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An Integrated Approach to Understanding the Occupational Trajectory of Mercadal in Southern Aragon, Spain

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ABSTRACT
This article presents an integrated historical ecological investigation of the abandoned Medieval village of Mercadal in southern Aragon, Spain. Combining non-invasive archaeogeophysical survey (magnetometry and ground-penetrating radar), targeted excavation, shovel testing, radiocarbon dating, and analytical cartography, we examine spatial organization, geomorphic context, and occupational chronology of the site. Bayesian modeling indicates a bimodal occupation ca. A.D. 800–1500, spanning Islamic and Christian regimes, with ceramics ranging from Iberian and Proto-Historic to Medieval and Modern. Geophysical survey reveals dense domestic structures, including combustion features and subsurface architecture, while excavation confirms stratified surfaces, burials, and construction episodes linked to the Ermita San Miguel. Medieval documentary evidence situates Mercadal within the *Comunidad de aldeas* of Daroca, a collective property regime. Situated in the karstic Ebro Basin, Mercadal reflects strategic engagement with water, terrain, and agricultural land, while its occupational trajectory illustrates demographic, environmental, and governance dynamics shaping durable socio-ecological systems.

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Introduction

We present a historical ecological analysis of the organization of space, geomorphic context, and chronology of the archaeological site of Mercadal in southern Aragon, Spain, contributing to matters of governance and the collective management of resources. Mercadal is in the Ebro River Basin in the northeastern Iberian Peninsula. It first drew our curiosity for being abandoned between A.D. 1489 and 1495 during Aragon's greatest period of economic prosperity, asking, as others before us had, whether its abandonment was due to a failure to adapt to the challenging inland Mediterranean climate and the poor soils of the Ebro Basin or perhaps instead the demographic ravages of the Black Death or the impacts of Castilian cattle rustlers (Rubio 2013). The settlement and abandonment of Mercadal are equifinal states, and the site's real archaeological value is the opportunity it presents for examining the plasticity of people's needs and the structured coherence of their interpersonal relations across time (Braje et al. 2017; Cobb et al. 2023; Pauketat 2016; Quirós Castillo, Narbarte, and Iriarte 2023; Rick 2023).

When Beresford (1951) and Darby (1951) introduced the investigation of Medieval "lost villages" in England, they drew their reader's attention away from abandonment to how these villages reflected human organization in response to local circumstances, events, and activities. Causation cannot be reduced to a simple process. Place and time do matter in explaining the materiality of a site and the compounding effect of individual action over time while also being fundamental to the search for regularities in homologous situations despite their counterintuitively different histories (Bliege Bird and Nimmo 2018; Feinman 2023; Fernández Fernández and Fernández Mier 2019; Pauketat 2016; Quirós Castillo 2009). We frame our investigation within the theory of collective action, which is any situation where two or more individuals take action to improve their status, power, or influence within a group (Carballo 2025; North 1990; Olson 1965; Van Zomeren and Iyer 2009). Empirical resolution of variation in the material record of Mercadal was as important as our choice of theory to ensure we could contribute to addressing contemporary environmental challenges (Crumley 2021; Rick 2023; Smith 2021).

Contemporary advances in data-collection technology and spatial analytic techniques have increased the ability of archaeologists to address processual and post-processual questions about human organization in response to local circumstances, events, and activities not possible for Beresford and Darby (Cobb et al. 2023; Müller and Kirleis 2019; Pauketat 2016). We draw particular attention to variation in response, in opposition to the directive force of environment, procurement, demography, or elite power that used to be common causal explanations. For example, archaeologists now interested in why humans "settled down" explore the multiple dimensions and scales of interpersonal relationships and how they relate to societal change (Feinman and Neitzel 2023; Feinman and Thompson 2025; Gragson and Coughlan 2024). This paradigm shift is an explicit recognition that managing resources is about managing people (Natcher, Davis, and Hickey 2005; Ostrom 1990).

Our investigation of Mercadal touches directly on how migrant populations shape newly encountered landscapes

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through their resource practices; how the construction of borders, boundaries, and frontiers affect land use practices; how peripheries vs. centers are characterized with respect to governance and resource management; and, the impacts of colonialism on cultural ecosystems. Landscapes of the Iberian Peninsula have repeatedly been taken by conquest over the last 2000 years, with each conquest interlude resetting relations between people and resources, resulting in distinct yet entwined property regimes over time (Benda-Beckmann, Benda-Beckmann, and Wiber 2006; Ostrom 1990). Mercadal is one of many loci within this region where place-based residents fine-tuned subsistence and social strategies to their local environment, making it a nexus of micro- and macroscale change (Bliege Bird and Nimmo 2018; Kintigh et al. 2017; Norström et al. 2022). Our results are a window into past forms of governance and the management of resources that speak directly to contemporary historical ecology and contribute to problem-solving local issues (Crumley 2021; Rick 2023; Shriver-Rice, Schneider, and Pardo 2022).

Site Setting

Mercadal is a catalogued historical archaeological site (Burillo 1991) located on a small hill in the middle reach of the 85,611 km^2 erosional drainage basin of the Ebro River in northeastern Spain. The site lies in the contemporary municipality of Loscos, nested within the county (*comarca*) of Jiloca, the province of Teruel, and the autonomous community of Aragon (Figure 1). The local geographic setting of Mercadal is the Jiloca River Valley within the Serranía Celtíbera. This is a historic region of Spain with no access to the Mediterranean Sea, traversed by the Iberian System and centered on the Montes Universales that define the border between the autonomous communities of Aragon and Castile. The Serranía Celtíbera is one of many rural European regions, typically mountainous, being transformed by the abandonment of lands by residents who relocate temporarily or permanently to surrounding urban centers (Quintas-Soriano, Buerkert, and Plieninger 2022).

The Ebro River now flows southeast, draining into the Mediterranean Sea, but it originally flowed northwest, draining into the Atlantic Ocean. Its original outlet was closed in the Late Eocene ca. 35 mya from uplift of the Pyrenees Mountains and the Iberian Range. This orogenic event created the endorheic Ebro Paleolake and the depositional environment responsible for much of the contemporary landscape in the Ebro Basin (Arlegui and Simón 2001; Garcés et al. 2020; Pardo et al. 2004). High deposition rates between 12 and 8.5 mya raised the basin floor of the Ebro Paleolake ca. 1000 m above the eustatic level of the Mediterranean Sea, and when the Ebro River outlet to the Mediterranean opened, it triggered accelerated removal of softer materials across the region (Garcés et al. 2020; García-Castellanos et al. 2003; Pérez-Lambán et al. 2018; Pérez-Rivarés et al. 2002). Quaternary fluvial processes reworked surface materials in alternating episodes of erosion, incision, and accumulation, resulting in surface depositions of variable thickness that can include multiple buried soil horizons (Pérez-Lambán et al. 2018). Large pans comprised of thin (< 0.5 m) carbonate crusts over Neogene evaporites are common, and as an active karstic landscape, the Ebro Basin also contains numerous isolated and clustered dolines and sinkholes (Pueyo Anchuela et al. 2009; Soriano and Simón 1995).

Mercadal is located at ca. 900 masl on a west-to-east trending structural limestone bench that is a geological witness to the Miocene opening of the Ebro River Basin, consisting of resistant lacustrine limestones locally referred to as a *muela* or a *plana*. The bench is located at the contact zone between Paleozoic lithology (> 250 mya) and Quaternary deposits made up of silts, clays, and alluvium (< 2.58 mya). The bench is part of the Sierra de Oriche, an eastern extension of the Sierra de Cucalón that in turn is a member of the Aragonese slope of the Iberian Range. The site area opens to the north onto the plains of the Ebro River, while to the south lies the valley formed by the sources of the Huerva River and Aguasvivas River, tributaries to the Ebro River. The seasonal Pilero Stream is the closest watercourse to Mercadal that, combined with numerous local springs (*manantial*) and an extensive network of earthen irrigation canals (*acequia*), are used to water local agricultural fields. When running, the Pilero joins the Cámaras River near El Villar de los Navarros that in turn joins the Aguasvivas River at Letux. The average annual temperature of the site area is 18–20°C, while the precipitation rate is between 500 and 700 mm/y, with rain concentrated in spring and autumn, and frost and snow being regular occurrences in winter.

Methodology

A pedestrian surface survey of the residential portion of Mercadal was completed in 2015 for an M.A. thesis (Allué Andrés 2016) with key results published in *Aragón en la Edad Media* (Allué Andrés 2018). Surface features observed in 2015 still presently visible include stone alignments ca. 50 cm in height above the surface that form what appear to be conjoined room blocks generally aligned along cleared areas resembling pathways. The eastern portion of the site, delimited by an earthen canal used to irrigate surrounding agricultural fields, contains no visible remains and is colloquially said to have been the market square when the village was inhabited (the name Mercadal literally means “the place where the market is held”). The central portion of the site is dominated by the consecrated Ermita San Miguel de Mercadal, regularly used by area residents (an *ermita* in this area of Spain is a small, rural church, chapel, or sanctuary). Adjoining the Ermita is a small house used as a sacristy and inhabited by the church caretaker until the 1960s. Adjacent to the church is a ruined, abandoned farmhouse with a sheep corral still used by local herders; both most likely date to the late 1960s and were built with stones harvested from nearby archaeological features of Mercadal.

We conducted preliminary site visits in 2019 and the beginning of 2023 (the COVID-19 pandemic interrupted a scheduled 2020 project at the site). Our observations and the results of the 2015 survey indicated the site was in a good state of preservation, covered an estimated 4.75 ha, and presented an excellent opportunity for systematically exploring a Medieval abandoned village that had neither been plowed over or buried by later construction, as is common across Europe (Fernández Fernández and Fernández Mier 2019; Quirós Castillo 2009; Quirós Castillo, Narbarte, and Iriarte 2023). We applied for and

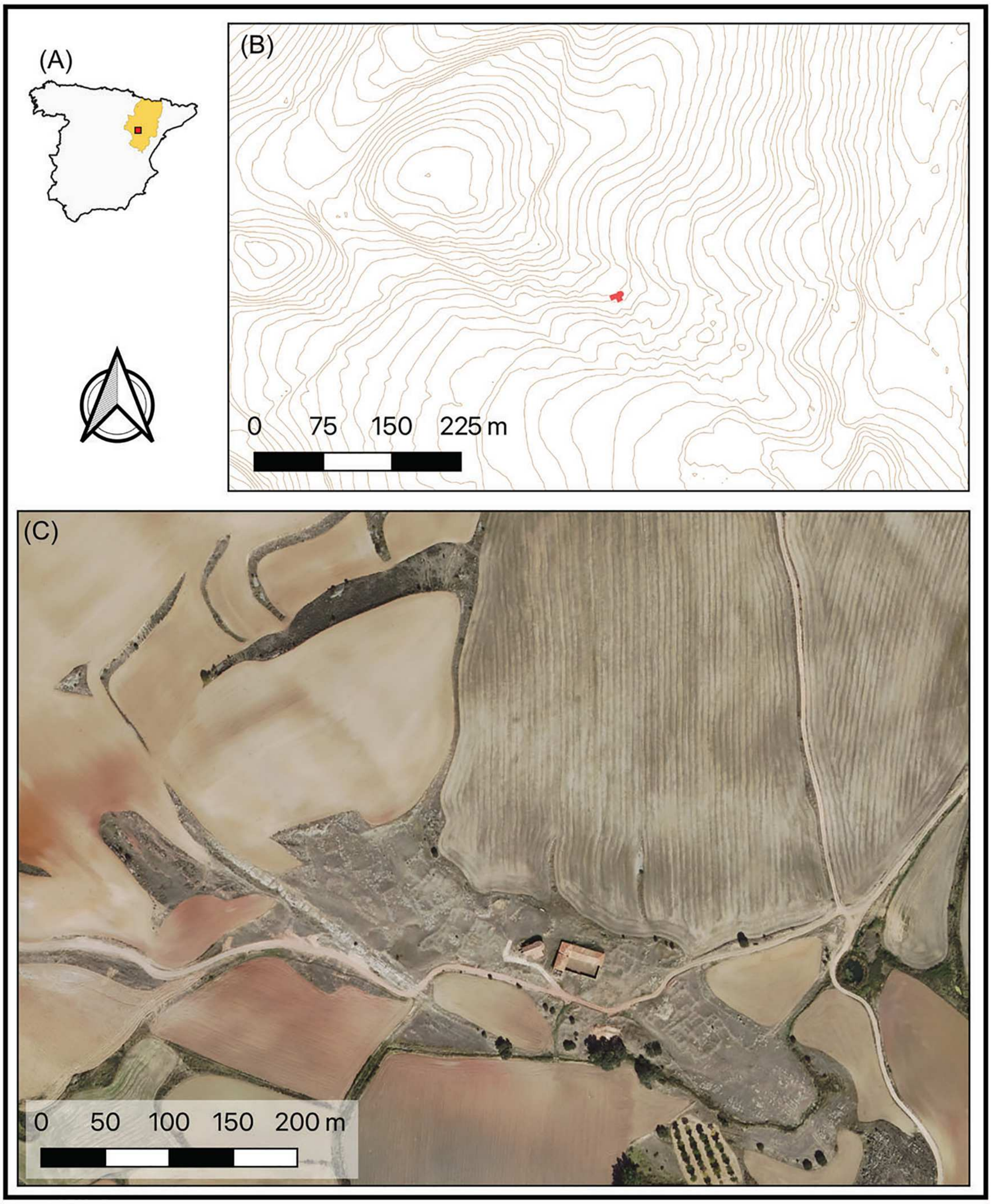


Figure 1. Location of study site. A) Position of Mercadal within the Autonomous Community of Aragon (yellow) and Spain. B) 1 m contour map of the site and surrounding area centered on Ermita San Miguel (red). C) ICEARAGON orthophotograph (2021) of the site and surrounding area.

received authorization in early 2023 from the Government of Aragon, *Departamento de Educación, Cultura y Deporte* (dossier 239/2019) to conduct a theoretically oriented archaeogeophysical investigation (Skousen and Friberg 2021; Thompson et al. 2011) of Mercadal. The objective was to generate complementary datasets for the residential portion of the site, centered on the Ermita, supplemented with selective exploration of the surrounding areas. We sought and obtained additional clearance from the Loscos City Council to work at Mercadal, since the residential portion of the site, including the Ermita, the historic buildings, and much of the surrounding area, is either owned by the municipality or residents of it. We carried out the fieldwork between May 5 and 20, 2023, and complemented our ground-based activities with analysis of remotely sensed airborne and satellite data.

The field crew included seven people divided into smaller groups appropriate to the activities they were engaged in. We established a 20 × 20 m base grid (n = 214 units) over the site (Figure 2) using a GPS with a horizontal precision of ca. 1 cm tied to the national grid (ETRS89, UTM zone 30N; EPSG 2026) and used this grid to geo-reference all field-collected information. We used an ArcGIS Field Maps portfolio on iPads in the field to upload information in real time to the University System of Georgia ArcGIS service via cellular connectivity (Movistar). Our workflow in the field combined non-invasive (ground-penetrating radar, magnetometry, and surface survey) and invasive (shovel testing and excavation) procedures and recovery of radiocarbon samples, all supported by analytical cartography. We briefly describe our procedures below and more comprehensively in Supplemental Material 1.

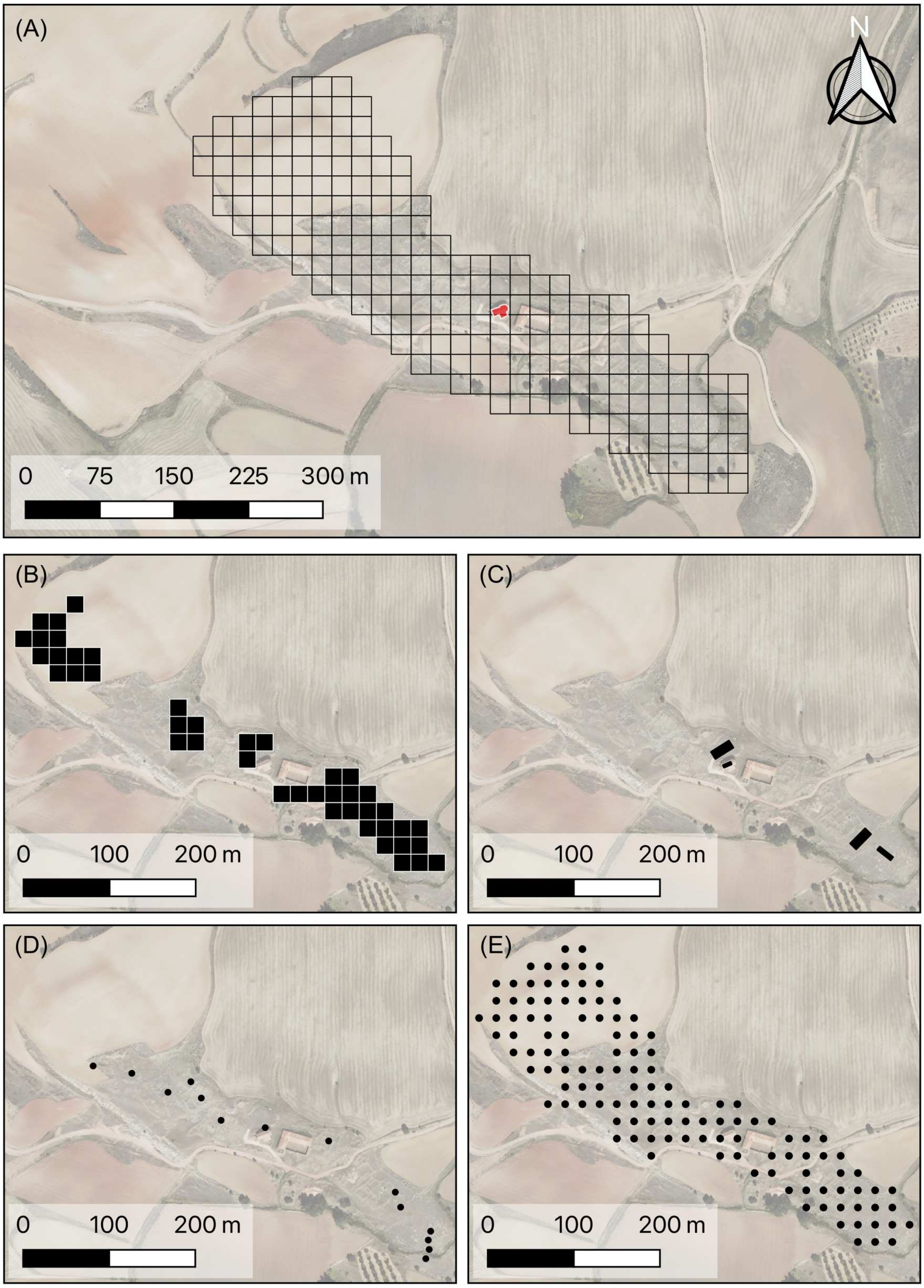


Figure 2. Field sampling grids. A) 20 × 20 m base grid. B) Magnetometer units. C) Ground penetrating radar units. D) Shovel test units. E) Dog Leash survey units.

Ground-penetrating radar

We used a GSSI SIR 4000 with a 400 MHz antenna attached to a calibration wheel to collect reflection data in four grids on level ground covering a total of 640 m^2. The horizontal resolution of survey grids was 25 or 50 cm, with 50 reflection traces digitized every meter along transects. The profiles were processed using standard procedures (Conyers 2016, 2023; Goodman and Piro 2013) and analyzed using GPR Viewer (Conyers 2010) and GPR Slice (Goodman 2025). The average wave velocity across all four grids is estimated as 0.094 m/ns, giving a wavelength of 0.24 m, a vertical resolution of ca. 0.06 m, and a horizonal resolution of ca. 0.34 m at 1 m depth.

Magnetometer

We used a Förster Fluxgate 4.032 DLG magnetometer with a 65 cm vertical probe and sensors at ca. 20 cm and ca. 85 cm above the ground surface. The unit has a resolution of < 0.2 nT and a measuring uncertainty of < 2% over its ± 10,000 nT measurement range. We surveyed 46 20 × 20 m grid units covering a total of 18,400 m^2 (1.69 ha). Each grid was traversed bidirectionally with an inline sample spacing of 0.1 m and a traverse sample spacing of 0.5 m, resulting in 8000 measurements per grid (20 samples/m^2). Raw magnetic data were processed in Terrasurveyor64 (Wilbourn 2025) following standard procedures (Aspinall, Gaffney, and Schmidt 2008; Witten 2006) to produce a composite datafile with a cell resolution of 0.125 × 0.125 m we analyzed in QGIS (OSGeo 2026).

Surface survey

We surface-surveyed and bagged all portable material culture in 111 units covering a total of 35,093 m^2 (3.5 ha) of the site. Each unit was defined as a 20 m diameter circle with an area of 314 m^2 centered on the intersection of every four 20 × 20 m units of the base grid (i.e., a "Dog Leash" survey). We placed recovered diagnostic sherds (e.g., rims, bases, and handles) into four broad regional time periods (Iberian, Proto-Historic, Medieval, and Modern) and undiagnostic sherds in unknown.

Shovel testing

We completed 14 30 × 30 cm shovel tests randomly distributed across the site. Units were hand dug to a maximum depth of ca. 30 cm to either a sterile level or refusal on bedrock and passed sediment from each unit through a 6.35 mm screen. Recovered cultural material and radiocarbon samples were bagged separately, and the unit was backfilled. We processed the cultural material as described for the surface survey. Radiocarbon samples were processed as described below.

Excavation

We completed five excavation units with a total extent of 16.75 m^2 to sterile substrate using natural levels (the area is too small to be displayed on Figure 2). Stratigraphy was recorded using Harris Matrices and Structure for Motion photogrammetry from control points established with a total station. We passed sediment through a 6.35 mm screen, and all cultural material and radiocarbon samples were bagged separately and processed as described. We laid a ground cloth in each excavation unit, then backfilled it. The relative chronological sequence and stratigraphic details of the Harris Matrices from all excavation units are presented in Supplemental Material 2.

Radiocarbon samples

We recovered 13 radiocarbon samples from shovel test units and eight from excavation units that we submitted to the Center for Applied Isotope Studies at the University of Georgia. No sample provided more than one radiometric date. We corrected and modeled all radiocarbon dates using OxCal 4.4.4 with the IntCal20 calibration curve (Bronk Ramsey 2009; Reimer et al. 2020). We report dates in calendar years A.D. rounded to the nearest five years and present results using best practices as described by Bayliss and Marshall (2022) and Bronk Ramsey (2017). Full sample details and chronometric results are presented in Supplemental Materials 3 and 4; the OxCal used in modeling radiocarbon dates are presented in Supplemental Material 5.

Analytical cartography

We developed a geodatabase prior to the fieldwork from diverse Spanish and commercial sources of information (ICEARAGON, IGN, and Apollo Mapping) to prepare the ArcGIS Field Maps portfolio we used in the field. Following fieldwork, we added derivative products including lidar, VAT (visualization for archaeological topography), GPR, and magnetometer images that we generated using LASTools (Isenburg 2025), Relief Visualization Toolbox (Kokalj, Zakšek, and Pehani 2013), GPR Slice (Goodman 2025), and Terrasurveyor64 (Wilbourn 2025). We used QGIS (OSGis 2026) for spatial analysis and cartographic representation.

Results

We generated discrete lines of evidence using the described archaeological procedures that we integrated into the following three domains of inquiry supported and advanced by analytical cartography: 1) surface patterns (surface survey, magnetometry, and ground-penetrating radar), 2) sub-surface patterns (shovel testing, ground-penetrating radar, and excavation), and 3) chronology (radiocarbon sampling). The following narrative synthesizes our most important findings about the organization of space, geomorphic context, and chronology of Mercadal that we then use in the discussion section to address issues of governance and collective action.

Organization and use of space

The surface survey and magnetometer results collectively highlight the complexity and occupational intensity of the inhabited portion of Mercadal. Sherd density is sparse at 0.01 sherds/m^2 and shows clear spatial patterning around architectural features and natural boundaries such as the edge of the bench. This points to biases in surface visibility and post-depositional effects on materials from the continuing movement of people, animals, and vehicles across the site, as well as the effect of slope and wind action (average wind speed is ca. 23 km/h with regular gusts over 60 km/h). We observed considerably more surface ceramics at contemporaneous sites we visited in the surrounding region not subject to the same level of movement or with less exposure to the elements. We do not think the ceramic material recovered at Mercadal offers a good basis for drawing inferences about intra-site occupation trends, given the quality of the material and the factors influencing its detectability.

The sherds recovered from Mercadal are almost exclusively common ware. This material is undiagnostic for manufacture, style, or decoration and was used from the Andalusian through early Modern periods. At best, we can state the ceramic surface material suggests use of the area since at least the Iberian period and concentrated use during the Medieval period that spans approximately 1000 years, so the sherds tell us more about the status of regional ceramic typology than site occupation.

Our interpretation of magnetometer signatures across Mercadal is primarily based on our familiarity with the magnetic properties of features encountered on sites like it until we can return to Mercadal and obtain confirmatory subsurface information (Kvamme 2003, 2008). The results reveal dozens of dipole (and monopole) anomalies across Mercadal, which are particularly common in the central and eastern areas of the site where most of the stone features defining room blocks are located. The 40 × 40 m survey block delineated in Figure 3 contains at least 13 clearly defined dipoles. Their diameters lie between 0.8 and 2.1 m with an average estimated depth of 0.5 m and an average estimated mass of 1.43 kg, and none of the axes through the center of each pole-pair is aligned with magnetic north (i.e., declined 0.91° E). This strongly suggests these dipoles represent hearths or other combustion features (Urban et al. 2019) associated with the extensive domestic occupation of the site. This inference is supported by the hearth discovered in Excavation Unit 2 (discussed below).

The blended, transformed Visualization for Archaeological Topography image or VAT (Crabb et al. 2023; Kokalj and Hesse 2017; Kokalj and Somrak 2019) highlights both the small-scale features and local geomorphic character of the landscape in and around Mercadal (Figure 4). The VAT is centered on the Ermita and reveals diverse convex and concave features that vary in scale, height, and orientation across a generally flat terrain with pronounced changes in microrelief. The stone courses that form walls and conjoined room blocks can be seen to cover large portions of the site to the northwest and the southeast of the Ermita. The residential portion of the site is encircled by a clear boundary that wraps around the eastern end of the site and consists of a water canal partially incised into the limestone bench.

The western and northern limits of the residential area of Mercadal are delimited by the natural edge of the limestone bench that consists of a sharp drop between 0.5 and 2 m in height with a developed talus slope. In all directions beyond the defined limits of the residential area are open agricultural fields with no fencing or hedges to impede the movement of people or animals. Individual parcels are defined by walking trails, accumulations of field stones, or dirt tracks that appear in the image as linear, triangular features with strongly contrasting light and dark slopes. The only trees evident in the VAT are a small natural grove within the site boundary defined by the canal and a small orchard (regularly spaced trees) to the southeast across the canal from the residential portion of Mercadal. The image strongly suggests both deliberate spatial planning and opportunistic use of natural terrain features.

Geomorphic context

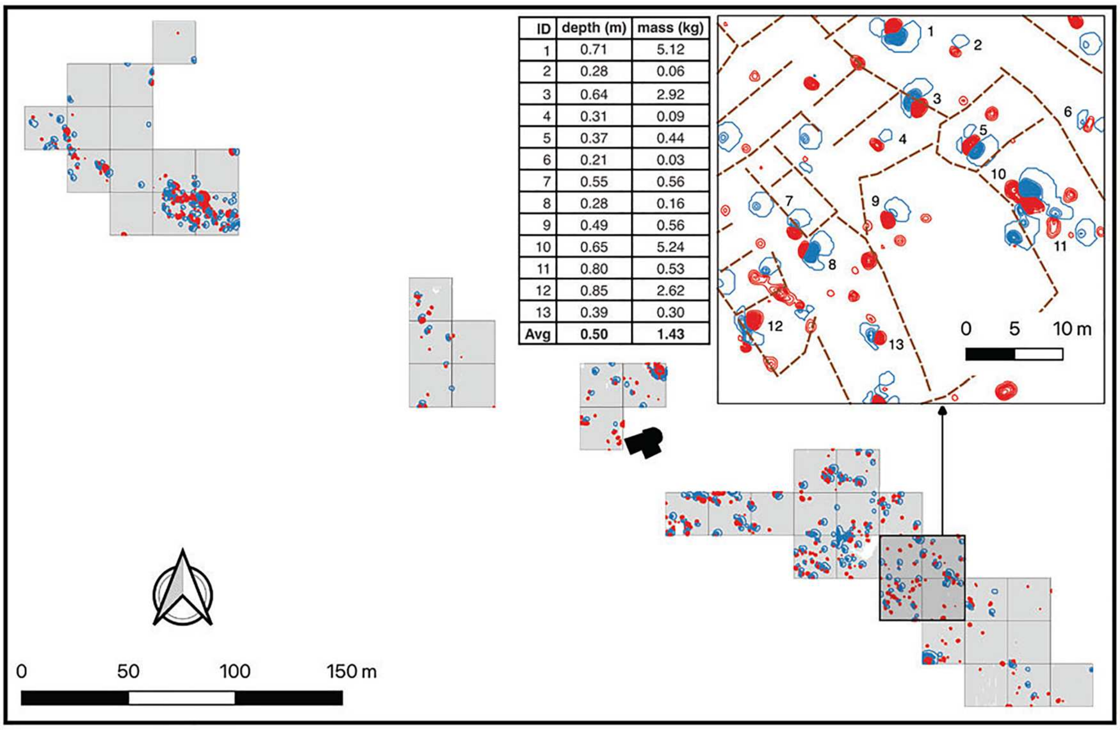
All our field observations indicate that the soil mantel over the site is thin, fine-grained, extremely dry, and compacted in places to the point of concretion. The subsurface stratigraphy varies significantly as a function of architectural activity that includes both building and artificial fill and site formation processes, including eolian action and dissolution of the karstic lithology of the bench. Several shovel test units passed through a carbonate illuviation zone at around 20 cm, after which the fine-grained sediments were unconsolidated and included a significant proportion of angular gravel. GPR results suggest, as would be expected, that the illuviation zone is more pronounced in open areas of the site than in protected areas.

All GPR profiles from all grids reveal columnar shadow zones, dipping planar surfaces, and stacked hyperbolas consistent with fractured and dissolving limestone. These are characteristic attributes of a temperate karstic carbonate environment, as currently prevails in the Ebro Basin (Ford and Williams 2007; Gracia Prieto and Gutiérrez Santolalla 1999; Nicod 2000; Salomon 2005). Sedimentary limestone is structurally continuous below the 200 cm profile depth, while the "shadowy" columnar spaces that merge with the attenuation zone likely represent areas undergoing dissolution. Karstic processes are particularly evident beneath the brick-paved floor of the Ermita nave (Figure 5A), nominally protected from ambient processes for ca. 1000 years. The GPR profiles from the nave show a strong initial planar ground response corresponding to the unmortised baked brick and tile floor; in some instances, individual bricks (ca. 10 cm in profile) are resolved. Beneath the bricks is ca. 20 cm of homogeneous fill with some layering likely representing individual loads of fill. A high amplitude planar reflection beneath the fill layer at ca. 30 cm spanning the width of all profiles beneath the nave represents an original baked brick or tile floor. In some areas, the floor was laid directly on bedrock, and in others, it was separated from bedrock by fill.

There is a high amplitude columnar feature (Figure 5B, y = 1.85 m) with a circular ca. 80 cm cross-section that extends vertically from 25 cm through the attenuation zone ca. 200 cm. The initial concave response displays a "bowtie" feature produced by complex travel paths of radar emissions expected in a narrow feature incised into the ground. The fill between the contemporary floor and the concave response is slumped, creating a small cavity with reverse polarity. The columnar feature below the initial response is composed of multiple stacked high amplitude hyperbolas with their axes arrayed in a fishbone pattern the length of the column. We interpret this evidence as indicating a brick- or stone-lined well shaft ca. 2 m in depth with a collared well-head, perhaps made of stone that projects above the original floor of the nave, suggesting they are contemporaneous. Those who dug the well likely took advantage of a dissolution column in the karstic lithology to capture artesian water.

There are two high-amplitude, reverse polarity hyperbolae indicating voids beneath the original floor of the nave (see Figure 5B, y = 1.9–3.65 m) that are ca. 75 cm long and span three adjacent profiles. The apices of the hyperbolae are at a depth of ca. 27 cm and crown through the original floor, indicating reflection signature "pull up" from the underlying void. Both hyperbolae create a break of ca. 80 cm in the original floor and extend down through approximately 50 cm of fill overlying bedrock. Centered beneath the apex of both hyperbolae are two adjacent high amplitude point reflectors within a homogenous, low amplitude matrix. We interpret these as two human burials that are structural homologues to the sealed burial uncovered in Excavation Unit 5 (discussed below) in which the cranium was held in place by two large cobbles.

We uncovered stratified cultural deposits, including compacted floors, tile and cobble collapse, and charcoal-rich ash layers in different excavation units, suggesting sustained use of the site over time. Unit 5 (Figure 6A) contains a stratigraphic sequence that transitions from a surface horizon with masonry and roof tile debris fill (UE 1) to an intact cobbled floor made of rounded stones ca. 15 cm in diameter (UE 2), characteristic of both the Medieval and Modern periods. The placement and elevation of the floor match that of the original sacristy floor, while the cobbled floor



ID	depth (m)	mass (kg)
1	0.71	5.12
2	0.28	0.06
3	0.64	2.92
4	0.31	0.09
5	0.37	0.44
6	0.21	0.03
7	0.55	0.56
8	0.28	0.16
9	0.49	0.56
10	0.65	5.24
11	0.80	0.53
12	0.85	2.62
13	0.39	0.30
Avg	**0.50**	**1.43**

Figure 3. Magnetometer survey results with ± 1 nT contours (red = neg., blue = pos.) centered on Ermita San Miguel (black). Inset in upper right corner lists attributes of 13 dipoles in a 40 × 40 m area (four 20 × 20 m survey units) in the eastern room-block area of the site.

was dissected by an early 19th century A.D. renovation that reduced the size of the sacristy and extended the narthex of the Ermita. Beneath the cobbled floor was a layer of fill (UE 3) containing fragmentary human remains that covered a partial, in situ articulated burial (UE 4) resting on dolomitic bedrock (UE 6) with a mean model-calibrated date of A.D. 1350 ± 30 (95.4%). The remains were in primary position and oriented southwest-northeast, matching the alignment of the Ermita. The cranium was positioned to the northeast and held in place by two large cobbles, one on either side; the lower extremities were truncated by the 19th century A.D. renovation work.

Excavation Unit 2 (Figure 6B) was placed to characterize the walls defining interior spaces of residential room blocks. These walls are ca. 1 m thick and made of large cobbles held in place with mud mortar into which small, irregular stones were inserted. The cobbles were not placed with any regularity and resemble the Roman *opus incertum* construction technique (Mogetta 2021) consisting of irregularly shaped and randomly placed uncut stones. The irregularity of the wall face in Excavation Unit 2 suggests it might have been surface treated, although we did not recover any evidence for this. The conjoined rooms were built into a terraced slope, indicating that planning went into their construction, since the walls defining inhabited interior spaces doubled as soil retention walls. The living surface of space #1 and the adjacent alleyway are at approximately the same elevation and ca. 70 cm higher than the living surface of space #2. The small volume of cobble remains suggests the walls were finished to a livable height using adobe and/or wattle and daub, but again, we found no evidence of superstructure during the excavation. The alleyway between the walls, as well as the living surfaces defined by them, consists of a fine, red sediment with small, embedded pebbles and scattered charcoal fragments. In space #1, we exposed a small, double hearth abutting an interior wall with sherds from a single, small Medieval pot and charcoal we radiocarbon dated that indicate a use-date of A.D. 1350 ± 30 (95.4%).

Chronology

Our present chronology is based on a limited number of radiocarbon samples, although we are currently processing additional samples obtained in December 2024 that we will use to improve our site chronology. The Kernel Density Estimation (Figure 7A) (Bronk Ramsey 2017) indicates a distinctly bimodal temporal distribution of dated events at Mercadal between A.D. 770 and 1520. Our first-order Bayesian bounded phased models (Bronk Ramsey 2009) provide unanticipated details about the duration of site occupation anchored by critical historical events from the end of the Visigothic (ca. A.D. 712) through the beginning of the Modern period (ca. A.D. 1600), as contained in the waterfall plot (Figure 7B) that shows the overall model structure, as well as the prior and posterior distribution of dates. We also developed a simple Bayesian bounded-phase model with dates obtained from excavation units 2, 4, and 5 (Figure 8).

Discussion

The integrated and multilayered approach we used at Mercadal demonstrates the multiplicative advantages of bringing independent lines of evidence together to address the organization and use of space, geomorphic context, and occupation chronology of the site while also complementing what is known or speculated about the occupation of the site from archival sources. It simultaneously positions our case study in the broader archaeological concern with understanding the settlement history of individual sites and regions (Bourin and Durand 2000; Cobb et al. 2023; Dyer 2010; Quirós Castillo 2009; Thompson et al. 2018).

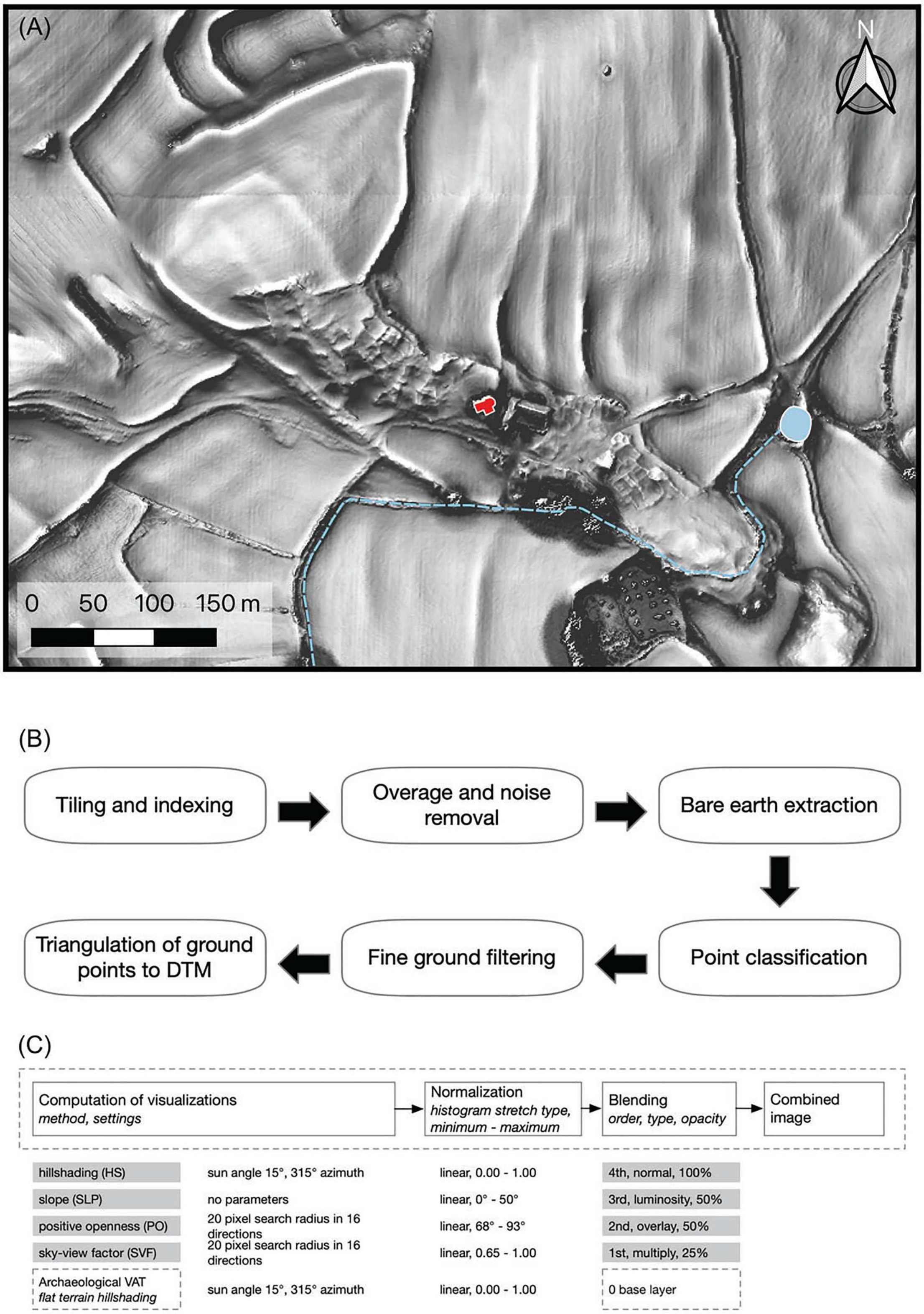


Figure 4. Visualization for Archaeological Topography (VAT) image and processing steps. A) VAT of Mercadal and its context characterized by pronounced changes in micro-relief. B) Lidar pre-processing workflow from raw point cloud to Digital Terrain Model (DTM). C) Schematic VAT workflow with steps, variables, and settings for producing the Mercadal VAT.

The first record of Mercadal as an inhabited village is in the A.D. 1280 *Rationes decimarum hispaniae*, a church tithing account book (Rius Serra 1947) that indicates the village was under the ecclesiastical care of the archbishop of Belchite. However, our radiometric chronology indicates that Mercadal had a much longer and more complicated occupation trajectory. For our Bayesian two-phase bounded model, we used a TPQ (terminus post quem) of A.D. 790 ± 10, corresponding to the increased regional importance of the city of Daroca during the Al-Andalus Period, and a TAQ (terminus ante quem) of A.D. 1495 ± 10 to match the date archival documents indicate that Mercadal was officially abandoned. Phase 1 spans A.D. 805–1150, and Phase 2 spans A.D. 1160–1490, corresponding respectively with the locally defined Islamic and Christian portions of the Iberian Medieval period. The modeled transition between the two

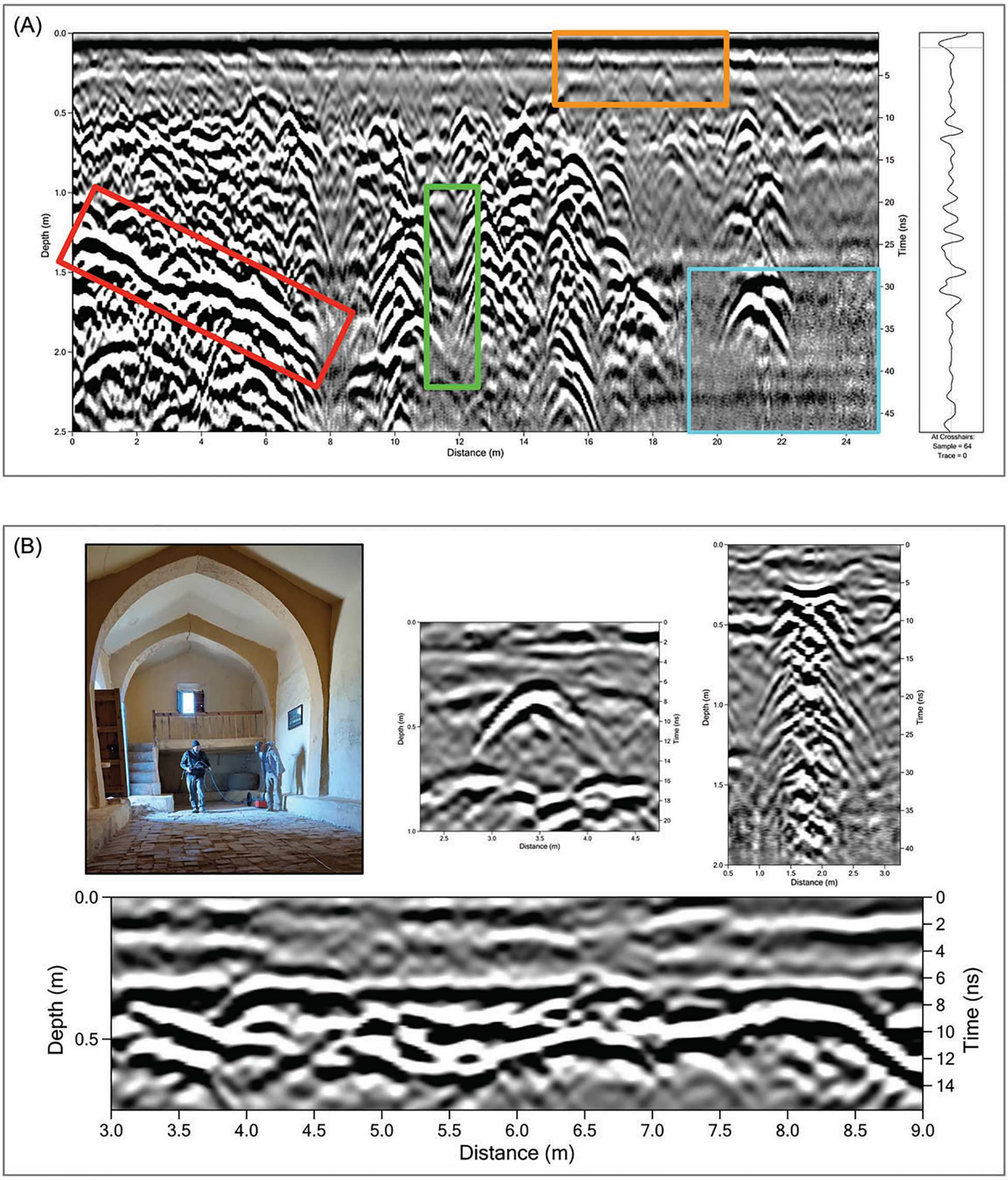


Figure 5. Selected GPR results. A) Grid 2, profile 33 (open-air site): red box delineates a dipping bedrock layer; green box delineates a dissolution zone within the bedrock; orange box outlines illuviation boundary and unconsolidated fill over bedrock; cyan box encloses transition to the attenuation zone. B) GPR results from the nave of Ermita San Miguel de Mercadal (Grid 4): upper left photograph shows GPR survey in process; upper center image is a reflection profile of one of two human burials showing paired headstones; upper right image is the reflection profile of the artesian well. Reflection profile at the bottom shows the contemporary floor at 0 ns, followed by a fill layer between ca. 1 and 5 ns and the original floor at ca. 6 ns.

phases spans A.D. 1050–1205, which aligns with the period of increased political instability and military conflict in this region that begins with the fall of the Caliphate of Cordoba in A.D. 1031 and ends with the A.D. 1162 ascension of Alfonso II of Aragon to the Crown of Aragon, a composite monarchy.

The active karstic lithology characteristic of the Ebro Basin has and continues to shape the cultural and geomorphic history of the region and the site of Mercadal. Ground penetrating radar, coring, and geological profiles indicate the residential portion of Mercadal was located atop a limestone bench of fractured clints and infilling grykes that channeled sediment into dissolution features, creating a complex and localized hydrostratigraphy. The southern boundary of the residential area of Mercadal is defined by an earthen canal. The canal connects a natural year-round spring less than 1000 m from the residential area, Fuente de Mercadal, to a doline (a closed depression, Balsa de Mercadal), also fed by groundwater flow and located on a small dolomite outcrop at the terminus of the bench Mercadal is

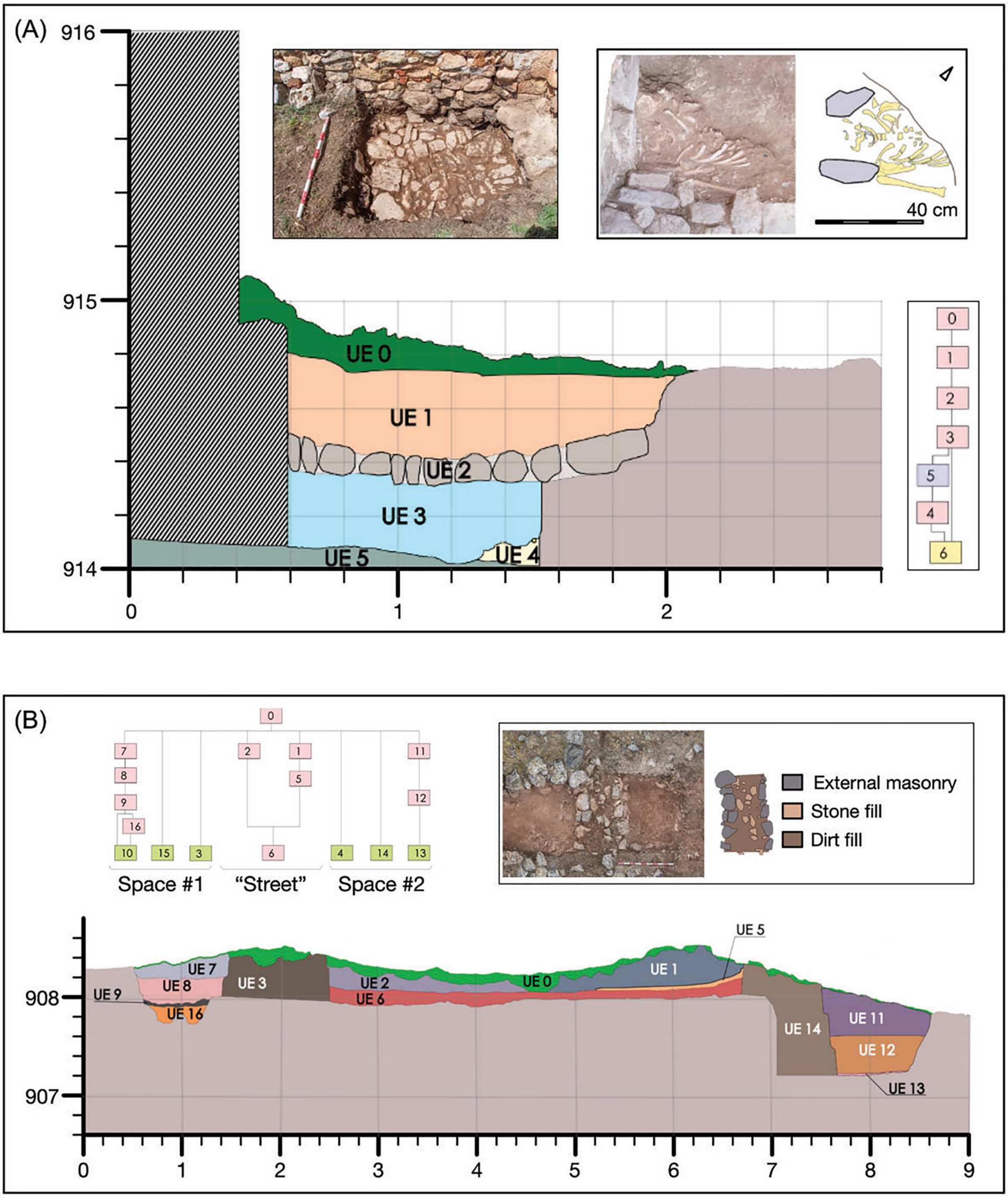


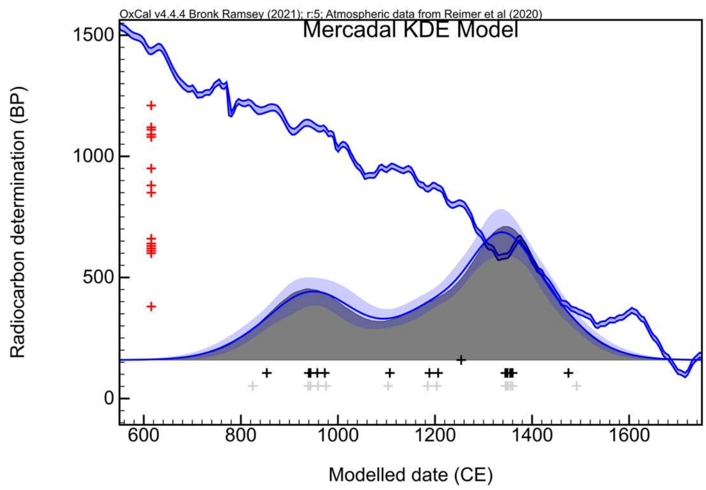
Figure 6. Visual details of A) Excavation Unit 5 and B) Excavation Unit 2, including their stratigraphic sequences, Harris Matrices, and planimetric images described further in text.

located on. The Balsa retains an estimated year-round volume of ca. 1000 m^3.

The Balsa and the network of secondary canals branching from the main canal connecting it to the Fuente are currently used to irrigate agricultural fields bordering the site, as well as an oak-truffle orchard on a nearby slope. This region is characterized by an inland Mediterranean climatic regime, in which water constitutes a critical resource for contemporary agropastoral production. Mercadal was occupied during the Medieval Climate Anomaly (A.D. 800–1300) (Lüning et al. 2019) and throughout much of the Little Ice Age (A.D. 1300–1850) (Shindell 2009), strongly suggesting that water has been a vital resource for local inhabitants since the village's founding. Doline lakes in mid-elevation zones of the Ebro River Basin, geomorphologically analogous to the Balsa de Mercadal, preserve continuous sedimentary records documenting human agropastoral activity in the region over the past 2000 years. These records provide clear evidence that communities across the region successfully managed water resources over the long term (Barreiro-Lostres et al. 2017; López-Blanco 2013; Romero-Viana et al. 2009; Valero-Garcés et al. 2014).

The founding of Mercadal and other villages in southern Aragon have long attracted the interest of historians, since

(A)



(B)

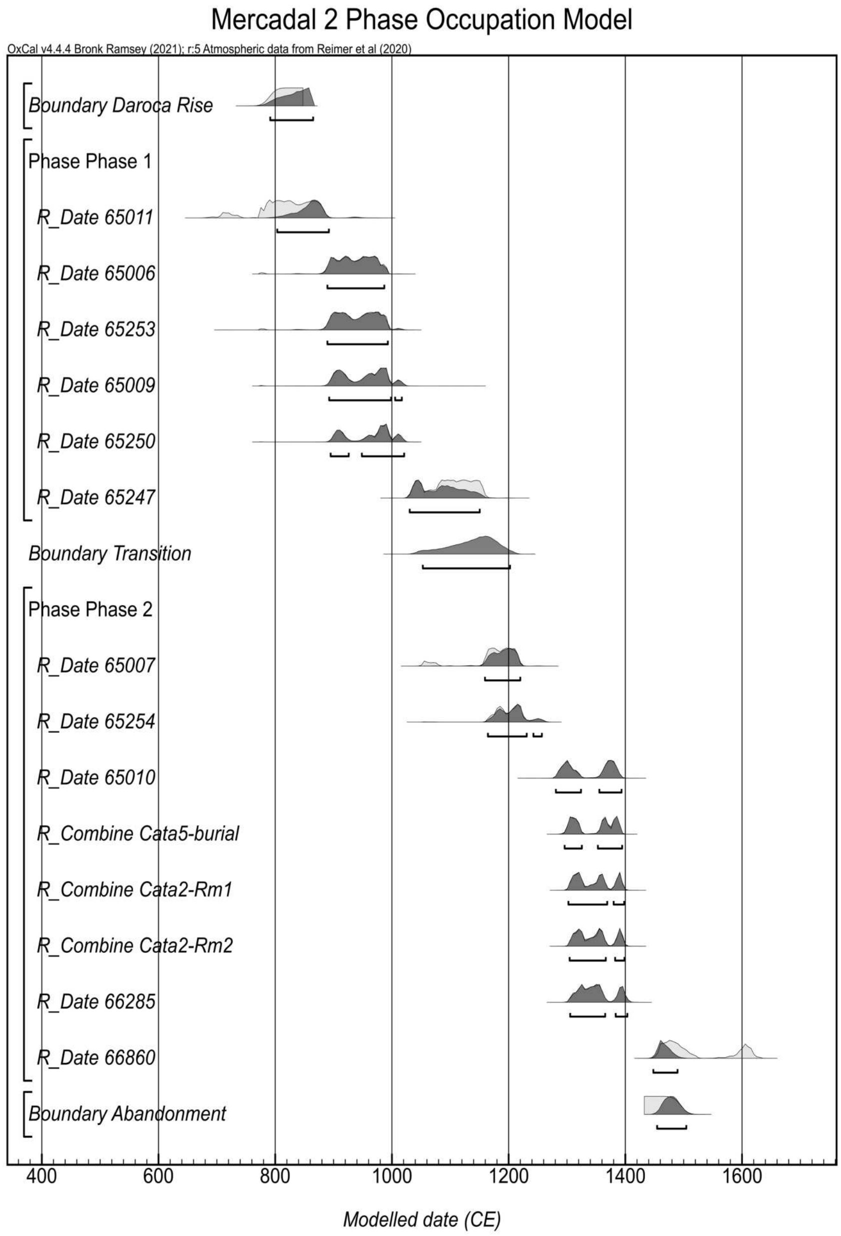


Figure 7. Radiocarbon results. A) Kernel-Density Estimate (KDE) summarizing 18 radiocarbon dates using the OxCal function KDE_Model with default parameter values. The estimated distribution (dark gray), blue line, and blue band show the mean ± 1 sigma for snapshots of the KDE distribution during the Markov Chain Monte Carlo (MCMC) process. Red crosses (y-axis) are central values of the simulated ^{14}C dates on the relevant section of the IntCal20 calibration curve. Black crosses (x-axis) are medians of the posterior distributions; light gray crosses are the medians of the likelihood distributions from the simulated ^{14}C measurements. B) Waterfall diagram of the 2-phase occupation model for Mercadal.

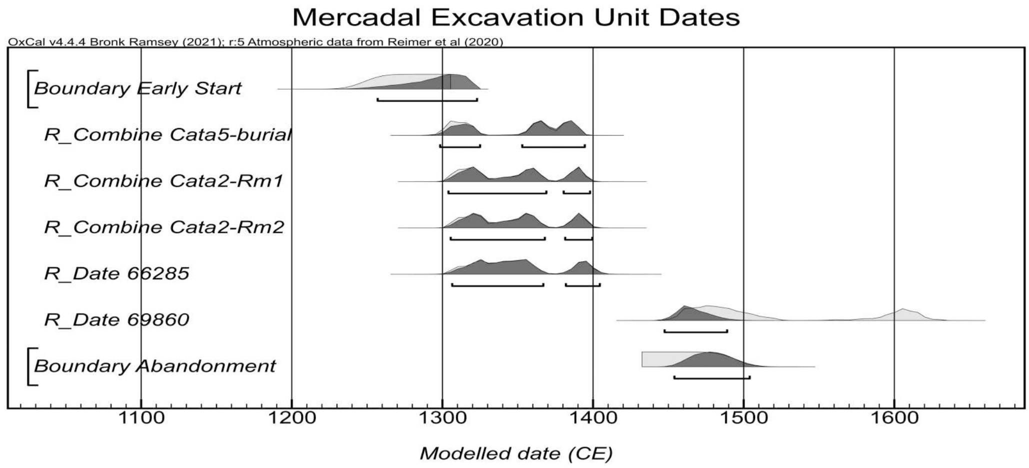


Figure 8. Modeled radiocarbon dates from Excavation Units 2, 4, and 5.

they lie in one of the first regions taken through conquest by Alfonso I "The Battler," King of Aragon and Navarre (A.D. 1118–1134) from Islamic Party-Kings (Wasserstein 1985). Until recently, little attention was given to the period of Islamic rule in Spain from A.D. 711–1492, as it was viewed as an interruption of the Christian continuum of the country initiated by the Visigoth. Villages like Mercadal were assumed to come into existence when Christian kings encouraged immigration of Christian settlers from France following a conquest event deposing a local Muslim ruler. The support for this hypothesis typically rested on place names with Basque-like or Occitan-like word stems and isolated finds like a grave marker in a style common to the Pyrenees region (Rubio 2013; Simón Domingo, Loscos Pastor, and Martínez Andrés 1992). There is no architectural history of the Ermita San Miguel de Mercadal, yet its construction is assumed to have occurred in the 11th or 12th century A.D. during the Christian conquest of southern Aragon, as it resembles other rural Romanesque style churches in Spain built approximately from the late 10th–13th century A.D.

First contact between Islamic troops and the Visigoths who then ruled the Iberian Peninsula took place in A.D. 675 on the central Mediterranean coast near the contemporary city of Cartagena (founded ca. 227 B.C.). In A.D. 711, Mūsa ibn Nuṣayr met the Visigothic army at the Battle of Guadalete where Roderick, King of the Visigoths, was killed. Within four years, Islamic forces took control of large portions of the Iberian Peninsula, then fragmented among Visigoth and Hispano-Roman nobleman independently controlling deteriorating urban spaces (Laliena Corbera 2009). The Islamic takeover of the Iberian Peninsula was also facilitated by a near-simultaneous abandonment of many rural settlements across the Peninsula attributed to broader social and economic transformations unfolding across the European sub-continent (Vigil-Escalera Guirado 2011). We hypothesize that Mercadal (and other period villages in the region) were founded in an "empty quarter" as the Umayyad Caliphate of Cordoba expanded its control of the Peninsula (Wasserstein 1985). The expansion mirrored the governance and resource management systems that emerged across Europe with the advent of low-input farming regimes, the expansion of towns and markets, and the rise of lordships between A.D. 800 and 1200 as conditioned by the Islamic power structure in Iberia (Bisson 2009; Duby 1954; Hamerow et al. 2020; Wickham 2005).

The Ebro Valley was the Upper March (*al-Ṯağr al-Aʿlā*) of Al-Andalus during the Caliphate of Cordoba against the Frankish Kingdom expanding south across the Pyrenees Mountains from Roncevaux and Narbonne at opposite ends of the mountain chain. There were also numerous internal uprisings against the caliphate between the 9th and the middle of the 11th century A.D. by Muslim (Arab, Berber, Yemeni, and Syrian) and Muladi (Hispano-Visigoth converts to Islam) clans and tribes vying for territorial control of the Upper March (Brufal 2017; Coope 2020). Muladi prevailed when Fortūn ibn Mūsa of the Banū Qasī joined the A.D. 802 rebellion and numerous subsequent uprisings against Emir al-Hakam I. Fortūn ibn Mūsa was a descendant of Cassius, a Hispano-Roman nobleman who converted to Islam after the Muslim Conquest whose son—Mūsa ibn Mūsa ibn Furtūn ibn Qasī—was appointed *wālī* (a political/military governor appointed to oversee an administrative province) of Saragossa (now Zaragoza) and the Upper March in A.D. 852.

Mercadal is in the hinterland of Daroca that by A.D. 837 was a city of some importance in the developing Islamic urban-rural governance-production system in Al-Andalus and a central node in the settlement of the Upper March. In A.D. 890, Emir Abd Al·lāh encouraged the Banū Tuğib Arab family to settle in Saragossa to weaken Muladi control of the regional administration. He also sponsored reconstruction of fortresses across the Upper March, including Daroca (Jiménez Lorenzo 2010). Over time, the Banū Tuğib consolidated their authority, becoming a powerful dynasty whose control of urban government and rural production sustained the *taifa* of Saragossa that emerged ca. A.D. 1010 during the political fragmentation preceding the dissolution of the Caliphate of Cordoba in A.D. 1031. A taifa was an independent Muslim principality, most of which formed after the collapse of the Caliphate in A.D. 1031. Historical sources document rulers for at least 38 taifa that individually existed between a few years and several decades and several short-lived local regimes in which a minor ruler or military strongman controlled a fortress and its surrounding territory (Wasserstein 1985).

During the Caliphate's expansion beginning in the 9th and especially the 10th century A.D., substantial numbers of rural farming settlements with diverse domestic buildings, land parcels, and wells collectively termed *alquerias* were established across the Ebro Valley (Brufal 2013, 2017; Laliena

Corbera 2009; Laliena Corbera and Ortega Ortega 2010). These rural farming settlements were in the lower portions of the landscape and alternated with defensive fortresses on strategic high points (Balañà i Abadia 2002; Brufal 2017; Laliena Corbera 2009). The settlement model was based on proximity to major and minor watercourses, humid areas, and the management of wells and springs that served the local needs of irrigated agriculture, dry-land farming, and livestock pasturing combined with selective use of nearby mountain pastures. The troops stationed in fortresses provided protection for the inhabitants of surrounding alquerias and controlled the collection of taxes while monitoring movement over roads and across fords. High-resolution natural archives from doline lakes indicate that low- to mid-elevation mountain areas in the Montes Universales, ca. 140 km south of Mercadal, were important to Andalusian agropastoral production (López-Blanco 2013; Romero-Viana et al. 2009).

At the end of the 11th century A.D., the geographical focus of the Christian conquest shifted from the southern slopes of the Pyrenees Mountains to the central Iberian Cordillera. As the Christian kings increased the number and intensity of raids on rural places under Islamic rule, many of these places were abandoned (Sénac 2009). The situation was more complicated than merely Christian antagonism toward Muslims. The kings of Aragon and Castile were allied against the taifa Party-Kings on the southern borderlands of their respective kingdoms yet competed against each other on the shared border between their kingdoms. In A.D. 1086, the Almoravid crossed the Straits of Gibraltar and, over the next two decades, incorporated most of the independent taifas into the Almoravid Empire while competing for land with the kingdoms of Aragon and Castille.

The Bearnese, Gascon, Aragonese, Navarrese, Biscayan, and Catalan troops that helped King Alfonso I capture Saragossa in A.D. 1118 continued with him on his march south of the Ebro River, entering the lands where Mercadal is located. Their objective was to capture fortified cities like Daroca in the Upper March so King Alfonso I could control the trade routes to the coastal taifa of Valencia. The Almoravids sent an army to halt the Christian advance, and the contingents met in Cutanda on June 17, A.D. 1120. The battle ended in a major victory for King Alfonso I and was followed by another victory at Calatayud on June 24 (Corral Lafuente 1987). By A.D. 1120, King Alfonso I had extended the territory of the Kingdom of Aragon from the Pyrenees Mountains in the north across the Ebro River to the Jalón and Jiloca Rivers in the south. The newly conquered lands were consolidated by the middle of the 12th century A.D. when the Crown of Aragon was formed by the dynastic union of the Kingdom of Aragon and the County of Barcelona.

We have a rare insight into the landscape surrounding Mercadal from this time from the Charter of Montfort (Bofarull y Mascaró 1847) that gives evidence the area was under Christian control by A.D. 1157. The charter provides names for several castles, landmarks, and roads in the area and makes note of an unnamed hamlet adjacent to a place called Castillejo. From other sources, we know Castillejo refers to a 12 m tall human-modified mound 1.6 km due south of Mercadal and separated from it by open agricultural fields. Local lore says that Castillejo was initially used as an Iberian hillfort and subsequently a fort or lookout for Roman then Islamic troops. It is unquestionably the present location of the Ermita Santa Agüeda that is an architectural homologue to the Ermita San Miguel of Mercadal.

Following King Alfonso's successes at Cutanda and Calatayud, he treated the city council (*universitas*) of Daroca as a feudal lord and disposed on it a territory (*alfoz*) of ca. 10,000 km^2 along with the authority to manage the land and the villages within it (Allué Andrés 2018; Corral Lafuente 1987). An A.D. 1205 document contains a list of 107 villages within this territory. Mercadal is not listed, yet other documentary evidence from the territory suggests the village did exist and was included in the alfoz. For unknown reasons, in A.D. 1258, King James I of Aragon granted the villages within the alfoz of Daroca autonomy from the city council and allowed them to form a novel property regime called a *comunidad de aldeas*. This was the first of four such property regimes formed during the Medieval period in southern Aragon (Corral Lafuente 1984).

In modeling the radiocarbon dates from Excavation Units 2, 4, and 5, we set the TAQ to A.D. 1495 ± 10, marking the official abandonment of Mercadal, and set the TPQ to A.D. 1250 ± 10 to correspond to the year the Comunidad de aldeas of Daroca was established. The individual dates for excavation units 2 and 5 indicate a use-date centered on A.D. 1350 ± 30 (95.4%), while the aggregate of the dates directly associated with the Ermita from excavation units 4 and 5 suggest a construction date no later than between A.D. 1295 and 1395 (95%).

The Comunidad de aldeas of Daroca covered 3,500 km^2, and the villages were organized into five districts (*sesmas*) named for a prominent natural feature (Figure 9A). By A.D. 1300, the Comunidad de aldeas of Daroca was organized into a quasi-sovereign spatial holarchy (Ferber, Gutknecht, and Michel 2004; Horling and Lesser 2005; Wooldridge 2009) with specific responsibilities to allocate, organize, and manage land and resources to meet community needs and produce commodities for exchange in the emerging Mediterranean market. The Concordia of A.D. 1559 provides spatial and physical details for 203 wood-pastures (*dehesas*) within the territory of the Comunidad used in commodity production (Allué Andrés 2023); place-based agents within the organization of the Comunidad and with the appropriate expertise were responsible for managing local resources and residents. While the chain of command within the Comunidad de aldeas of Daroca was upward, household-to-household, village-to-village, and district-to-district alliances were allowed and encouraged, resulting in a web-like organizational structure that flexibly changed shape over time as needs and demands shifted.

The Comunidad de aldeas of Daroca (and the other comunidades in the region) enabled member villages to scale their responses by location and context to mitigate the risks from recurring macro-climatic, socio-economic, and political changes that characterized the Medieval period (Catalan 2020; Franklin-Lyons 2022). There are hints but no substantive evidence yet that this property regime was scaffolded onto a system that developed during the Andalusian period. Whether the system originated after the Christian conquest of this region or was built on an older Andalusian system, Mercadal and the other rural villages that were members of the Comunidad de aldeas of Daroca developed over time a property regime that ensured remarkable resilience to known episodes of crop failure and famine in Aragon.

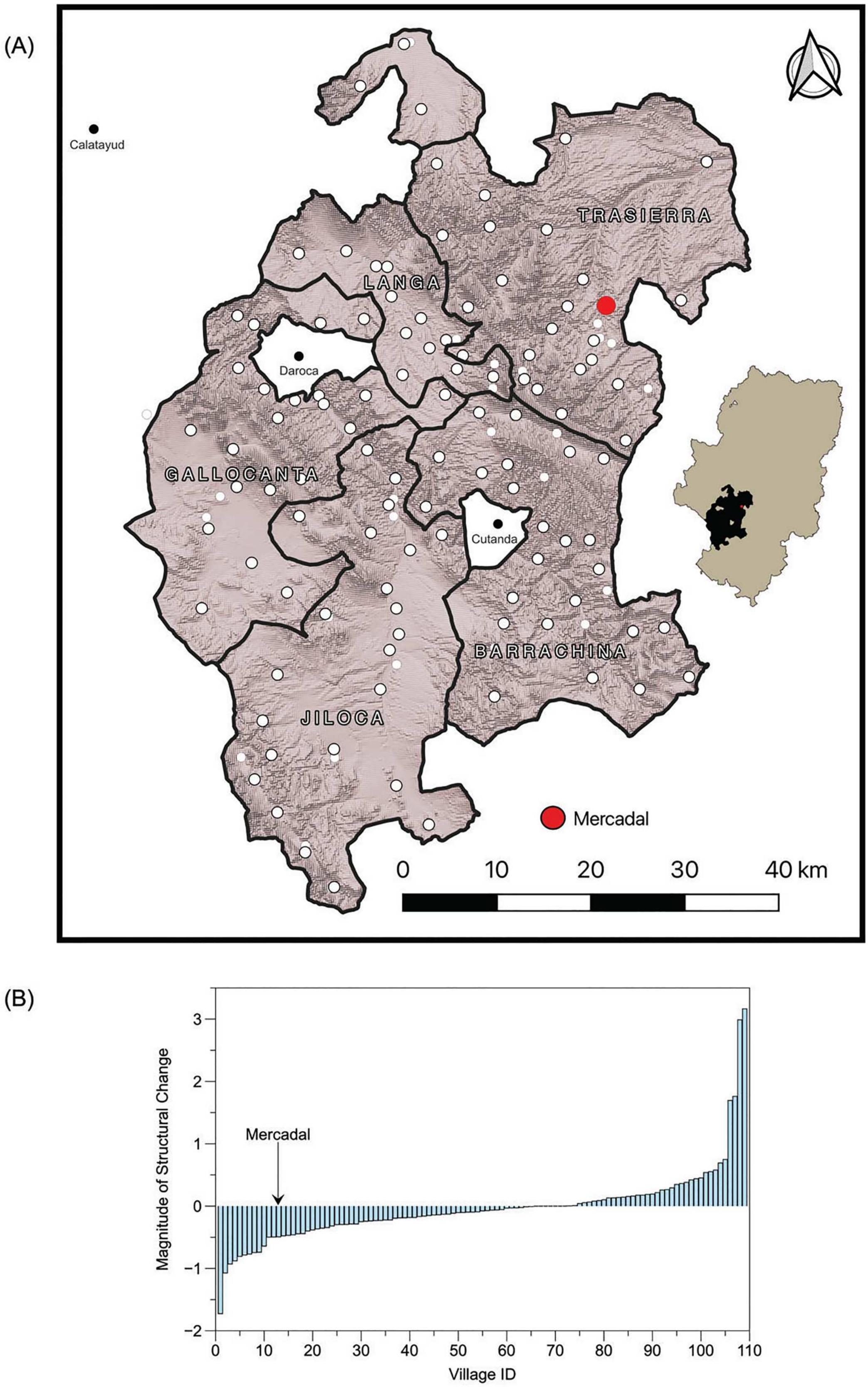


Figure 9. Comunidad de aldeas of Daroca ca. A.D. 1300. A) Sesmas and villages within the Comunidad de aldeas of Daroca over a Digital Elevation Model of the area, with the cities of Calatayud, Daroca, and Cutanda mentioned in text. B) Magnitude of structural change in settlement size between A.D. 1373 and 1495 of villages within the Comunidad de aldeas of Daroca based on the Relative Size Index.

Tax assessments of the villages within the Comunidad based on *monedajes* (a coinage tax), *puestas* (a village tax), and *fogajes* (a hearth tax) for the years A.D. 1373, 1389, 1400, 1414, 1489, and 1495 indicate that Mercadal never had a large population and progressively lost inhabitants over the course of the 15th century A.D. (Allué Andrés 2018; Arroyo Ilera 1974; Corral Lafuente 1987; Crespo Vicente 1998; Lezaun y Tornos 1990 [1778]; Serrano Montalvo 1995; Ubieto Arteta 1985). To develop a preliminary measure of how demographically similar or different Mercadal is to village trends in the Comunidad de aldeas of Daroca, we converted tax values between A.D. 1373 and 1495 to estimated population equivalents (monedaje = 1:1; puesta = 1:16; fogaje = 1:5) then normalized the values by dividing them by the mean population for the tax year. This provided us a dimensionless Relative Size Index (RSI) with a yearly mean of 1 that preserves within-year settlement size differences while removing structural differences between tax years. Mercadal underwent structural change between A.D. 1373 and 1495, yet the size shift was not uniquely dramatic relative to the full range of variation among villages belonging to the Comunidad de aldeas of Daroca (Figure 9B).

No discrete reason for the abandonment of Mercadal has been uncovered, although various documents indicate the village faced several difficulties during the 15th century A.D. (Allué Andrés 2017, 2018). On November 7, A.D. 1415, Mercadal received compensation for hail damage, and on November 16, A.D. 1446, it received a refund for tax overpayment when it was realized the number of inhabitants had decreased since the previous assessment. An entry dated August 21, A.D. 1464, states the residents were having difficulty paying their tax due to property damage and the theft of livestock by Castilian and French rustlers. The final tax assessment of Mercadal in A.D. 1495 recorded a single village resident and declared the village officially abandoned. Twenty-six of the 107 villages listed on the A.D. 1205 document, as well as Mercadal, were abandoned over the subsequent two centuries, even though most of the listed villages remain inhabited to this day (Allué Andrés 2018).

There is reason to believe cattle rustling, as well as conflict over access to resources within the territory of the Comunidad de aldeas of Daroca, was a systemic problem faced by many of the villages. Several documentary lines of evidence indicate the Comunidad de aldeas of Daroca was in a long dispute with the Casa de Ganaderos of Zaragoza over access to wood pastures within the territory of the Comunidad. The first indicators of the dispute date to the early 14th century A.D., and they increase in number and intensity in the following years until an agreement was finally reached in A.D. 1559 (Allué Andrés 2023).

Rather than an abrupt abandonment as might ensue from a disease or a royal decree, Mercadal underwent a slow, steady decline in the number of its inhabitants, suggesting a local demographic/economic problem. Perhaps the resident population was past the age of reproduction or the lack of amenities failed to attract or retain reproductive age adults. Located on the northeastern boundary of the Comunidad de aldeas of Daroca, perhaps Mercadal was subject to disproportionate conflict with non-members seeking access to resources within the village commons. What is likely true is that the slow, steady decline in the number of Mercadal residents evident from the tax records would have circumscribed the ability of the community to self-govern under the operating principles of the Comunidad de aldeas property regime. A question we are now separately working on answering is why some villages within the Comunidad de aldeas of Daroca survived and others did not during Aragon's greatest period of economic prosperity (Benedicto and Boñilla 2010; Gual Camarena 1967).

Evidence from period documents and the RSI-based population assessment indicate variations in the timescale that villages increased or decreased in size, pointing to differences in local circumstances rather than a universal force simultaneously affecting all villages. In the case of Mercadal, our present evidence indicates what is best described as strategic residential abandonment with retention of control over resources within the territory of the former village. This situation can be inferred from period documents and is observable among current residents of the village of Loscos (an original member of the Comunidad) who continue to use the agropastoral lands surrounding Mercadal and express a social identity resting on the Ermita and the residential area of the site. There is no substantive difference to what has been inferred and reported in homologous prehistoric to present situations in other areas of the world (Cobb et al. 2023; Coughlan and Gragson 2016; Lillios 1993; Nelson and Schachner 2002; Quintas-Soriano, Buerkert, and Plieninger 2022). From our integrated approach to the occupational trajectory of Mercadal, we can say that from its onset ca. A.D. 850 through its final abandonment ca. A.D. 1495, residents were not merely victims of misfortune, they were active participants in the life and death of their community.

Conclusion

Our investigations in Mercadal and the region are beginning to provide answers to the questions we posed in the introduction about collective action, governance, and the management of resources. In December 2024, we systematically sampled magnetometer anomalies and collected soil and radiocarbon samples at Mercadal with the purpose of validating the organizational, geomorphic, and chronometric results presented in this article. We are also compiling and analyzing documentary and spatial information for the Jiloca Valley that we conceptualize as a natural laboratory for examining how small-scale, recurring decisions about irrigation, commons management, land allocation, and settlement scale over time into the durable socio-ecological patterns still visible today. As noted by Dyer and Jones (2010), the study of abandoned villages that began with a seminar at Cambridge in 1948 continues to inspire exploration of fundamental questions about landscape, material culture, and society.

Our results provide a window on more than a millennium of place-based human-environment interactions, governance, and resource management in the Ebro River Basin that continues into the present even though Mercadal was abandoned ca. A.D. 1495. The village area and the agropastoral lands surrounding it never stopped being used by area residents. The property regime represented by the Comunidad de aldeas of Daroca and others in southern Aragon are homologous to such systems elsewhere in Europe (Agnoletti 2007; Bordessoule 2007; Clément 2002; Couturier 2000) that enable members to collectively manage mosaics of forests, croplands, pastures, and infrastructure across large territories. The unique operating principle of these varied systems is that individual/household interests are balanced against collective obligations through formal rules, periodic assemblies, and material boundaries, generating resilient socio-ecological configurations that endure for centuries, elevating the importance of place-based decision-making at the nexus of micro- and macroscale change.

The Medieval charters of privileges granted to autonomous entities, including the city council of Daroca and the Comunidad de aldeas of Daroca, were dissolved by the A.D. 1837 constitutional reform of the Crown of Aragon. Nevertheless, the principles of cooperative and collective behavior expressed in these charters of privileges carry through in contemporary Aragonese Civil Law (*derecho foral*). Some authors state these principles are the very foundation of the modern European culture of governance (Molho 1964; Speed 2016), providing a robust bridge between archaeology and ecology (Crumley 2021) that informs contemporary practices in socio-ecological conservation (Hayashida 2005; Shriver-Rice, Schneider, and Pardo 2022). Like many rural areas around the world, southern Aragon is undergoing abandonment as residents move temporarily or permanently to surrounding urban centers. Abandonment of Mediterranean lands has less to do with macro-regional attractors and more with indirect local drivers, including social behavior, cultural values, and policy effectiveness (Bliege Bird and Nimmo 2018; Manzano et al. 2021; Martín-López et al. 2019; Quintas-Soriano, Buerkert, and Plieninger 2022; Ustaoglu and Collier 2018).

From a policy standpoint, land abandonment is not an "agricultural problem" that can be fixed by development but a "recognition problem" requiring greater attention to the role of place-based people in ecosystem function (Bliege Bliege Bird and Nimmo 2018; Manzano et al. 2021; Martín-López et al. 2019; Ustaoglu and Collier 2018). Spanish law and EU ordinances (Aragón 2011; Bunce et al. 2006; Gómez Sal and Lorente 2004; Hatfield and Davies 2007) are relatively unique, recognizing provisioning, community identity, and traditional ecological knowledge in maintaining (or re-wilding as appropriate) landscape connectivity, seed dispersal, fire prevention, soil fertility, and biodiversity conservation (Bagella et al. 2014; Navarro and Pereira 2015; Peco, Sánchez, and Azcárate 2006). What is still required is taking account of individual practices, providing support to communities that individuals depend on, and scaling local responses up to, regional resilience of recognizable, not abstract, social-ecological systems (Dolton-Thornton 2021; Graskemper, Yu, and Feil 2021; Valujeva et al. 2022). This is the hard work on middle-range, empirical issues described by Smith (2021) that depend on giving equal attention to the theoretical *and* practical ambitions of archaeology so that it can remain relevant to global concerns and other disciplines.

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Disclosure Statement

No potential conflict of interest was reported by the author(s).

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