new structural units while selectively reusing portions of earlier Iberian walls and foundations. The resulting urban grid differs in orientation and spatial articulation from the preceding phase, indicating deliberate planning rather than gradual modification.

The most clearly documented architectural transformation is located in the southeastern sector of the site. In this area, the Iberian tower was dismantled and subsequently overlain by a new structure, designated as “Building 1”. This building exhibits a quadrangular plan and was constructed beyond the original Iberian perimeter line (Fig. 4.).

The construction of Building 1 modified the earlier access configuration and extended the occupied area toward the slope. Stratigraphic relationships indicate that parts of the Iberian rampart were intentionally truncated to accommodate the new structure, while other segments were incorporated into its construction, with some walls partially abutting or resting against the earlier defensive line. In the southernmost sector of the rampart, an additional internal wall was constructed, possibly reinforcing an area weakened by earlier dismantling. Architecturally, Building 1 reflects variability in construction techniques, combining well-built masonry segments with others of lower structural quality. This heterogeneity may indicate rapid construction episodes or adaptive reuse of available materials. Within the broader regional context of Roman Republican transformation, this architectural pattern

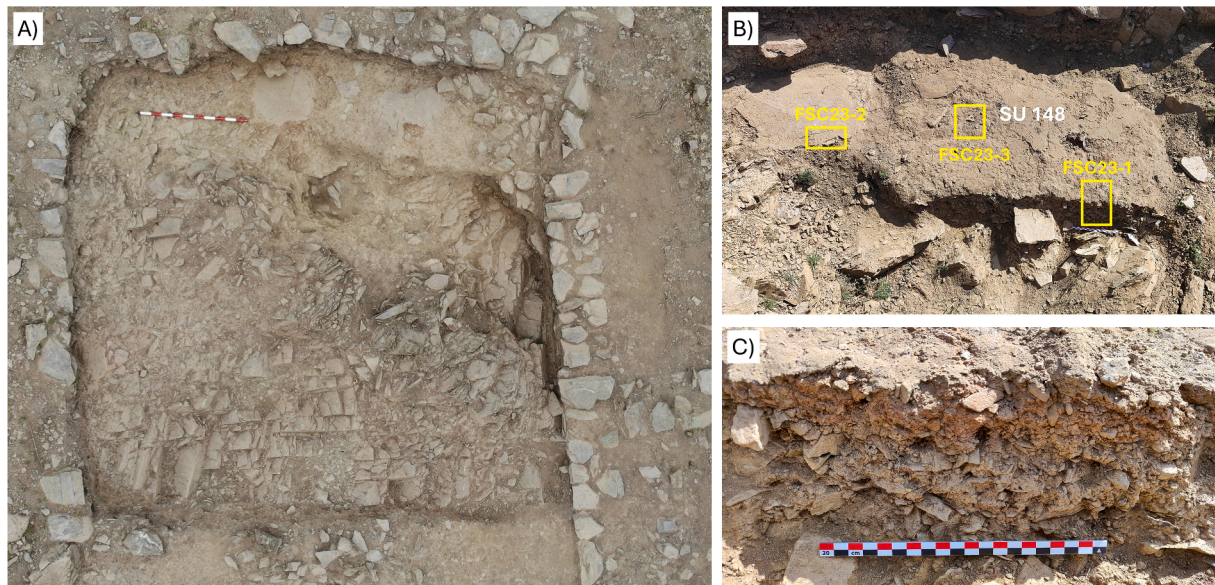


Fig. 3. Building 2 and sample locations. A) Aerial view of Building 2 after excavation, showing the exposed bedrock and the Iberian combustion feature (SU 148). B) Combustion feature SU 148 and sample location. C) Section view of SU 148.

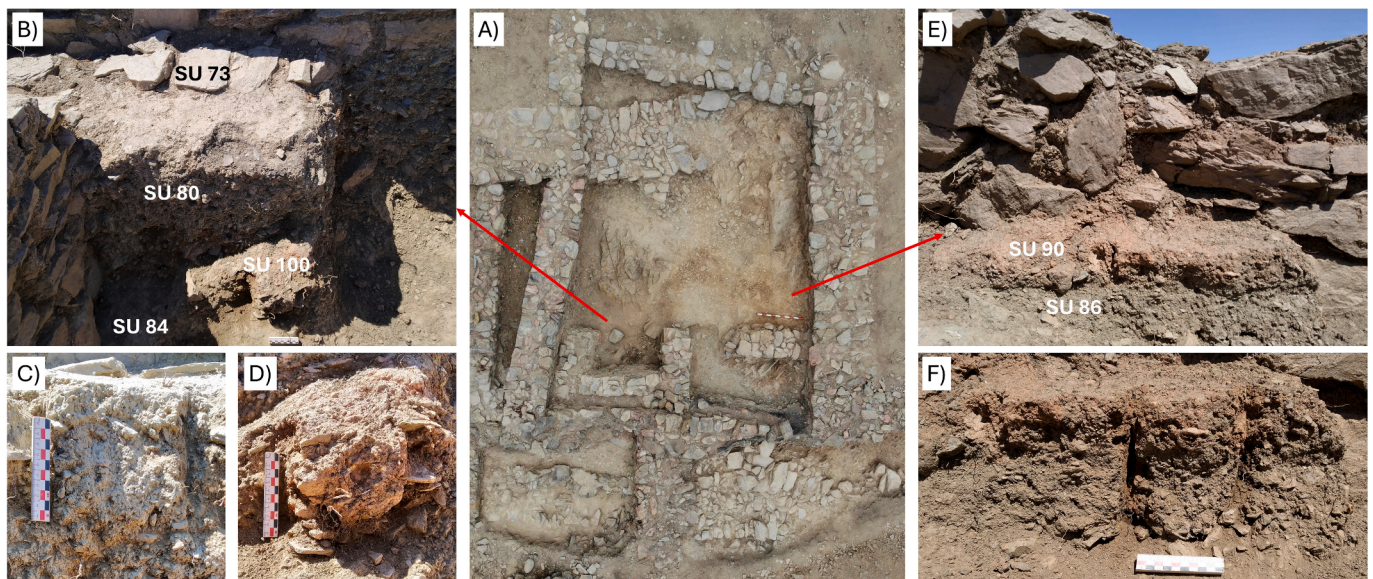


Fig. 4. Building 1 and sample locations. A) Aerial view of Building 1; B) Northeastern corner of Building 1 and its stratigraphic sequence; C) Sample FSC21-2 collected from SU 80; D) Sample FSC21-1 collected from SU 100; E) Northwestern corner of Building 1 and its stratigraphic sequence; F) Sample FSC21-3 comprising SUs 90/86.

may reflect fluctuating occupation intensity and episodic reinforcement of strategic locations. The settlement may therefore have alternated between phases of more stable occupation and periods characterised by heightened defensive requirements.

Adjacent to the southern sector of the rampart, several architectural units were constructed, forming a new and relatively regular spatial arrangement comprising Buildings 2, 3, and 4. Construction techniques are characterised by the use of locally sourced schist slabs laid in horizontal courses and bonded with clay. No evidence of mortar has been documented. The masonry exhibits irregular alignment and limited structural standardisation, and overall preservation is poor due to erosion and later disturbances.

Building 2 preserves three structural walls, with the western boundary lost, preventing reconstruction of its original ground plan and total dimensions. Within this unit, several fire spots were identified.

Handmade ceramic vessels were found partially embedded in the ground, containing burnt residues with additional evidence of thermal alteration in the surrounding sediment. The spatial association of combustion features and fixed ceramic containers may indicate small-scale domestic activities.

Immediately east of Building 2 lies Building 4. This structure exhibits a quadrangular plan with an estimated surface area of approximately 12 m². The Roman Republican occupation levels reveal a well-defined architectural unit whose function remains undetermined. The associated artefactual assemblage includes several iron nails, an iron projectile point, and fragments of a thin silver plaque. The presence of weapon-related and metal artefacts may indicate activities extending beyond purely domestic functions.

Building 3 is located south of Buildings 2 and 4 and directly abuts the Iberian rampart (Fig. 5.). In this case, all four perimeter walls are

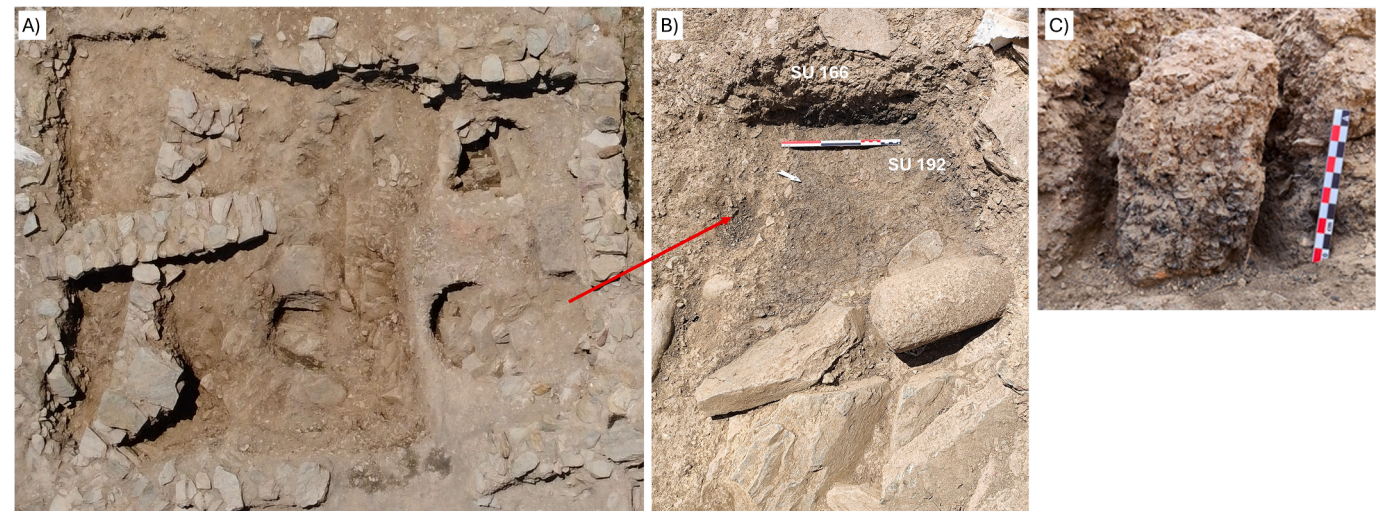


Fig. 5. Building 3 and sample location. A) Aerial view of Building 3; B) Sampled area and stratigraphic sequence; C) Sample FSC23-4 comprising SUs 166/192.

documented, although partial erosion and later disturbances have affected their preservation. A doorway connects Building 3 with Building 2, supporting the interpretation of a larger interconnected architectural complex rather than isolated units. The internal configuration includes a central fire installation. Additional finds include a 20 cm-long iron chisel, likely associated with woodworking activities.

The material assemblage from the Roman Republican phase includes abundant ceramic and faunal remains. Handmade pottery continues to predominate (approximately 80–85 % of the assemblage), although wheel-made productions increase in frequency, including Iberian oxidised and grey wares. Imported materials are also present in limited quantities, including Italian amphorae and Campanian fine wares. The artefactual record further includes worked bone objects, such as a fibula manufactured from bear bone and several perforated astragals currently under analysis. Metal finds comprise iron hobnails (*clavi caligarii*), an iron spur, lead projectiles (*glades*), coins, and numerous iron nails.

Overall, this assemblage reflects a diversification of material culture compared to the preceding Iberian phase. The presence of military-associated artefacts may indicate integration within broader Roman political and economic networks active in the region during the 2nd–1st centuries BCE. Comparable patterns have been documented at El Castellot de Bolvir and Tossal de Baltarga. Stratigraphic evidence indicates that the Roman Republican occupation terminated with a widespread destruction horizon sealing most architectural units and associated deposits, possibly in the second half of the 1st century. BCE, consistent

with abandonment phases documented at other Cerretan sites.

3. Materials and methods

A total of seven oriented and undisturbed sediment blocks were collected for high-resolution micromorphological and integrated phytolith analysis from Building 1, Building 2, and Building 3 during the fieldwork carried out in 2021 and 2023, comprising both the Iberian and Roman Republican phases (Table 1). The sampling strategy was designed to address spatial variability between buildings and to compare patterns of space use, site biographies, and depositional as well as post-depositional processes, while also accounting for the differing chronologies represented across the structures. While blocks from Buildings 1 and 3 comprise the internal sequence, sampling in Building 2 was focused on a suspected fire installation (Figs. 3–5). This approach facilitates the identification of diachronic continuities and transformations in building function, occupational practices, and material deposition, to assess cultural and environmental dynamics across the transitional Iberian–Roman horizon.

3.1. Micromorphological analysis

The micromorphological analysis was carried out on eight thin sections prepared at the Thin Section Service of the Faculty of Earth Sciences, at the University of Barcelona (Table 1; Fig. 6). After oven-drying

Table 1
Micromorphology sediment blocks and corresponding thin sections, phytolith subsamples, and contextual information.

Sediment Block	Micromorphological thin section	Phytolith subsamples	SU	Area	Period
FSC21-1	FSC21-1	FSC21-1-ss1, FSC21-1-ss2	100	Building 1	Iberian
FSC21-2	FSC21-2	FSC21-2-ss1, FSC21-2-ss2	80	Building 1	Roman republican
FSC21-3	FSC21-3	FSC21-3-ss1, FSC21-3-ss2	90/86	Building 1	Iberian
FSC23-1	FSC23-1	FSC23-1-ss1, FSC23-1-ss2, FSC23-1-ss3	148	Building 2	Iberian
FSC23-2	FSC23-2	FSC23-2-ss1, FSC23-2-ss2, FSC23-2-ss3	148	Building 2	Iberian
FSC23-3	FSC23-3		148	Building 2	Iberian
FSC23-4	FSC23-4 sup	FSC23-4-ss1, FSC23-4-ss2, FSC23-4-ss3	166	Building 3	Roman republican
	FSC23-4 inf		192	Building 3	Iberian

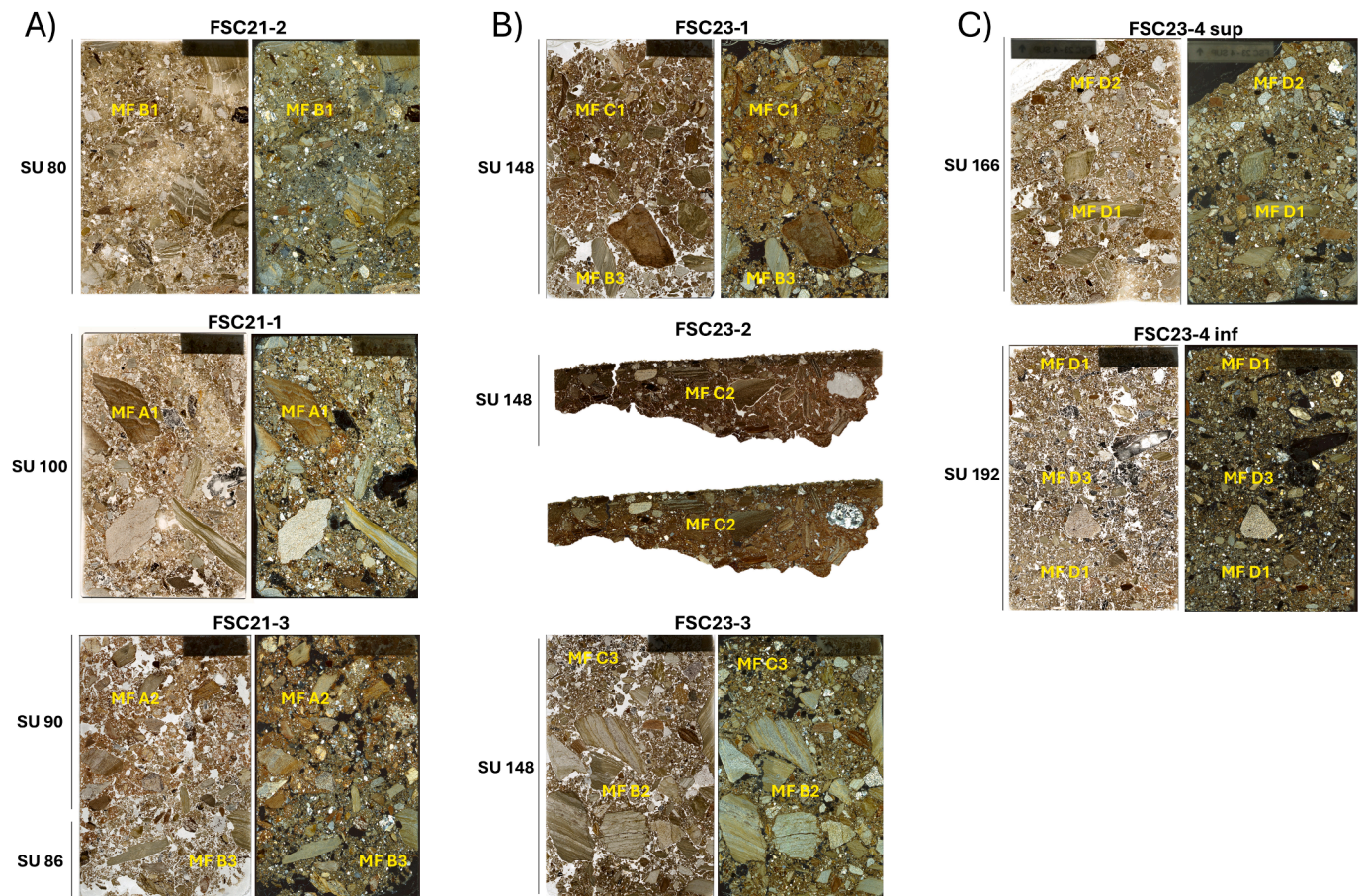


Fig. 6. Thin section scans of the studied sequences in PPL and XPL showing stratigraphic units (SU) and associated microfacies (MF). A) Building 1; B) Building 2; C) Building 3.

at approximately 40 °C, the sediment blocks were stabilised through impregnation with polystyrene resin and subsequently left to cure for several weeks. Standard-sized thin sections (78 × 53 mm, 30 µm thick) were then produced.

The thin sections were analysed with a petrographic microscope at magnifications ranging from × 25 to × 400, employing plane-polarised light (PPL), cross-polarised light (XPL), and oblique incident light (OIL), in accordance with established protocols (Stoops 2021). Additional reference atlases were consulted where required to aid in the identification and interpretation of micromorphological features (Bullock et al. 1985; Courty et al. 1989; MacKenzie et al. 2017; Nicosia and Stoops 2017; Stoops et al. 2018; Verrecchia and Trombino 2021).

Microstratigraphic units (MSUs) identified in thin section were classified into distinctive microfacies (MF) according to the matrix characteristics of the sediments, inclusions, and post-depositional alterations in order to reconstruct their pre-depositional, depositional and post-depositional histories (Courty, 2001). This methodology enhances the interpretation of site formation processes by recognising characteristic combinations of micromorphological traits within the stratigraphic sequences (Courty, 2001; Karkanis and Van de Moortel, 2014). The classification should not be regarded as fixed, but rather as open to modifications as the sample set expands in future studies. Such flexibility allows for direct comparison between different areas of the site and ensures more effective management of the resulting data. Micromorphological analysis was performed at the laboratories of the Department of Prehistory, Autonomous University of Barcelona.

3.2. Phytolith analysis

A total number of fifteen sediment subsamples from six micromorphological blocks were selected in this study for phytolith analyses. Phytolith methods followed Katz et al. (2010). Aliquots of ca. 40 mg of dried sediment were treated with 50 µl of a volume solution of 6 N HCl and 450 µl 2.4 g/ml of sodium polytungstate $[\text{Na}_6(\text{H}_2\text{W}_{12}\text{O}_{40})\cdot\text{H}_2\text{O}]$. Microscope slides were mounted with aliquots of 50 µl of sample. A minimum of 200 phytoliths with consistent morphologies were examined at × 200 and × 400 magnifications using a Zeiss Axiscope 5 optical microscope. Digital images were obtained using an Axiocam 208 camera and Zeiss Zen 3.8 image analysis software. The amounts of phytoliths were recorded as total numbers in 1 g of sediment. Percentages of multicellular phytoliths (multi-celled or in anatomical connection) in addition to percentages of weathered morphotypes were also recorded (phytoliths displaying pitted surfaces because of weathering and alteration by dissolution, which can not be assigned to specific morphotypes) (Portillo et al. 2021). The terms used to describe phytolith morphologies followed the standards of the International Code for Phytolith Nomenclature, ICPN 2.0 (International Committee for Phytolith Taxonomy (ICPT) et al., 2019). Morphological identification was based on standard literature (Brown 1984; Rosen 1992; Twiss 1992; Mulholland and Rapp 1992; Piperno 2006) and modern plant reference collections from the Mediterranean region (Albert and Weiner 2001; Tsartsidou et al. 2007; Albert et al. 2008, Albert et al., 2016; Portillo et al. 2014). Phytolith analyses were conducted at the Institució Milà i Fontanals, Spanish National Research Council (IMF-CSIC) in Barcelona.

4. Results

4.1. Soil micromorphology

The microscopic examination of resin-impregnated thin sections has allowed the identification of 14 MSUs, subsequently classified into eleven different MFs (Fig. 6). Each MF's distinctive characteristics are discussed below, but first, the lithology will be examined as all MFs share the same properties. A micromorphological description of MF is provided in Table 2.

4.1.1. Lithological properties

All samples exhibited a broadly comparable lithological composition, dominated by terrigenous, siliciclastic sediments composed primarily of angular to sub-angular quartz grains ranging from silt to coarse sand in size. In addition, heterometric angular and sub-angular fragments of schist, quartzite, and slate, varying between silt and gravel fractions, were consistently observed, together with recurrent occurrences of silt-sized minerals belonging to the mica group. Where notable differences between microfacies occur, these will be highlighted.

4.1.2. Microfacies A

MF A has been further divided into two variants (MF A1–A2) (Fig. 7a–b), which share broad similarities. All are defined by a reddish silty-clay to silty-sandy micromass, with predominantly local massive microstructures, variably modified by bioturbation and other post-depositional processes. The red colour that characterises these deposits is caused by fire, indicating fire-related activities or events (Canti and Linford 2000; Röpke and Dietl 2017).

MF A1 comprises MSUs characterised by a heterogeneous micromass, predominantly composed of reddish silty-sandy clay with a complex microstructure. Although locally massive, the microstructure is frequently modified by bioturbation, primarily root activity, which promotes pedality and the formation of channels, occasionally with clay coatings, as well as vughs and packing voids. Some rock fragments display cracks and reddening, particularly along their external surfaces, consistent with thermal alteration (Wattez 1992; Villagran et al. 2011). Charred plant material, and more specifically charcoal, is the primary anthropogenic component, occurring as subrounded fragments ranging from millimetric to centimetric sizes, most of them crushed, suggesting reworking of the deposit. Additional inclusions are less frequent and include small heat-altered bone fragments, recognisable by their orangish-brown colour in PPL (Villagran et al., 2011), and isolated charred seeds. Aggregates of earthen construction material are also present, mainly burnt, alongside isolated, randomly oriented phytoliths. Coarse components occur in a subvertical orientation and are irregularly distributed throughout the sample. The heterogeneity in size among both anthropogenic and minerogenic elements indicates moderate to poor sorting. Clay coatings indicative of clay illuviation are observed inside channels but also displaced within the matrix, further supporting evidence of reworking. Taken together, these features suggest that materials were displaced and therefore re-deposited. Additionally, the absence of distinguishable stratification within these units suggests deposition in a single event.

The variant MF A2 is composed of deposits with red silty-clay massive aggregates containing well-accommodated sand-sized quartz grains, bounded by channels and fissures. These features are consistent with an origin as earth building materials, further supported by the presence of plant impressions preserved within the reddish aggregates, possibly reflecting the use of vegetal fibres in earth construction materials. The subrounded, poorly accommodated appearance of the aggregates indicates reworking and disaggregation of the original materials. Porosity consists mainly of channels and packing voids, with fissures occurring less frequently. Anthropogenic inclusions, in addition to plant impressions, comprise charred seeds randomly distributed and oriented, while charcoal fragments are very scarce. Post-depositional alterations

Table 2

Micromorphological description of microfacies.

MF	Main characteristics	Thin sections	SU
A1	Reddish silty-sandy clay micromass, grano-striated and undifferentiated b-fabric Complex microstructure (locally massive, channels, vughs) 30 % porosity: channels, vughs, fissures Porphyric c/f related distribution Abundant charcoal, few burnt bones, occasional charred seeds and phytoliths Random distribution and subvertical orientation	FSC21-1	100
A2	Reddish silty-clay micromass, weakly speckled and grano-striated b-fabric Complex microstructure (locally massive, with channels and packing voids) 35–40 % porosity: channels, packing voids, vughs Porphyric/enualic c/f related distribution Charred seeds, few charcoal and occasional plant impressions Random distribution and orientation	FSC21-3	90
B1	Pale yellowish-brown silty-sandy clayey micromass, speckled and grano-striated b-fabric Massive to crumb microstructure 20–25 % porosity: fissures, vughs, channels Porphyric c/f related distribution Very few charcoal and bones, some burnt, as well as isolated phytoliths and earthbuilding material fragments Random distribution and subhorizontal orientation	FSC21-2	80
B2	Pale yellowish-brown silty-sandy clayey micromass mixed with reddish-brown silty clays, weakly speckled and grano-striated b-fabric Complex microstructure (inter-grain microaggregate and locally massive with channels) 35 % porosity: channels, packing voids, vughs Porphyric/enualic c/f related distribution Very few charcoal and bones, some burnt, as well as earth building material fragments Random distribution and orientation	FSC23-3	148
B3	Pale yellowish-brown silty-sandy clayey micromass, speckled and grano-striated b-fabric Inter-grain microaggregate microstructure 50–60 % porosity: packing voids, channels, vughs Enaulic c/f related distribution Very few charcoal and bones, some burnt, as well as earth building material fragments Random distribution and orientation	FSC21-3 FSC23-1	86 148
C1	Reddish-brown silty-clay micromass, speckled and grano-striated b-fabric Densely packed, massive, subrounded aggregates delineated by fine fissures 25–30 % porosity: fissures, channels, packing voids Porphyric c/f related distribution Very few charcoal Random distribution and orientation	FSC23-1	148
C2	Reddish-brown silty-clay micromass, weakly speckled b-fabric Massive microstructure 5–10 % porosity: fissures, vughs Porphyric c/f related distribution Very few charcoal Random distribution and orientation (except close to the surface where components are horizontally oriented)	FSC23-2	148
C3	Reddish-brown silty-clay micromass, weakly speckled b-fabric Complex microstructure (crumb, inter-grain microaggregate) 35–40 % porosity: channels, vughs, packing voids Porphyric/enualic c/f related distribution Charcoal and charred seeds Random distribution and orientation	FSC23-3	148
D1	Dark brown silty-sandy clay micromass, weakly speckled and grano-striated b-fabric Vughy microstructure	FSC23-4 Sup	166 192

(continued on next page)

Table 2 (continued)

MF	Main characteristics	Thin sections	SU
	30–35 % porosity: vughs, channels, fissures Porphyric c/f related distribution Some charcoal, few earthen material fragments burnt and isolated bones (usually burnt), and very few charred seeds Poor to moderate parallel distribution and horizontal orientation	FSC23-4 Inf	
D2	Dark brown silty-sandy clay micromass, weakly speckled and grano-straited b-fabric Vughy microstructure 30–35 % porosity: vughs, channels, fissures Porphyric c/f related distribution Some charcoals, few earthen material fragments burnt and isolated bones (usually burnt) Inclined linear distribution and random orientation	FSC23-4 Sup	166
D3	Blackish-dark brown silty-sandy clay micromass, undifferentiated b-fabric Vughy microstructure 30–35 % porosity: vughs, channels, fissures Porphyric c/f related distribution Very abundant charcoal, few earthen material fragments burnt, very few bone fragments (mostly burnt) and phytoliths Moderate parallel distribution and horizontal orientation	FSC23-4 Inf	192

are evident in the effects of root activity, documented by channels and oxidised root tissues, as well as water percolation, which produced clay illuviation, observed as limpid clay coatings along voids and channels.

4.1.3. Microfacies B

Microfacies B has been subdivided into three variants (MF B1–B3) (Fig. 7c–e). All are characterised by pale yellowish-brown deposits with a silty-sandy clayey micromass. While they share additional features, such as the general scarcity of anthropogenic inclusions, they also differ in aspects like their microstructure or the orientation of the components.

MF B1 is characterised by pale yellowish-brown deposits with a silty-sandy clayey micromass and a microstructure ranging from massive to crumbly. Porosity is dominated by fissures, particularly surrounding coarse components, consistent with compaction, and to a lesser extent by vughs, packing voids, and occasional channels, some of which display clay coatings. Rock fragments frequently exhibit fissuring, further indicative of mechanical stress, possibly linked to compaction. Anthropogenic inclusions are rare and consist of millimetric subrounded charcoal fragments, occasionally accompanied by small bone fragments, some showing evidence of burning, likely reflecting remnants of fire-related activities. Disarticulated phytoliths and aggregates of earthen construction material also occur sporadically. Most components appear well accommodated, randomly distributed, and subhorizontally oriented. The wide size range of inclusions suggests that these deposits are poorly sorted.

MF B2 also presents pale yellowish-brown deposits, although in this case they are more heterogeneous, with intercalations of reddish-brown silty clays, possibly indicating mixing with contact deposits. Coarse elements, reaching up to 2 cm in size, are more abundant than in MF B1 and appear partially accommodated, randomly oriented, and sometimes parallel distributed. The main difference compared to MF B1, however, lies in the microstructure, which is more complex in MF B2. It is characterised by channels, packing voids, and vughs, probably resulting from bioturbation, together with fissures around the coarse fraction and massive fine aggregates, features that may indicate compaction. Anthropogenic inclusions are very scarce, consisting only of a few small charcoal fragments and heat-altered bone, both randomly distributed and oriented, likely reflecting minor burning residues.

The third variant, MF B3, is distinguished primarily by its microstructure, which is strongly affected by bioturbation, resulting in

enhanced pedality and characterised by packing voids and channels. As in the other B microfacies, the primary anthropogenic inclusions are charcoal fragments, accompanied by fewer small bone fragments, both of which are randomly distributed and oriented. Coarse elements also exhibit a random distribution and orientation, are weakly accommodated or not accommodated at all, and display poor sorting. In sum, these features suggest that MF B3 represents a reworked deposit affected by extensive bioturbation.

4.1.4. Microfacies C

Three variants of microfacies C have been identified (MF C1, MF C2 and MF C3) (Fig. 7f–h). These are characterised by a reddish-brown silty-clay micromass, with well-accommodated, sand-sized quartz grains and fine gravel, but they differ in some aspects, including grain size and sorting. As in MF A, the reddish colouration of these deposits results from exposure to fire, reflecting fire-related activities or events.

MF C1 consists of a reddish-brown silty-clay micromass with well-accommodated sand-sized quartz grains. The coarse fraction is more abundant than in the other microfacies, although the size of the coarse elements is relatively regular, with most not exceeding 1 cm, indicating well-sorted deposits. Many of these show evidence of reddening and are well accommodated, often delineated by fine curvilinear fissures. Such fissures also define subangular earthen aggregates, resulting in a microstructure characterised by fissures or cracks. The massive character of the earthen aggregates suggests that they represent intentionally prepared materials for construction. Within these aggregates, post-depositional silty-clay intercalations occur, possibly reflecting water circulation. No clear anthropogenic inclusions were identified. Notably, some channels display clay coatings, attributed to clay illuviation. Occasionally, these appear randomly oriented and distributed within the aggregates, indicating that they are inherited features of the sediment subsequently displaced.

MF C2 represents a variation of the previous MF, displaying very similar characteristics, but in this case, the coarse fraction is highly homogeneous, with individual grains not exceeding 0.5 cm in length, indicating very well-sorted deposits. These coarse inclusions appear perfectly accommodated within the matrix. The microstructure is massive, with very low porosity, mainly characterised by fine, curvilinear fissures surrounding some of the coarse inclusions. Another distinguishing trait is that the orientation of the coarser minerals located near the surface is predominantly horizontal. Additionally, the vertical colour variation, with darker tones at the surface and paler hues at the base, is consistent with differential thermal alteration depending on depth, resulting from varying heat exposure (Aldeias et al. 2016; Röpke and Dietl 2017).

A third type, MF C3, shares broad similarities with MF C1 and MF C2 but is distinguished primarily by its complex crumb microstructure, which features areas with inter-grain microaggregates. Porosity is dominated by channels, vughs, and, to a lesser extent, packing voids. As in MF C2, the coarse fraction is represented by clasts not exceeding 0.5 cm in size, however, in MF C3, these are randomly oriented and irregularly distributed and are poorly accommodated. In contrast to MFs C1 and C2, anthropogenic inclusions are frequent, especially charred seeds and, to a lesser extent, charcoal.

4.1.5. Microfacies D

Microfacies D comprise three subgroups (MF D1–D3) (Fig. 7i–k), all characterised by dark brown deposits with compacted coarse inclusions and a predominantly vughy microstructure. Still, they differ in the size, orientation, and composition of the coarse fraction.

MF D1 is composed of deposits with a dark brown micromass. The coarse fraction does not exceed 2 cm in length and is generally oriented horizontally, displaying a moderate parallel distribution with a laminated appearance. These components appear compacted, as indicated by the fine curvilinear fissures surrounding them, and some display evidence of thermal alteration. The microstructure is predominantly vughy,

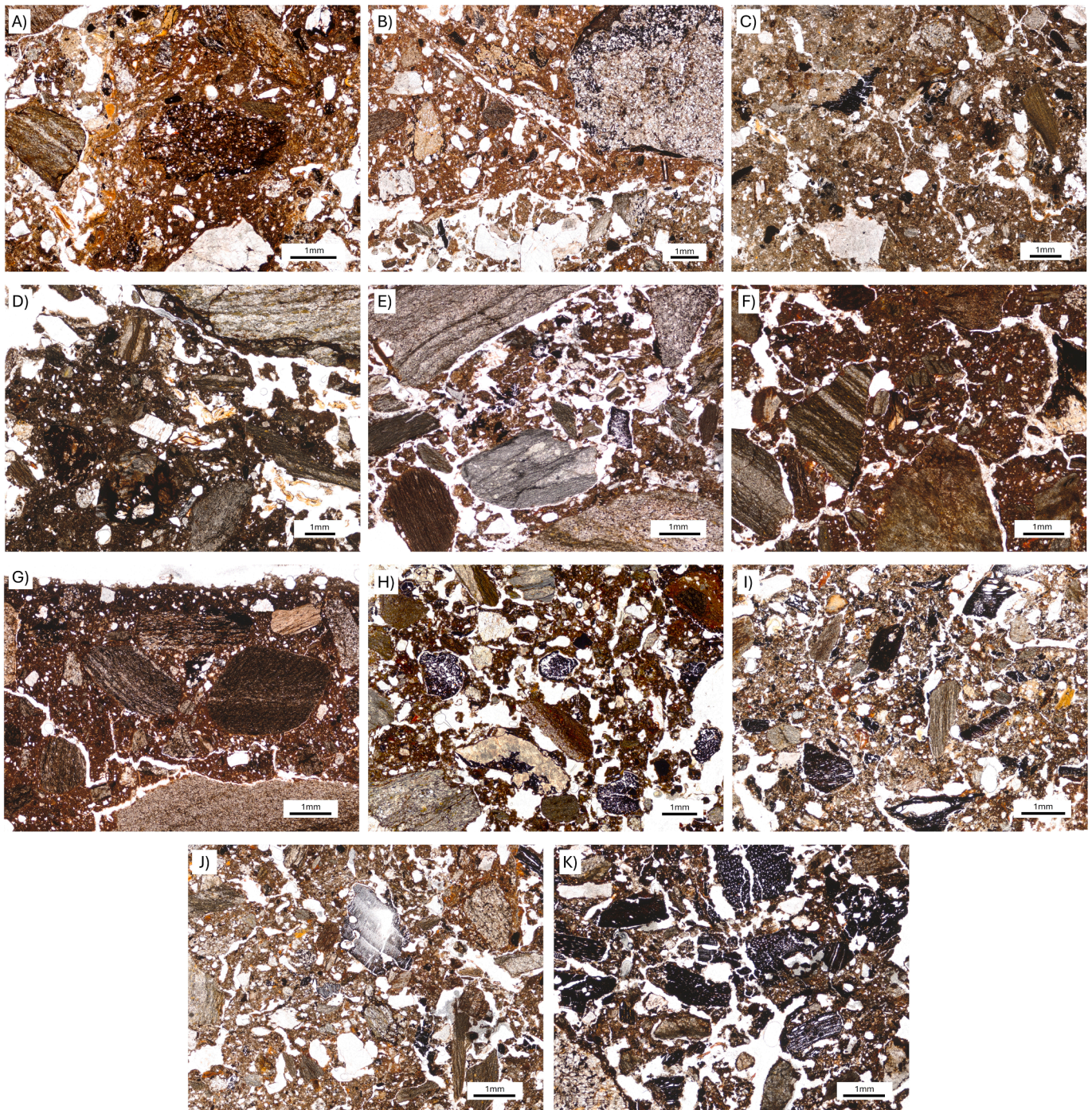


Fig. 7. Microphotographs of identified microfacies (MF) through the micromorphological analysis, PPL. A) MF A1; B) MF A2; C) MF B1; D) MF B2; E) MF B3; F) MF C1; G) MF C2; H) MF C3; I) MF D1; J) MF D2; K) MF D3.

although channels are also frequently documented. The main anthropogenic inclusions are millimetric subrounded charcoal fragments, along with occasional subrounded rubified sediment aggregates and isolated bone fragments, which are usually burnt. Sporadically, charred seeds are also observed. This microfacies exhibits limited evidence of bioturbation, particularly when compared to some of the preceding microfacies, although clay coatings are present around coarse grains and within certain channels.

A second type of MF D, designated MF D2, closely resembles the former but presents subtle differences that may reflect distinct formation processes. In this microfacies, although the materials remain partially accommodated and appear compacted, their orientation is no longer

predominantly horizontal but instead random and follows an inclined linear distribution. The coarse fraction is also smaller, not exceeding 0.5 cm in size.

Another variant of MF D has been identified, designated MF D3. Its dark colouration is due to the high concentration of charcoal fragments of varying sizes, which constitute the dominant component of this type of deposit. The charcoals occur in a wide size range, from 75 μm up to 2 cm, mainly displaying subrounded shapes and are predominantly oriented horizontally, lying parallel to the surface. Additionally, smaller quantities of rubified earthen aggregates and thermally altered bone fragments are also present. Disarticulated phytoliths also occur sporadically. The deposits exhibit a vuggy microstructure, although the

abundance of channels is also noteworthy; these locally disrupt the orientation of inclusions, most likely as a result of root activity.

4.2. Phytolith results

Phytolith concentrations in most of the sediment subsamples range between 0.3 and 0.9 million per 1 g of sediment (Table 3). The only exceptions were FSC23-1-ss3 and FSC23-2 micromorphological block subsamples (ca. 0.06–0.09 million phytoliths/g sediment). These subsamples belong to the combustion feature (SU 148) from Building 2, with correspondence to microfacies (MF) C1 and C2 respectively, defined as compacted thin layers of earth mixed with fine sands in which phytoliths were scarce.

In general, the presence of multicelled phytoliths (anatomically connected) in most of the samples (up to 10–13 % in samples FSC21-2-ss2 and FSC21-3-ss2, Table 3), in addition to the relatively low proportion of weathered morphotypes in the assemblages (ca. 0.4–5.9 %), were indicative of the general good state of preservation of the phytolith records (Fig. 8a). However, multicelled phytoliths were almost completely absent from samples obtained from Building 2 combustion structure (SU 148), in association to increased weathering (FSC23-1-ss3 and FSC23-2, up to 6 %). Of particular note, is the lack of both unidentifiable and partially melted phytoliths, related to increased heating (or burning) that range from slightly bubbled surfaces to completely opaque vesicular or sinuous morphologies, which can no longer be assigned to specific morphotypes (Portillo et al. 2021).

The morphological results indicated that monocotyledonous phytoliths, and particularly grasses, dominated in most of the assemblages, with an average of around 90 % of all the counted morphotypes (Supplementary material SM1). According to the dominant grass silica short cell morphologies (rondels, crenates, trapezoids and polylobates, Fig. 8b), grasses mostly belonged to the Pooideae subfamily in most of the samples (ca. 30–65 % of the total grass phytoliths counted, SM1).

The only exceptions with lower proportions of short cell phytoliths were again the above reported subsamples from combustion structure contexts (FSC23-1-ss3 and FSC23-2, average ca. 10.6 %). In addition to the dominant short cell rondel morphotypes, diagnostic chloridoid grass short cell phytoliths (saddles) as well as short cell morphologies from the Panicoideae subfamily (bilobates and crosses), were also recorded although to a lesser extent (up to 6.8 and 11.8, respectively, Fig. 8c-d). Interestingly, panicoid phytoliths were completely absent from FSC23-1-ss3 and FSC23-2 combustion structure samples.

Characteristic morphotypes from the leaves and culms of grasses, including blocky and flabellate bulliforms, acute bulbosus (trichomes), in addition to single-celled and multicelled entire elongates were common in the phytolith assemblages (Fig. 8e). Further, diagnostic phytoliths from the inflorescences of grasses such as elongate dendritics and dentates (Fig. 8f), occur in greater amounts in certain subsamples, rather than being ubiquitous in all assemblages (up to 35–45 % of the total of grass phytoliths counted, SM1). The latter morphologies which are considered as delicate or fragile cells (Cabanes et al. 2011) in association with the relatively low index of weathered morphotypes (ca. 0.4–2.2 %, Table 3), further point to a general good state of preservation of the examined assemblages. This is particularly the case of the phytolith records from Building 1 (FSC21-1, FSC21-2 and FSC21-3 block subsamples), showing the largest ratios in terms of inflorescences/leaves and stems of grasses, pointing towards an important input of the floral part of these plants in these building contexts (ratios ranging from 1.1 to 1.9, Table 3). The only exception is subsample FSC21-1-ss1 displaying lower ratio values, belonging to a microfacies micromorphologically characterised as a reddish silty-sandy clay micromass (MF A1, ca. 0.1 ratio, Table 3).

Table 3

Location, description of samples and main quantitative and morphologic phytolith results, with correspondence to micromorphological block samples, microfacies (MF) and stratigraphic units (SU).

Subsample	Block sample	MF	SU	Area/ Building	Phytoliths 1 g of sediment (million)	Phytoliths weathering (%)	Multicelled phytoliths (%)	Grass phytoliths (%)	Ratio grass inflorescence/leaves- stems
FSC21-1-ss1	FSC21-1	A1	100	1	0.77	0.4	5.7	93.9	0.11
FSC21-1-ss2					0.75	0.5	7.1	87	1.11
FSC21-2-ss1	FSC21-2	B1	80	1	0.92	2.2	6.6	84.9	1.26
FSC21-2-ss2					0.7	2.1	12.9	87.7	1.72
FSC21-3-ss1	FSC21-3	B3	86	1	0.51	0.7	2.3	87.4	1.98
FSC21-3-ss2		A2	90		0.94	0.4	10.1	85.3	1.19
FSC23-1-ss1	FSC23-1	B3	148	2	0.35	1.1	0	93.9	0.11
FSC23-1-ss2		C1			0.65	2.2	0.5	92.7	0.37
FSC23-1-ss3		C1			0.06	5.9	0	75.3	0.31
FSC23-2-ss1	FSC23-2	C2	148	2	0.08	4.2	0	89.2	0.21
FSC23-2-ss2		C2			0.09	3.6	0	84.3	0.11
FSC23-2-ss3		C2			0.08	5	5	74	0.41
FSC23-4-ss1	FSC23-4	D1	166	3	0.8	3.8	1.3	93.2	0.76
FSC23-4-ss2		D1			0.78	2.7	0	92.6	0.65
FSC23-4-ss3		D2			0.67	3.1	0	87.6	0.29

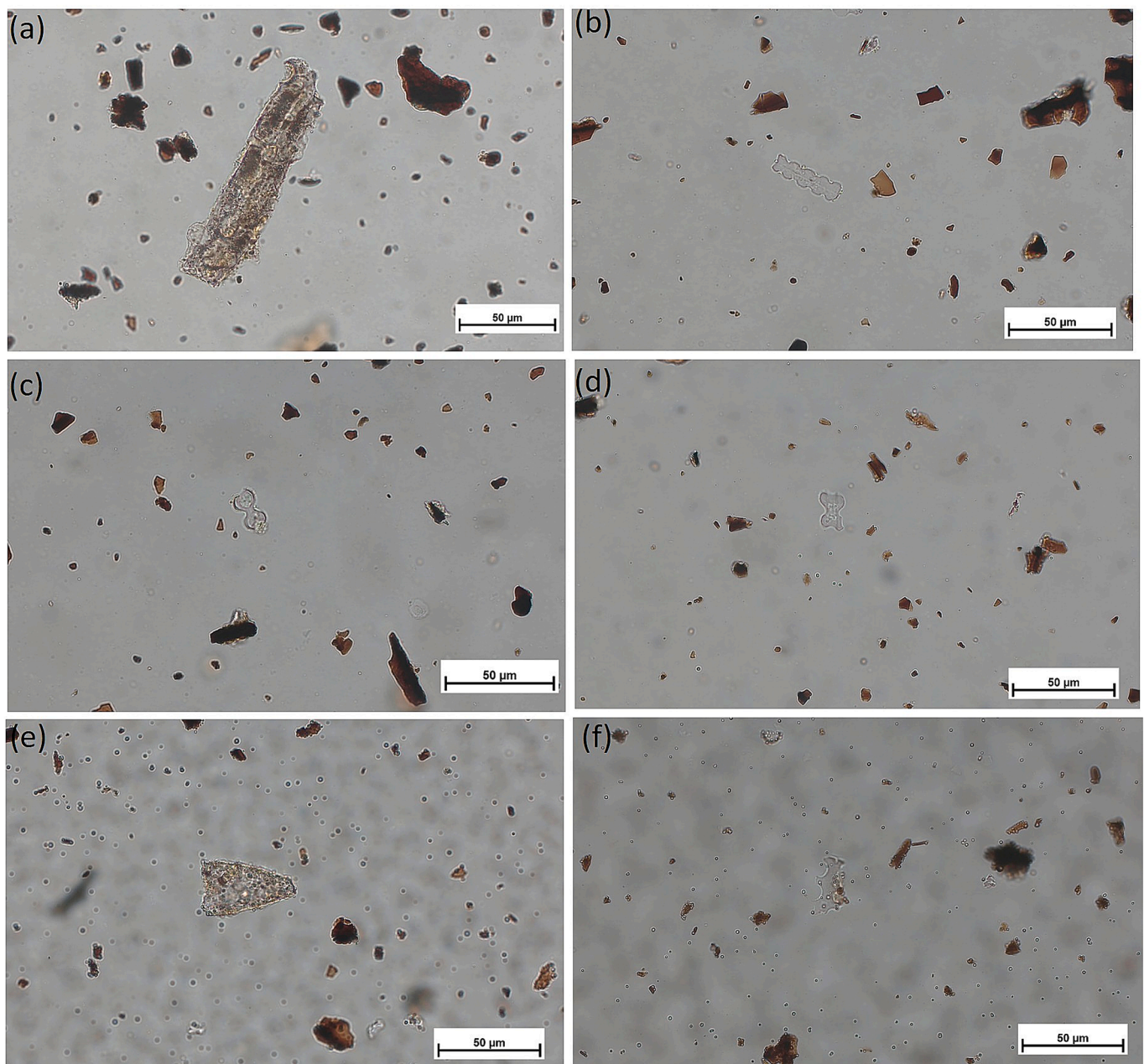


Fig. 8. Photomicrographs of phytoliths identified in the samples (x400). (a) multicellular elongate phytoliths with grass silica short cell rondels from Pooideae grasses (subsample FSC23-4-ss1); (b) polylobate phytolith from Pooideae grasses (FSC23-4-ss1); (c-d) grass silica short cell bilobates from Panicoideae grasses (FSC23-4-ss1); (e) acute bulbous from grass leaves (FSC23-4-ss2); (f) elongate dendritic from grass inflorescences (FSC23-4-ss2).

5. Discussion

5.1. Microfacies interpretation

The classification of the archaeological deposits identified through microstratigraphic analysis into distinct microfacies and variants within each type has enabled the documentation of different formation processes of the stratigraphic record in the sampled contexts. Two main groups can be distinguished based on the nature of their sediments and whether or not they were affected by fire: on one side, MFs A and C, and on the other, MFs B and D.

The first group, consisting of MFs A and C, includes archaeological deposits characterised by reddening caused by fire. However, differences between them suggest distinct formation processes. For example, MF C comprises three subtypes (MF C1, MF C2, and MF C3) directly

related to the construction of a combustion structure in Building 2. MFs C1 and C3 correspond to the deposit located immediately beneath the combustion surface, that is, the substrate. Their characteristics indicate the intentional selection of sediments and the sizing of coarse mineral components, as well as the manipulation of these elements, reflected in their massive and homogeneous appearance. Nonetheless, post-depositional alterations, such as the presence of fissures, are noteworthy. These fissures are likely caused by high-intensity firing (Wattez 1992) and accentuated by channels resulting from bioturbation. These microfacies are therefore directly associated with the basal or preparatory layer of the combustion structure. MF C3 is particularly interesting as it was collected from an area with a dark surface where the constructed surface was absent, and consequently, residues percolated, explaining the higher concentration of charcoal, possibly fuel residues, as well as charred seeds.

By contrast, MF C2 is identified in the sample taken from the constructed surface of the combustion structure. Although it shares similarities with MF C1, its high degree of homogeneity, along with features such as its microstructure, the orientation of the coarse fraction, and the uniform size of inclusions, indicates a more carefully prepared material. Its low porosity and the lack of textural features suggest it was manufactured in a plastic state (Cammass 2003, 2018; Wattez 2003). Likewise, the absence of vegetal fibres points to a preference for mineral stabilisers. Its careful manufacture and massive character prevented the incorporation of residues associated with fuel use or other activities. This is also consistent with maintenance practices focused on cleaning residues from the surface of the structure.

Type A MF were identified in Building 1 and comprise burnt materials formed mainly of earthen construction material, with some variations, leading to their division into two subtypes. MF A1 shows evidence of thermal alteration, visible not only through the presence of charcoal and reddened sediments but also in the alteration of certain mineral components. The orientation, distribution, and sorting of the materials suggest that this is a displaced deposit, likely resulting from rapid or sudden deposition. Accordingly, it may represent a single depositional event, either deliberate, such as the dismantling or cleaning of a combustion structure, or accidental, resulting from fire destruction.

MF A2, on the other hand, also displays features that clearly point to its origin as earthen construction material. Notably, it contains vegetal fibres, which are absent from the construction of the combustion structure in Building 2. This may point to different earth-building strategies or suggest that the material comes from another type of structure. The characteristics of MF A2 imply it is a secondary deposit resulting from the collapse or dismantling of earthen structures. Its limited charcoal and charred seed inclusions suggest incidental incorporation of occupation debris.

The second group comprises MFs B and D. Starting with group B, these MFs are characterised by sediments typical of the local environment where the site is located. MF B1 is distinguished by fissures around coarse components, fissured rock fragments, and a massive-to-crumbly microstructure, all of which suggest mechanical stress and compaction. This pattern aligns with trampling or pressure from overlying deposits. Considering its stratigraphic position in Building 1, at the transition between the Iberian and Roman periods, it may have functioned as a packing layer, serving much like a floor, as flat worked slabs were found on top. The anthropogenic inclusions identified, mainly residues from fire-related activities and fragments of construction material, imply the recycling of sediments from occupied areas. Extracting material from pits dug directly on site is a well-documented form of resource exploitation in archaeological and ethnoarchaeological contexts, commonly known as sedimentary recycling (Berna 2017; Lorenzon 2023). The poor sorting of inclusions, along with their distribution and orientation, suggests that the packing floor was not carefully prepared (Wattez 2003; Cammass 2018).

MF B2 represents a deposit located at the base of the combustion structure in Building 2. Its composition is somewhat heterogeneous due to the intercalation of reddish-brown silty clays derived from overlying levels, that is, thermally altered materials forming the substrate of the structure, as seen in MF C1 and C3. Its microstructure and porosity exhibit clear signs of bioturbation, which accounts for the mixing of sediments. In some areas, however, the deposit appears massive, while fissures around the coarse material indicate mechanical stress and compaction, probably linked to pressure. Therefore, MF B2 can be interpreted as a packing deposit, similar to MF B1, although in this case it is more affected by post-depositional disturbance and seems to be intended for levelling rather than as a floor. The very low occurrence of anthropogenic inclusions, limited to a few charcoal fragments and heat-altered bones, suggests minimal burning residues, probably incidentally incorporated, yet still providing insight into domestic activities. MF B3 also seems to represent a packing layer, given its textural similarities with the other B microfacies and its stratigraphic position, as it occurs in

the same unit as MF B2 in Building 2 and is also visible at the base of the sequence in Building 1. However, in this case, the deposit has undergone more extensive post-depositional alteration. The dominance of bioturbation features, including packing voids, channels, and increased pedality, indicates substantial root activity, which has significantly modified the original structure. As a result, signs of compaction or deliberate preparation are masked.

Finally, type D MF are all found in Building 3 and can be grouped into three subtypes, each characterised by a dark brown micromass associated with finely comminuted charcoal and unidentifiable charred plant materials in varying proportions. Their main differences lie in the degree of sorting and the orientation and distribution of inclusions. In the case of MF D1, the dark brown micromass combined with the presence of charcoal, burnt bone, and rubified earthen aggregates indicates a deposit directly linked to fire-related activities, particularly the burning of fuel and food processing or disposal. The horizontal orientation and moderate parallel distribution of coarse elements, together with evidence of compaction, suggest the accumulation of combustion debris that was subsequently compacted, possibly through trampling.

In contrast, MF D2 appears more fragmented, redistributed, and less ordered. As in MF D1, the materials show compaction and partial accommodation of coarse elements, but the inclusions are oriented randomly or along an inclined linear pattern. This indicates that the deposit may represent redeposition downslope, dumping reorganised by gravitational processes, or human redistribution.

MF D3, by contrast, is composed of abundant charcoal fragments ranging in size from microscopic to centimetric scale. This composition points to a deposit strongly linked to fire-related activities, most likely fuel residues of burning events. The predominantly horizontal orientation and subrounded shape of the charcoal fragments, lying parallel to the surface, indicate that the deposit remained largely *in situ*, suggesting a rake-out layer rich in fuel residues (Meignen et al. 2007).

5.2. Building biographies and settlement transformation

In this section, we examine the different formation processes documented in each of the sampled buildings through the integration of micromorphological and phytolith evidence, situating them within their stratigraphic context to reconstruct their biographies. We then assess how these trajectories inform broader processes of settlement reorganisation during the Iberian–Roman transition (Guimerà et al. 2026).

5.2.1. Building 1

The sampled stratigraphic sequence begins with SU 86. Micromorphological analysis indicates correspondence with microfacies type B3, suggesting that this unit may represent a packing layer possibly used as a floor, affected after deposition by pedoturbation. Since this unit lies beneath the wall associated with the Roman period, it is assigned to the Iberian phase.

Immediately above, and still associated with the Iberian phase, lies SU 90. Micromorphological analysis reveals an abrupt transition defined by a very sharp boundary, indicating a sudden, single depositional event. This unit corresponds to MF A2, pointing to the collapse or reworking of earth-based materials affected by fire. The presence of charred seeds, mostly cereal-like (Fig. 9a–c), in association with concentrations of phytoliths from the inflorescences of Poideae grasses and the relatively well-preserved multicellular forms reflected in the phytolith assemblage within this collapse deposit, may suggest that it derived from a structure or space dedicated to food storage or crop-processing. Furthermore, increased concentrations of articulated phytoliths pointing to an important input of the floral part of these plants, may suggest that cereals were stored in their bracts, rather than just the grain. Additionally, the low phytolith weathering indices further suggest that plant materials were incorporated into the deposit shortly before burial rather than deriving from long-term background accumulation. Notably, the lack of residues during the transition between SU 86 and SU

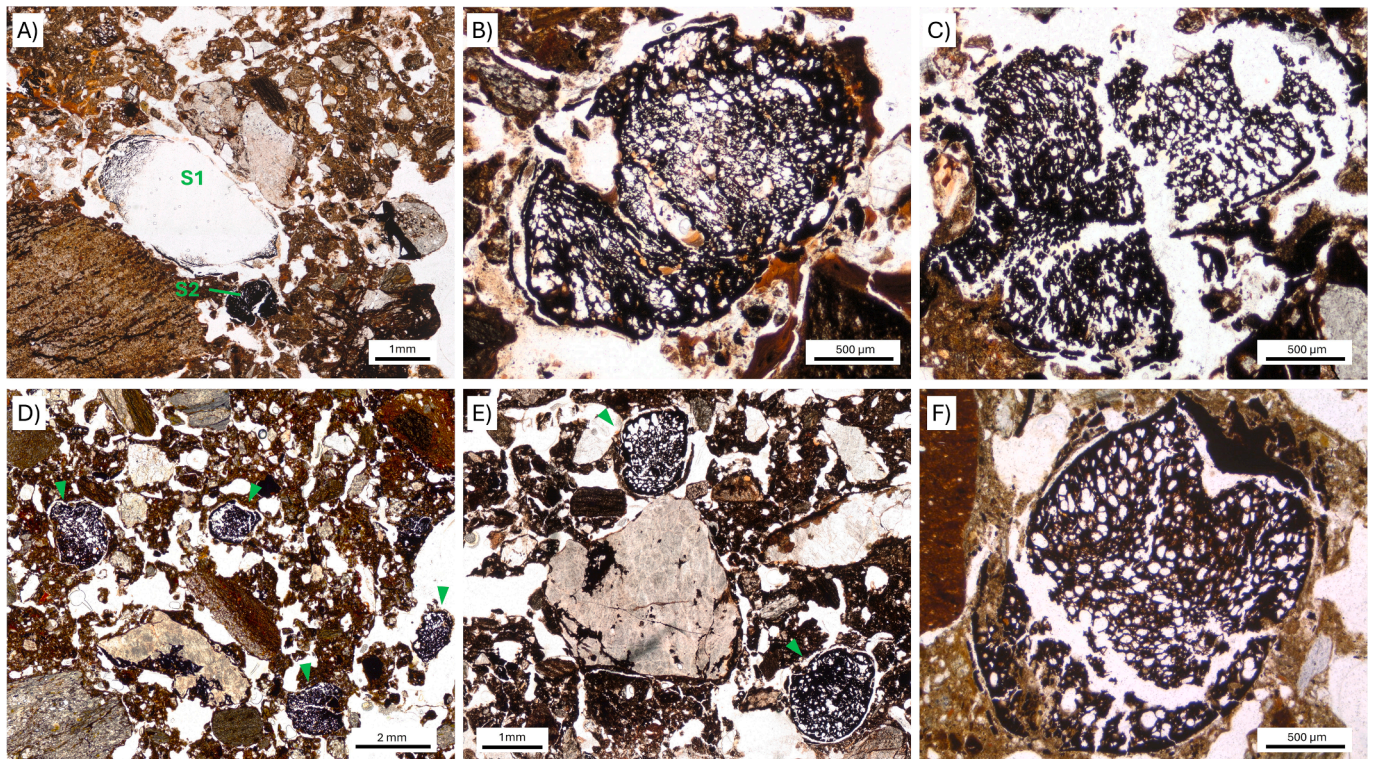


Fig. 9. Microphotographs of charred seed inclusions, PPL. A) Cereal-like charred grains identified in SU 90, MF A2, Building 1, specimen S1 is sectioned tangentially and S2 transversely; B) Cereal-like charred grain in SU 90, MF A2, Building 1; C) Cereal-like charred grain in SU 90, MF A2, Building 1; D) Charred seed fragments (green arrows) in SU 148, MF C3, Building 2; E) Charred seed fragments (green arrows) in SU 148, MF C3, Building 2; F) Crop-like charred grain in SU 148, MF C3, Building 2.

90 indicates that, during the Iberian period, the floor was maintained and kept clean. This pattern has also been observed through micromorphological analysis at other sites in the same region and chronological horizon, such as Building F at Baltarga and sites from different geographical settings or periods (Karkanas and Van de Moortel 2014; Mateu et al. 2019; Tomé et al. 2024; Sisa-López de Pablo et al. 2025).

On the opposite side of the building lies SU 100, which directly overlays the geological level. This unit shares very similar characteristics with SU 90 and is micromorphologically characterised as MF A1. It is located in the eastern corner of the building, where a natural slope of the terrain occurs, explaining the arrangement of components subject to gravitational settling, either by natural fall or anthropic redistribution. While SU 90 is directly overlain by the wall closing the western side of Building 1, SU 100 is overlain by SU 80, already associated with the Roman period and micromorphologically characterised as MF B1. This represents a loosely prepared architectural packing used as a levelling floor for paving. The presence of micro-residues, including charcoal and thermally altered construction material, together with phytolith concentrations and the degree of weathering observed, suggests that sediments were reworked collected from previously occupied, and possibly destroyed, areas for its preparation.

5.2.2. Building 2

Sampling in Building 2 focused exclusively on the combustion structure SU 148, associated with the Iberian period. Integrated micromorphological and phytolith analyses at high-resolution provide further insight into its construction, maintenance, combustion processes and potential uses.

At the base of the sequence, microfacies B2 and B3 were identified. Both are associated with packing deposits, albeit with different degrees of preservation, and in fact represent the same deposit, more extensively altered in one of the sampled locations. This layer constitutes a fill directly over the geological substrate, very similar to the Iberian-period

packing observed in Building 1, upon which the combustion structure SU 148 was built, and which may have served as a floor for the rest of the room.

Directly above MF B2 and MF B3, MF C3 and MF C1 were identified, respectively. Micromorphological evidence indicates that the substrate of the combustion structure was deliberately constructed. This substrate was subsequently covered by a thin layer of earth mixed with fine sands, carefully smoothed and compacted, and applied in a plastic state, as indicated by its textural features. The sequence thus reflects a construction process involving a slight hollowing of the ground, the application of a preparatory layer, and finally the creation of a finished surface. This type of construction technique has also been identified through high-resolution microcontextual analysis in other hearths of similar chronology elsewhere in the northeast of the Iberian Peninsula (Belarte et al. 2025).

The limited preservation of silica plant remains and other residues on the surface, as evidenced by both micromorphological and phytolith datasets, prevented the determination of any specific function for the structure. This is likely attributable to both the careful finishing of the surface and subsequent cleaning practices, as has been documented for numerous Iron Age combustion installations in northeastern Iberia (Belarte et al. 2023a, 2025). However, residues were recovered from one sample taken from an area where the combustion surface was less well preserved, allowing residues to penetrate. This sample contained fragments of charred seeds (Fig. 9d-f) and fuel residues. Although seed preservation is generally poor, making species identification difficult, morphological differences suggest distinct types. Notably, charred chaff has not been observed. Altogether points to a combustion structure likely related to food processing/cooking.

Regarding the combustion processes, the reddening of sediments combined with the initial fragmentation of the rubified sedimentary matrix indicates an oxidising combustion, which likely reached temperatures in the range of approximately 500–600 °C (Wattez 1992; Canti

and Linford 2000; Röpke and Dietl 2017). This is further supported by the phytolith evidence, as no melted phytoliths, nor any phytoliths exhibiting signs of partial melting due to exposure to increased temperatures or burning, were identified in either dataset. Phytolith melting has been widely reported in Iron Age combustion installations and associated ashes, including both hearths and ovens from diverse Mediterranean regions (Gur-Arieh et al. 2014; Portillo et al. 2017, 2021, Belarte et al., 2023b; Belarte et al. 2023a, Portillo et al., 2026). According to experimental studies both under laboratory-controlled conditions and fuel records experimentally-produced in modern replicas of Iron Age Iberian fire installations, the maximal production of completely melted phytoliths occurs in the range of ca. 800–900 °C (Portillo et al. 2021; Belarte et al. 2023a; Portillo et al.), further pointing to exposure to lower temperatures in the current case-study.

5.2.3. Building 3

At the base of the sampled stratigraphic sequence, associated with the Iberian period, lies UE 192. Micromorphological analysis has subdivided this unit into three microstratigraphic units, beginning with MF D1 at the base. This microfacies is interpreted as an accumulation of combustion residues, possibly linked to domestic activities, given the presence not only of fuel remains but also thermally altered bones and occasional charred seeds.

Overlying this deposit is MF D3, interpreted as a rake-out deposit mainly consisting of charcoal fragments, that is, fuel residues. Notably, charcoal is abundant while ash is absent. Under stable environmental conditions, this difference in proportions may reflect interrupted combustion (Homsey and Capo 2006; Braadbaart and Poole 2008; Mentzer 2012). Alternatively, it could result from combustion under low-oxygen conditions, which favours charcoal production over ash (Wattez 1988; Boardman and Jones 1990; Braadbaart and Poole 2008). Another factor explaining the absence of ash may be chemical diagenesis, as ash typically dissolves in acidic environments with pH < 6.5 (Weiner et al. 2002; Canti 2003; Friesem et al. 2014). Soil analyses from the study area show slightly acidic conditions (Poch and Boixadera, 2008). Additionally, the presence of clay coatings within the channels in the samples indicates water infiltration, which, in non-calcareous settings, would have further promoted ash dissolution (Drever 1997). This accumulation of combustion by-products could potentially be linked to the combustion features identified during excavation in the same building, and therefore constitutes rake-out deposits derived from fire-related activities.

Finally, at the top of the sequence, another deposit of combustion residues is documented. Above SU 192 lies SU 166, this time associated with the Roman period. This context corresponds to MF D1 and MF D2, which indicate the reuse of earlier accumulation layers of combustion residues as the foundation for a new Roman circulation surface. This interpretation is supported by micromorphological evidence of mechanical reworking and subsequent compaction affecting these levels, as well as by the low proportion of articulated phytoliths, suggesting disturbance and remobilisation of the deposit for its implementation as a circulation surface.

5.2.4. Settlement dynamics across the Iberian-Roman transition

The building biographies reconstructed through the integration of micromorphological and phytolith evidence provide an opportunity to examine broader processes of settlement transformation during the Iberian–Roman transition. Comparison of the three sampled buildings reveals distinct formation processes comprising construction, use, maintenance, destruction, and material reuse. Considered together, these records contribute to a more comprehensive understanding of occupation dynamics within the settlement.

During the Iberian phase, the examined buildings reflect different patterns of space use within the settlement. Building 1 is characterised by deposits containing abundant plant-related remains, including grass inflorescence phytoliths and charred seeds, suggesting activities potentially associated with storage or crop-processing. According to the

phytolith morphologic results, grasses belonged mainly to the Pooideae subfamily, which includes cereals such as wheat and barley, along with panicoids, although into a lesser extent. Archaeobotanical records from nearby Castellot de Bolvir and Baltarga point to a cereal production based on hulled barley (*Hordeum vulgare*) and free-threshing cereals such as naked wheat (*Triticum aestivum/durum/turgidum*), in addition to broomcorn millet (*Panicum miliaceum*) (Berrocal-Barberà 2021; Colominas et al. 2023; Portillo et al. 2023; Guimerà et al. 2026). In contrast, Building 2 is dominated by a carefully constructed combustion installation, where micromorphological and phytolith evidence indicate domestic fire-related activities, potentially associated with food processing and/or cooking, and continuous cleaning. However, both Building 1 and Building 2 share similar floor construction techniques and appear to have been kept relatively clean during use. This continuity in construction and maintenance practices suggests shared building techniques and similar concerns about managing occupation surfaces across activity areas that otherwise fulfilled different roles within the Iberian settlement. Building 3, by contrast, presents a different depositional history, characterised by the accumulation of combustion residues interpreted as rake-out deposits, where panicoid phytoliths are completely absent. Although fire-related activities were also carried out in this area, the accumulation of fuel residues suggests a different spatial relationship between combustion practices and waste management than in Building 2.

The transition to the Roman Republican occupation is most clearly documented microscopically in Building 1, where the Iberian sequence culminates in the rapid accumulation of fire-affected earthen materials, indicating an abrupt destruction or collapse event. Following this phase, the settlement underwent a reorganisation characterised by the establishment of a new architectural layout. The available evidence suggests that this transformation did not involve a complete break with the preceding Iberian occupation. In addition to the reuse of earlier walls and structural elements documented during excavation, microscopic evidence indicates that deposits derived from Iberian occupation contexts were reworked and incorporated into the construction of new Roman-period packing floors. This pattern is also reflected in Building 3, where earlier combustion-derived deposits were mechanically reworked and compacted to form a circulation surface. Together, these examples demonstrate that Roman Republican activity incorporated materials from earlier occupation phases into newly organised spaces. The recycling of occupation deposits, combustion residues, and earthen construction materials suggests that sediments derived from Iberian contexts were intentionally mobilised during the creation of new floors and circulation surfaces. Beyond its practical value as a readily available source of construction material, this process highlights the material continuity that links successive phases of occupation despite broader changes in the organisation of the settlement.

6. Conclusions

The combination of site stratigraphy with integrated bio-geoarchaeological approaches at Serrat del Castellar provides a high-resolution reconstruction of depositional dynamics and activity areas across the Iberian–Roman transition in a mountain settlement context. By combining microfacies analysis with quantitative and morphologic phytolith data, this study disentangles construction events, combustion and maintenance practices, reworking episodes, collapse deposits, and sedimentary recycling processes that are often difficult to identify at the macroscopic scale. The resulting microstratigraphic framework enables a refined reconstruction of building biographies and site formation trajectories.

During the Iberian phase, floors were constructed through compacted packing layers reflecting shared technological principles across different buildings. Evidence from Building 1 indicates the rapid accumulation of fire-affected deposits containing plant-related remains, suggesting activities associated with storage or crop-processing prior to

destruction and subsequent reuse during later occupation phases. The combustion structure documented in Building 2 illustrates the value of integrating micromorphological and phytolith evidence to reconstruct domestic fire-related activities, maintenance practices, and combustion conditions within Iberian occupation contexts. Building 3 documents the accumulation and subsequent reuse of combustion residues, highlighting the importance of sedimentary recycling and depositional reworking within later phases of occupation.

The Roman Republican phase is characterised by spatial restructuring combined with the selective reuse of earlier Iberian deposits and construction materials in Building 1 and Building 3. Rather than representing a complete rupture, the transition reflects a process of adaptive reconfiguration in which architectural transformation coexisted with continuity in construction practices, sediment management, and the reuse of occupation deposits.

The integration of micromorphological and phytolith studies at high-resolution has provided a refined understanding of activity areas, depositional histories, and construction practices within the settlement, linking building-scale biographies with broader processes of settlement reorganisation across the Iberian–Roman transition. Such micro-contextual resolution is particularly valuable in erosion-prone high-land environments, where stratigraphic compression and post-depositional reworking frequently obscure occupational histories. The results demonstrate the analytical potential of combining micromorphology and phytolith analysis for investigating complex multi-phase settlement sequences and transitional contexts.

Finally, the Serrat del Castellar sequence shows that the Iberian–Roman transition in the Eastern Pyrenees was characterised by processes of destruction, adaptive rebuilding, sedimentary recycling, and selective continuity in domestic practice. This study highlights the value of a micro-contextual, multi-proxy approach for investigating transitional contexts across Late Iron Age and early Roman built environments in the north-eastern Iberian Peninsula, particularly in mountainous settlement contexts, where high-resolution micro-contextual studies remain relatively scarce.

CRediT authorship contribution statement

Joaquim Sisa-López de Pablo: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ariadna Guimerà:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marta Portillo:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Joan Oller Guzmán:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

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

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jasrep.2026.105954>.

Data availability

No data was used for the research described in the article.

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