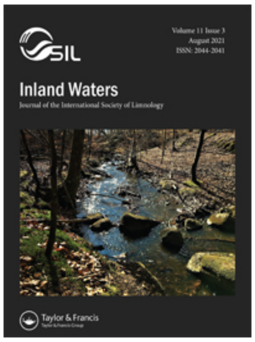

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ABSTRACT

Paleo-wetlands have fragmented in archaeological times associated with human stressors. We present an interdisciplinary analysis of a past temporary paleo-wetland located at an important junction between the valleys of the Rivers Guadalquivir and Guadalimar in the province of Jaén (Eastern Andalusia, Spain). We applied a high-resolution protocol to identify the paleo-wetland used for ritual purposes during the Iron Age. Based on archaeological excavations and analyses (soil micromorphology, pollen and phytoliths analyses, optically stimulated luminescence [OSL] datings, and other techniques), we found a palaeosoil formed in a wetland environment active during the Late Holocene, dating back to the 9th century AD.

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archaeological analysis; phytolith analysis; pollen analysis; ritual landscapes; soil micromorphology

Introduction

Study of the imprint of past societies on the landscape is a target of archaeological research. In past decades, the application of methods and techniques from earth sciences to the archaeological record has enriched our comprehension of how humans lived and conceptualised global landscapes. These methods include geophysics, remote sensing and georeferencing techniques, geomorphological studies, soil analysis, palaeoenvironmental techniques, and dating methods, among others. This interdisciplinary approach can be important for ephemeral wetlands that were spaces of ritual during prehistory and protohistory (French 2003, Livarda et al. 2018). Water-related features in the landscape such as wetlands, swamps, lakes, and rivers were recurrent sacred places for depositing offerings that left material evidence in the archaeological record. Recently, the cultural use of landmarks in the Iron Age landscape in Spain has been studied to analyse how societies have historically identified with their surroundings (Orejas et al. 2002, Grau 2019).

The aim of this work was to present the study of an Iron Age ritualistic space located in an ancient wetland, the Iberian sanctuary of Haza del Rayo (Andalusia, southern Spain; Fig. 1). We explored the archaeological, sedimentary, and paleobotanical records through a wide range of methods and techniques: microsurveying and georeferencing of the archaeological items and ritual offerings (bronze figurines); photogrammetry of the archaeological site and the sedimentary sequence; soil micromorphology to understand the sedimentary formation and evolution of the paleo-wetland; and finally pollen and phytolith analysis to explore the remnant vegetation.

Study site and methods

Interdisciplinary archaeological methods (detailed later, see Supplemental Material Fig. S1) allowed us to document the ritual dynamics. Microspatial studies (surface archaeological microsurvey and archaeological excavation) made it possible to delimit the extinct wetland. The generation of a digital terrain model and a high-resolution digital orthophotograph from a photogrammetric unmanned aerial vehicle (UAV) flight was complemented by historical aerial photography of the site. From the earliest record available (American Flight of 1946), an imprint of the clayey sediment from the extinct and inactive wetland was identified (Fig. 1). The subsequent historical aerial photographs (1956, 1979, and 1986) show how the site remained nearly

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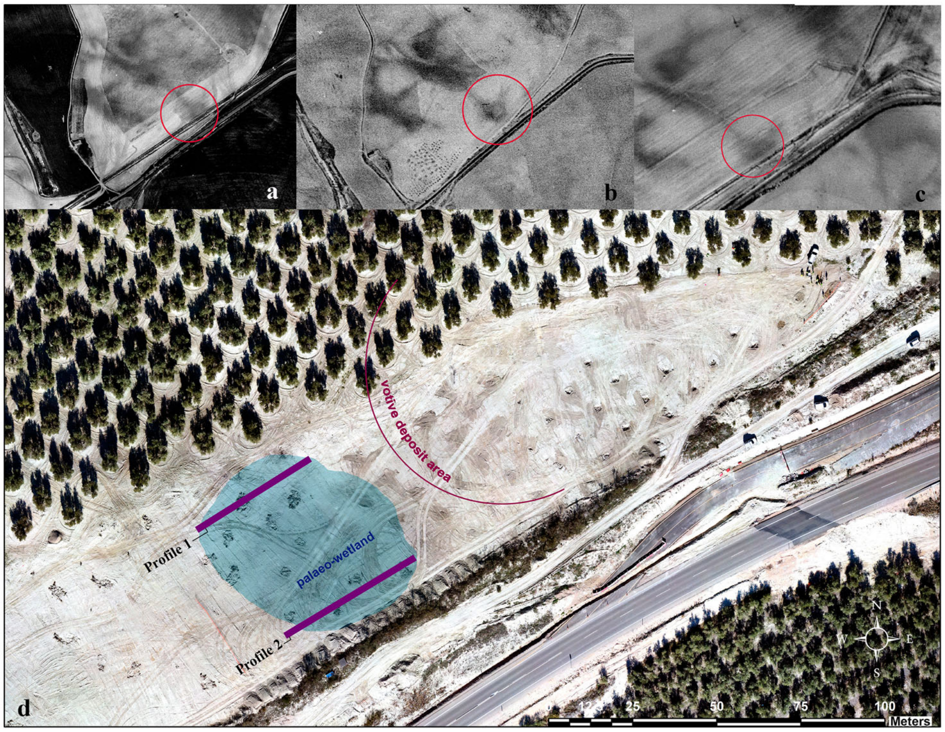

Figure 1. Superficial delimitation of the palaeo-wetland. Historical aerial photography of the site: (a) 1946 (approximate scale: 1:4000), (b) 1956 (approximate scale: 1:4000), (c) 1986 (approximate scale: 1:3000); (d) high-resolution digital orthophotograph from a photogrammetric UAV, indicating the main areas of the study and the transects.

unchanged until the late 1980s or early 1990s, when olive groves were planted (which define the current landscape) and obscured surface evidence of the wetland. In 2016, when the land was cleared for a carriageway, the wetland deposits were again unearthed.

The paleo-wetland is located in a 1.3 ha dark paleosoil located between 2 hills. The site acted as a communication hub between 2 important valleys. The presence of Iron Age offerings denotes human frequentation and ritual use of this wetland (Fig. 1). To explore this feature with stratigraphic sequencing, 2 trenches were dug across the site denoted as Profile 1 and 2 (Fig. 2 and 3).

Sampling methodology

Archaeological microsurveying. We combined archaeological surface surveying using metal detectors and high-precision GPS georeferencing. For the archaeological surveys we used White's DFX metal detectors (White's Electronics, Inc., Oregon) to record metal archaeological finds (Bellón et al. 2020) and a GPS (Leica model CS 25) with centimetre precision and real-time correction accompanied by specific annotations with correlative numbering to georeference each field item.

Soil micromorphology, phytoliths, pollen analysis, and optically stimulated luminescence dating. Undisturbed palaeoenvironmental samples were collected from chronostratigraphic profiles produced during the excavation and microsurvey of the 2 stratigraphic trenches. The sampling strategy was systematic, covering all the soil horizons identified in the field. The 9 sediment samples from Profile 1 selected for phytolith analysis were obtained from a depositional sequence comprising Miocene marls (samples G-1 to G-3), palaeosoil (G-4 to G-8), and colluvial marls (G-9; Fig. 2). Fourteen sedimentological samples were taken along the length of a vertical profile to identify pollen and non-pollen palynomorphs. Subsamples (10 g) were subjected to chemical treatments for archaeopalynological analysis (Burjachs et al. 2003). For optically stimulated luminescence (OSL) dating, 2 samples of the palaeosoil were taken (HR-1; HR-2), along with 14 other supplementary samples (Fig. 3, Table 1).

Sampling strategy

Archaeological microsurveying. The data collected from the archaeological survey were georeferenced (ArcGIS 10.6.1). To support the cartographic documentation, a UAV flight was used to create a photogrammetric restitution and digital orthophoto. The flight was made using a DJI Inspire UAV fitted with a 15 mm Zenmuse X5 focal length camera (DJI) confined to an area of 19.5 ha encompassing the palaeo-wetland and its

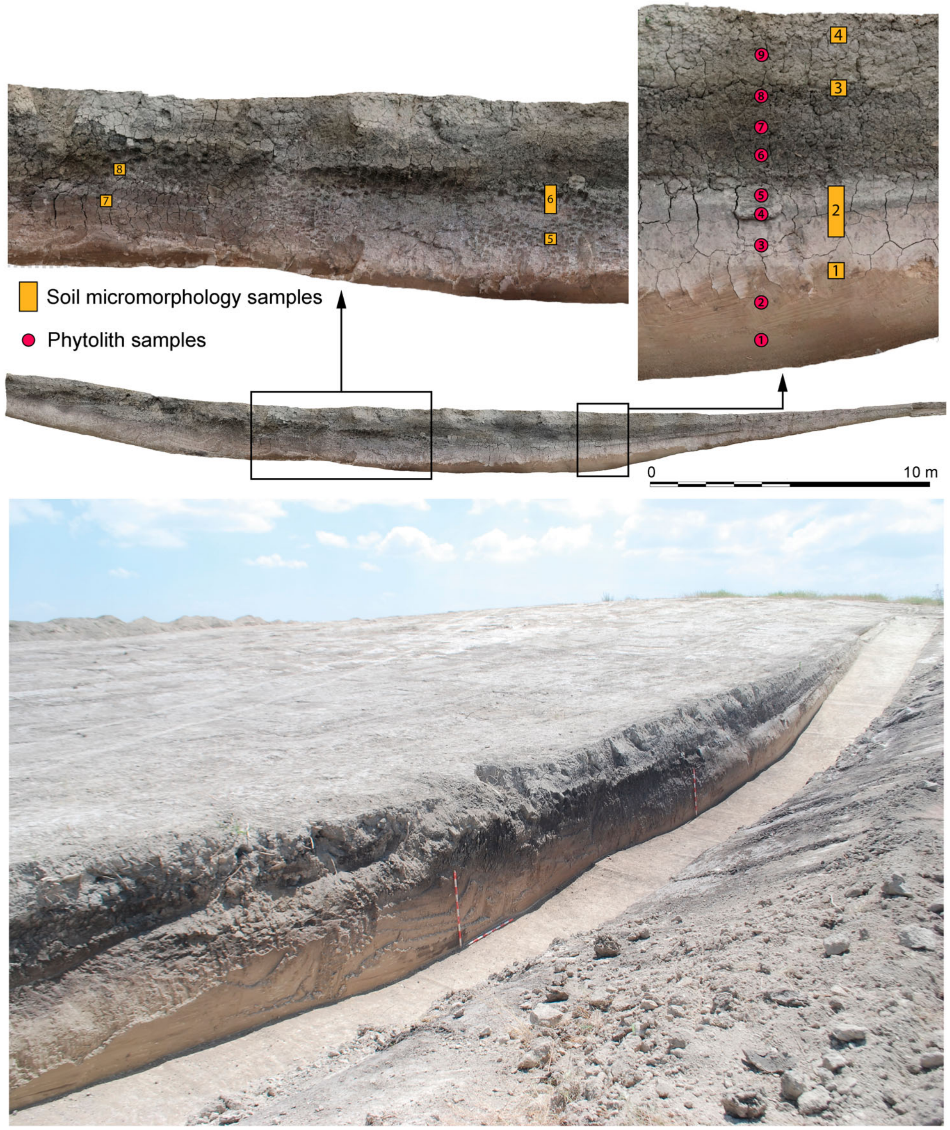

Figure 2. Profile 1. Detail of the stratigraphic sequence and the samples obtained for soil micromorphology and phytolith analysis.

surroundings. We obtained and processed 425 georeferenced frames using Agisoft Photoscan to generate 2 basic cartographic products: a high precision orthoimage and a digital surface model with a resolution of 7.5 cm/pixel.

Soil micromorphology. Blocks of soil stabilised with plaster of paris wrappings were removed and oven-dried for 1 day at 50 °C. Soil block impregnation was carried out under vacuum with polyester resin (Palatal P4-01), styrene monomer, and methyl ethyl ketone peroxide catalyst. Ten thin sections were analysed under plane-polarised (PPL), cross-polarised (XPL), and oblique incident (OIL) light following soil thin-section standard descriptive criteria (Courty et al. 1989, Stoops 2003, Stoops et al. 2018).

Phytolith analysis. Phytolith assemblages were determined by a systematic sampling covering all the deposits of the sequence (Table 2). The phytolith analyses followed the methods of Katz et al. (2010). A weighed aliquot of 40 mg of dried sediment was treated with 50 µL of 6N HCl. The phytoliths were concentrated with 450 µL of 2.4 g/mL sodium polytungstate solution [$Na_6(H_2W_{12}O_{40})$]. Aliquots of 50 µL were mounted on microscope slides. A minimum of 200 phytoliths with recognisable morphologies was examined at ×200 and ×400 magnification using an Olympus BX-43 optical microscope. Morphological identification was based on modern plant reference collections and standard literature (Twiss et al. 1969, Brown 1984, Mulholland and Rapp 1992, Twiss 1992, Albert and Weiner 2001, Piperno 2006, Tsartsidou et al. 2007, Albert et al. 2008, 2016, Portillo et al. 2014). The terms used to

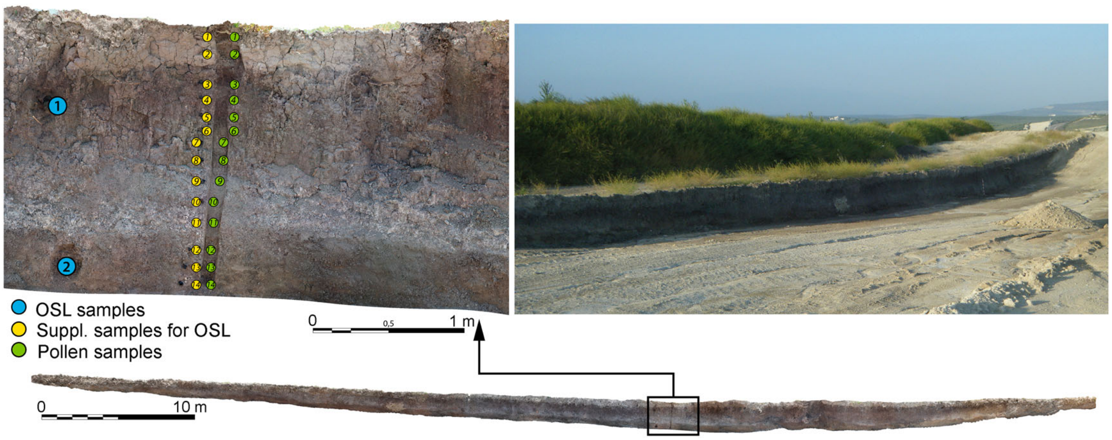

Figure 3. Profile 2. Detail of the stratigraphic sequence and the samples obtained for OSL and pollen analysis.

describe the phytolith morphologies follow the standards of the International Code for Phytolith Nomenclature in ICPN 2.0 (Neumann et al. 2019). Phytolith analyses were conducted at the Archaeobotany Laboratory, Department of Prehistory, Autonomous University of Barcelona (Spain).

Pollen analysis. Statistical and taphonomic guidelines (López Sáez et al. 2003, 2006, 2013) were used to validate the palynological data. Samples were considered valid when the number of pollen grains counted or base pollen sum (BPS) exceeded 200 grains from terrestrial plants, with a minimum taxonomic variety of 20 different pollen types. We created a palynologic histogram using the TILIA and TGView software (Supplemental Material Table S1; Grimm 1992, 2004). Pollen analysis was developed at the Department of Botany, University of Granada (Spain).

Optically stimulated luminescence (OSL) dating. OSL dating analyses were carried out by the Instituto Universitario de Xeoloxía Isidro Parga Pondal, Universidad Da Coruña (Spain), with an RISØ TL/ OSL-DA-15 automatic reader equipped with an EMI 9635 QA photomultiplier, using an internal generator 90Sr/90Y to provide a dose of 0.090 ± 0.003 Gy/s. A Lexsyg Research Reader from Freiberg Instruments was also used. The analysis applied the Single Aliquot Regenerative Dose (Wintle and Murray 2006) and the conversion factors of Guerin et al. (2011) and cosmic dose estimates of Prescott and Hutton (1994). The samples did not contain enough quartz to date by OSL, so the polymineral fraction rich in feldspars was used for infrared-stimulated luminescence dating (IRSL) with the post-infrared–infrared stimulated luminescence protocol.

Table 1. Ages obtained for each sample with the 2 measured signals (Sanjurjo 2020).

Sample	Signal	Age	Year	Cal. Year
HR-1	$IRSL_{50}$	1455 ± 253	564 ± 253	311–818 DC
	$pIRIRSL_{225}$	1362 ± 248	657 ± 248	409–905 DC
HR-2	$IRSL_{50}$	2806 ± 602	787 ± 602 AC	1389–185 AC
	$pIRIRSL_{225}$	3198 ± 209	1179 ± 209 AC	1389–970 AC

Results

Microspatial study using archaeological analysis techniques

This approach using high quality, high-precision cartographic documentation techniques was essential for analysing aspects related to the spatial distribution and the organisation of the different functional areas. The archaeological material associated with the cultural use of this wetland was documented in the eastern zone (outside the circular-shaped dark deposit; Fig. 4). Most of the archaeological material was composed of small bronze figurines (votive offerings; 78%), followed by decorated bronze plates (8.3%), fibulae (small brooches for clothing; 7%), bronze needles (2.7%), and bronze rings (4%; Fig. 4). A small set of ceramic material was also documented, but fragmented. All materials were found in the topsoil of the slope east of the circular-shaped dark deposit.

The analytical series as a whole revealed no building structures and no evidence of worship buildings or structures such as artificial terraces or chapels that would imply the modification, albeit superficial, of the morphology of the site.

The lack of structures was not due to alteration of the record, but to the original configuration of the site as an open-air place of worship in which ritual activities were carried out and offerings were deposited. The characterisation of the type of worship site was based on an

Table 2: Main quantitative phytolith and siliceous microfossil results obtained from Trench 9 samples.

Sample	Provenance	No. phytoliths/1 g sediment (million)	Monocot. phytoliths (%)	Dicot. phytoliths (%)	Weathered phytoliths (%)	No. diatoms	No. sponge spicules
G-1	Miocene marls	0.38	78.3	16.1	5.6	3	154
G-2		0.17	87.1	8.4	4.4	1	79
G-3		0.41	82.3	8.2	9.6	0	66
G-4	Paleosoil	0.32	83.4	7.5	9.1	0	74
G-5		0.44	87.7	9.6	2.7	1	68
G-6		0.41	86.9	9.1	4	0	67
G-7		0.26	83.5	10.4	6.2	1	43
G-8		0.30	75.8	16	8.2	0	49
G-9	Colluvial marls	0.26	84.1	10.9	5.1	0	81

analysis of the documented offerings. The bronze ex-votos provided us with the most valuable information. As idealised representations of the person, they contribute analytical data related to rituality, status, gender, and age. In the case of El Haza del Rayo, we obtained semi-schematic representations in bronze of men and women in diverse ritual poses related to cohesion, fertility, and protection practices. This corpus also included a small set of anatomical ex-votos representing legs, hands, and arms, as well as phalluses, findings related to health-giving and curative cults. We also documented small ceramic votive vessels that would have been used as part of libation and food consumption practices. As a whole, these finds are common in the territory of Cástulo and fit with the material evidence of the characteristic religiosity of those Iberian Iron Age communities in the 4th–3rd centuries BC (Rueda 2011).

Chronologically, OSL dating allowed us to establish a sequence from the Late Prehistory to the 9th century. The HR-2 sample dates a prehistoric level of palaeosoil while the HR-1 sample defines a historical moment that prolonged the use of the wetland until early medieval times (wetland environment level; Table 1). The determination of its long diachrony reaffirms that it covered a significant part of the late Holocene, including the Iberian period, in contrast to the spatial dialectic of the votive deposit, which never goes beyond the limits of the wetland, delimited in plan and sections by the extension of the paleosoil. The material was always deposited outside the wetland, with the placement of votive

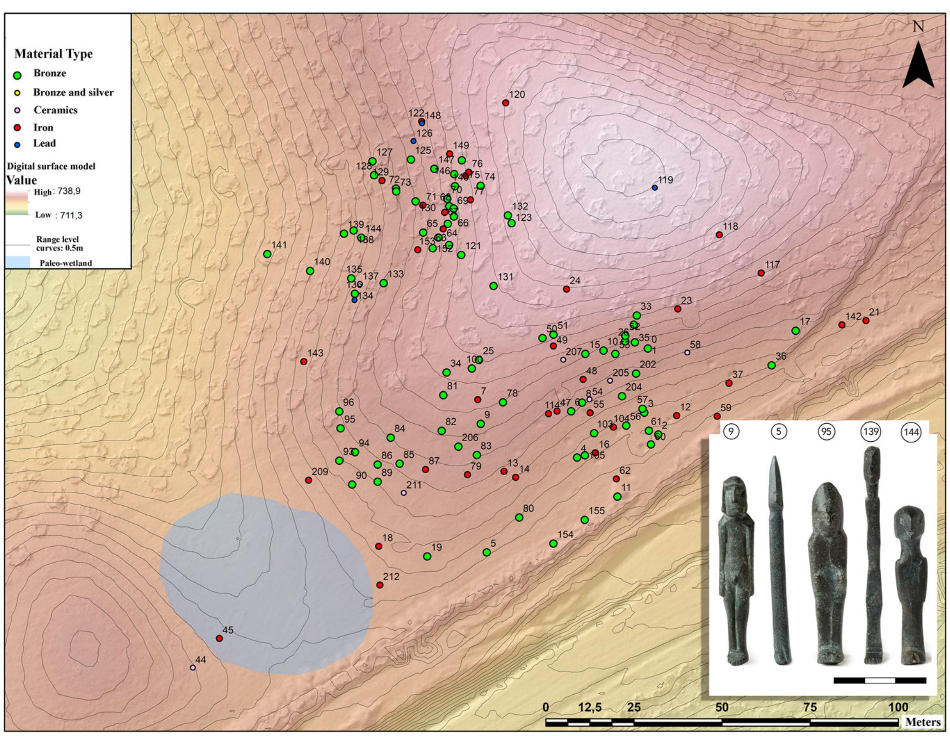

Figure 4. Digital surface model with the total distribution of the documented archaeological material, classified by type of material. Offerings documented in the votive deposit. The numbers on the votive offerings refer to their location on the cartography.

offerings in the geological substrate, hidden in small deposit pits. The use of this wetland as a worship space is set in the 3rd century BC and possibly surviving into the early 2nd century BC, according to the chronology of the archaeological materials.

Soil micromorphology

As noted earlier, a feature in this landscape stood out during the archaeological survey: a 1.3 ha circular-shaped dark deposit located between 2 hills (Fig. 4). The 2 excavated trenches showed the same sequence: a pale beige-yellowish massive clayey marl forming the geological substrate on which 2 dark horizons had developed. These brownish dark clays had a highly developed pedality that resulted in a subangular blocky to granular structure from the bottom to the top of the horizon (Fig. 5a). In both cases, these dark layers showed a gradational contact in the base with bioturbation features such as root channels infilled with dark material that penetrate the underlying marls, while the top of these horizons showed a sharp contact. This succession of pale clayey marly materials and brownish dark clays, together with the development of different features and porosity, suggests that this sequence corresponds to a buried

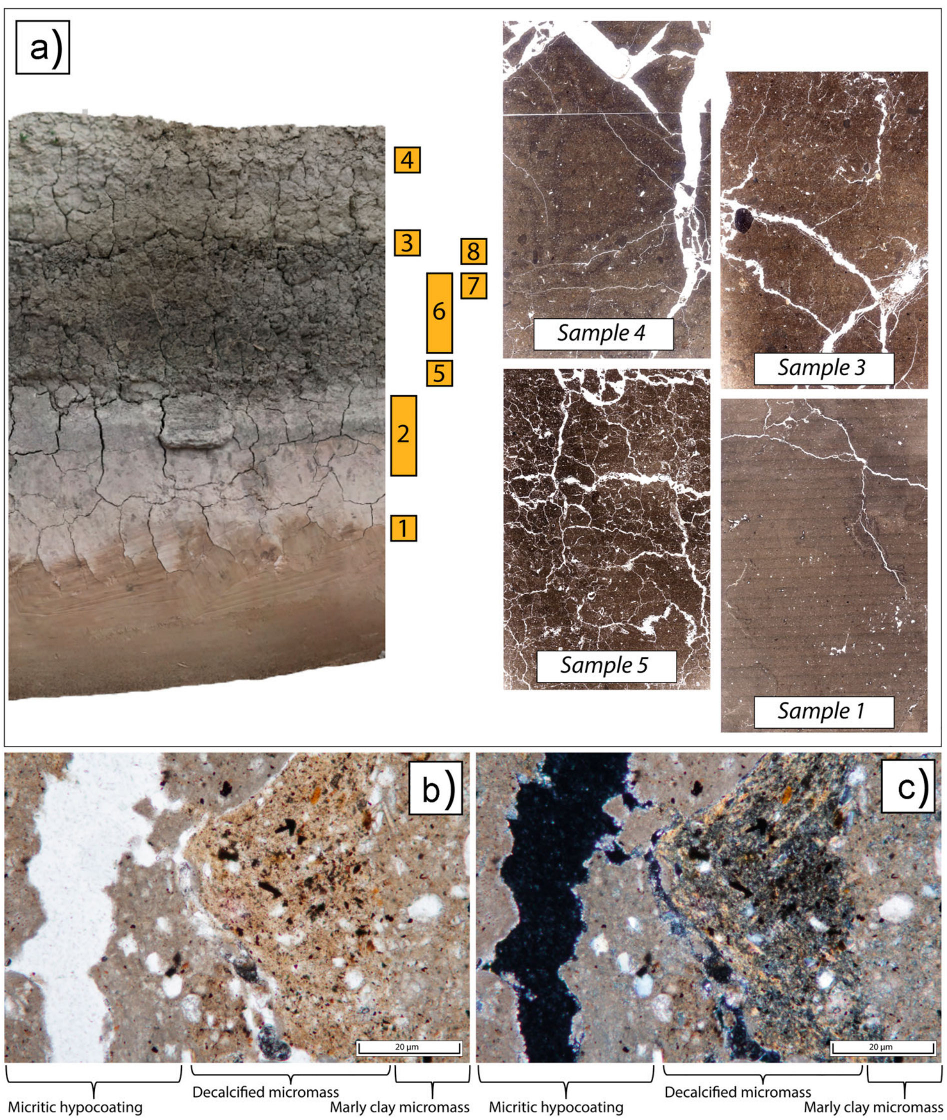

Figure 5. Soil micromorphology (Profile 1): (a) thin section scans and their location within the different horizons of the sampled profile, showing a gradational change of subangular blocky to granular microstructure from the bottom to the top of the paleosoil. This microstructure resulted from shrink–swell processes after intermittent saturation and open-air exposure conditions; (b) succession of a micritic hypocoating and a decalcified micromass within a pore, suggesting carbonate-rich water solutions circulating and cyclical changes of crystallisation and decarbonation processes (plane-polarized light: PPL); (c) same as (b), but for cross-polarized light: XPL.

palaeosoil formed in different environmental conditions than those of the present day.

These sequences were characterised through soil micromorphology. Two types of deposits were identified:

- The marly materials show a pale-yellow groundmass under the microscope, with a coarse mineral fraction composed of silt-sized smooth angular calcite crystals (10%) and silt-sized quartz (2%), and a fine fraction composed of micrite. These components show a double-spaced porphyric to fine monic c/f-related distribution. This material shows a massive to fissure microstructure and a crystallitic b-fabric, and the few existing pores are composed of planar voids (60%), channels (30%), and chambers (10%). These materials show a high content of siliceous bioclasts, including planktonic foraminifera (mainly *globigerina*), sponge spicules, and diatoms. In contact with the brownish dark clays, the marls show depletion hypocoatings within the pore walls (Fig. 6d). Other pedofeatures present in the marly materials are Mn dendrites (Fig. 6e).
- The brownish dark clays show significant compositional and textural differences under thin section. Coarse mineral fraction shows silt-sized quartz (20%), sand to fine gravel cemented marls (5%), and a fine fraction composed of dark-brown clay. These components show a single spaced porphyric c/f-related distribution. The groundmass shows abundant silt-sized humified organic matter particles. This horizon shows a subangular blocky to granular microstructure and a crystallitic b-fabric that gives way to a very porous horizon with a well-developed pedality showing highly separated and partially accommodated angular blocky peds and porous crumbs. Porosity is composed of planar voids (40%) and channels (60%). These horizons show a wide range of pedofeatures, like authigenic micritic nodules, micritic hypocoatings (Fig. 5b–c), needle fibre calcite (Fig. 6a–b), secondary micritic calcium carbonate, mesofaunal excrements (Fig. 6c), calcitic biospheroids, and intrapedal Fe-Mn features such as nodules and dendrites (Fig. 6e).

Phytolith analyses

Phytoliths were noted in all samples throughout the soil sequence, ranging from 0.17–0.44 million per gram of sediment (Table 2). The morphological results show that monocotyledonous phytoliths, and particularly grasses, dominated in most of the assemblages, comprising ~75-90% of all counted morphotypes. Grass phytoliths mostly belong to the Pooideae subfamily composed mainly of rondel grass silica short cells (Neumann et al. 2019), which are widely distributed in well-watered environments. Grasses were generally represented by leaf/culm phytoliths (e.g., flabellate bulliforms) and acute bulbosus (i.e., trichomes; Supplemental Material Fig. S2a), whereas inflorescence morphotypes (e.g., papillate and decorated elongates such as dendritics) were scarce in most of the assemblages. Additionally, diagnostic spheroid echinate phytoliths from the leaves of the Arecaceae family (palms, such as dwarf palm, *Chamaerops humilis*) were also common within the deposit, although to a lesser extent. Arecaceae leaf phytoliths were particularly observed in sample G-7 of the palaeosoil (Supplemental Material Fig. S2b).

Also significant was the presence of other siliceous biogenic components such as diatoms and sponge spicules (Supplemental Material Fig. S2c) counted in many phytolith slides (Table 2), indicating humid conditions. Their presence in association with a relatively low index of unidentifiable weathered phytoliths (~6%, Table 2), such as those with pitted surfaces and irregular shapes related to depositional and postdepositional weathering and alteration by dissolution (Cabanes et al. 2011, Portillo et al. 2021), indicates generally good preservation conditions of the silica assemblages. Both diatoms and sponge spicules, the inorganic support structures in sponges that occur in marine and freshwater habitats (Wilding and Drees 1971, Schwandes and Collins 1994), may potentially serve as indicators of general environmental conditions or as evidence of hydrological change (Coil et al. 2003). Overall, the phytolith records dominated by Pooideae grasses, along with accumulations of other silica biogenic microfossils (diatoms and sponge spicules), indicate generally humid conditions and well-watered environments throughout the depositional sequence.

Pollen analysis

Of the 14 pollen (P) samples, only 6 provided results (P1, P2, P3, P4, P9, and P12; Fig. 3); all others were considered sterile (Supplemental Material Table S1). Sample P12 could likely correspond to the Late Prehistory, whereas the others could be assigned to the Historical period.

The deepest sample, P12 (Fig. 3), indicated an open landscape of predominantely Poaceae. The presence of agricultural activities could be confirmed by the signs of *Cichorioideae*, *Cardueae*, and *Aster*, indicators of human activity (Moore et al. 1991, López Sáez et al. 2003, 2013). Arboreal vegetation would have been predominantly pines, probably *Pinus halepensis*, with a minor presence of other Mediterranean woodland

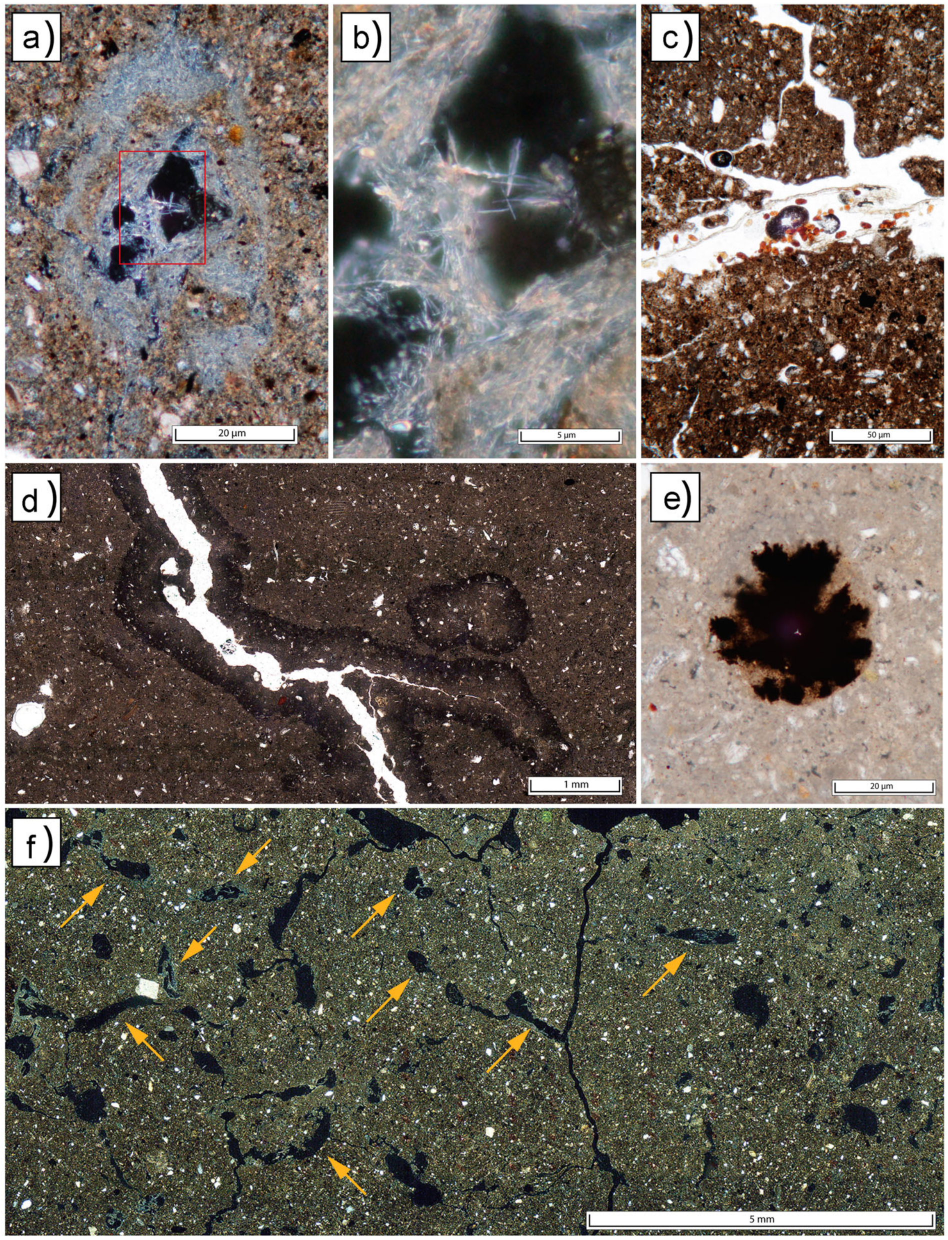

Figure 6. Soil micromorphology (Profile 2): (a) paleosoil: needle-fibre calcite infilling showing parallel and convoluted arrangements within a pore (XPL). Note that the infilling shows a succession of needle-fibre calcite, clay, and a second needle-fibre calcite infilling, suggesting cyclical changes of sedimentary conditions. The red rectangle is the area shown in Fig. 5b; (b) paleosoil: detail of the needle-fibre calcite crystals (XPL); (c) paleosoil: mesofaunal excrement and fresh root tissue inside a channel (PPL), indicative of plant growth, soil fauna colonisation, and open-air exposure; (d) marl substrate: depletion hypocoatings within the pore walls (PPL), indicative of decarbonation processes; (e) marl substrate: Mn dendrite (PPL), showing Fe-Mn reduction and mobilisation due to saturation conditions; and (f) paleosoil: channels (orange arrows), indicating plant growth (XPL).

species such as holm oak (*Quercus ilex*) and wild olive (*Olea europaea*). Of particular interest was the presence of scrubland consisting mainly of leguminous shrubs (*Cytisus*) and rockrose (*Cistus*), which would confirm a landscape that had been altered to some extent (Supplemental Material Table S1).

Sample P9 indicated an increase in tree cover, especially *Olea europea*, possibly linked to the presence of the Mediterranean woodland. In addition to the olive/wild olive and shrubs well adapted to the xeric conditions, this woodland would have had a notable tree cover of pines and holm oaks. The amount of scrubland and, above all, grasses would have decreased considerably, as would have, to a lesser extent, the species associated with human activity. All these factors could be evidence of a relative reduction in human impact on the area.

The samples from nearest the surface showed a progressive expansion of olive compared to pine, with olive reaching its peak in Sample P1, indicating an almost complete domination of the landscape.

Samples P4, P3, and P2 had similar characteristics, with a tree cover dominated by pine (*P. halepensis* and *P. pinaster*) and olive, open areas of holm oak, and isolated scrublands. The grasslands were predominantly Poaceae, although with a notable presence of leguminous plants and a sparse representation of species linked to human activity.

Of particular note were the species related to damper conditions, such as algae (chlorophytes), bryophytes and, to a lesser extent, sedges (Cyperaceae) and buttercups (*Ranunculaceae*), as well as spores of *Zygnemataceae* (*Debarya*) algae. The presence of *Debarya*, together with other chlorophyte algae and aquatic plants, could suggest the existence of shallow waterbodies at the sondage site (Van Geel 2001, Birks 2019).

Also of note is the observed increase in coprophilic mushroom spores (Type 55), an indication of stock breeding, and of *Glomus*, related to erosion events (Van Geel 2001, Cugny et al. 2010, Cook et al. 2011).

Discussion

The documented palaeo-wetland shows a homogeneous stratigraphy made up of dark muddy and clayey deposits with a maximum depth of ~1.50 m. The sharp contact of the dark muddy deposits with the upper horizon and the presence of bioturbation and plant growth-related features suggest that this dark deposit corresponds with a buried paleosoil. Soil micromorphology effectively characterised the different soil formation processes involved in its genesis. It was formed in a wetland environment under seasonally changing humid and saturation conditions, which perhaps resulted in periods of a temporary rise in the water table, as shown by the presence of Fe-Mn, carbonation/decarbonation, and desiccation features. The changing humidity fostered the formation of a rich ecosystem in which soil mesofauna, plants, and fungi played a significant role in the formation of the different deposits. Among the deposits, the presence of needle-fibre calcite is noteworthy. These deposits are typical of vadose settings (where water occurs above the water table) formed during rapid evaporation and desiccation under supersaturation and/or a direct/indirect biological origin from fungal biomineralisation inside mycelia bundles (Verrecchia and Verrecchia 1994, Durand et al. 2018). Other bioturbation features present in the brownish dark layers are sparitic calcite biospheroids (excreta produced by soil-ingesting worm species), mesofaunal excrements (Fig. 6c), fresh roots, and a well-developed porosity composed of channels (Fig. 6f; Durand et al. 2018, Kooistra and Pulleman 2018). Micromorphology shows how this temporary wetland was formed in periods of soil development under favourable climatic conditions, or biostasy, as well as how this ecosystem was a changing environment subject to seasonal modification and alternating periods of saturation and soil exposure.

The phytolith analyses confirmed the interpretation of this deposit as a wetland and help to characterise it. The results of the phytolith study indicate a homogeneous vegetal composition throughout the depositional sequence, dominated by Gramineae of the Pooideae subfamily common in humid environments. The concentrations of Poaceae (Gramineae) as well as Arecaceae (palm) leaves were particularly found in the palaeosoil. These humid conditions can be seen not only in the vegetal composition, but also in the presence of other siliceous biomicrofossils, such as diatoms and sponge spicules characteristic of aquatic ecosystems or humid environments.

Pollen analysis indicated the presence of a Mediterranean forest composed of pines and open oaks as well as wild olive trees. More interesting for the specific analysis of the site was the presence of species associated with shallow waterbodies and vadose environments (Van Geel 2001, Cook et al. 2011), such as *Zygnemataceae* algae (Debarya) and chlorinates and aquatic plants, consistent with our reported results.

This wetland would have stood out as a landmark and point of reference in the landscape and would have been culturally incorporated with an unconventional use linked to ritual practices. The communities of the past recognised these ecosystems in their surroundings and highlighted specific characteristics that added symbolic values to the landscape (Bradley 1998, 2000, Fontijin 2007, Menotti and O'Sullivan 2012, Van de Noort 2016). In different cultural contexts the concept of "abnormal water" has been defined as that appropriated for worship due to its properties (physical, visual, spatial, and others; Whitehouse 1992). This concept can be analysed from an intercultural perspective because it is observable in diverse contexts, societies, and cultures in which water is believed to have the power to transform the ordinary into the extraordinary. Thus, in the Iberian societies, the use of water and "places with water" in a ritual sense took on a broad and complex dimension. Many cases document a link between sanctuaries and springs in Iberian religiosity (Olmos 1992, Sánchez del Moral 2018).

The present case study points to the original configuration of this space as an open-air place of worship where offerings were deposited next to the wetland. The characteristics of the deposit itself provide us with insights into the ritual practice carried out. The offerings were never deposited inside the wetland and were always documented in the geological substrate (pale beige-yellowish clayey marl), sometimes perfectly delimiting a small deposit pit where they would be hidden, highlighting the importance of the environment. The site could be defined as a sacred forest, in which diverse and complementary elements interact, such as the plant environment with the wetland itself as a landscape landmark. This sanctuary serves as a stop on the ritual pilgrimage route from the city of Baecula (Santo Tomé, Jaén) to the sanctuary of La Cueva de la Lobera (Castellar, Jaén), within the territory of the ancient city of Cástulo (Linares, Jaén). With the available data, it is difficult to specify the dates on which the rituals were performed in this wetland, but we know that the equinox seems to play a regulatory role for seasonal norms, at least for the Castellar sanctuary, governed by astrological phenomena linked to sunset (solar hierophanies; Esteban et al. 2014).

The El Haza del Rayo wetland forms part of this religious route (a pilgrimage route in the territory) in which water and other landmarks enter into a dialogue and create the idea of the sacred. The communication between these sacred sites and the different ritual landscapes must have been fluent and organised. The wetland would have been a stop on the itinerary, a stage sanctioned through the offering of ex-votos that referred to cohesion and aggregation practices and rites of protection and health that focused attention on the presence of the wetland. At this precise point in the territory, certain values of cultural perception were projected, framed within the concept of permission, health, and protection, and linked to the ritual journey and in turn to the transitional frontiers (i.e., the gateways of the territory; Galdames 1990).

In conclusion, the finding of this worship site highlights important questions of a historical nature. First, it provides further evidence of the complexity of seemingly heterogeneous ancient landscapes. The case analyses emphasise the hierarchisation of the ritual landscapes with diverse and complementary meanings, particularly the landmark landscapes that act as exceptional points where the divine and the human coincide. They are places where the supernatural becomes tangible and can be identified through natural landmarks acting as mediators through the ritual. In this way, caves, mountains, forests, springs, lakes, and other land features take on a cosmological meaning, contributing to building memory in the landscape through rites and mythology. This idea leads us to other questions (which are not addressed in this study) regarding the analysis of multisensoriality in the past and how the landscape acted as a link to those emotions (Hamilakis 2017).

Additionally, contexts such as the one analysed here, allow us to approach further special uses of water. As a place of recurrent seasonal pilgrimages, the El Haza del Rayo wetland incorporates an important variation to the rite: water and the type of offering deposited that help explain its sacred function. The concept of water is emphasised as a principle of divine prowess endowed with dynamic action, attested through its own healing, oracular, initiator, purifying, and other effects (Olmos 1992). At El Haza del Rayo, the healing, protecting, and fecundating nature is highlighted indirectly through the deposited bronze images that represent naked men, women carrying out fecundation rites, and even body parts such as legs or phalluses that introduce us to the healing properties of the water of this wetland. The images themselves possibly also allude, indirectly, to the ways the water was used as part of the ritual practice, through libations, the purification of the body, or by drinking. The small pottery vessels are incorporated as the main liturgical instrument for such a purpose. Irrespective of whether we can pinpoint these aspects to a greater or lesser extent, the wetland and its waters clearly played an active role in the practices. These collective ideas are contextualised in the concept of sacred nature because the fecundating water–vegetation binomial is a constant presence in Iberian Iron Age religiosity.

Conclusions

Our integrated methodological approach allowed us to identify the sedimentary sequence of Haza del Rayo as a buried palaeosoil formed during the Late Holocene in a temporary wetland environment that today is no longer active. Marly materials represent rhexistasy periods of soil erosion while the dark horizons were formed in periods of biostasy under favourable climatic conditions that gave way to soil development in a temporary wetland environment. Bioturbation and soil fauna/plant colonisation played a significant role in the genesis of the paleosoil and were a significant part of this ecosystem. In the 3rd century BC, this temporary wetland became a basic reference for the local Iberian Iron Age communities, and specific rituals were performed in its margins, including the deposit of bronze figurines and other offerings. Thus, this case study can be interpreted from an archaeological point of view as the ritualisation of natural landmarks with specific cultural meanings. The interdisciplinary study of this ancient ecosystem allows us to understand the social and ritual behaviours of the societies that inhabited this territory (Rueda 2011).

Our case study reveals the historical and cultural use of the wetlands beyond their intrinsic ecological or economic value. This work undoubtedly opens an interesting field of study that accentuates the need to contextualise this type of ecosystem in the landscape diachronically and also to approach its cultural aspect. Furthermore, on a methodological level, it highlights the potential of this type of analysis with a strong interdisciplinary nature. As a line of research, for example, it can be used to undertake in-depth historical studies of wetlands and their uses in different periods or their evolution as cultural landmarks. This approach could include the analysis of inactive or extinct palaeowetlands using multidisciplinary methods incorporated into the archaeological analysis, investigations of the historical significance of wetlands and their integration into the dynamics of territorial occupation, and studies to compare aspects (physical, spatial, and other) of historical wetlands with others that exist in the same territory. In summary, a line of research aimed at recovering the memory of past landscapes and their diversity provides recognition of the specific values that characterise them and can endow present day values with content and history.

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