



A new roman fish-salting workshop in the Saltés Island (Tinto-Odiel Estuary, SW Spain): La Cascajera and its archaeological and geological context

Un nuevo taller pesquero-salazonero romano en la Isla de Saltés (Estuario Tinto-Odiel, SO España): La Cascajera y su contexto arqueológico y geológico

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Abstract

The southwestern Atlantic coast of the Iberian Peninsula presents an important Roman heritage that includes numerous fish-salting workshops, with an industrial activity that went on for almost a millennium (1st century BC-7th century AD). Nevertheless, a future broad research is still necessary to determine the geologic substratum on which they are based, their palaeoenvironmental evolution, their main economic objectives and the byproducts derived from their activities. This paper is focused on the geology, dating and the archaeological record of La Cascajera, a new site located in the Tinto-Odiel estuary (SW Spain). This new *cetaria* occupied the northwestern end of La Cascajera ridge (Saltés Island), constituted by sandy, bioclastic deposits of previous washover fans (1st-2th centuries AD). During the main period of activity (middle of 4th century AD-5th century AD), the existence of a certain typology of amphorae as well as the documentation of a shell deposit formed mostly by *Glycymeris* suggest that this factory was oriented to the production of mixed fish sauces and the handling of edible bivalves. The main features of this deposit (texture, paleontology, taphonomy) could be used to differentiate middens from natural shelly ridges.

Key words: Roman halieutic workshop; Geological evolution; midden; late Antiquity; Saltés Island; SW Spain.



Resumen

La costa suratlántica de la Península Ibérica posee un importante legado romano que incluye numerosos talleres halieúticos, con una actividad que se desarrolló durante casi un milenio (siglo I a.C.-siglo VII d.C.). Sin embargo, se precisan nuevas investigaciones que determinen el contexto geológico en el que se desarrollaron, su evolución paleoambiental, sus principales objetivos económicos y los subproductos derivados de sus actividades. Este trabajo se centra en la geología, datación y registro arqueológico de La Cascajera, un nuevo yacimiento localizado en el estuario de los ríos Tinto y Odiel (S.O. de España). Esta nueva *cetaria* ocupaba el extremo noroccidental de la cresta de La Cascajera (Isla de Saltés), constituida por depósitos bioclásticos arenosos de abanicos de derrame previos (siglos I-II d.C.). Durante su principal periodo de actividad (mitad del siglo IV d.C.-siglo V d.C.), la existencia de una cierta tipología de ánforas así como la existencia de un conchero formado principalmente por *Glycymeris* sugieren que esta factoría estaba dedicada a la producción de salsas mixtas de pescado y la extracción de bivalvos comestibles. Las principales características de este conchero (textura, paleontología, tafonomía) podrían ser usadas para diferenciar concheros de acumulaciones naturales de conchas.

Palabras clave: talleres halieúticos; evolución geológica; conchero; Antigüedad tardía; Isla de Saltés; S.O. España.

1. Introduction

During the Roman period, both the salting activities and the extraction of edible marine species were one of the main productive sectors in all the Mediterranean coasts, especially on the coasts of the western Mediterranean and those of the Black Sea, insomuch as the fish-salting complexes are missing from the Eastern Mediterranean (Marzano, 2013). With an important tradition inherited from the Phoenician and Punic periods (Sáez, 2008, 2010; Sáez and Díaz, 2012), the southern part of Hispania witnessed the maintenance of a significant industry specializing in the marine resources from the Republican Roman period (1st century BC), which will survived more than eight centuries. The fish-salting complexes are identified by a series of architectural, urban and functional characteristics clearly oriented to the transformation of fishing products. Architecturally, these complexes usually had a central yard for the processing, evisceration and bleeding of the catches, around which there were a variable number, and sometimes, considerable salting basins. In the same way, the marine faunal remains

recovered from archaeological contexts are often extremely significant and offer important information regarding the various species worked, scombrids, cetaceans, chondrichthyes, molluscs (e.g. *Glycymeris*, *Hexaplex*) and even crustaceans (Bernal and García, 2014).

In the southwestern Iberian coast, there were numerous fish-salting workshops (Figs. 1A and B), some of them located in the Tinto-Odiel Estuary (SW Spain), very close to the old *cetaria* of *Onoba* (Fig. 1C). The main activities of these complexes ranged from the 1st century BC to the 7th century AD (Fig. 1D). A period of expansion and consolidation of these salting workshops is defined along this coast and the adjacent areas of Portugal from the 4th century AD until the beginning of the 5th century AD (Campos *et al.*, 1999; Vidal and Campos, 2008). For this period the factories increased in number and size when large sets of *villae maritimae* with interesting residential complexes appeared (Campos *et al.*, 2015).

This paper is dedicated to a multidisciplinary analysis of La Cascajera, a new *cetaria* discovered in Saltés Island (Tinto-Odiel Estuary). The following objectives have been achieved

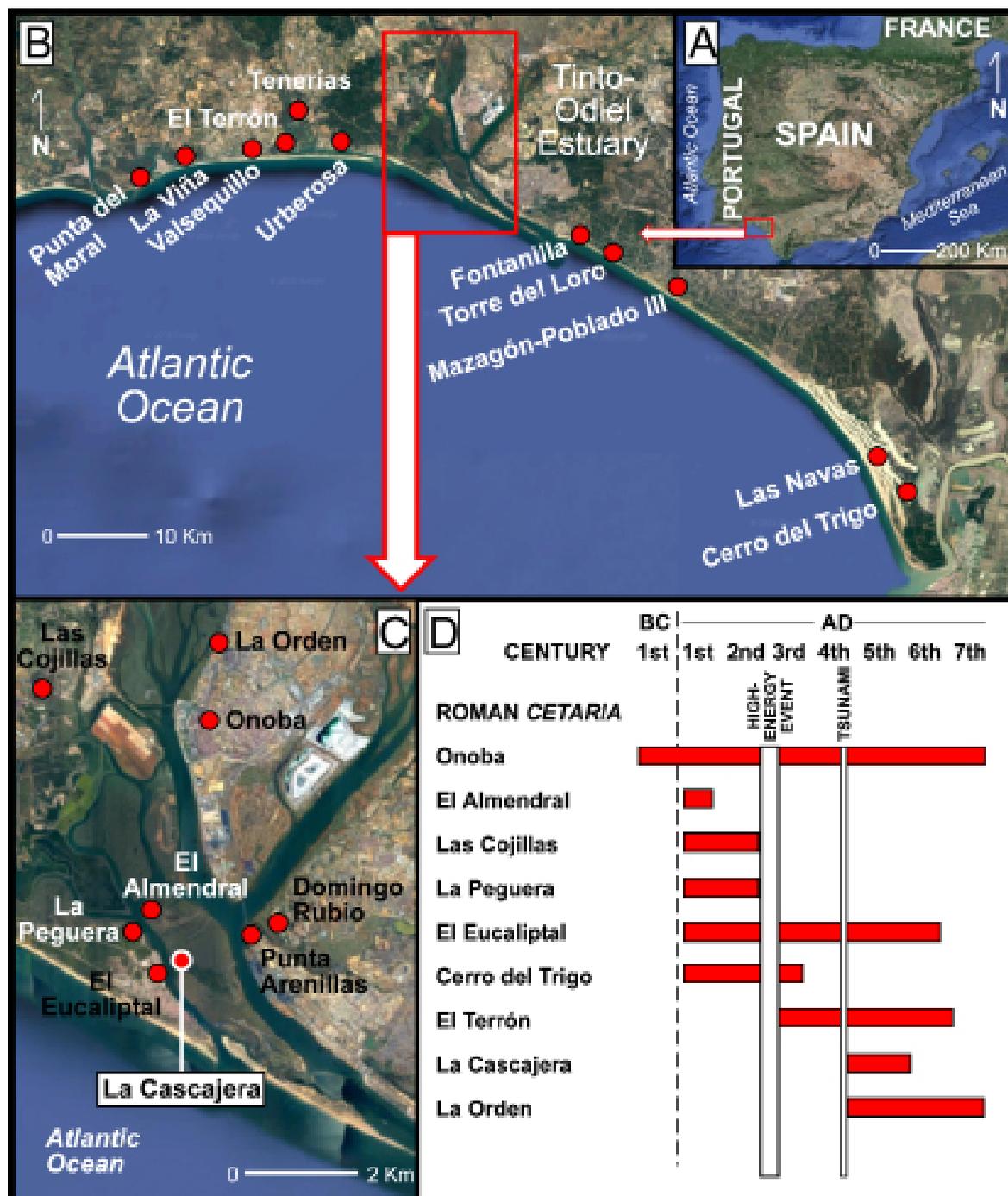


Figure 1. A-B: Location of the main Roman salting factories (*cetariae*) on the southwestern Atlantic coast of Spain; C: Main *cetariae* of the Tinto-Odiel estuary; D: Temporal distribution of activity in different *cetariae* of this area.

Figura 1. A-B: Localización de las principales factorías romanas de salazones (*cetariae*) en la costa suratlántica española; C: Principales *cetariae* del estuario de los ríos Tinto y Odiel; D: Distribución temporal de la actividad en diferentes *cetariae* de esta área.

in this short paper: a) to define the geological evolution that caused the formation of La Casajera, the basal ridge of the factory; b) to delimit the extension of the archaeological site; c) to analyze both the archaeological and palaeontological record in order to deduce the main activities to which it was dedicated; d) to establish a chronology for the archaeological site, from its birth to its death; and e) to determine the main palaeontological features of the associated fossil record.

2. Study area

2.1. The marine domain of the Tinto-Odiel Estuary: Saltés Island.

The Tinto and Odiel Rivers are small streams (<150 km length) that flow through the province of Huelva in southwest Spain, with a final stretch that runs through Neogene-Quaternary sediments and forms a barrier estuary at the Atlantic Ocean (Figs. 2A and B). The marine domain of the Tinto-Odiel estuary is protected from open sea by two main spits (Fig. 2B: Punta Umbría and Punta Arenillas). This domain includes two main channels (Fig. 2C: Punta Umbría Channel and Padre Santo Channel) and a series of barrier islands (e.g. Bacuta, Saltés) composed of sandy ridges separated by salt marshes.

Saltés Island (Fig. 2C) is part of a UNESCO Biosphere Reserve because of its wide variety of ecosystems (marshes, ebb-tidal channels, sandy spits, bioclastic ridges). One of its most important geomorphological features is the presence of curved sandy ridges constituted by different generations of sandy/bioclastic crests, cheniers and washover fans (Fig. 2C: El Almendral, El Acebuchal, La Casajera), with a hook shape related to coastal drift and wave refraction (Figueroa and Clemente, 1979). The southernmost part of the island is formed by a wide tidal flat, separated from the town of Punta Umbría by a tidal inlet (Punta Um-

bría channel). The natural sedimentary evolution of this island has been modified due to the construction of a jetty in 1979, with numerous collateral effects (Fig. 2C: creation of a new beach).

2.2. Brief history of the Onoba hinterland.

The first evidence for Roman period regarding the establishment of cetariae in the maritime hinterland of *Onoba* (Fig. 1C) can be found in the Punta Umbría spit (e.g. El Eucaliptal, La Peguera; O’Kelly, 2017). These evidences are reduced to a few Republican fragments of pottery that reveal a shortage occupation and weak halieutic industry for this period. Once the Imperial period began, the fishing processing activity has new evidences that highlight an important growth. The Eucaliptal, El Almendral or the halieutic workshops of *Onoba* itself are clear testimonies of an increase in the production and occupation of the coast. The excavations developed in each of the archaeological sites reveal a whole set of salting basins, materials, and so on, which show an important industrial development for these moments (Amo, 1976; Campos and Vidal, 2004; Bedia, 2008). The remains of fish-salting complexes in *Onoba* confirm the existence of a clearly defined area in its urban topography. In the port district of the city there are numerous examples of fish-salting workshops grounds that have been discovered since the 1970s. Two *cetariae* have been located in the Tres de Agosto and Palos streets, perhaps the most important examples of these salting activities in the city. In addition to what was conserved, it could be inferred that medium/small sized building, following a model of water-proof vats aligned on either side of a central corridor (Bermejo *et al.*, 2017). Probably because of the land available or due to the exploitation regime by “small owners” or investors, since for some authors (Bernal and García, 2014) in the large-scale, especially urban, fish-saltings workshops, it is possible

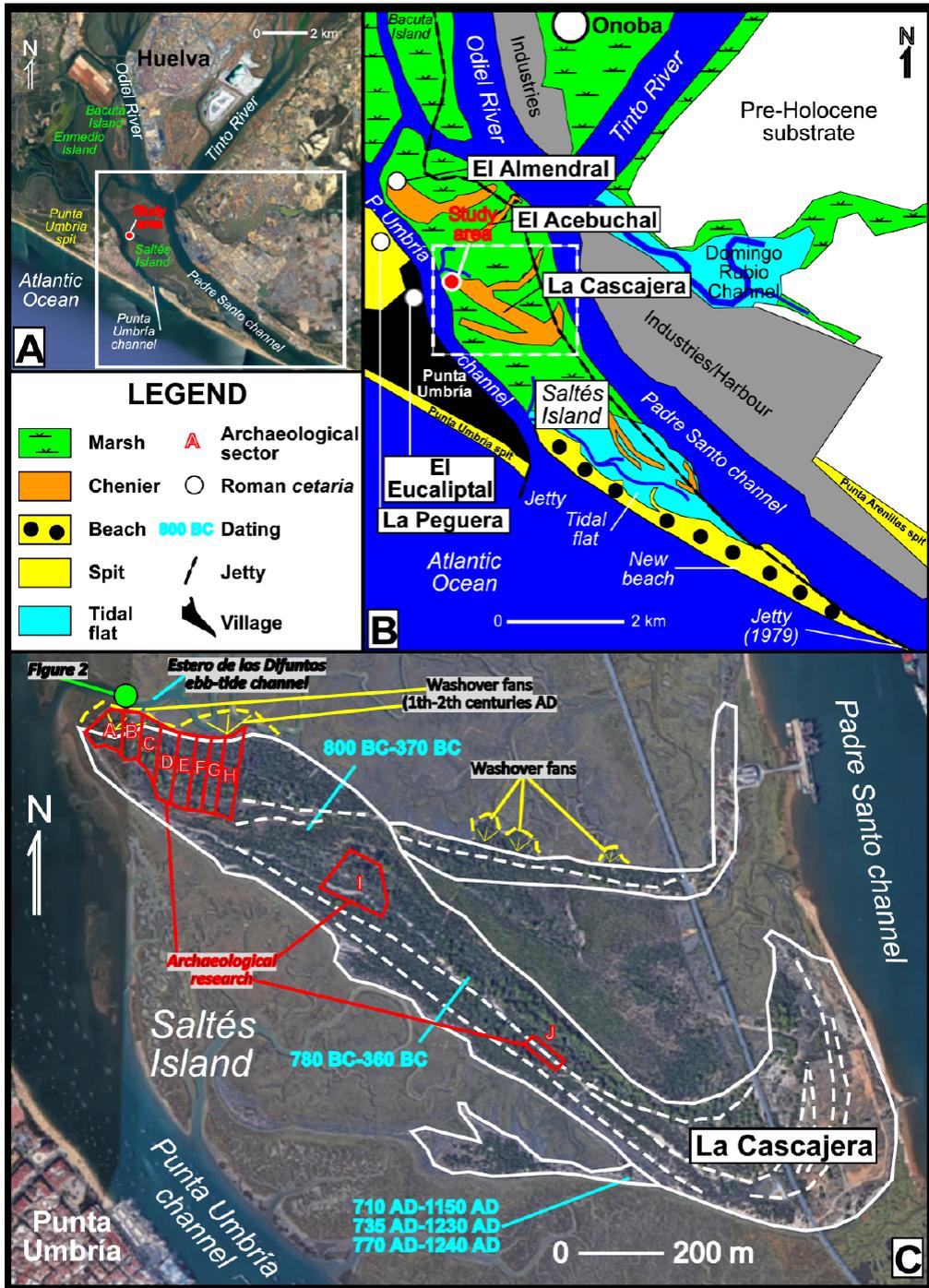


Figure 2. A-B: Location of Saltés Island, the study area and several Roman *cetariae* (white circles); C: Main geomorphological features of the Tinto-Odiel estuary; D: Main features of La Cascajera ridge (white stroke); red stroke: archaeological sites; blue datings: see Table 1 for explanation.

Figura 2. A-B: Localización de la isla de Saltés, el área de estudio y distintas *cetariae* romanas (círculos blancos); C: Principales características geomorfológicas del estuario de los ríos Tinto y Odiel; D: Principales características de la cresta de La Cascajera (trazos blancos); trazos rojos: yacimientos arqueológicos; dataciones (azul): ver Tabla 1 para su localización.

that the management was directed through a corporation or *societas*, and the conduct of several of them was maintained in a manner joint. In short, there is an important industrial district with various workshops or offices dedicated to the fishery activities which, from high imperial moments, begin their production; in this respect the archaeological testimonies seem to show a clear flourish in late julio-claudius moments, with a long diachrony until late ancient times.

At the end of the 2nd century AD and throughout the first decades of the 3rd century AD there seems to be a population and productive hiatus in the context of the Tinto-Odiel Estuary, as well as in other archaeological sites on the Huelva coast, which have been put in relation to the possible existence of an extreme wave event. Signs of abandonment are found in the salting basins of El Eucaliptal (Campos, 2011).

A recovery occurred at the beginning of the 4th century AD in the population of the Tinto-Odiel Estuary in particular and the Huelva coast in general, with a maximum development at the end of this century and especially in the early 5th century AD (Campos *et al.*, 2015). At this time, several *cetariae* were active (Fig. 1D) and the analysis of the archaeological sites revealed important commercial connections with the main Mediterranean routes, the north of Africa through producing centers like Tunisia, the Moroccan coast, the east Mediterranean and the Atlantic coasts. This economic impulse ended at the beginning of the 7th century AD.

3. Methodology

3.1. Geological methods

The chosen study site (~60 m long) was an elliptical cliff exposed by the erosional action of an ebb-tide channel (Figs. 2D and 3A: Estero

de los Difuntos) located at the northwestern part of La Cascajera sandy ridge (NW Saltés Island), near the Punta Umbría channel. The main features of the different sedimentary facies (Fig. 3) were initially described in the field.

Twelve surface sediment samples (1.5 kg dry weight) were collected for textural and palaeontological analyzes by manual picking at outcrop level. Some subsamples (0.1 kg) were wet sieved through a sieving column ($-1 < \phi < 4$) for determining the grain size distribution. Further subsamples (1 kg) were separated for the study of the bivalves present at a specific level. Additional subsamples were separated for the foraminiferal analysis. Ten grams were wet sieved (0.125 μm mesh) using distilled water and dried in an oven at 70 °C. The total population of this group was analyzed at specific level.

3.2. Archaeological methods

The analysis on the sandy barrier of La Cascajera has been done by an extensive archaeological prospection. Depending on the archaeological interest and the remains that were shown on the surface, different transects were established and surveyed in a micro-spatial manner, with a total of nine surveying sectors listed alphabetically (Fig. 2C: A to J). Transects corresponding to the letters from A to H were established in the westernmost area of the barrier and arranged continuously one after another and separating areas of special concentration of materials. Transects I and J were located in the southernmost area of La Cascajera, in a second sandy hook since other structures of special surface interest were found. In this regard, the previous analysis of land recognition as well as the geological information showed this area as a potentially interesting space from the archaeological point of view.

3.3. Dating

In the westernmost corner, a shell midden was found with a powerful stratigraphy of more than four meters, the arrangement, as well as the classification of the shells leads to think of an anthropic formation. Two pristine shells of *Glycymeris* were selected for dating (Figs. 3B and C and F and Table 1). The ^{14}C method was applied by AMS to sample C-1 at the Spanish National Centre for Accelerators (CNA), with the application of the reservoir effect correction (-108 ± 31 ^{14}C yr) calculated by Martins and Soares (2013) in this area. Results are presented as calibrated ages for 2σ intervals. This method was applied to samples collected in previous investigations carried out in the Tinto-Odiel estuary to obtain a general chronological evolution of La Cascajera ridge (see Fig. 2D and Table 1). In addition, the U/Th dating method was applied to sample A-1, followed standard methods which are described by Van Calsteren and Thomas (2012). These datings were made at the laboratory of Applied Physics I of the University of Se-

ville. Results are compared to those obtained by González-Regalado *et al.* (2019) from five samples collected in the washover fans located on the northern bank of the Estero de los Difuntos ebb-channel, the lateral geological extension of the deposits here studied. Additional dates from Dabrio *et al.* (2000) have been included to delimit different stages in the evolution of Saltés Island (see Fig. C and Table 1).

4. Results and discussion

4.1. Fish-salting workshop: geological evolution

The multidisciplinary analysis of the section studied has allowed to differentiated six main sedimentary facies, very similar to those observed in this estuary and the adjacent areas (Borrego, 1992; Morales *et al.*, 2014; Cáceres *et al.*, 2018): I) silty-clayey tidal flat (Fig. 3B), characterized by massive clayey silts with abundant organic matter, frequent bioturbation, scattered valves of *Chamelea gallina*

Table 1. Database of ^{14}C and U/Th samples and results. Reservoir effect corrected (-108 ± 31 years BP).
Tabla 1. Base de datos y resultados de las dataciones mediante ^{14}C and U/Th. Efecto reservorio corregido (-108 ± 31 años BP).

^{14}C age (yr BP) - U/Th age (* yr AD)	Calibrated age (yr BC/AD)	Median probability age (yr BC/AD)	References
2705 \pm 90	585 BC \pm 215 (800 BC - 370 BC)	602 BC	Dabrio <i>et al.</i> (2000)
2675 \pm 90	570 BC \pm 210 (780 BC - 360 BC)	572 BC	Dabrio <i>et al.</i> (2000)
2263 \pm 31	50 BC \pm 120 (170 BC - 70 AD)	48 BC	González-Regalado <i>et al.</i> (2019)
2210 \pm 32	10 AD \pm 120 (110 BC - 130 AD)	15 AD	González-Regalado <i>et al.</i> (2019)
2172 \pm 32	60 AD \pm 120 (60 BC - 180 AD)	59 AD	González-Regalado <i>et al.</i> (2019)
2170 \pm 32	62 AD \pm 122 (60 BC - 185 AD)	61 AD	González-Regalado <i>et al.</i> (2019)
2150 \pm 33	90 AD \pm 120 (30 BC - 210 AD)	85 AD	González-Regalado <i>et al.</i> (2019)
2100 \pm 35	147 AD \pm 117 (30 AD - 265 AD)	143 AD	This paper
440 \pm 70	440 AD \pm 70 (370 AD - 510 AD)	440 AD	This paper
1360	930 AD \pm 220 (710 AD - 1150 AD)	926 AD	Dabrio <i>et al.</i> (2000)
1300	982 AD \pm 247 (735 AD - 1230 AD)	989 AD	Dabrio <i>et al.</i> (2000)
1290	1005 AD \pm 235 (770 AD - 1240 AD)	1001 AD	Dabrio <i>et al.</i> (2000)

and a foraminiferal population (12 species; 36 individuals/10 g) with *Ammonia beccarii*, *Ammonia tepida* and *Elphidium crispum* as main species; II) washover fan (Fig. 3C), represented by numerous beds of two layers (erosive lower bioclastic layer dominated by *Glycymeris* spp; upper sandy layer dominated by *C. gallina*), a steep avalanche face to the north (25°-30°) near the base and a clear horizontal lamination towards the top (Fig. 3A), with *A. beccarii* as the most representative species of a low foraminiferal density (1-6 species/sample) and diversity (< 20 individuals/10 g in most samples) ; III) sandy tidal flat (Fig. 3D), composed of coarse to medium sands with horizontal lamination, well-pre-

served valves of *Glycymeris* spp. (60%) and *Chamelea gallina* (20%), and a diverse foraminiferal assemblage (17 species; 70 individuals/10 g) dominated by *A. beccarii*, *Elphidium complanatum* and *E. crispum* ; IV) chenier (Fig. 3E), composed of bioclastic, well-sorted very coarse sands and gravels that show a patent ENE-WSW planar cross-stratification and include fragments and abraded/bioeroded valves of *C. gallina* (50%) and *Glycymeris* spp. (40%), as well as scarce foraminifera (*A. beccarii*, *E. crispum*, *Neoconorbina orbicularis*); V) bioclastic-supported midden (Fig. 3F), with valves of *Glycymeris* spp. as main component (>90% dry weight), a scarce clayey blackish-organic matrix, an absence of for-

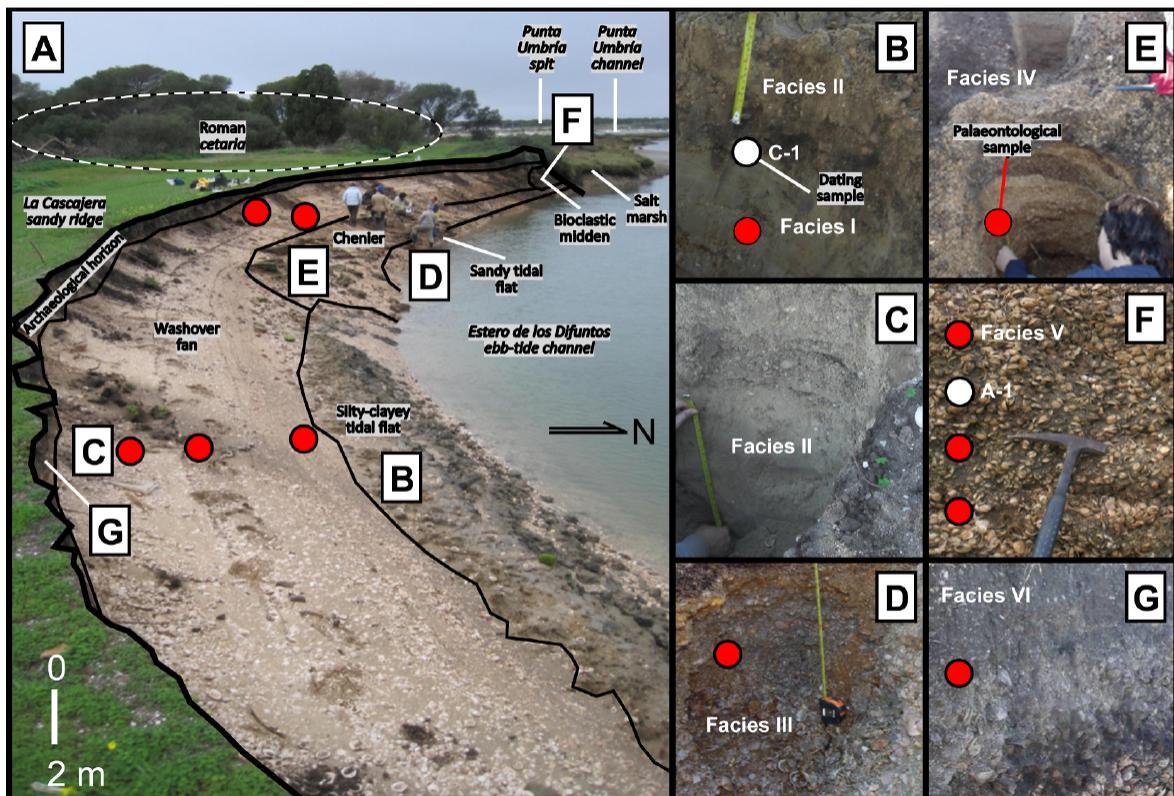


Figure 3. A-G: General overview of the studied section, including the spatial/vertical distribution of facies, a detail of each of them, the geological sampling (red circles) and the three datings (white circles). B: facies I; C: facies II; D: facies III; E: facies IV; F: facies V; G: facies VI.

Figura 3. A-G: Vista general de la sección estudiada, con inclusión de la distribución espacial/vertical de las facies, un detalle de cada una de ellas, el muestreo geológico efectuado (círculos rojos) y las tres dataciones (círculos blancos); B: facies I; C: facies II; D: facies III; E: facies IV; F: facies V; G: facies VI.

aminifera in the three samples studied (Fig. 3F) and scattered fragments of amphorae; and VI) edaphic organic-rich horizon (Fig. 3G), composed of black medium sands with numerous archaeological remains and frequent accumulations of bivalves (*Glycymeris glycymeris*, *G. nummaria*, *C. gallina*) that contrast with the absence of foraminifera.

A new dating obtained from facies II (Table 1: 147 ± 117 cal yr AD) agrees with those obtained by González-Regalado *et al.* (2019) for the same deposits, with average ages that places them in the 1st century cal AD (Table 1). These washover fans are disposed on older silty-sandy tidal flats and they are more recent than the cheniers that occupy the central part of Saltés Island (Fig. 2C and Table 1: 800-700 cal yr BC; Dabrio *et al.*, 2000). Facies V is more recent since it was deposited between the end of the 4th century AD and the beginning of the 6th century AD (Table 1: 440 ± 70 cal yr AD), with the IV century AD as most probable age. Datings obtained from Dabrio *et al.* (2000) also confirm that the sandy bioclastic deposits of the southern sector of La Cascajera are more recent than all the deposits described above (Fig. 2C and Table 1: 710-1240 cal yr AD).

Both spatial distribution of facies and these different datings permit to infer four stages in the geological evolution of La Cascajera ridge (Fig. 4): 1) Before the 1st century cal BC: the central zone of La Cascajera ridge were emerged about 700-800 cal yr BC, probably on a previous chenier plain (e.g. facies IV) that was arranged on tidal flats (facies I and/or III); 2) 1st century cal BC-2nd century cal AD: several washover fans were deposited at the northern end of La Cascajera (Fig. 3D), as consequence of the erosion of previous deposits palaeoenvironmentally corresponding to tidal flats, barrier island, beaches, shallow coastal areas) by high-energy events such as storms or tsunamis (Hudock *et al.*, 2014); 3)

4th-5th centuries cal AD: the upper edaphic horizon developed on previous washover fans, whereas the bioclastic midden was accumulated in the western part of the studied section, close to the Estero de los Difuntos channel (Table 1: 440 ± 70 cal yr AD); and 4) 6th-12th century cal AD: the southern part of La Cascajera ridge emerged.

Data obtained in this work and those provided by previous ones (e.g. Dabrio *et al.*, 2000; Morales *et al.*, 2014) allow us to reconstruct the evolution of Saltés Island during more than a millenium (see Figs. 2, 3 and Table 1 for ages). Before 800 BC, this area was occupied by a tidal plain initially sandy (facies III) and later muddy (facies I), on which cheniers (facies IV) migrated in a northern direction. The southern sector of La Cascajera emerged in the following centuries, with the appearance of sub-aerial bioclastic ridges (800 BC-360 BC; Dabrio *et al.*, 2000) linked to the progressive growing and increasing protection of the Punta Umbría spit. This creation and migration of cheniers increased in the following three centuries and probably some marshes or clayey tidal flats appeared in the most protected areas. These cheniers, ridges and the adjacent flats were eroded between 40 BC and 200 AD by a set of high-energy events, with the deposit of several washover fans northward (Fig. 2C). Depressions between the old southern bioclastic crests and these new deposits formed initially part of the tidal plain and progressively filled up resulting in the appearance of marshes. This northern area was occupied by the Roman fish-salting workshop later, probably when the continued growth of the Punta Umbría spit, the creation of new marshlands and the presence of the new bioclastic ridges provided sufficient shelter from the high energy events that generated them. Finally, new cheniers were added in the southern part of the island, with the subsequent appearance of new marshes between them (Fig. 2C).

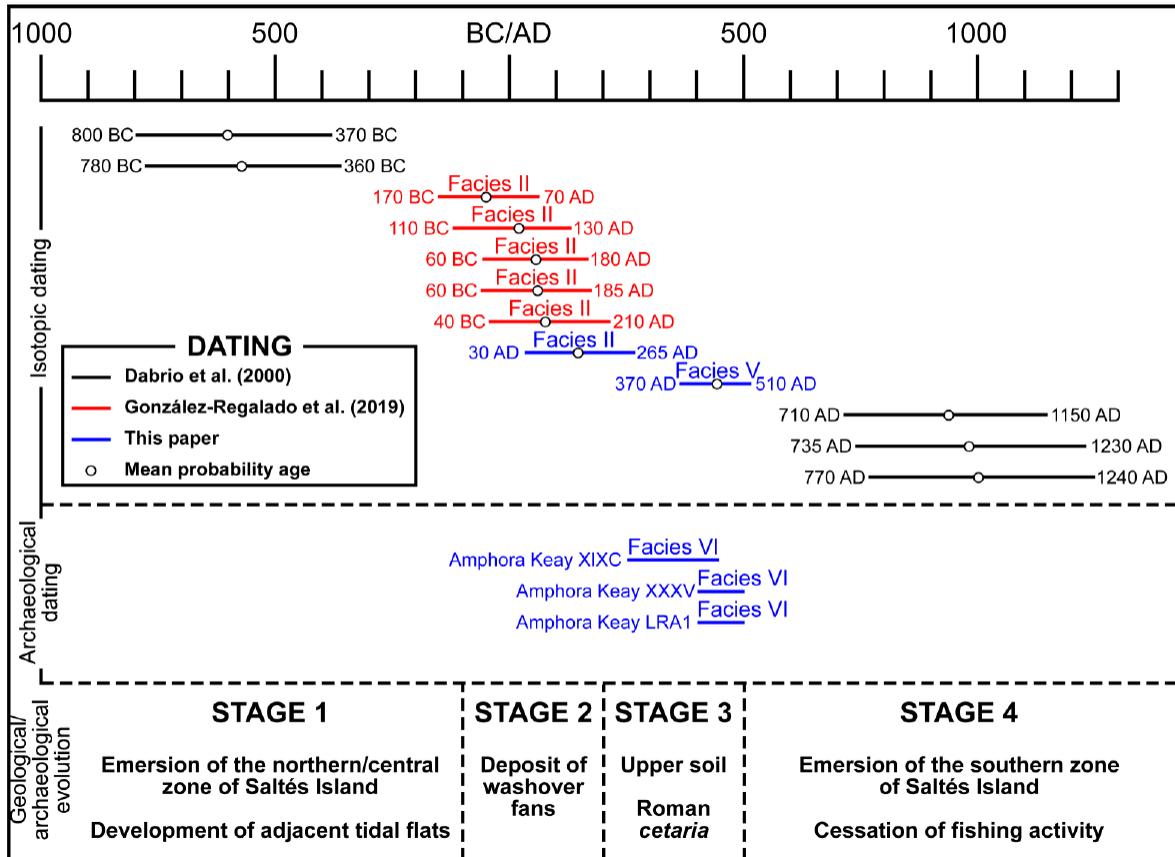


Figura 4. Geographical evolution and archaeological record of Saltés Island. Radiometric datings from Dabrio *et al.* (2000), González-Regalado *et al.* (2019) and this paper (see Tab. 1). The original paper of each is indicated with different colors.

Figura 4. Evolución geológica y registro arqueológico de la Isla de Saltés. Dataciones radiométricas tomadas de Dabrio *et al.* (2000), González-Regalado *et al.* (2019) y este trabajo (ver Tab. 1). El trabajo original de cada datación ha sido diferenciado con colores distintos.

4.2. Fish-salting workshop: its archaeological context

Prospecting activities on La Cascajera sandy barrier reveal that the Roman occupation was concentrated in the northwesternmost area, in front of El Eucaliptal site and just above the washover deposits (Fig. 3C), although the site has an extension of 6 hectares, according to the distribution of the remains found. The highest percentages of these remains are concentrated in sectors A and B (Fig. 3D), with a progressive decrease in the volume of surface material towards the eastern in an approximate front of about 500 meters. The archaeological record is

represented by Late Roman amphorae (Key XXXV A and B, XXXVI B, XIX, LR1A) (Fig. 5), cooking pottery (*aulae*, *caccabus*), storage (*dolia*) (Figs. 6A and B) as well as individuals of ARSW D (Hayes 67, 71, 87a, 91) (Fig. 7). In addition, some pillars and other constructive elements have been found in these northernmost sectors. This material proposes a chronology for the archaeological site since the end of the 4th century AD until the 5th century AD (Fig. 4; Keay, 1984; Hayes, 1976; Bonifay, 1987; 2004; 2005). According to this archaeological record (Figs. 2D and 4), this site was occupied about 1200 years about the emersion of La Cascajera ridge and 200-300 years about the deposit of washover

fans (facies V). It is very important to note that the isotopic datings of this facies and the archaeological datings are coincident and point to an industrial activity developed mainly during the 5th century AD (Fig. 4).

The Estero de los Difuntos cliff (Fig. 3A) also presented important levels of shell dumping as products of industrial activity (facies V), with high percentages of bivalves (mainly *Glycymeris*) and, to a lesser extent, of gastropods (*Bolinus brandaris*). Both the volume and variety of the archaeological material decrease eastward except in the central transects, where an important percentage of amphoric, very fragmented material is concentrated (sectors C, D and E). This material could be indicative of the existence of storage areas (*horrea*), and so on, an aspect that should be contrasted with future fieldworks.

All these materials would indicate that the northern part of La Cascajera ridge was a fish-salting workshop dedicated to fishing and processing products derived from it, and especially focused on the use of bivalve meat (e.g. *Glycymeris*). The site represents a new point in the Tinto-Odiel Estuary, in which numerous Roman archaeological sites dedicated to this activity (*cetariae*) and to the supply of transport containers (*figlinae*) have been located (see Fig. 1: Onoba, La Orden, Las Cojillas, El Almendral, La Peguera, El Eucaliptal).

The proximity of the Cascajera with La Peguera and El Eucaliptal (Fig. 1C) is very significant, since they are on the other side of the Punta Umbría channel and coexisted for a time during Late Antiquity, which could lead us to think of the same exploitation unit that presented a diversification of production in

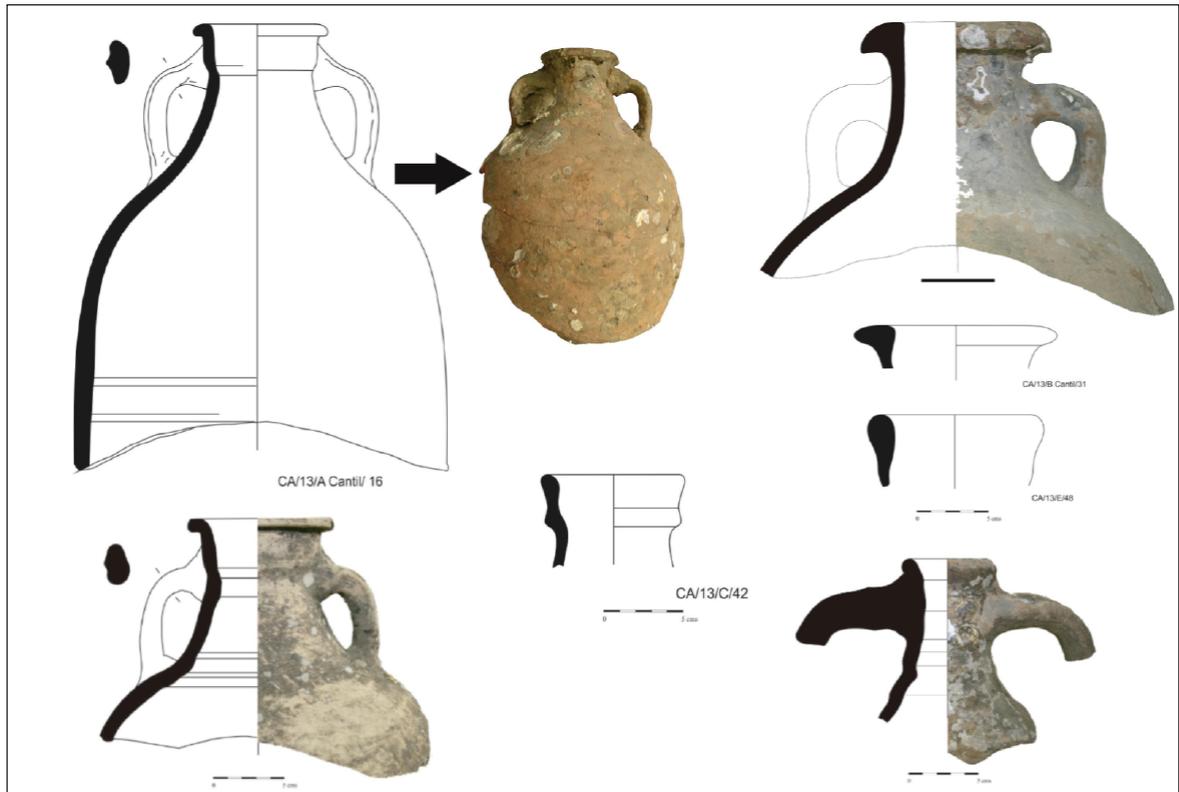


Figure 5. La Cascajera. Late Roman Amphorae (Keay XIX, XXXV y LR1A)
 Figura 5. La Cascajera. Ánforas romanas tardías. (Keay XIX, XXXV y LR1A)

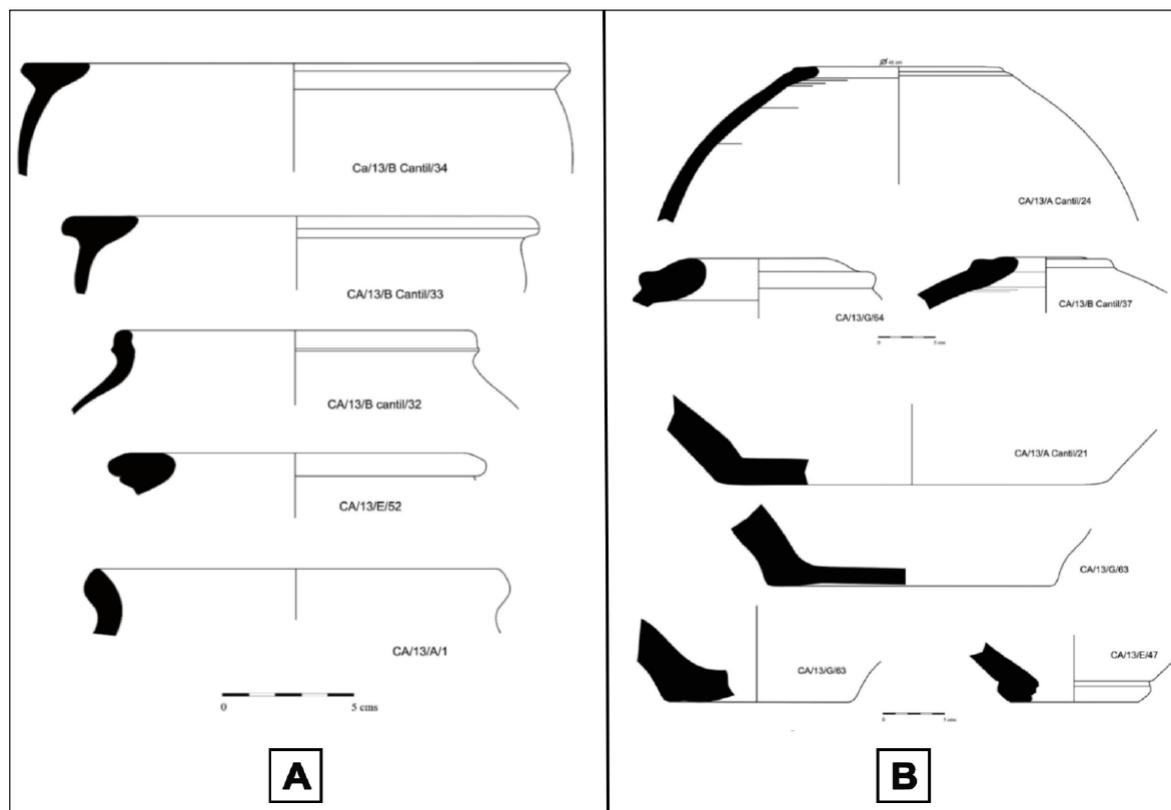


Figure 6. La Cascajera. A: Roman common pottery (*aullae*); B: Pottery storage (*dolia*).

Figura 6. La Cascajera. A: Cerámica romana común (*aullae*); B: Cerámica de almacenamiento (*dolia*).

nearby and separate areas. In this respect, the large volume of the shell deposit documented would indicate the main activity of La Cascajera factory, dedicated primarily to the use of meat from mollusks for the production of mixed fish sauces, as opposed to El Eucalipital where an important fishing processing activity developed from the 1st century AD to the 2nd century AD (O'Kelly, 2017).

4.3. Fish-salting workshop: the end of the use

At present, there is an interesting debate about the reasons that caused the cessation of these salting factories in this area and other adjacent Atlantic coasts around 6th century AD. In the Tinto-Odiel Estuary, the latest research of different archaeological sites (Fig. 1: e.g. El Eucalipital, La Orden) have revealed

that the production of these centers does not exceed the 6th century AD (O'Kelly, 2017). In this sense La Cascajera is an example given that the material record does not exceed 5th century AD. In absence of new detailed studies or reviews of well-known archaeological sites, the latest research reveals that the fishing activity destined to the trade of long distance Mediterranean in the West-East direction finished in this period. This is the case of centers such as Picola, *Barcino*, Mazarrón, *Malaca*, or *Olissipo* whose production does not exceed the second half of the 5th century, or in the first half of the 6th c. AD in Rosas, *Malaca* - Calle Afligidos - Lagos and *Septem* (Lagóstena, 2001; Bernal, 2008). The reason for the end of this production seems to be related to the Byzantine presence in the Hispanic coasts that produced a change in the struc-

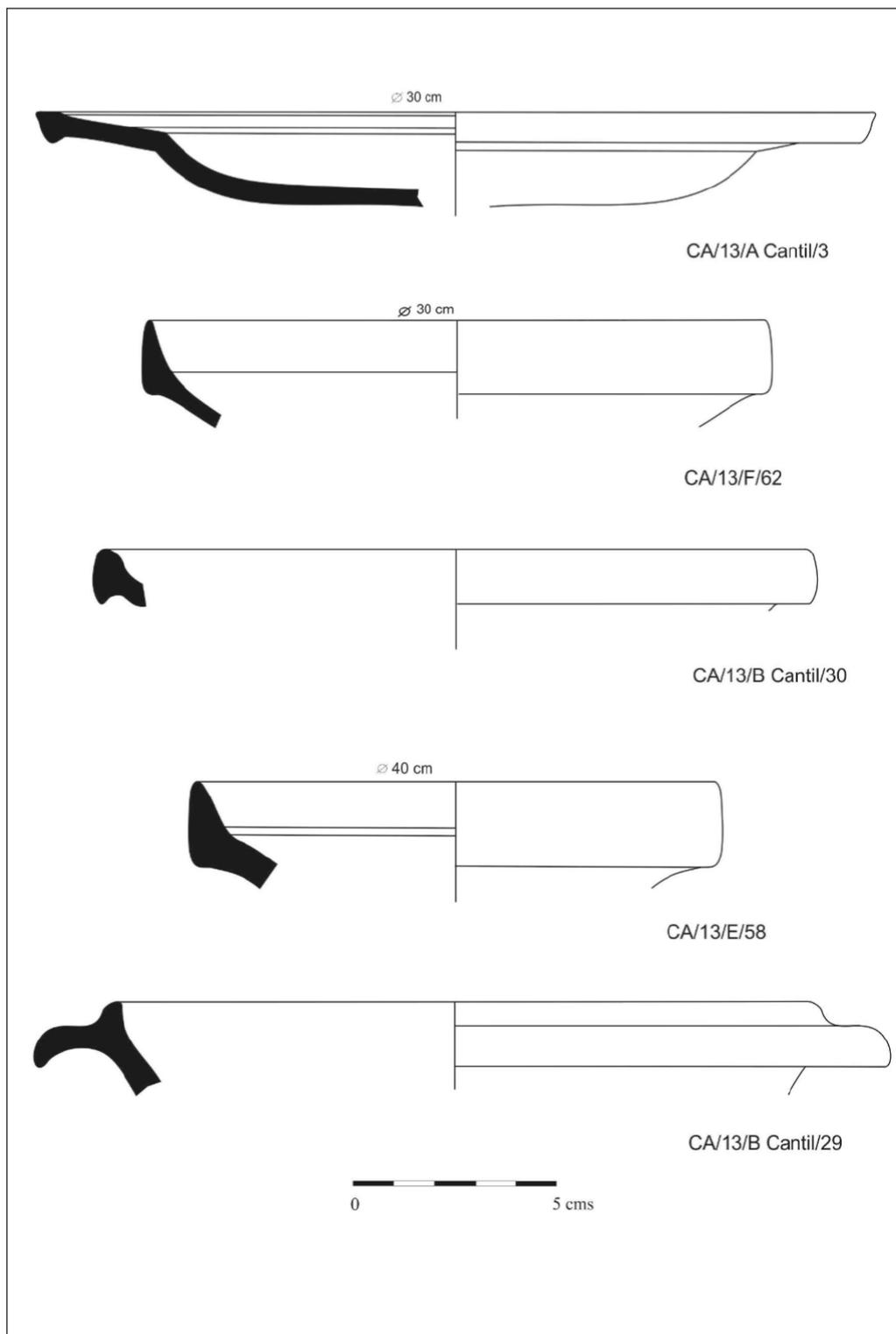


Figure 7. La Cascajera. ARSW D.
Figura 7. La Cascajera. ARSW D.

tures of production as a result of the control of the *fretum gaditanum* by the Byzantines (Bernal, 2008). However, in the coast of Huelva, the decrease and abandonment of production would be better related to the changes produced after the increasingly effective presence of Visigothic power in the ancient Hispano-Roman cities from the middle of the 5th. c. AD (Vizcaíno, 2009).

4.4. How to distinguish a midden: a distinctive palaeontological record?

The following palaeontological features of the bioclastic midden (facies V) could be used to differentiate them from other bioclastic accumulations of natural origin (e.g. beach ridges, washover fans, cheniers): I) the grain size distribution, with an almost non-existent matrix and up to 95% of gravel-size bioclasts; II) the almost monospecificity of the bivalve assemblages (*Glycymeris* spp >90% dry weight) compared to the greater diversity found in other bioclastic facies, such as cheniers or washover fans; III) the presence of *Glycymeris* shells with acute fractures on the ventral margin due to industrial manufacturing; and IV) the absence of foraminifera, a feature described in some middens of Australia (Lilley *et al.*, 1999).

5. Conclusions

A multidisciplinary analysis of La Cascajera ridge (Saltés Island, Tinto-Odiel Estuary, SW Spain) has allowed to discover a new Roman fish-salting workshop, located on previous washover fan deposits. Both the archaeological (amphorae, pottery, storage) and paleontological (mainly mollusks) records permit to deduce that this likely *cetaria* was dedicated to the handling of edible bivalve species and, maybe to, the production of fish sauces, although no ichthyofauna remains have been found. The temporary period of production

expanded from the end of the 4th century AD and continued throughout the 5th century AD, in which this *cetaria* was framed within the hinterland of *Onoba*, the main salting factory of this area during that time. The palaeontological analysis of the associated midden (facies V) has allowed detecting up to five characteristics that could be applied to differentiate middens from other bioclastic accumulations.

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