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## ACROSS THE UNIVERSE OF SALT: THE PRODUCTION IN CERAMIC POTS

# VS#1



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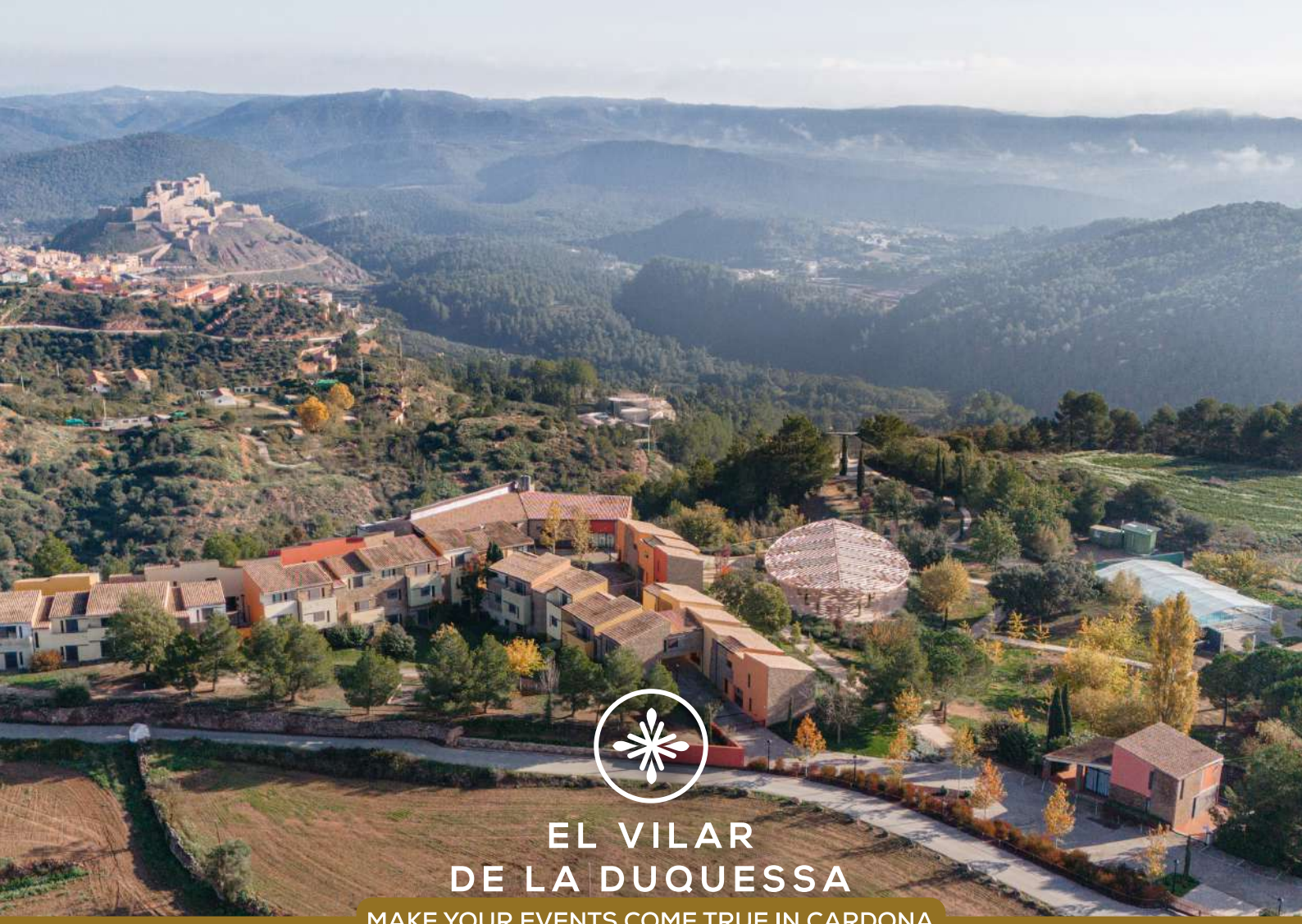

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# Before the sun evaporates the brine: the prehistoric production of salt at Gerri de la Sal in the Pyrennes Mountains

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## Resum

*La sal s'ha produït al poble de Gerri de la Sal des de l'edat mitjana mitjançant l'evaporació solar de la font salada en bassetes poc profundes. Les excavacions arqueològiques al Pla de la Guineu (Gerri de la Sal) han revelat estructures relacionades amb el procés d'ebullició de la salmorra utilitzant bols ceràmics durant l'Edat del Bronze (segon mil·lenni aC).*

## Abstract

*Salt has been produced since medieval times at the village of Gerri de la Sal through solar evaporation of brine spring in shallow pans. Archaeological excavations at the site of Pla de la Guineu (Gerri de la Sal) revealed structures related to the boiling process of the brine using ceramic bowls during the Bronze Age (2th millennia BC).*

Keywords: Brine spring, briquetage, ceramic bowl, salt, structure of combustion

## Introduction

The village of Gerri de la Sal (Catalonia, Spain) is located at the southern side of the Pirennes mountains, in an area of contact within the lower mountains and the plain at 589m of elevation (Fig. 1). It is extended along the river bank of Noguera Pallaresa river which is a path through the mountains. A salt water spring flow in the vicinity of Gerri de la Sal which traditionally has been used to obtain salt from its evaporation by solar exposure inside of shallow salt pans. It is likely that this salt activity dates to medieval times. The salt pans are mostly abandoned but still visible on the riverbank. Currently it is still in use one salt pan unit which makes seasonal salt in a traditional way.

The salt water of the spring has 8-10°Be of density in salinity and 21°C of temperature. Traditionally, the saltwater was transported to the salt pans located beside of the spring. The salt pans in Gerri de la Sal is a complex made up of different production units, each made up of several structures and connected by pipeline systems-hallowed wooden trunks- and channels that distribute the salt water from the spring to the different units. The water from the spring is first transferred to a pond where it is deposited and stored for several months. The water from the bottom

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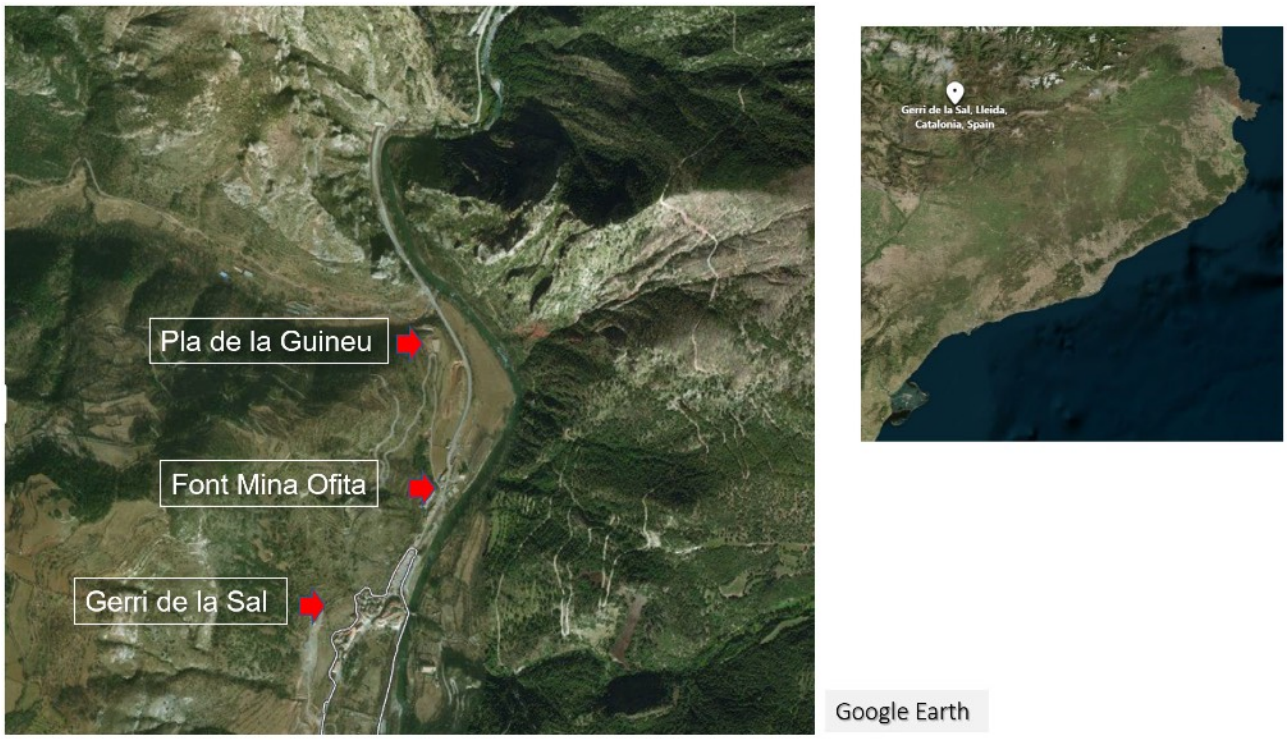


Fig. 1: Site location. Source: Google Earth.

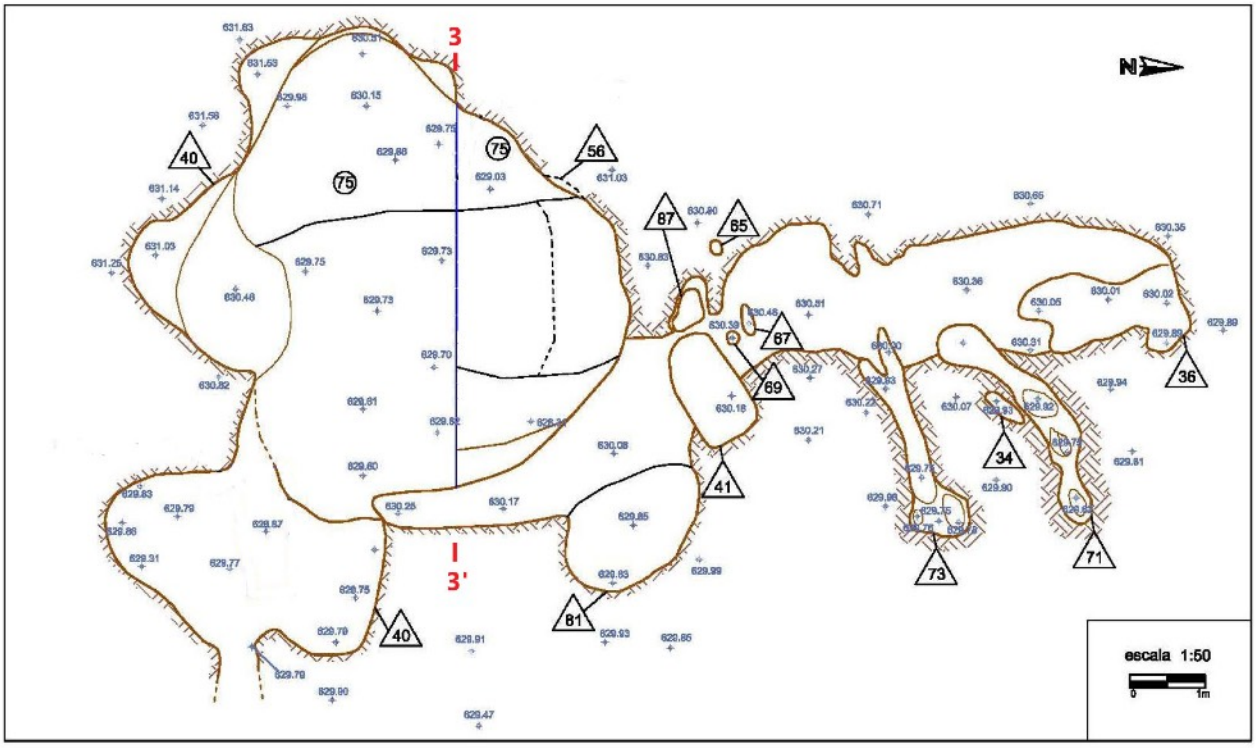


Fig. 2: Plan of site. Author: Pla de la Guineu Team.

of the pond-with a higher degree of salinity- is distributed through a conduit to a first flat and rectangular shallow structure; made of stone and clay which makes it impermeable. Inside, the salt water is left to rest in the open air, and through the action of the sun and wind, it evaporates, increasing its salinity. Once a high degree of salinization of the water has been reached, it is transferred to a second shallower



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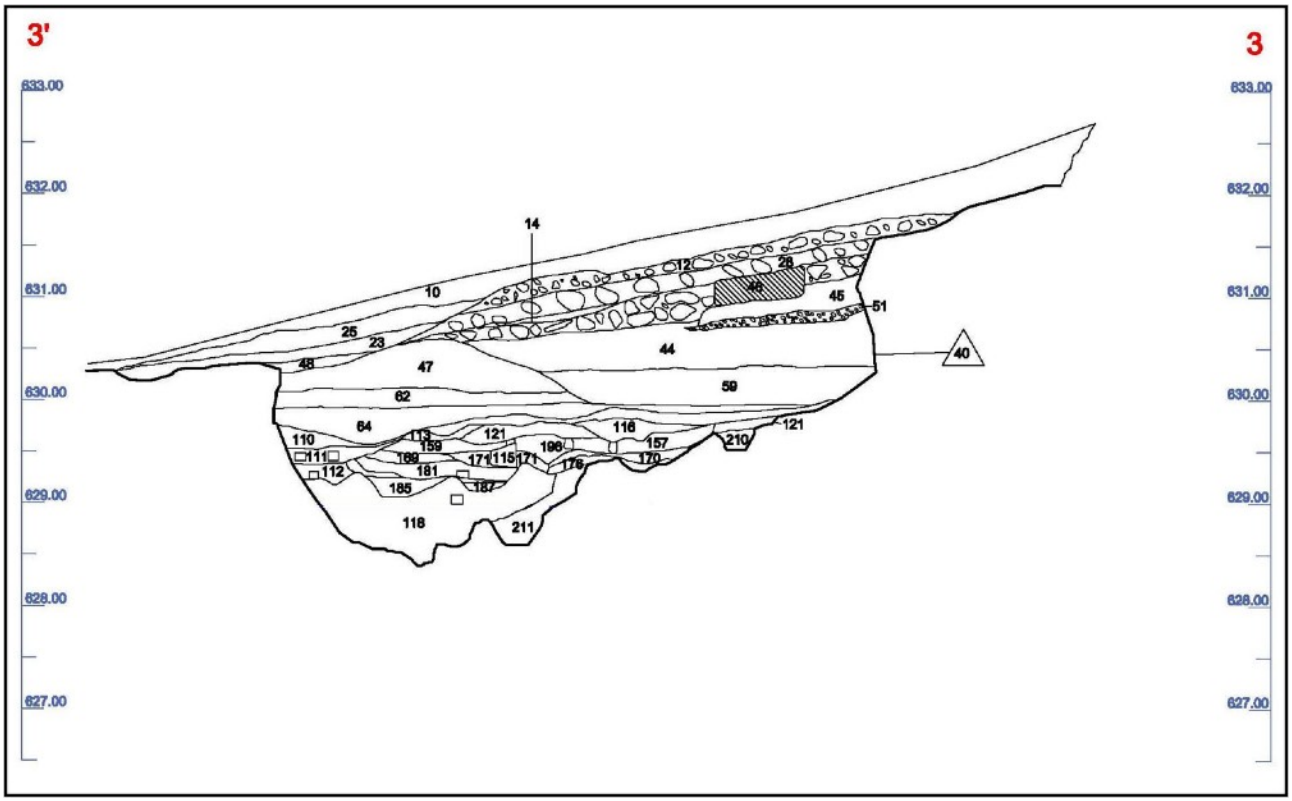


Fig. 3: North facing section of Structure 1. Author: Pla de la Guineu Team.

flat platform. In the latter platform, a thin layer of salt water is deposited. Under solar radiation, the crystallisation process begins in which the water evaporates, leaving salt crystals on the top, forming a crust. This crust is then broken so that the water below continues to evaporate. Finally, the crystallised salt is scraped off until a pile of salt is formed in the center of the platform floor. Traditionally, the salt was stored inside the small shed located in each of the salt pans. At the end of the summer season, the salt was transported to the warehouse where it was stored and treated until two types of salt were obtained, one for animal consumption and the other for human consumption. Currently, the warehouse accommodates the Salt Museum of Gerri de la Sal.

The site of Pla de la Guineu is located 800 meters to the north of Gerri de la Sal (Fig. 2). At this point, the valley of the Noguera Pallaresa river is enclosed by mountainous elevations from which lateral streams emerge and converge. Precisely, the site is located on the western slope of the valley, on a small terrace elevated with respect to the course of the river. The site was discovered in 2011 during the course of archaeological monitoring of road works. At the same year a first archaeological excavation was carried out where two main structures were identified within an area 20m long by 10m wide (Piera 2015). Large assemblages of pottery (c.40.000 sherds of pottery) were concentrated in rich-charcoal layers, burning surfaces and burials within the two structures. All features were fully excavated except for the deeper pit which was only partially recorded. The site was interpreted as a salt making place related to the method of elaboration of salt trough the boiling process of the brine into ceramic bowls.

In 2014 started a research project of the University Autonomous of Barcelona which consisted in two further archaeological excavations carried out in 2015 and 2017 focused exclusively in the fully excavation of the deeper pit. The objective of the research was complete the archaeological excavation of the site with a multidisciplinary approach, with the objective to validate the process of elaboration of salt through boiling brine into the ceramic bowls. These excavations revealed two kilns and one linear furnace which were interpreted as structures associated to the process of production of salt (Fig. 3 and 4) (Piera 2019).



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Fig. 4: Structure 1, facing south. Author: Pla de la Guineu Team.

The present article has the intention of expose the results of several years of investigation of the Pla de la Guineu, showing the main archaeological structures recorded with the associated materials and the results of the main analysis realized.

## Methods of work

Archaeological excavations based on stratigraphic relations of archaeological contexts as layers, fills, structures and cuts. Each context was recorded with a pro-forma sheet with descriptions, measurements and relationships between contexts. Photographic and video images, plans and sections were drawn. The artefacts and ecofacts recovered were registered in each context and different type of soil samples and micro-soil samples were taken. Post-excavation works and material studies were carried out by different specialist and several soil samples and potteries were analysed in the lab. An experimental program replicating the method of salt production was carried out. Diffraction X-ray (XRD) and Scanning Electron Microscope (SEM) and X-ray Fluorescence (XRF) analysis of experimental and archaeological samples were realized.

## Results of the archaeological excavations

The Pla de la Guineu site consisted of two large pits excavated in the geological subsoil that had a series of internal structures (Fig. 2). Both pits were physically connected and were distinguished by having differentiated fillings. The deeper pit, structure 1, was located in the southern part and the other pit, structure 2, in the northern part of the Pla de la Guineu.

### Structure 1

It was identified following a cut (C40) into the natural subsoil filled on top with frequent stones that



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Fig. 5: Aerial view of trench C184. Author: Pla de la Guineu Team.

defined an irregular oval plan (Fig. 3). It was 8m long, 6m wide and 1.8m to 2.5m deep. The sides of the pit were vertical and with a slightly undercut profile. The bottom had mostly a uniform surface and followed a slight downward slope towards the eastern side. It was filled with a variety of clay and stony fill layers, floors and internal structures-such as graves, shallow pits, post-holes, kilns, linear furnace and burning surface-that configured a complex stratigraphy.

The archaeological excavation of the pit was carried out following various strategies that were adapted depending on the results, targets and specific circumstances of the excavation. It began with a 1x1m slot survey on the northern side that reached half a meter in depth. Then, the full internal area of the pit was excavated until reaching a meter in depth. Later, it was decided to carry out a 1x5m slot survey on the northern side than allowed recording the entire stratigraphic section of the pit from east to west. From this section several samples were taken for the study of the micro-morphology of the soils. Finally, the excavation was completed by exhausting all the filling of the structure. The main phases of use and activity of the structure have been summarized as follows:

**Initial phase**

This phase corresponds to the process of excavation of the pit (C40) in the natural clay subsoil. Several concavities were observed on the sides of the pit showing irregular profiles of the pit. The base of pit coincidently reaches the level of the outcrop line of a second geological level which is formed by gravel and stones, and emerged below the level of the clay deposit where pit was excavated.

**Phase 1**

The first phase is marked by a shallow pit (C193) excavated at the eastern end of the base of the structure. The pit was oval in shape -1.6m long and



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Fig. 6: Aerial view of kiln C173/206. Author: Pla de la Guineu Team.

1.4m wide- with 0.4m in depth. It was filled with two layers, one of dark rich-charcoal clay mixed with reddish silts (C194) and, a lower one, of brown clay with occasional stones resting on the edges (C300). Few ceramic sherds with undulated edge rim were recovered.

**Phase 2**

A clayey fill was distinguished at the eastern side, levelling the slope of the bottom of the pit. It was about 0.3m thick and with very compact surface. A linear feature trench (C184) was excavated into this surface, measuring 2.4m long, 0.2-0.3m wide and 0.15-0.3m deep (Fig. 5). This was filled with dark greyish clay with frequent charcoal flecks inclusions (C183). Two small stone slabs were identified resting on the sides and a thin reddish layer of fired clay (C182) was exposed on the edges and some parts of the base of the trench. The reddening of the fired clay was very fine and did not extend over the entire internal surface of the trench. Although, the fine burning within the sides this indicates that a fire was realized inside of the feature.

**Phase 3**

This phase is defined by the incorporation of a layer of clay levelling a new surface at the base of the pit. In this surface the remains of a kiln and a post-hole were identified. The kiln (C173/206) was formed by two well-defined spaces, on the one hand, an oval chamber (C173) and, on the other, an access area defined by a narrow and elongated channel (C206) (Fig. 6). The chamber had an internal space of 0.7m long by 0.56m wide and was surrounded by a perimeter band of clay 0.1m wide. This band of clay had a differentiated composition, both from the inner layer of the chamber and the external floor surface, and represent the remains of the walls of the chamber. Inside the chamber, a layer of white ash, fired clay and reddish burning was identified. The access channel was 0.8m long by 0.15m wide and was surrounded by a compact soil layer (C112) in which there were ceramic sherds arranged flatly. The access channel was filled by a layer formed by soft clay with frequent charcoal, ash and small fragments of fired clay.



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**Phase 4**
The fourth phase is defined by the incorporation of a mixture of fills (C122, C161 and C196) forming a flat and compact surface. A total of 12 post-holes were identified in an irregularly distributed manner at this level. This flat surface was located between 1 and 1.5m deep respect the ground level and, inside, no other structure was recorded other than small cuts with the corresponding fills of the post-holes.

**Phase 5**
A thin compact clay layer was identified (C121) on top of previous level. In this case, a kiln (C201/C203) and other 3 post-holes were distinguished. The kiln was formed by two well-defined spaces, on the one hand, a chamber (C201) and, on the other, an access channel (C203) that was connected to the previous one. The access channel was narrow and elongated and slightly deeper than the chamber. It was 1m long and 0.15m deep, without being able to certify its width as it was sectioned by a slot survey carried out in 2011 excavation. The channel was filled with a soft sediment (C111) of dark grey clay, with abundant remains of ash and charcoal. The chamber was 1m long by at least 0.4m wide and 0.1m deep. A reddish hue was observed along the sides of the feature due to the action of a fire. Its filling (C113) was a compact clay with small charcoal inclusions. It is a kiln morphologically very similar to the other recorded in phase 3. A layer of clay (C110) was covering these features and constate the closure of the kiln.

**Phase 6**
This phase is marked by a backfilling activity, without having any specific structure or surface associated with. These are several layers of clay (C44, C45, C47, C51, C59, C62 and C64) of considerable thickness and dark coloration that shared the characteristic of having a large volume of fragmented pottery (briquetage) with abundant charcoal, ashes and remains of fired clay. In certain areas the fills were formed exclusively of ceramic sherds piled one top of the other. Approximately 30,000 ceramic fragments were recovered in these intermediate levels. One of the fills (C47) had a dejection cone profile.

Fig. 7: Grave C56, facing west. Author: Pla de la Guineu Team.

**Phase 7**
In this phase, a radical change in the use of the pit is identified, which involved the construction of a grave (C56) at the side of the structure (Fig. 7). This is a small niche, excavated in the northern side of the pit and about 0.5m deep. The burial was covered by a flat stone slab with a line of stones at the edge of cut. Inside was a skeleton (C52) of an individual of child age, in a supine position and with hyper-flexed legs. The grave was oval in shape measuring 0.5m long, 0.28m wide and 0.2m deep. Just 2m away to the southwest, an elongated stone slab was located and placed in a semi-upright position. The stone slab was 2m long by 0.3m wide and 0.15m thick.

**Phase 8**
This phase is marked by a backfilling activity, without having any specific surface associated with. The filling (C37) was formed by a layer of stones and large blocks of stone with a brown clay and charcoal within the stones (Fig. 8). Ceramic sherds with undulated rims (briqueteage) were recovered.



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Fig. 8: Fill C37, facing south. Author: Pla de la Guineu Team.

**Phase 9**
In this phase, a burning surface or hearth (C14) was identified on top of the previous stone dump. It had an elongated plan, 2m long by 0.6m wide and 0.02m thick. It consists of a reddish orange burnt clay altered due to the heat of a fire. Remnants of charcoal were also noted within the hearth itself.

**Phase 10**
At the uppermost area of the pit, thin layers of clay with stones (C12 and C28) were identified at the northern side and layers of clay without stones (C23, C24 and C25) at the southern side.

**Phase 11**
The last phase is marked by the opening of a grave cut (C26) excavated in the western side of the uppermost filling of the pit. It is a simple pit, with an oval plan, measuring 1.1m long, 0.4m wide and 0.25m deep. A skeleton of a young individual was identified in a supine position, orientated north-south and with the skull located at the south side. The northern part of the grave and the lower extremities of the skeleton were not preserved for modern truncation. It corresponds to a funerary practice carried out after structure 1 was completely sealed.

**Structure 2**
This is a shallow pit (C83) excavated into the natural subsoil, measuring 7m long, 2.5-4m wide and 0.2-0.3m deep. Inside, five post-holes, three shallow pits and two narrow linear trenches were identified. The last two features (C71 and C73) were arranged in parallel, separated by a meter of distance and orientated from east to west. Both measuring 3m long by 0.3m wide and 0.2m deep, and filled by layers of clay with frequent charcoal and small inclusions of fired clay. A layer of ash and charcoal was filling an oval pit beside (C33). These are clay layers with a large amount of charcoal and ash linked to a burning activity. The sides of the trenches were



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Fig. 7: Pottery with undulations on the rim. Author: Pla de la Guineu Team.

slightly reddish-orange colour due to thermal alteration of the clay by fire. The other three shallow internal pits provide large number of ceramic sherds with undulated rims, ash and charcoal. Four of the post-holes were clustered in a small area at the base of the structure 2. The main phases of use and activity have been summarized as follows:

**Initial phase**
This phase corresponds to the process of excavation of the pit (C83) into the natural subsoil.

**Phase 1**
The aperture of the two trenches and other shallow pits and post-holes within the pit indicate a different phase of activity within the structure. Small remnants of scorched surface and layers of charcoal and ash were observed within the two trenches.

**Phase 2**
This phase is characterized by the closure of the internal structures and the backfilling of the pit.

**Study of the ceramic bowls**
A total of 40.396 sherds of pottery recovered from site. Only three completed profiles of pottery have been reconstruct showing a high grade of fragmentation. Approximately 2200 rims and 1575 bases were identified. The majority of the sherds are undecorated and have a rough finish, with frequent digital and instrument marks on the surface, suggesting rapid fabrication without concern for smoothing their surface. These are part of a specific type of coarse pot which is characterized for its morphological simplicity, consisting of flat bases joined to rectilinear sides, making a tapered cylinder pot. This distinctive pottery has also a very specific rim which contains undulations on the edge of the rim, made through digital pressure with the fingers or using small stick (Fig. 9). Approximately 94% of the rims of the site contain undulations and are related to this type of coarse pottery. This type of rim has been identified in several salt making sites from different continents and periods of time. For example, this type of rim is observed at Stanford Whalf in England dating to the Iron Age (Biddulph et al 2012), Santioste in Spain (Abarquero et al 2017) and Zhongba in China (Li 2009).

Other type of potteries was also present, basically small sized bowls with polished surfaces and decorated with incisions or impressions, few large vessels with decorated cordons applied and a jar with handles decorated with impressions along the external surface.

## Microanalysis of the soil

Two microanalyses of the soil were carried out in relation to the kilns identified within structure 1. This samples were taken from the half section profile of the structure 1 using metal boxes which were inserted into the archaeological soils. Then this soil was cut in thin sections and observed into the microscopy. One sample was obtained of the surface C112 which surrounded the flue of kiln C173/C206 (phase 3 of structure 1) and another one of the fill C111 from the flue of kiln C203 (phase 5 of structure 1).

From C112 signs of trampling and high compaction of the soil was observed, with micro fragments of charcoal, pottery and burnt clay identified. The surface layer was originated for fast deposition of waste material related to a burning activity and highly frequented.

From C111 micro fragments of charcoal, ash, burnt clay and pottery were identified. The filling was composed for the succession of several depositions events as shown the distribution and orientation of the inclusions. Truncations are also identified within the fill showing recutting events with consequent soil taken away. These truncations are showing multiple episodes of use of the kiln. Small fragments of burnt clay were recurrent and may came from of the burning surfaces of the kiln. Finally, sedimentary clay



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crust was also present and may be indicative of no protective roof of the place around the kiln.

## Radiocarbon dates

Two radiocarbon dates were obtained from animal bone, one obtained from fill C110 related to the closure of kiln (C201/C203) and another one from fill C59 related to the mid layer -briquetage fill- of the structure 1. The first C110 with a result of 1945-1865 Cal BC (3540 ± 30 BP) is associated with phase 5 of structure 1 and the second C59 with a result of 1745-1615 Cal BC (3380 ± 30 BP) is related to phase 6 of structure 1.

## Study of the animal bone

Animal bone was scarce on site and was recovered mostly very fragmented. A total of 149 animal bones were retrieved from the archaeological interventions. Most of the animal remains represent domestic livestock. It has been possible to verify the presence of cattle, domestic pigs and sheep (Bos taurus, Sus domesticus and Ovis aries, respectively). Several bones have been attributed to the generic category of sheep/goat for the absence of diagnostic fragments in the remains that allow differentiating between sheep and goat. It has been possible only identified sheep, however the presence of goat it cannot be ruled out. The category of sheep/goat is the most abundant of this set, followed by cattle and then suids. Two bones of lagomorphs and one of roe deer were also identified and represent wild animals.

## Microscopy analysis of pottery

An experimental program was carried out with the aim of replicating the method of salt production inferred from the archaeological remains. First step was the elaboration of ceramic pots following the ceramic forms identified on site and using local clays. A sample of salt water from the Mina Ofita Spring was taken and heated using the ceramic vessel reproduced. As expected, evaporation of the liquid led to the obtaining of solid residue in the lower part of the vessel which was identified as salt (Na Cl). This residue was analysed together with the archaeological remains.

Diffraction studies have been carried out X-ray (XRD) comparing diffractograms of experimental sample of the solid residue (Na Cl) with a sherd of pottery from the site. The result of the application of this technique was no correspondence found between the experimental and archaeological sample. This fact could indicate that, although it is not possible to rule out that the ceramic pots contain salt, the preserved form of the crystals would not correspond to the obtained experimentally.

Samples of ceramic pots replica were studied using Scanning Electron Microscope (SEM) and X-ray Fluorescence (XRF). In this case, the results were positive as samples of ceramic pots replica from experimental program showed the presence of chloride sodium (NaCl), demonstrating the validity of the method to detect salt in the ceramic vessels.
Regarding the archaeological samples analysed, two sherds of pottery from the site, contained sodium (Na) in several angular inclusions in the internal side of the vessels with aluminium (Al), silicon (Si) and calcium (Ca). These crystals of sodium may be indicative of their use in the process to obtain salt. However, no evidence of chloride (Cl) was identified.

## Discussion

It is interpreted that the original purpose of the structures 1 and 2 (initial phase) would be the extraction of clays for use as raw material. The structures were excavated into a clay natural subsoil layer. In the structure 1, the soil at the base of the structure followed the outcrop line of a second lower geological level. This was formed by gravel and stones which emerged below the level of the clay deposits in which the structure was excavated. This factor could indicate that, once the gravel level was reached, no further deepening was done and the extraction of clay extended towards the sides. In this sense, several concavities were observed on the sides of the pit that could indicate that it was expanded by making lateral extractions from the centre and base of the pit. It is interpreted to have been made in staggered manner over time. The structure 2 is quite shallow and may indicate a sporadic or less intensive extraction of clay. The need of raw clay may be related to the manufacture of ceramic vessels, practice which occurs on site.

The first phase of activity within the internal area of the structures (phase 1) is identified at the base of the structures where oval shallow pits had been excavated.



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The functionality of these shallow pits has not been defined. However, ceramic sherds with undulated rims were recovered-a type of rim linked to ceramic vessels intended for salt production- which could suggest a dumping of waste from salt manufacture activity. On the other hand, two trenches were identified at the base of the structure 2 which are similar to the trench found within second phase structure 1. On the edges and in parts of the base of these trenches, thin reddish layer of fired clay was exposed, which showed burning inside of the features. However, the reddening of the fired clay was very fine and did not extend over the entire internal surface of the trenches, suggesting burning carried out a low temperature. It is interpreted that they would be furnaces structures, linked to the heating and boiling of salt water using the support of ceramic vessels.

The operation of the furnace would be based on lighting a fire at the bottom of the trench that would be controlled from one end; the end where the trench is deeper and wider. At the other end of the trench, an aperture would probably be opened to allow air to circulate and extract the smoke. In the middle section of the trench, it is interpreted that series of ceramic vessels arranged in line would be encased between the sides of the trench, or over a thin stone slaps placed at the top of the trench that would allow the caloric action of fire to be transferred to the interior of the ceramic vessels. In this sense, two thin stone slabs were identified in the fill resting on the sides of the trench, and that could form part of a hypothetical slab cover. A fire below and controlled from one of the ends of the trench would heat the contents until the salt crystallized inside of the ceramic vessels. This structure is morphologically similar to other furnaces/ kilns structures recorded in sites linked to salt production such as Molina Sanchón II in Villafáfila, Zamora (Abarquero et al 2010), Sur l'Ille des Ebihens in France (Langouet 1989), Essex in England (De Brisay 1975) and the Bad Nauheim site in Germany (Vogt 2003).

A kiln is identified in Phase 3 of structure 1. It is interpreted as a kiln intended for firing ceramic vessels. The small dimensions of the chamber would indicate a limited capacity of each firing cycle. It is estimated that there is enough space for the placement of 4 ceramic vessels -between 15-20cm in diameter-and, possibly, up to a maximum number of 8; if they were placed one on top of the other and depending on the height achieved by the chamber cover.

A compact surface with 12 post-holes were identified in Phase 4 of structure 1. This is a time when there could have been some type of roof judging by the presence of the post-holes. However, these were shallow and suggested a type of light cover. It is also not obviated that they may were used for other purposes.

Another kiln was identified at phase 5 of structure 1. It is interpreted as a kiln intended for firing vessels, morphologically very similar to the other found in phase 3.

Phase 6 is marked by a backfilling activity, involving several fills which contained rich charcoal inclusions and abundant sherds of coarse pottery at the middle of the pit. One of the fills (C47) had a dejection cone profile, indicating a dumping carried out quickly and probably in a short space of time. It is interpreted that these would be layers of dumping of salt production waste which are indicative of the salt production must have been carried out in the immediate area.

Phase 7 is characterized by a small grave excavated at the site of the pit. A semi-vertical standing stone slab located in the vicinity could mark the presence of the burial like a funerary stela. Later, it could have been partially turned over and remained in the filling. However, it cannot be ruled out, as it is a stone slab of irregular shape, that corresponds to a stone from the backfill behind the grave.

Phase 8 is marked by a backfilling activity with substantial among of stones and large stone blocks which are interpreted as possible intention to seal the burial. However, in the filling frequent ceramic sherds with undulated rims were recovered -linked to the salt production-which would suggest a clear link with this activity.

Phase 9 is characterized with a burning surface or hearth on top of the stone dump. It may represent a short fire event of undefined purpose.

Phase 10 is identified at the uppermost area of the pit where layers of clay and stones were identified. This is the definitive sealing of the structure 1.

The last phase (phase 11) is marked by the opening of a grave cut excavated in the western side of the uppermost filling of the pit. It corresponds to a



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funerary practice carried out after structure 1 was completely sealed.

The two main structures of the site could have opened simultaneously throughout the various phases of activity identified. This coeval operation is suggested by the dumping layers linked to the production of salt in phase 6 of structure 1 and the use of the furnaces in phase 2 of structure 2. Fill C47 show a dejection cone profile that would indicate a deposition from the top of the pit, which contained large number of ceramic sherds, charcoal and fired clay inclusions. At this time, is suggested that the waste generate by furnaces in structure 2 and further pottery waste for extracted block of salt would have been deposited inside of structure 1.

## Conclusions

Archaeological excavations at Pla de la Guineu site have provided evidence of the salt production in prehistoric times. Specifically, trench furnaces have been identified that could have been used to heat salt water inside ceramic containers throuhg burning processes that would cause the water to boil and the salt to crystallize inside the pots.

The ceramic vessels would be placed in a line on top of a stone slab roof or boxed between the sides of the furnace and an internal fire controlled from one end of the trench would allow the continuous heating of the salt water until it crystallized inside the ceramic vessels. The process of evaporating the water would be long and would require continuous maintenance of the fire as well as control of the salt crystallization process, with a possible task of compacting the already crystallized salt inside the vessel and adding salt water once it had evaporated. To help this process, the ceramic vessels intended for the production of salt had a specific morphology of tapered cylinder, with an increased diameter at the mouth respect of the base, rough finish and undulated rim. That type of rim appears exclusively within coarse pottery and may play a functional role rather than decorative. It is thought a lid may cover the vessel in the boiling process which would allow steam to pass between the empty spaces between the undulations of the rim while at the same time allowing a constant temperature to be maintainded inside of the vessel and preventing a possible loss of salt during the boiling process.

The cooking would cause the evaporation of the water, in such a way that the salt would solidify and crystallise inside the ceramic container, until it become a compact mass. It is interpreted that once dried and hardenend, it was extracted by breaking the ceramic vessels, obtaining a block of salt. This production process would require, as a previous step, the manufacture of ceramic vessels which were produced and fired also on site. At the end of the salt production cycle, these would be broken, which is why a large volume of ceramic waste would be generated. On the other hand, the burning processes necessary to force the evaporation of the water in the furnaces and firing the pottery in the kilns would involve a large volume of ash and charcoal waste. These types of waste have been recorded along the site.

This method of producing salt through cooking brine until its cristalization inside of the pottery vessels implies breaking the pots at the end of the process. This requires a constant replacement of the pottery in each cycle of the salt production. For this reason, it would be convenient to manufacture and firing them in the same place where the salt is produced. The main raw material required to make pottery is clay. The location of the site on top of a river terrace is a place with a good source of clay deposits. Precisely, the archaeological structures of the site are excavated into the clay deposits which from the original ground level reached between 2 and 2.5m of depth. It is interpreted that the cuts of the archaeological structures are traces of clay extraction activity. In this sense, the morphology of structure 1, with irregular shape, undercut sides and excavated until reach the natural gravel level could fit with this type of activity.

Two ceramic kilns have been identified on site. Both have the same morphology with a firing oval chamber connected to a narrow and elongated access channel. The internal space of the chamber would be limited but could house between 4 and 8 ceramic vessels (of c.20cm in diameter) per firing, and potentially more depending on the height achieved by the kiln. The micro-morphology analyses of the soils around the kilns would reinforce the functionality of the kilns towards and artisanal activity due to the absence of animal micro-remains.

The ceramic vessels intended for the production of salt followed a specific morphological model, they would be vessels with a tapered cylinder shape, with rectilinear or slightly open walls and flat base. The



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rims were specifically undulated, that is, with deep impressions made on the lip seeking an undulation around the entire perimeter of the rim. The rest of the body of the vessel would be made in a less careful way, with a rough finish that allows the traces of the manufacture of the vessel to be observed.

The salt production process would require a large amount of fuel, both for firing the pottery in the kilns and for boiling the brine in the ceramic containers. All these burnings would generate a large amount of waste and, for this reason, most of the fill layers within the structures of the site were blackish in color and contained frequent fragments of charcoal, ash and fired clay.

The source of salt water could come from the current location of the salt water spring called Ofita Mine, located c.500m from the site or from possible other small salt water springs in the immediate area that have been not identified.

Finally, it should be emphasized that the archaeological excavations were carried out in a very limited space, defined by the limits of the road works and without any exploration of the immediate surroundings of the site. In this sense, another site is known, called as La Pleta de Comte, located in small terrace at the other side of a small stream, just 250m from the site, in which very similar undulated ceramic rims were recovered (Panyella 1944). This could suggest salt production activity at this site too or some type of connection between the sites. This may be indicative that salt production could consist of several productive units distributed in diferent points of the immediate surroundings at this time.

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# MUSEUM OF SALT

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The Museum of Salt is dedicated to the preservation, study and dissemination of the salt industry of Gerri de la Sal (Pallars Sobirà).
It is located in the Reial Alfolí, the 16th century old salt warehouse, one of the most important heritage elements of the Pyrenees.