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Brine-boiling not using briquetage? Technical, socio-economical and ritual aspects of salt production at the Villafáfila lagoons (central Iberia) in Late Chalcolithic/Bronze Age

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ABSTRACT

By combining a multidisciplinary approach and an intensive program of scientific techniques, this paper provides a comprehensive overview of salt production at the Villafáfila lagoons (Zamora, Spain) in prehistoric times. During the Late Chalcolithic and the Early/Middle Bronze Age salt was obtained by boiling brine from salt lagoons. In many parts of western and central Europe at the time the standard procedure for forcing evaporation usually involved the use of crudely fired clay vessels (briquetage) to concentrate brine, and then to mould salt. We suggest that the methods during the final stages of the process differed at Villafáfila, having found evidence of basketry and textiles, which may have been used in the step of crystallization/transport of salt in cake, instead of the small ceramic salt moulds which would be expected in such sites. The role of salt within the socioeconomic setting of the 3rd and 2nd millennia BCE in Central Iberia is also assessed. It is argued that the production and distribution of salt contributed significantly to the political economy, as elites controlled this activity, supporting the idea that salt was a prestige good that contributed to the accumulation of wealth. There is also evidence of ritual practices in the salt-processing areas, as human burials and animal sacrifices have been documented in the excavated sites.

1. Introduction

Salt has been an important commodity in non-industrialized communities for centuries and is often referred to as "white gold" due to its physiological, economic, social, and ritual value in human societies (Harding, 2021; Brigand and Weller, 2015). Due to its limited supply in the past, salt has been a vital strategic resource since prehistoric times (Nenquin, 1961; Harding, 2013, 2014). In the Villafáfila region, in northwest Spain, salt production thrived in the Middle Ages. The earliest documentary evidence of salt processing is from the year 917 CE, which uses the term *pausatas* in reference to artificial pools used to collect brine (Yáñez, 1972: doc 3). According to historical records and archaeological data, salt was obtained in the Middle Ages by a combination of solar evaporation and brine-boiling. During the Early Middle Ages, salt from Villafáfila was traded and exchanged throughout north-western Iberia, as there were no other production centers within a radius of 150 km. However, due to geopolitical factors, this activity gradually began to diminish towards the 13th century, and eventually, the salt works closed in the middle of the 16th century (Rodríguez Rodríguez, 2000).

Given that the Villafáfila landscape has been intensely populated since prehistoric times, salt production may have begun earlier than previously thought. Recent archaeological research has shown that salt boiling in the area dates back at least to the mid-3rd millennium BCE (Abarquero et al., 2017). Here we provide a concise account of a

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multi-disciplinary research project into the origins of salt production at Villafáfila, focusing on techniques for obtaining salt. Remarkably, there are some differences compared to the evaporation method most used in Europe at that time, which usually involved briquetage. We also present the results of the most recent analytical work (as earlier studies have been published elsewhere, only a brief description of the methods is given in these cases), and further discuss some socio-economic and symbolic issues.

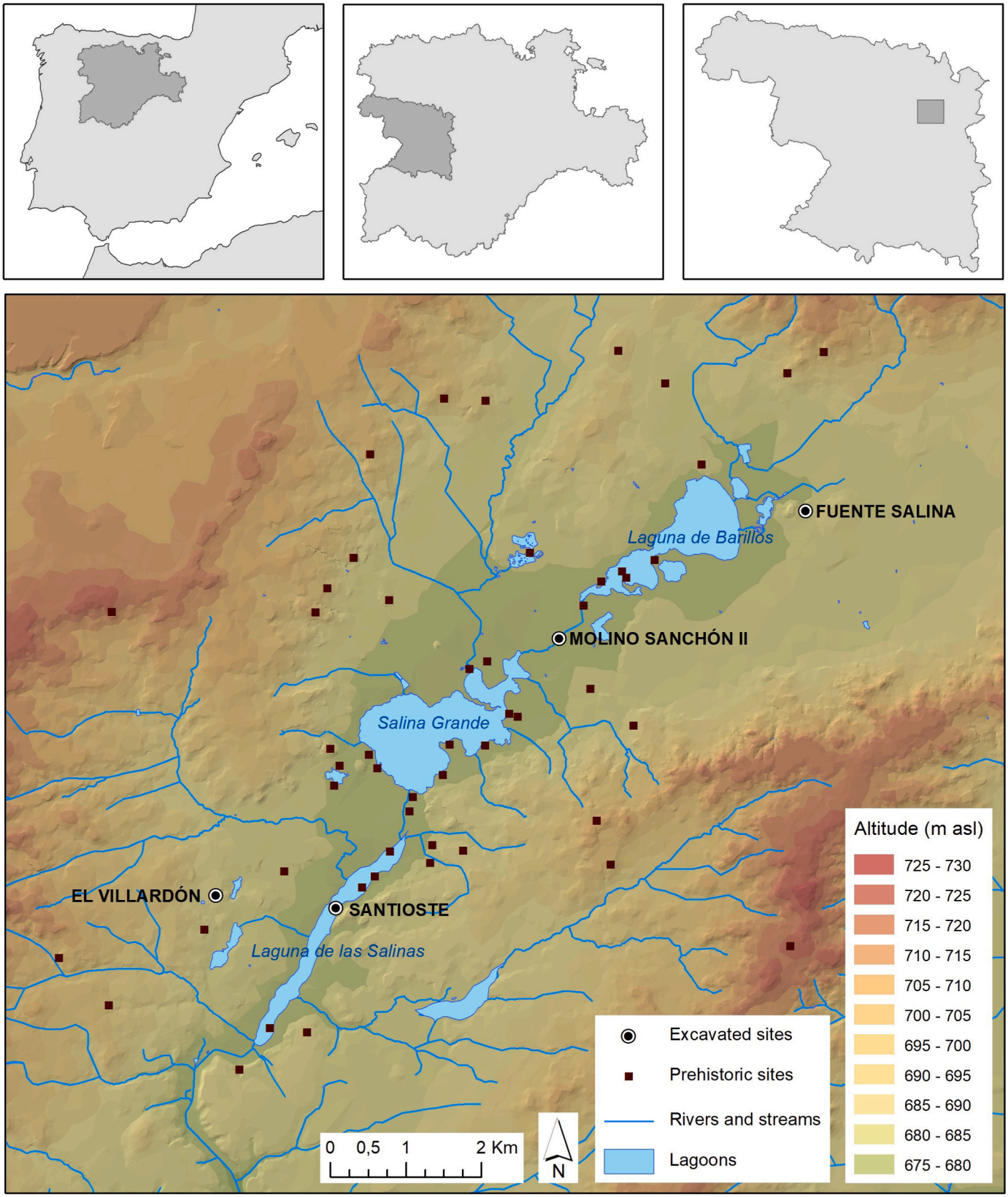


Fig. 1. Map with the location of the prehistoric sites in the Villafáfila lagoon complex.

2. The salinity of the lagoons: some geological notes

Located in the north-east of the province of Zamora, in the community of Castilla y León (north-west Spain), the Villafáfila lagoon complex is a Nature Reserve of 32,682 ha. In 1989 the site was included in the Ramsar Convention's List of Wetlands of International Importance (site 451). Initially, the protected area covered 2854 ha, but in 2011 the boundaries were partially reduced and at present it covers 2713 ha (https://rsis.ramsar.org/ris/451?language=en).

Dominated by Cenozoic sedimentary rocks, this low relief area, ranging from 670 to 680 m a.s.l., is bounded by gently sloping hills that reach up to 730m. These brackish-saline lagoons, with a surface area of about 500 ha and a NE/SW orientation, are located in the semi-endorheic basin of the Río Salado (Spanish: Śalty river'), on the watershed of the rivers Esla and Valderaduey, two tributaries of the River Duero on its right bank. The largest lagoons are Salina Grande (194 ha), Barillos (119 ha), and Las Salinas or Laguna de Villarrín (70 ha), but there are many others in the area (Rodríguez and Palacios, 1993). The lagoons, mostly shallow, and with a maximum depth of 0.75 m (Alonso, 2002), are fed by meteoric waters -deriving from direct precipitation- and by shallow groundwater, with some minor contributions from runoff and deep groundwater (Fernández Pérez and Cabrera Lagunilla, 1987).

Villafáfila has a semi-arid Continental Mediterranean climate. It is markedly seasonal, characterized by cold and wet winters (November–February) and hot and dry summers (June–September). In winter, average monthly temperatures are around 4 °C, but minimum temperatures are often below zero. In summer, the average monthly temperature is about 22 °C. The average annual evaporation is 720 mm and the evapotranspiration is 237 mm. The average annual rainfall rate is 330 mm, concentrated in the rainy months (October to May). During this wet period, when precipitation exceeds evapotranspiration, the aquifer is recharged, and the lakes fill up. On the other hand, during the summer, when evapotranspiration exceeds precipitation, the lagoons dry out and their bottoms and shores are covered with halite-containing efflorescences (Huerta et al., 2021).

Physicochemical analyses of the lake and groundwater have identified three hydrochemical facies at Villafáfila: Type 1 are calcium-magnesium bicarbonate freshwaters; Type 2 are waters dominated by sodium and chloride-bicarbonate, and Type 3 are brackish to saline sodium-choride waters (Armenteros et al., 2019). Considering both that Na^+/Cl^- ratios are indicative of halite dissolution, and the absence of evaporites in the Villafáfila basin, we can infer that Type 3 waters must originate from deep groundwaters. In the Duero aquifer system, the groundwater flow pattern comes from the basin margins (IGME, 1980). At Villafáfila these deep groundwaters, with a long-term presence in the aquifer (22.3–18.9 ka), originate from the dissolution of Triassic or Cretaceous evaporites, mainly halite and gypsum, from the eastern part of the Cantabrian Mountains, and from Cenozoic evaporites in the north-eastern part of the Duero basin, located about 150 km NE of Villafáfila. Time-domain electromagnetic (TDEM) surveys link the salinity of the lake waters with a Paleozoic metamorphic basement elevation in the southern zone of the Salina Grande Lake and the town of Villarrín, which forces saline groundwater to flow up (Huerta et al., 2021). Most prehistoric sites at Villafáfila tend to concentrate in this area (Fig. 1).

As the dynamics of groundwaters and the lake-groundwater interaction show multi-annual changes due to the variations in evapotranspiration and precipitation throughout the year, the salinity of the water is also subject to seasonal variations. Salinity is highest during periods of low flow and increases as water levels fall. Water salinity can be measured in several ways, including Electrical Conductivity (EC), as its rate is influenced by the concentration and composition of dissolved salts. As salts increase the ability of a solution to conduct an electrical current, a high EC value indicates a high salinity level. Recently, TDEM surveys combined with TDEM soundings and EC of lake water and groundwater at Villafáfila have confirmed the rise of brine in the lake aquitard during the summer. EC shows that the surficial groundwater has values between 6000 and 9000 μS/cm, and the brine below the Salina Grande lagoon reaches 42,000 μS/cm (Huerta et al., 2022). Using the general classification of saline waters based on EC, provided by the Saline Agriculture Worldwide section of the Dutch Ministry of Agriculture, Nature and Food Quality, these values fall into the brackish and strongly brackish categories, respectively (https://www.salineagriculturworldwide.com/classification-of-saline-water).

Therefore, the low salinity rates of the Villafáfila waters, much lower than that of marine waters or that of some inland saltwater springs (such as Poza de la Sal or Añana, in Iberia), conditioned the exploitation techniques, as it would have been necessary to concentrate the brine before forcing the evaporation. Also, the fluctuations in the water salinity due to those seasonal dynamics meant that salt processing had to be limited to the summer months.

3. Palaeoenvironmental reconstruction

To gather information about the palaeoenvironment of the lagoon complex, a 395 cm long core drilling was obtained from the western shore of Las Salinas lagoon during the 2013 archaeological field season. The selection of the core location (UTM 30T, X: 282.770,19 E, Y: 4.632.263,45 N, Z: 680 m a.s.l) was based on a systematic survey along the lagoons. The sedimentological core was taken using a Van Walt/Eijkelkamp window corer, which allows the sedimentary record to be recovered by accumulating 1m-depth operations. The core is composed of organic silt with intercalated white marl lithoclastic layers representing lake margin erosion phases (lowstands). Samples of 2 cm^3 were taken from the core for palynological analysis and sectioned into continuous 2-5 cm-thick slices. Palynomorphs were isolated following the classic procedure (Moore et al., 1991). Pollen counting was conducted at 400× magnification, and a minimum of 400 terrestrial pollen grains were considered in the pollen sum. Pollen identification was aided by the reference collection of the Laboratory of Environmental Archaeology at the Spanish National Research Council (CSIC) in Madrid, standard identification keys (Moore et al., 1991), and the photographic atlas (Reille, 1992, 1995) of European pollen flora.

14 sediment samples were ^{14}C dated using AMS technique. The dates were used to build an age model by linear interpolation considering the maximum probability intervals at 2 sigma rates (López Sáez et al. 2017). In this paper, we discuss the 120–180 cm interval. According to the model, the base of the 180 cm dates to ca. 3305 BCE and the sequence extends up to ca. 1110 BCE (120 cm) without any sedimentary hiatus recorded.

Between ca. 3305-3185 BCE deciduous and evergreen *Quercus* are the most abundant trees (20%), with the continuous presence of riparian taxa such as *Alnus* and *Tamarix*, indicating an open landscape, probably due to local human activities, as well as warm and humid conditions. Additionally, cold (*Betula*, *Pinus sylvestris*) and xeric taxa (*Artemisia*, Chenopodiaceae) are present but with low values. Shrubs are non-abundant (<5%), with *Cistus*, *Erica*, Labiatae and *Cystisus/Ulex* the most important taxa. Poaceae is the main herbaceous component (25%). Anthropozoogenous taxa (*Urtica dioica*, *Plantago*, *Polygonum aviculare*) are present, as well as weed crops such as *Erodium*, *Malva sylvestris*, *Centaurea cyanus*, *Convolvulus arvensis*, *Rumex* sp. and anthropogenic-nitrophilous taxa (Cardueae, Cichorioideae) with low values (sensu Behre, 1981). Cerealia type presents very low percentages (0-0,7%). This period is associated with high levels of aquatic plants (Cyperaceae, Apiaceae, *Phragmites*, Potamogetonaceae, *Ranunculus*, *Typha angustifolia*) as well as algae (*Spirogyra*, *Closterium*) and cyanobacteria (*Anabaena*) indicative of a marked seasonality with springs and warmer summers, lacustrine sites with meso to eutrophic conditions due to an enrichment of waters in dissolved organic matter (van Geel et al., 1996).

Tree cover gradually diminishes (ca. 3185-2350 BCE), as indicated by lower percentages of deciduous *Quercus*. The most notable feature is the disappearance of *Alnus* and *Tamarix* and the spread of *Betula* and

Pinus sylvestris, indicating colder and drier conditions. Percentages of xerophilousic taxa such as *Artemisia* and Chenopodiaceae increase possibly in response to increased salt concentration in surface at this time. However, aquatics and *Spirogyra* values show a decreasing trend (*Closterium* and *Anabaena* completely disappear), while Dictyoconodies percentages increase. Despite the relative landscape stability, one small-scale clearance event has been detected from 3185 BCE, suggesting a small opening of oak woodlands surrounding Las Salinas lagoon due to agricultural and pastoral farming, as indicated by Cerealia type (1.3–2.5%), weed crops, anthropozoogenous and anthropogenic taxa increases (López Sáez and López Merino, 2005). Coprophilous fungi (*Sordaria, Podospora, Trichodelistschia, Melanospora*) appear for the first time (<5%).

The overall picture is more complex during the Chalcolithic-Bronze Age transition, ca. 2350-1900 BCE, and not only in terms of human activities. The increasing pattern of both evergreen and deciduous *Quercus*, as well as the recurrence of *Alnus* and *Tamarix* between ca. 2350-2150 BCE and ca. 2050–1900 BCE suggests warmer temperatures and an important rise in water-table. *Betula*, *Pinus sylvestris,* xerophilousic taxa (*Artemisia*, Chenopodiaceae) and Dictyoconodies values decrease in both sub-zones, while aquatics, *Spirogyra* and *Anabaena* increase markedly, suggesting wet conditions, mainly winter rainfall, and a marked seasonality with hot summer. A completely contrary dynamic is observed ca. 2150-2050 BCE, where climatic conditions become dry again.

Interestingly, ca. 2350-2150 BCE human impact decreases significantly: anthropozoogenous and anthropogenic taxa and weed crops reduce in percentage, while coprophilous fungi and Cerealia type are virtually absent. This period corresponds to the Chalcolithic-Early Bronze Age transition. It seems reasonable to consider, for the humid period ca. 2350-2150 BCE, that the effects of this climate change would have significantly modified the former economic strategy, replacing by one less predictable and productive because of the dramatic salinity decrease in soils. In fact, at the beginning of the Bronze Age (ca. 2150-1900 BCE) Cerealia type reappears with very high percentages (6%), probably indicating an increase in the extent of crop fields and greater proximity of these to the lagoons. At the same time, a significant increase in coprophilous fungi occurs probably due to increased grazing pressure in the immediate environment.

Finally, between ca. 1900-1110 BCE, arid conditions similar to those already described recover, with the progressive increase of Chenopodiaceae and a decreasing pattern for oaks, aquatics, algae and cyanobacteria. Tree cover dramatically diminishes (deciduous *Quercus* >5%). This phase is the most obvious deforestation moment in the vicinity of Villafáfila lagoons. Percentages of anthropozoogenous and anthropogenic taxa and coprophilous fungi all increase until ca. 1400 BCE (Cerealia type appears constantly until this date) and subsequently decrease, coinciding with a drastic reduction in settlements in the area during the Middle-LBA (ca. 1500-1000 BCE).

4. Field-walking surveys

Archaeological surveys in the area during the 1980s revealed a high density of surface artefacts at the lake complex, mainly consisting of pottery remains from different periods. It was quite clear that the density of archaeological sites per km^2 was far higher here than in any other area in the province of Zamora (Rodríguez et al., 1990). Moreover, excavations at the Bronze Age site of Santioste, carried out in the early 1990s in two separate seasons, revealed archaeological remains (pits, kilns, and large quantities of discarded pottery) corresponding to a specialized area (Viñe et al., 1990, 1991). Due to the similarity of this evidence to that recovered from Bronze Age and Iron Age contexts in many parts of Europe that were engaged in brine boiling, Santioste was later interpreted as a salt-producing workshop (Delibes, 1993).

Would salt have been a major attraction for settlement in Villafáfila during prehistoric times? With this question in mind, the University of Valladolid, in collaboration with Aratikos Arqueólogos, set up a multidisciplinary research project in 2007 aimed at tracing back the prehistoric origins of the production of salt at Villafáfila. It was entitled *Estrategias de explotación salina en las Lagunas de Villafáfila durante la Prehistoria Reciente* and was supported by the European Regional Development Fund (ERDF) within the Spain-Portugal Cross-Border Cooperation Programme (POCTEP, 2007–2013/FEDER), and by the Regional Government of Castilla y León, in Spain (Plan PAHIS, 2004–2012 Consejería de Cultura, Turismo y Deporte, Junta de Castilla y León) (http://www.jcyl.es/jcyl/patrimoniocultural/Villafafila/01-inicio.html).

Therefore, as one of the hypotheses to validate in the project was the relation of the intensity of land use over the centuries with the production of salt, during the 2007 field season archaeological surveys were carried out at Villafáfila to locate and define the boundaries of every prehistoric site identified within the project area. This phase combined different strategies (Abarquero et al., 2010): 1) review of the Inventario Arqueólogico Provincial (IAP) of Zamora, the province-wide inventory of recorded archaeological sites; 2) reassessment of older museum collections resulting from previous surveys, which were curated at the Museo de Zamora; 3) intensive field-walking surveys at the lake complex and its surroundings.

By mapping the surface scatters, which consisted almost entirely of broken potsherds 55 prehistoric sites were recorded within 2 km of the edges of the lakes (Fig. 1). Most of the sites are less than 3 ha in extent, reveal multi-period occupations, and in some cases, prehistoric materials lay beneath medieval salt factories, as the excavation of Prado de los Llamares had previously uncovered (Sanz and Viñé, 1991). Across the region, artefactual evidence from the Neolithic remains elusive and has been unambiguously noted only at Fuente de San Pedro, which provided diagnostic pottery of the Early Neolithic. Some stone axes were also recovered, but they were all isolated finds, and in any case, they are culturally undiagnostic. Nonetheless, palynological data deriving from the sediment core indicate that cereal cultivation and pastoral practices were introduced ca. 5120-5055 BCE, during the Early Neolithic (López Sáez et al., 2017: 83).

Based on the surface collections the most prominent period of occupation of the remaining 54 sites is as follows: 13 sites are attributed to the pre-Beaker Chalcolithic period, 1 to the Beaker period, 30 to the Early Bronze Age, 5 to the Middle/Final Bronze Age and 5 to the Iron Age (Abarquero et al. 2012). This cultural sequence during prehistoric times matches the palaeoenvironmental pattern. Climatic changes occurring ca. 2350-2150 BCE would have led to the relocation of the settlements to other areas during the EBA. Palynological data indicates an increase in the extent of crop fields and grazing pressure ca. 2150-1900 BCE. These data is consistent with a substantial increase in settlement in the area until the Middle Bronze Age (2200-1500 BCE). By 1400 BCE Villafáfila witnessed a gradual and definitive degradation of the holm oak forest, probably because of the high demand for wood as fuel in the salt factories. The reasons for the low anthropogenic impact from the Middle Bronze and along the first millennium BCE remain unclear (López Sáez et al., 2017).

The topographical analysis of the sites was particularly important to better understand the surface artefacts. 36 sites (65% of the total) show a close spatial relationship with the waterbodies, as they are situated on the lakeshores or even on the lakebeds themselves (mainly in the southern zone of the Salina Grande Lake, where the basement elevation forces saline groundwater to flow up), and most of them are completely flooded during the rainy season. Consequently, they could not have functioned as settlements, and they could be active only in summer. 4 Pre-Beaker Copper Age sites have been identified on slight hillocks close to the pools, and a similar pattern exhibits Molino Sanchón II, the only site with a strong Beaker presence. The concentration on the Early Bronze Age is remarkable with a total of 26 sites situated on the lakeshores, an indication that salt activity reached its highest peak ca. 2000-1700 BCE. The extensive Bronze Age exploitation came to an apparently

abrupt end by ca. 1500 BCE: only 3 sites reveal activity during the Late Bronze Age and this trend continues during the Iron Age, as only 2 Early Iron Age sites have been located, but the reasons for this remain unclear. While the place name of Villafáfila might derive from the Latin *favilla salis*, referring to a fine salt recorded by Pliny the Elder (Nat. 31. 42), there is no direct evidence of salt production in Roman times either (Delibes et al., 2005).

5. Sites selected for excavation

As part of our research project looking at the exploitation of salt at the Villafáfila Lake Complex in prehistoric times, archaeological excavations were carried out at four sites: El Villardón (Pre-Beaker Copper Age), Molino Sanchón II (Beaker period), Santioste (Early/Middle Bronze Age) and Fuente de San Pedro (Early Iron Age).

Located between El Villardón and San Pedro Lakes, the site of El Villardón, at Villarrín de Campos, shows activity from the Copper Age (early 3rd millennium BCE) until the medieval period (Delibes et al., 2005). It was investigated in 2017 through a surface survey and targeted test trenching. The five trenches, with a total excavated area of 40 m^2 provided hand-made and wheel-made pottery, two flint blades, two iron objects, and some crudely fired clay pots which may, ambiguously, correspond to briquetage. However, no clear traces of firing structures nor evidence of salt production were found at the site (Delibes et al., 2017). (Fig. 2)

Fuente Salina, on the shores of La Fuente lagoon, is a multiperiod settlement of the Early and Late Iron Ages, and there was also evidence for at least some activity during the Roman period although much more

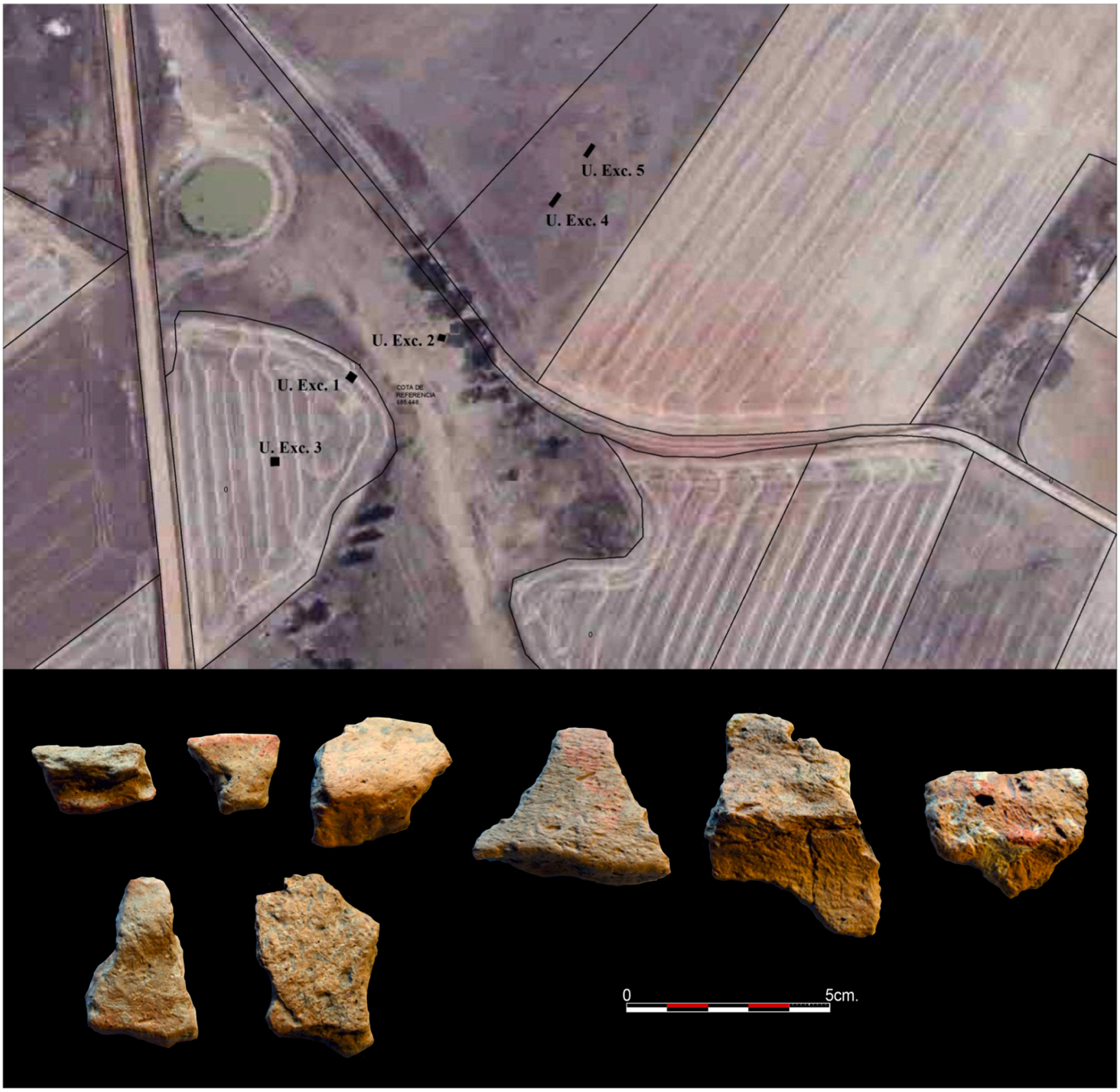


Fig. 2. El Villardón site: above, location of the excavated trenches in 2017; below, possible briquetage recovered.

limited. Geophysical prospection by caesium-magnetometry (further details below) identified up to eight fire structures in three of the eleven 40 × 40 m sampling grids (Fig. 3). The excavation of two testing trenches (a total surface of 36 m^2) revealed some burnt areas and a possible kiln. These firing structures are assumed to have served as domestic hearths, rather than being implements for salt processing, as they are associated with Iron Age domestic pottery, and there were no remains suggestive of brine boiling, such as layers of charcoal and ash, briquetage, or clay pedestals (Abarquero et al., 2012) (Fig. 4).

Secure evidence for salt production has only been established at Molino Sanchón II and Santioste (Abarquero et al., 2022). Features include wells, pits filled with clay for filtering the brackish waters, places for boiling the brine with clay or stone stands, and areas of clay burnt red, discarded pottery, ash, and other remains of firing (for a detailed description of the excavations see Abarquero et al., 2012) (Fig. 5).

5.1. The beaker site of Molino Sanchón II (Villafáfila)

Molino Sanchón II is situated on the Arroyo del Riego, a stream that links the Barillos and Salina Grande Lakes. Systematic pedestrian surveys at the site (2 ha in extent) were used in conjunction with geophysical methods thanks to the collaboration of Dr. Helmut Becker, from Becker Archaeological Prospection. Magnetometry is a non-destructive technique that is particularly effective in places where fire has been repeatedly practised. Using a highly sensitive caesium-magnetometer (model Geometrics G-858G in duo-sensor configuration, sensitivity of 20 pT at a 10 Hz cycle, dynamics ± 25 nT, and a spatial resolution of 0.25 × 0.5 m in a 40 m-grid), the prospection showed that hearths and burnt areas were widely present in some of the seventeen sampling grids. To the NE and SE of the survey area, magnetic anomalies detected strong evidence of soil clearance, possibly associated with the leaching of saline sediments in those sectors. The function of a very wide trench, up to 8m wide, which is visible to the north and west, remains unclear (Fig. 6).

The excavations at the site started in 2009 and were further expanded in 2013, ultimately covering a total area of 72 m^2. Details and correlations of the full stratigraphy of the site are presented elsewhere (Abarquero et al., 2012, 2022). Three phases of occupation were identified. Lying beneath an Early Medieval cemetery (phase III) the site witnessed sustained salt processing activity during the Chalcolithic (phase I), ca. 2480-2150 BCE, and the Early Bronze Age (phase II) ca. 2200 and 1950 BCE according to seven radiocarbon dates (Abarquero et al., 2017) (Table 1).

The deposits of Phases I and II in Molino Sanchón II are characterized by the following features (Fig. 7).

- well-pits that were dug down on the bedrock clay to reach the groundwater table. They were subsequently filled with successive layers of ashes and charcoal, possibly resulting from the conditioning of brine-boiling activity areas that may have been operating elsewhere.
- circular basins that served as firing structures, where clay or stone pedestals were occasionally found in their original position mixed with ash and charcoal.
- very close to these boiling areas, there are some post holes forming alignments
- circular pits (one of them with ca. 200 L of capacity) lined with impermeable clay

In Phase II the methods of production present the same pattern as in Phase I, with only slight modifications: 1) part of the test trench was covered with a bed of white clay sediment, forming a compact and hard surface, probably used to make the work area more uniform; 2) some of the settling features present two basins at different levels, and others incorporate a central concavity, and 3) Boiling Area East (feature 2061/2062/2010), one of those circular areas of burning, incorporates a thick clay rim around its mouth, presumably to better establish its limits.

Many horizontal layers of ashes, charcoal, and small mud pellets contained thousands of sherds from plain vessels broken *in situ,* and fragments of clay pedestals. Excavation produced large quantities of broken pottery (N = 52,500 sherds), but it is worth noting the under-representation of proper briquetage (that is, coarse fired clay containers, typically red or orange in colour). Pottery mainly consisted of large plain vessels of varying shapes, apparently corresponding to everyday domestic types, and a few of them show basketry impressions on their bases, Remarkably, Beaker pottery (N = 924 sherds) is quite abundant during Phase I. Pottery during Phase II is dominated by S-profiles and carinated pots and is representative of the local EBA tradition. Accordingly, Bell Beakers are less abundant (N = 51 sherds).

5.1.1. Micromorphological analysis and the formation processes of sediments

To clarify the depositional and post-depositional dynamics involved in the formation processes of sediments, as well as from the sterile deposit documented between phases I and II, micromorphological analysis was performed on a collection of samples from the E profile of the 2013 test trench. Four thin sections from intact sediment block samples were studied following international standards established in specialist literature (Stoops, 2003). Petrographic slides were prepared at the Spectrum Petrographics Lab, in Vancouver (USA). A petrographic microscope equipped with a digital camera was used for the micromorphological and petrographic thin section analysis, applying a range of magnifications (× 20– × 400) and lights (plain polarized light: PPL/crossed polarized light: XPL).

Preliminary results obtained so far by Dr Ana Polo, Universidad del País Vasco/Euskal Herriko Unibertsitatea (Polo, 2023) reveal the overall good preservation of the combustion residues. The occupation layers have been preserved in their original context of deposition. Interestingly, the mineral coarse fraction of some of the documented microfacies reveals light yellow-whitish features with variable size and morphology with vesicular porosity and isotropic in XPL, identified by Sordoillet et al. (2018) as possible salt residues. These results are a major sedimentary indicator of salt-processing at the site.

5.2. The Bronze Age site of Santioste (Otero de Sariegos)

The site of Santioste (also known as Los Pinos), approximately 1 ha, is located in a spit of land close to the drainage channel connecting the Salina Grande and Las Salinas Lakes. The 2009 excavation (affecting an area of 96 m^2) took place where large accumulations of pottery sherds had previously been reported in the early 1990s (Viñé et al., 1900, 1991), and were later interpreted as salt-production remains (Delibes, 1993). Details of the latter campaign have been presented elsewhere (Abarquero et al., 2012, 2022). Three phases of occupation were identified at Santioste, which was visited periodically throughout the Early and Middle Bronze Ages, between 2300 and 1500 BCE, according to four radiocarbon dates (Abarquero Moras et al., 2017) (Table 2).

Separated from the previous phase by a layer of white clay, Phase II witnessed a significant change in the production system, as those circular basins serving as areas of burning were replaced by chamber kilns (Fig. 8). These are rectangular hearths dug into the ground, with walls lined with fire-reddened clay and with abundant ashes, coals and pieces of pottery inside. They are up to 2m long, 40–50 cm wide and between 30 and 60 cm high, and apparently, they had no grids on top.

In purely functional terms, Phase III hardly differs from the preceding Phase II. The only aspect where a clear change is visible is in the furnaces, which are more varied in size, orientation, and position. Size openings in one or both ends serve the purpose of fuel inlet, and occasionally twinned furnaces share a fuel inlet. As in Phase II, the absence of pedestals inside the chambers suggests that medium-large vessels containing brine were placed directly on the walls.

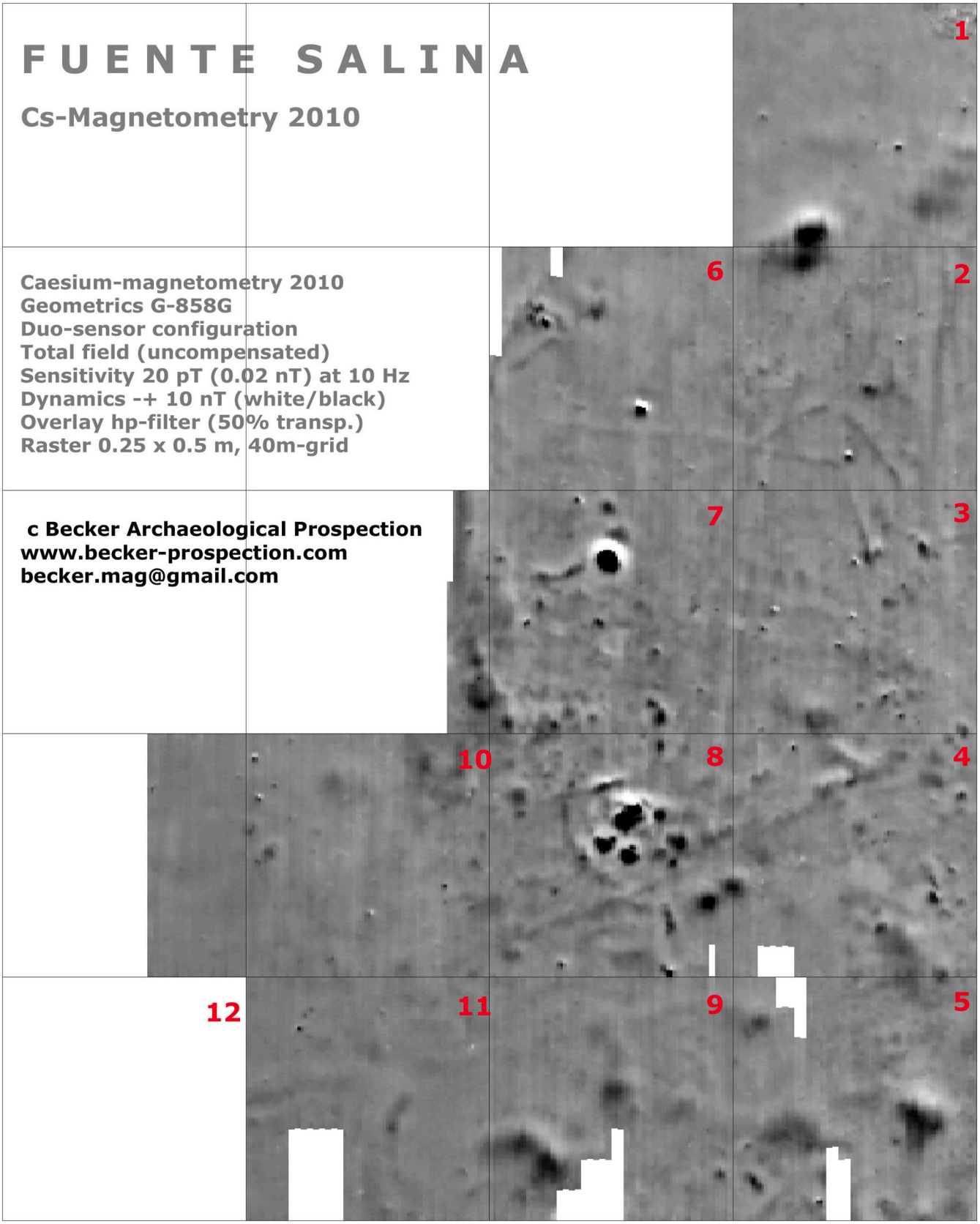


Fig. 3. Magnetometry survey from Fuente Salina.



Fig. 4. Fuente Salina: left, detail of a kiln; right; selection of pottery sherds.



Fig. 5. Molino Sanchón II: Detail of the excavated area in 2013 (the white plank to the left is part of a medieval cist).

As far as pottery is concerned, the Santioste collection (N = 7300 sherds) evolves from the Late Chalcolithic types found in the S–I phase (large globular-bodied pots and ovoid-profile vessels), to the EBA productions of the S-II phase (finger-impressions on the rims). In S-III phase, pottery assemblage fits in the Middle Bronze Age repertoire, with an increase in carinated vessels, S-profile pots, impressed decorations, and plastic motifs.

6. The operational sequence at Molino Sanchón II and Santioste: the absence of typical briquetage and the hypothesis of vegetable moulds

Archaeological evidence gives insights into the different methods employed in Neolithic and Bronze Age Europe for obtaining salt (Harding, 2013, 2014; Weller, 2002; Weller et al., 2008). According to Harding (2021: 42), forced evaporation is a four-stage process which comprises drawing out the brine, decanting and concentrating it, harvesting the salt and shaping it into molded blocks. This method usually involves the use of distinctive clay pots, known as briquetage, and certain artefacts (kilns and pedestals, among others) which differ hardly at all between sites. Brine, available from the sea or salt springs, is boiled in coarse clay containers placed over fires, the resulting salt paste is then heated in smaller vessels until crystals are formed, and finally, those vessels are broken open to obtain hard and transportable salt cakes. From the middle of the 5th millennium BCE brine-boiling was widely spread, and as a result, mould-making was intensified thereafter (Weller, 2015). Experimental approaches replicating the briquetage technique have had relatively low success, and as per Tencariu et al. (2015) the successful obtention of salt cakes is far from a straightforward procedure. While the general principle was always the same, the precise details of the technology varied between different areas and over time (Harding, 2021: 38).

In Villafáfila, the low salinity rates of the waters made it necessary to concentrate the brine in the first place. Excavations in Molino Sanchón II and Santioste revealed some circular pits lined with impermeable clay, very similar to those documented in ethnographic and archaeological contexts in Mexico that are used to decant and concentrate brine and/or to lixiviate salty soils (Castellón, 2014: 78, 2019: 38; Liot, 2002). The white clay layer recorded between the phases in both sites may relate to soil dumping derived from the leaching of saline sediments, which was later used to level the working space.

The next stage was the boiling. At Molino Sanchón II, the boiling areas adopt the form of circle hearths acting as trivets, as they accommodate some pedestals made of clay or stone and often grouped in threes, occasionally in fours, the function of which was to support over fires the large ceramic vessels containing the salt paste. The procedure was quite similar at Santioste, at least during Phase I, because around 2000 BC firing structures evolved. Circular hearths and pedestals were replaced by rectangular clay-walled kilns, showing openings in the shorter sides through which wood was inserted. The occurrence of almost exclusively holm oak/kermes oak (*Quercus ilex/Q. coccifera*) charcoal indicates a preference for these species as fuel wood, and evidence of vitrification results from the use of green wood (Zapata, 2012). Some kilns contained several ceramic sherds that correspond to flat-bottomed storage jars, supposedly used to heat brine.

Recently, Weller & Ard (2024) have established some general characteristics of the ceramics engaged in the briquetage technique.

- clay is from a local origin
- the inclusions are numerous and sometimes of significant volume
- the inclusions tend to be sandy in nature and may also include added organic temper
- the container shape is open
- the vessel is created by forming using coiling or modelling, or even by moulding or folding
- the marks left by fingers, as well as organic matter, or even textile prints, are frequent
- the external walls have no regularity but the internal smoothing is sometimes very meticulous
- the fragmentation is considerable having been intentionally broken. Removing the salt cake is the sole use for these forms.

Commonly, these are single use vessels, as the combination of brine and fire exposure causes a short service life (Ceja, 2011: 42). This would explain the massive deposits of discarded pottery sherds, consisting of

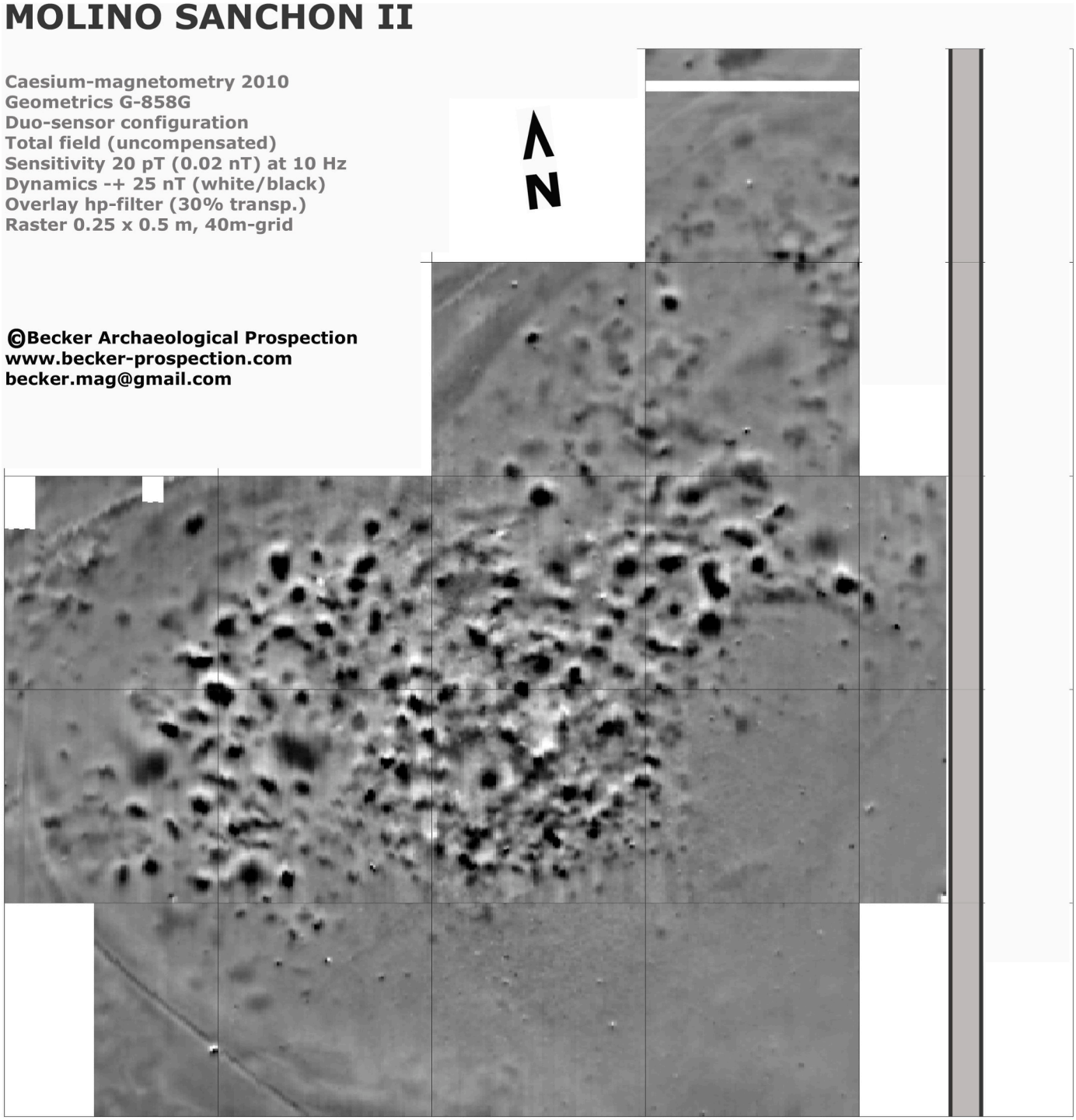


Fig. 6. Magnetrometry survey from Molino Sanchón II.

large reddish-orange ceramic vessels that are characteristic of salt-production sites through boiling. However, the relationship between these materials and salt production raises some doubts, with other possible uses being considered (di Fraia, 2023). In fact, one would expect clear signs of the firing process on vessels that originally contained salt, and colour variations on their walls, towards pink or whitish (Harding, 2021: 17–18).

Nonetheless, in the absence of genuine briquetage, brine-boiling and salt-moulding are also possible. Ethnographic observations and analytical work show varied technical choices engaging containers other than coarse clay vessels. At the Chalcolithic site of Solnitsata, near Provadia, in Bulgaria, three types of salt moulds were used. These are good quality pottery vessels, the volume of the largest ranging from 60 to 80 l. (which according to some estimations would have produced 100 kg salt cakes). A slip was applied to the internal surfaces of the moulds, and after firing a thick clay coat was applied to the external walls and base surfaces (Weller and Ard, 2024).

Typical briquetage containers are extremely scarce at the Villafáfila sites, representing less than 1% of the ceramic assemblage of Molino Sanchón II, 1,6% during Phase I at Santioste, and up to 20% during Phases II and III (Fig. 9). Most discarded sherds correspond to pots of considerable quality, which are morphologically and typologically

Table 1
Radiocarbon dataset and calibrated ^{14}C radiocarbon dates of Molino Sanchón II. Radiocarbon dates have been calibrated using the Oxcal 4.4.4 (Bronk Ramsey, 1994) and the Intcal 20 radiocarbon calibration curve (Reimer et al., 2020).

Phase	Context	Lab Ref	Sample	^{14}C Age	STD	Calibrated date (2 σ)
Ib	Pit	PoZ-35226	Charcoal	3910	35	2552–2238
I	Settling basin	PoZ-71989	Animal bone	3855	35	2459–2204
Ia	Well-pit	PoZ-35252	Charcoal	3835	35	2456–2150
Ib	Boiling area	PoZ-35227	Charcoal	3830	35	2455–2147
Ic	Layer of ash	PoZ-35223	Charcoal	3765	35	2293–2039
II	Settling basin	PoZ-35224	Charcoal	3745	30	2281–2035
II	Boiling area	PoZ-71991	Animal bone	3665	35	2191–1942

similar to those used in household units for everyday purposes. The results of the fabric analysis on some ceramic samples through X-ray diffraction (XRD), ATR-FTIR spectroscopy, and Thermogravimetry Differential Thermal Analysis (TG/DTA) indicate that the pots were produced with local clays and were fired at temperatures between 500°/600° and 800°/900°, the great majority of them undergoing a complete firing cycle (Martín Ramos et al., 2012).

Chemical and mineralogical composition was obtained for 7 clay samples and 136 ceramic samples from Molino Sanchón II and Santioste through Wavelength-dispersive X-ray fluorescence (WDXRF) and XRD analyses. It is unclear whether raw material procurement strategies were primarily focused on the use of CaO-rich deposits, or if calcite was deliberately added as temper. It has been proved that during the firing process, high CaO ceramic matrices undergo mineralogical transformations that activate processes of cracking (Teodorescu et al., 2022). However, the use of calcareous materials as temper could be a technological choice, as the presence of halite in the clays would reduce cracking (Odriozola and Martínez-Blanes, 2012). An indicator of the use of ceramic containers in brine-boiling activities is based on the percentage of chlorine content in their fabrics (Horiuchi et al., 2011). Samples from Molino Sanchón II revealed higher levels of Cl in plain pottery than in raw clay samples, Beaker pottery, and clay implements. In contrast, Cl content in plain pottery from Santioste presents similar values to that in proper briquetage, indicating different technical solutions.

Archaeological evidence at Villafáfila also points to a different formula for the moulding stage. The volumetric analysis of the ceramic assemblage highlights the almost complete absence of the small ceramic moulds employed to obtain salt ingots, as those frequently recovered in other salt workshops which employ the briquetage technique, frequently adopt a conical shape (Tencariu, 2018). Given the existence of several sherds displaying basketry impressions woven baskets and textile sacks may have served to complete the crystallization process and thus obtain standardized units intended for salt trade (Guerra-Doce et al., 2023).

6.1. Basket weaving in Villafáfila: preliminary results from Molino Sanchón II

Basket weaving imprints on ceramics constitute a fundamental resource to determine the techniques used in the production of crafts based on plant fibres during prehistory. Through these remains, it is possible to determine the technique used in the production of basketry, and, in some cases, even the raw material or its shape. In Villafáfila impressions of woven basketry on ceramic sherds have been recovered from various prehistoric sites during the field-walking surveys (Abarquero et al., 2012), however they have not been systematically studied

Table 2
Radiocarbon dataset and calibrated ^{14}C radiocarbon dates of Santioste. Radiocarbon dates have been calibrated using the Oxcal 4.4 (Bronk Ramsey, 1994) and the Intcal 20 radiocarbon calibration curve (Reimer et al., 2020).

Phase	Context	Lab Ref	Sample	14C Age	STD	Calibrated date (2 σ)
I	Boiling area	PoZ-35255	Charcoal	3860	35	2461–2205
II	Kiln	PoZ-35253	Charcoal	3660	35	2141–1936
III	Burial	PoZ-71992	Human tooth	3485	35	1900–1692
III	Ritual deposit	PoZ-35228	Animal bone	3380	35	1751–1540



Fig. 7. Molino Sanchón II: (left to right and top to bottom), well-pit, firing structure, post holes, and decanting basins.



Fig. 8. Santioste: a selection of kilns.

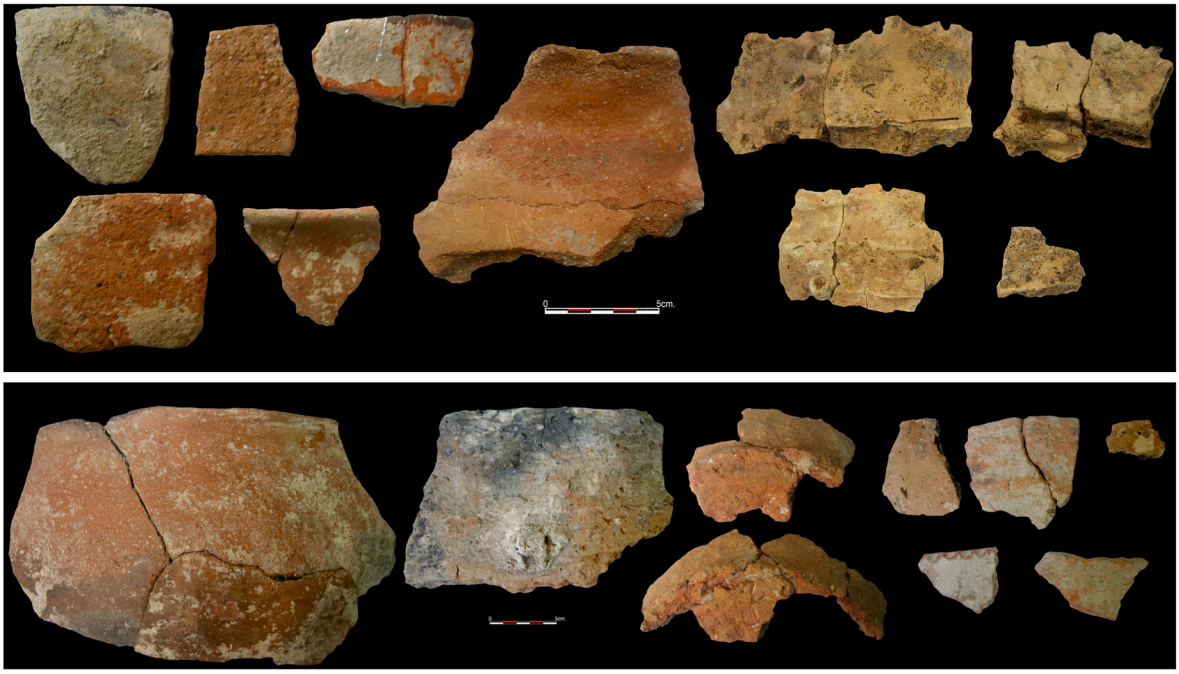


Fig. 9. Selection of briquetage from Molino Sanchón II, above, and Santioste, below.

in relation to the basketry techniques used.

During the last archaeological campaigns in Molino Sanchón II and Santioste some potsherds with basketry impressions on their bases clearly visible to the naked eye were recovered. We present the preliminary study of a collection of 78 pieces from Molino Sanchón II: 47 from Phase I, 26 from Phase II, and 5 from Phase III. Through the combination of direct analysis, 3D scanning of the sherds and the development of an experimental program to reproduce the impressions in clay (Romero-Brugués et al., 2022), it has been possible to characterize the basket weaving techniques that were used for the manufacture of baskets and mats in Villafáfila by the end of the 2nd millennium BCE. The experimental program has allowed us to compare the results of the analysis of the impressions with the impressions obtained through a reference collection of vegetable turntables organized according to different raw materials and techniques (Fig. 10).

The basket weaving technique determined in the prints is coiled basketry. The length and height of the ceramic fragment, the minimum and maximum width of both the bundles and the sewing stitches, the numbers of visible bundles, the spacing of the spiral, the type and shape of the stitch, the typology of the print and the minimum diameter of the basket fragment have been the parameters considered. Variability has been determined between the impressions of the minimum and maximum width of both the bundles and the stitches, as well as within each impression. This may be due, for example, to the fact that in certain basket manufactures the vegetal material used in the sewing varies in different areas of the piece, depending on the resistance or flexibility that is desired to be given to the basket part; It may also be due to the effort dedicated during the production of the basket bases, depending on

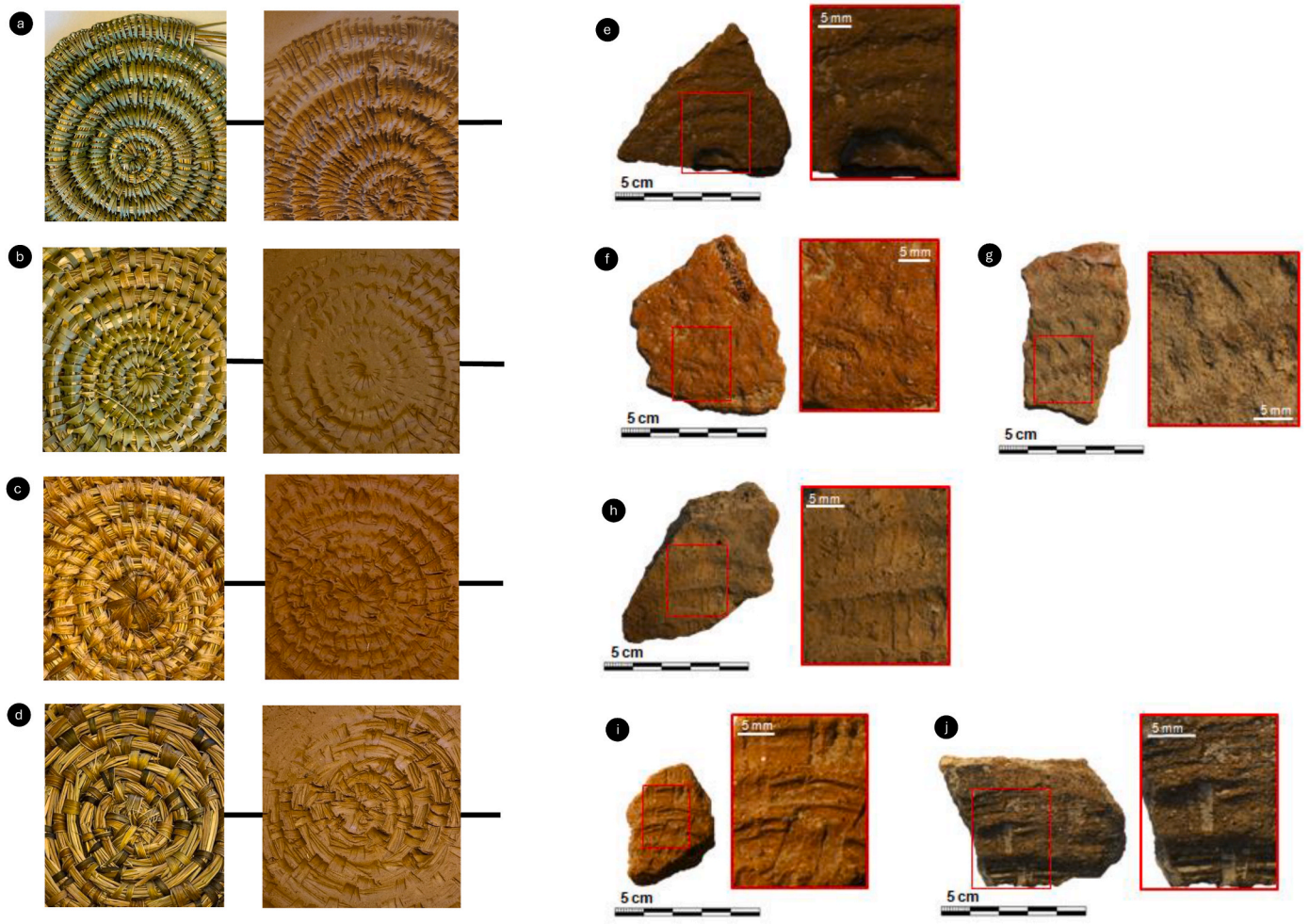


Fig. 10. Comparison between experimental replicas and ceramic fragments: a) - d) replicas 1–4; e) fragment 2010/30 Phase II; f) fragment 1030B/63 Phase Ic; g) fragment 1030B/64 Phase Ic; h) fragment 1108/88 Phase Ia-b; i) fragment 1110/160 Phase Ia-b; j) fragment 2212/11 Phase Ia.

the function for which they would be intended. Likewise, the fact that there was more than one artisan in its production cannot be ruled out. On the other hand, the type of stitch applied to sew the bundle produces a basketwork element of greater or lesser rigidity. The intricate stitch (related to open spirals) has been documented as the majority, being both interlocking and non-interlocking (50%), followed by the simple non-interlocking stitch (43%) and the simple interlocking stitch (7%). Likewise, some technical variability has been detected with respect to the centers or starting points of the sewn spiral, determining both circular and oval centers. Finally, most of the basket pieces would have a small/medium diameter between 25 and 50 mm, followed by larger diameters between 50 and 111 mm and smaller diameters than 25 mm.

Three morpho-technical categories have been identified among the impressions of the ceramic fragments: 50 bases, 26 profiles, and 1 wall. It has not been possible to determine it in a fragment. All the impressions are found on ceramic fragments without vertical curvature, assuming that these correspond to the bases of the ceramic piece, with flat support bases. In only one case has a non-basal impression been detected, that is, on the wall of the container (given its vertical curvature), which could correspond to the external face of a wall. However, in those fragments where the profile between the base and the wall of the vessel is preserved, it is not possible to determine whether the impression is preserved on the base or on the wall.

Most of the impressions have diffuse impressions, with little relief, which could be due to the intentional modification of the base (Fig. 10e), as a subsequent smoothing of the still fresh clay. The total impressions are more abundant than the partial ones and due to their basal arrangement, the basket pieces that caused the impressions likely had a lathe functionality related to the modelling of the clay. Some impressions may be the result of placing a ceramic vessel that was not yet dry on plant mats (Harris, 2014). There are known cases where plant bases are used to shape ceramic vessels during their production (Rovira, 2006). The most used type of spiral is the closed one, with or without the presence of grooves. In those cases where the separation between bundles has produced grooves, the majority present this very marked separation (Fig. 10i and j), like a ridge, a characteristic related to the functionality of the basket pieces. It is believed that the ceramics from Molino Sanchón II would have been made using the technique of superimposing clay cords with the help of a vegetable lathe. With this technique, the base of the vessels begins with a portion of clay, which can be molded in the hands or placed directly on the turntable. Depending on the pressure exerted, the impression is more or less deep, leaving separations in the spacing of the spiral in the form of a pronounced or rather flat groove (Fig. 10 a-c).

Likewise, it has been possible to identify certain characteristics of the raw material used from the traces left by the fibres themselves on the ceramic supports. To this end, the analysis has been possible by observing specific plant anatomical characteristics through a binocular magnifying glass and a Dino-Lite digital microscope. The presence or absence of subunits in the impression of the bundles has been analyzed in those fragments with greater visibility of their imprints, as well as the separation between the longitudinal lines in the form of striations that

can be seen in the sewing elements. Even the identification of the raw materials used to make the plant turntables from the analysis of their impressions in clay is not precise, as the characteristics used to identify the different plant species overlap. Thus, this part of the analysis is an approximation, which can take into account previous archaeobotanical analyses from the site in order to have information about the environmental description.

Finally, the comparison of the impressions on the ceramic fragments from Molino Sanchón II with the experimental impressions (Fig. 10) has allowed us to corroborate certain technological hypotheses about the production of the vegetable turntables used in ceramic production, as well as to identify similarities in terms of the vegetal raw material used. On the one hand, the impression of the plant object on the base of the ceramic support seems to be conditioned by the procedure followed in the production of the ceramic vessel: it shows differences where pressure is or is not exerted, depending on whether the base of the ceramic container is made in hand or directly on the plant support. This fact corroborates the hypothesis of the presence of open spirals with or without a pronounced groove. It is also detected that depending on the pressure exerted by the still-wet clay on the mat, its impression shows differences in terms of presenting open spirals with pronounced grooves in the shape of a crest or diffused grooves in the shape of a flat strip.

On the other hand, it has been observed that the use of fibres of different thicknesses along their length, as well as the lesser or greater processing of the plant matter, conditions the type of spiral and its opening, resulting in different impressions without changing the plant matter. Although a specific identification of the species used for the production of plant crafts in Molino Sanchón II is not possible, the comparison of the vegetable stretch marks visible in the stitching of the archaeological impressions with those of the experimental impressions has resulted in similarities in measurements and morphology to the lines left by different species. In this way, it is suggested that several species, both monocotyledonous (sedges, grasses, cattails, etc.), and dicotyledonous bark (brambles, etc.), could have been used for stitching. In the case of the bundles that form the spiral, it has been observed that they were made of several elements or subunits and they appear to have a rounded section. This could indicate that leaves and stems of different plants accessible in the vicinity of the site from small diameter reeds, or of various unidentified grasses, could have been used.

6.2. *Reproducing the moulding process using baskets: a field experiment*

Archaeologically, the presence of baskets in salt-works involved in brine-boiling through the briquetage method is attested from the discovery of ceramic sherds displaying plant imprints and traces of wickerwork on the bottom (Castellón, 2007; Liot, 2002; Valiente et al., 2003; Weller, 2015). At the Chalcolithic site of Provadia-Solnitsata, mat impressions may indicate that during their production, the bases of the pottery vessels used for salt extraction were in contact with woven mats (Weller, 2012: 74). Recently, Andonova and Nikolov (2021) have also argued that basketry played a part in the storage, transport and exchange of salt.

Based on archaeological evidence from Molino Sanchón II, in 2022 we performed an Experimental Archaeology study to explore how baskets may have been involved in the salt-processing activities developed at the site. Rather than a detailed scientific experiment, it was a loose attempt to contrast the differences between using exclusively salt-pots or recurring to baskets as well.

5 L of brackish water was brought to boil in an earthenware vessel placed over a stove-like implement housing embers. Gradually, a kind of salt slurry was formed and started to crystallise (Fig. 11.).

- Test 1: Some salt paste, still very wet, was collected and transferred to smaller vessels, an unfired pot and a pottery container that were placed in the stove until solidified blocks were formed. The option involving the raw clay pot has drawbacks, as the pot cracked and some clay got stuck to the resulting cake. In contrast, moulding in a ceramic pot facilitates the obtention of clean and compact salt cakes, but, in turn, the vessel cracked during the heating process, and it was necessary to break it in order to extract the salt cake.
- Test 2: in this case, salt paste was poured into baskets to drain the excess of water, and when there was no more dripping, one of the baskets was placed inside an earthenware vessel that was placed in the stove. Once a compacted lump was formed, the basket was pulled out. The final product was granulated salt, but still wet, possibly because the basket was taken out too early.

This experiment seems to validate the possible use of baskets in this way for salt-moulding at the Villafáfila sites. The use of baskets for dehydrating salt can be justified for several reasons: Ceramic vessels break easily due to the crystallization process of the salt during firing, which causes cracks in the pottery and fissures. Therefore, the use of ceramic vessels involves a high cost of energy in the form of firewood for firing the pieces. If unfired clay is used, the contact of the clay with the salt water causes the clay to fracture into thin layers that adhere to the salt and foul it. The ceramic vessels reach high temperatures when in direct contact with the embers. The salt dehydrated by this process remains compact, but the vessels have to be broken to extract the block of salt that then has to be ground. The use of baskets to prevent direct contact between the ceramics and the salt avoids the fracture of the ceramic pieces and the resulting salt is clean. With this procedure, the dehydration process is slower, as the temperature of the salt is not as high.

Ethnographic observations related to boiled brine all over the world illustrate the use of basketwork filters to remove moisture from salt paste, and to dry wet salt (Guerra, 2016: 100). In southern Mexico, indigenous saltmakers from the communities of Soconusco and Ohuilapan drain granular salt in bags that are hung over firing structures to



Fig. 11. The experiment, from left to right: boiling brine in a large vessel; test 1, salt paste has been transferred to an unfired pot and a pottery vessel; test 2, crystallization of salt in a basket placed inside an earthenware container; the final products.

eliminate as much residual moisture as possible from the sacks (Ceja, 2011: 41). Goutlequer and Weller (2015) provide examples of salt moulding in baskets and bark containers that can be reused several times.

A basic principle of salt trade is the standardisation of the cakes in units of similar shape and size (Weller, 2015: 72). For instance, at the mining centre of Taoudenni, in the desert region of northern Mali, rock salt is produced in standard slabs with an average size of 45x18x5 inches and a weight of 55–75 lb (Naval Intelligence, 1944: 209). While the size and shape of the slabs have practical origins, as camels can carry two 35-kg slabs on each side (150 lb per side), the standard size and shape of the slabs facilitate transactions, historically and presently, as salt has been and continues to be a form of currency (Kuan et al., 2015: 329). Salt-moulding in basketwork provides additional benefits: 1) once salt is compacted it can be easily exchanged, and 2) baskets can well be made in standard shapes. The Western Dani of Papua, who make salt by burning salty plants, mould their salt cakes in basketwork packaging (Goutlequer and Weller, 2015), and Santa María Ixtapa, an indigenous community in Chiapas, southern Mexico, make *benequenes*, palm-woven bags where salt is dried out, resulting in stable blocks, although not entirely solid (Castellón, 2023: 301).

7. Some insights into the social and ritual aspects of salt production

The implications of the salt-production for the ancient economy and ancient society are very hard to answer in the absence of more information on the populations undertaking the production (Harding, 2014: 594). At Villafáfila our understanding of the social organisation of labour is quite poor. We may assume that some of the sites located in the proximity of the lakes were settlements where people engaged in salt-activities lived. Since most salt factories were small sites and seasonally occupied, it is unlikely that brine-boiling was a full-time specialized activity or that it required many people. However, the massive accumulations of discarded pottery at the excavated sites (52, 300 sherds recovered at Molino Sanchón II, and 7300 sherds at Santioste) suggest that the production of salt was not intended for meeting domestic needs but for exchange.

In this regard, it is generally accepted that control over salt production/circulation in the past enabled wealth and prestige. In Iberia the connection between Beaker groups and salt has long been recognised, as evidenced by the location of the wealthiest Ciempozuelos graves in the middle Duero basin, close to salt resources (Delibes and del Val, 2007–2008). Interestingly, Late Copper Age sites with evidence of salt production are always associated with Bell Beaker contexts (Valera, 2017). The number of sites now known to have produced briquetage and Beaker sherds has increased in recent years, including new factories and also salt-production sites that were exploited in earlier periods, such as Añana (Guerra et al., 2019). We have suggested elsewhere that the spread of the Beaker phenomenon across Western Europe may be linked to trade routes along which prestige goods circulated, including salt (Guerra, 2016).

It is interesting to highlight that Molino Sanchón II has yielded the largest assemblage of Beaker pottery found so far in Iberia (N = 1088 sherds). Virtually all come Phase I, which has produced a total amount of 942 items (Phase II only comprises 51 sherds, and 25 sherds were unassociated finds, as they were found in Phase III). Beaker pottery occurs almost everywhere in spatial relation to salt processing areas but rather than being used in the processing and production of salt, they seem to have played a different role (Delibes et al., 2016). In the first place, Beaker pottery shows lower levels of Cl in comparison to plain vessels in the site (Odriozola and Martínez-Blanes, 2012: 461–463), and secondly, there is evidence for ritual activity involving the use of Bell Beakers. Complete Beaker pots were deliberately deposited into well-pits. The case of feature 1148 in sector 1F is particularly significant as it has provided some Beaker sherds, one displaying symbolic motifs, a complete large pot, and some animal bones that possibly represent the remains of a feast. Therefore, the presence of Beaker pottery at Molino Sanchón II points toward the celebration of propitiatory rituals, but as public events performed in front of the community, these ceremonies can also be explained as a way to claim property rights over salt production (Guerra Doce et al., 2015).

At Santioste there is also evidence of ritual activity, suggested by the discovery in the production area of two pits containing a complete calf (PoZ-35228: 3380 ± 35BP), and the skeleton of a child (PoZ-71992: 3485 ± 35BP) with a rich grave-good assemblage (including silver adornments and a prismatic V-perforated button made on ivory), respectively (Abarquero Moras et al., 2017). The discovery of high-status items of exotic origin in the child burial suggests long-distance contacts with El Argar culture, in south-eastern Spain (Delibes, 1993)(Fig. 12).

Ethnographical and historical accounts, as well as archaeological data, demonstrate that mining and metalworking within pre-industrial societies have symbolic and magical connotations, hence the need to perform ritual ceremonies as indicated by the discovery of burials and ritual offerings in these settings (Blas, 2010; Budd and Taylor, 1995). The purpose of such ceremonies is far from being purely functional; on the contrary, they are acts of propitiation and gratitude intended to please the beings of the underworld and the divinities who protect the minerals, whose domains have been desecrated (Eliade, 1978). Similarly, brine-boiling sites illustrate the importance of performing ritual ceremonies near the salt works (Castellón, 2007: 458, Castellón, 2016: 206–220, Ceja, 2008; Martell, 2011), for although they are not mines *sensu stricto*, the brine emanating from Mother Earth will eventually be converted into salt through an alchemical process.

8. Conclusions

Recent archaeological research has established that salt production in Villafáfila began at least as early as the Late Chalcolithic (Beaker) period. The excavations of Molino Sanchón II and Santioste have provided solid archaeological evidence for the production of salt by evaporating brine. Features include wells, pits filled with clay for filtering the brackish waters, places for boiling the brine, and areas of clay burnt red, discarded pottery, ash and other remains of firing. While similar production processes are documented at both sites, firing structures evolved over time. At Molino Sanchón II (*ca.* 2500-2000 cal BCE), the boiling areas adopt the form of circle hearths acting as trivets, as they accommodate some pedestals made of clay or stone and often grouped in threes, the function of which was to support over fires the large ceramic vessels containing the salt paste. The procedure was quite similar at Santioste (*ca.* 2400-1500 cal BCE), at least during the early stages of the occupation, because *ca.* 2000 BCE more complex firing structures (clay-walled kilns) prevailed there (Fig. 13).

While unfired red pots or those partially fired are characteristic of the brine-boiling factories elsewhere in Europe, containers of this type are extremely scarce in Villafáfila. Given the occurrence of many sherds displaying basketry impressions, we argue that woven baskets and textile sacks may have served to complete the crystallization process. These packets may have been strung up in wooden structures acting as racks, hence the presence of several pit-holes in the excavated areas, the location of which, close to firing structures, is occasionally indicative of wind-breaks. During the last stage of the process the use of baskets as moulds, tested through Experimental Archaeology would have led to obtain standardized sachets intended for salt trade.

Finally, in the absence of specific information on the social context of salt production at the Villafáfila sites, it is difficult to maintain a straightforward correlation between wealth and salt availability. However, it seems clear that Late Chalcolithic and Bronze Age elites were particularly interested in maintaining their control over salt.



Fig. 12. Ritual activity, from left to right: Detail of a ritual pit in Molino Sanchón II, Beaker vessel deposited in the ritual pit; burial of a girl in Santioste (courtesy of A. Viñé); burial of a calf in Santioste.

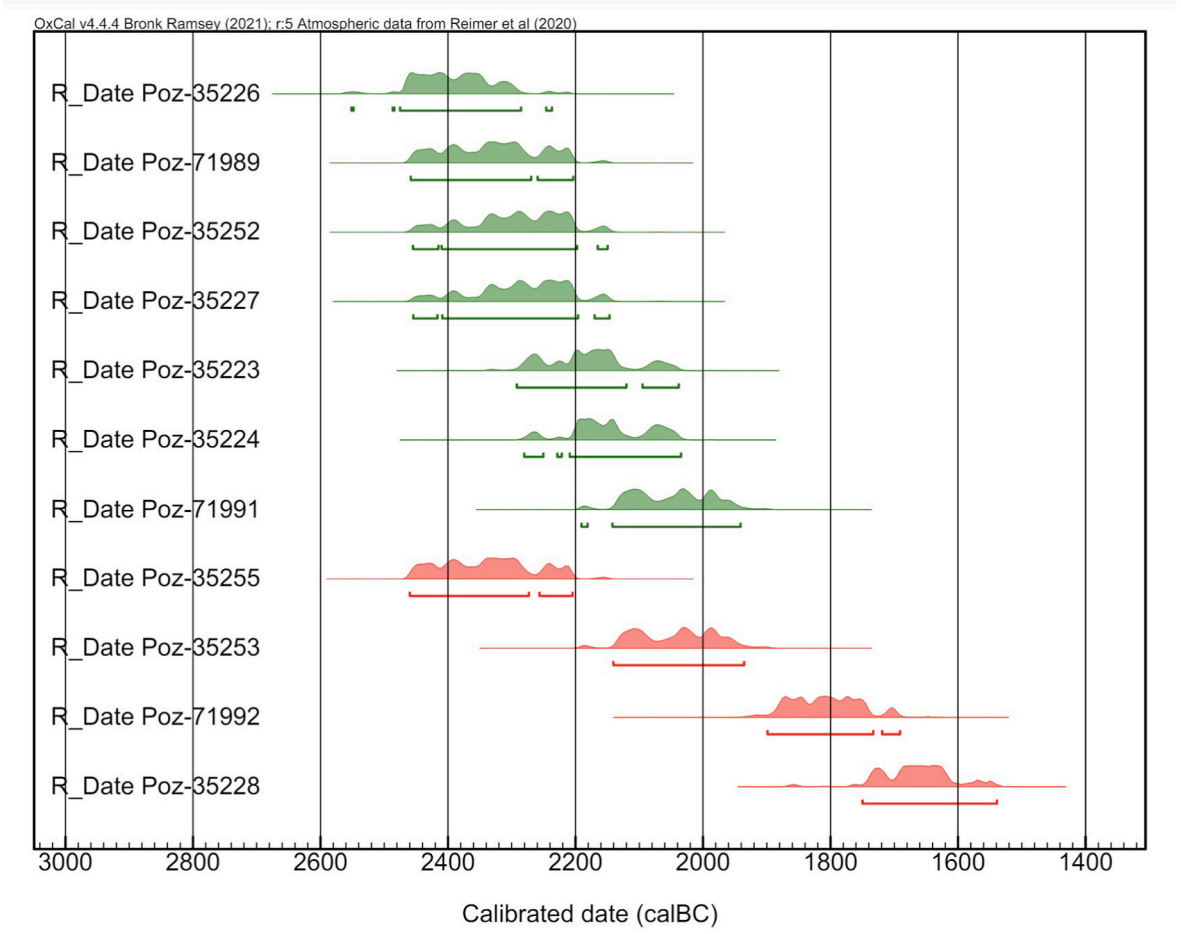


Fig. 13. Diagram (OxCal v. 4.4.4) with the 14C dates from Molino Sanchón II (in green) and Santioste (in red).

Credit author statement

All authors have been implied in the development of the present paper. E.G.D., F.J.A.M. and G.D.D.C. conceived and designed the study, conducted archaeological fieldwork, J.L.G.C. performed the spatial analysis, S.R.B., M.H.O., R.P. analyzed the basket imprints, A.H. conducted field experimentation, J.A.L.S performed palynological analysis, E.G.D. wrote the paper draft with contributions from all authors, all authors reviewed the manuscript and the revised version, and approved the submission.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used DeepL Write in order to translate some terms from Spanish into English. After using this tool/service, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

Declaration of competing interest

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

Data availability

Data will be made available on request.

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