Lusitanian Amphorae: Production and Distribution

edited by

Inês Vaz Pinto, Rui Roberto de Almeida and Archer Martin

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Inês Vaz Pinto,* Rui Roberto de Almeida and Archer Martin*****

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Contents

A Multi-Disciplinary Approach to the Maritime Economy and Palaeo-Environment of Southern Roman Lusitania

Felix Teichner*

*University of Marburg
teichner@staff.uni-marburg.de

*The exploitation and processing of marine resources, particularly the production of salted fish and fish sauces (*garum, liquamen *etc.), characterized the ancient economy in the south of the Roman province of Lusitania. As a result of their coast-bound occupations, the inhabitants of this area depended on the natural conditions to a far greater extent than the inhabitants of the country's interior. This article will look at concrete examples of the interdependence between humans and the environment in a highly dynamic habitat, something which is still true at present for the Portuguese Atlantic coast.*

A multi-disciplinary research project undertaken between 2006 and 2010 shows that the main driver in the environmental changes taking place during the late Holocene within the natural estuaries on the southern coast was the silting, due to human-caused erosion in the hydrographic catchment areas. This started as early as the Bronze Age and reached its end during the mediaeval period. During the existence of the Roman province of Lusitania, changes in the palaeo-environment, documented by a combination of sedimentological, palynological and microfossil analyses, reached their peak and had a lasting influence on living and economic patterns along the Atlantic coast.

An analysis of Roman settlements in the presently silted-up palaeo-estuaries reveals highly specialized production. On the palaeo-channels that were still navigable during the Roman period, stations specializing in fishing, processing of seafood (cetariae), production of transport vessels (figlinae) *or commercialization emerged. In the latter cases, the harbours were used for distribution and as important access points to the main ancient transport route, the sea. Thereafter, increasing social differentiation and resultant prosperity manifested itself, resulting in a greater independence for the Lusitanian economy from the Circle of the Strait* (Gades) *during the time to follow.*

KEYWORDS: LANDSCAPE ARCHAEOLOGY; GEOARCHAEOLOGY; PALAEO-ENVIRONMENT; LUSITANIA; ROMAN ECONOMY; AMPHORA PRODUCTION; FISH-SAUCE PRODUCTION

Introduction and aims

The Roman provinces of Hispania provide important sources for the understanding of the ancient economy (Teichner and Peña Cervantes 2010-2011; Remesal Rodríguez 2011; Bowman and Wilson 2013). The export of wine, oil and fish products that can be reconstructed on the basis of the transport vessels, the amphorae, was mainly transacted through the sea harbours of Hispania. The current discourse in ancient studies focuses on the corresponding 'maritime economy' of the Roman Empire (Robinson and Wilson 2011).

On the Atlantic coast of Hispania, primarily in the Roman province of Lusitania, a considerable number of fishing and harbour settlements that specialized in supplying the pan-Mediterranean market with fish sauces and salted fish has been identified (Fabião 1994; Fabião 2001; Fabião 2009; Teichner 2008: fig. 306). Besides the actual production sites and those for the transport vessels (amphorae), one has to consider the anchorages and harbour installations as system-relevant components of Hispania's export-oriented economy, i.e. as gateways between land and water.

The settlement areas relevant here, namely the transitional zone between land and the Atlantic Ocean, are, however, characterized by the varying dynamics in the development of the landscape. Causes for this are not only to be found in the strong energetic tidal events and long-term sea-level fluctuations but also in the culminating erosion processes in the hydrographic systems of the hinterland. Especially on the southern coast of the Iberian Peninsula under discussion here, the effects of the convergent plate boundaries between the Eurasian and African continents also add to the dynamics, resulting in high-energy geological risks. As one would expect, all these natural events have lastingly influenced the people living and working in the coastal zone, between land and sea, since prehistoric times (Teichner 2014; Teichner *et al*. 2014).

About the turn of the eras, the Greek geographer Strabo (II 5, 17) reported: '*It is the sea more than anything else that defines the contours of the land and gives it its shape, by forming gulfs, deep seas, straits, and likewise isthmuses, peninsulas, and promontories […]. And since different places exhibit different good and bad attributes, […] some due to nature and others resulting from human design, the geographer should mention those that are due to nature*.' Starting from this premise, the naturally coast-bound production and distribution of marine products and their transport vessels (amphorae) must also have been subject to such influences during the Roman period. Between 2006 and 2010, a multidisciplinary research project funded by the Deutsche Forschungsgemeinschaft (DFG)[1] focused on the development of the palaeo-environment on the southern

[1] Reference number of the project: TE590/2 & MA1208/21. – The final editing of this work was possible due to a grant of the Romanian Ministry of National Education, CNCS – UEFISCDI, project number PN-II-ID-PCE-2012-4-0490 (Project: 'The "*Other*" in *Action*' of Prof. Alexander Rubel, Romanian Academy of Sciences, Iasi Branch).

coast of Lusitania (Algarve) during the late Holocene. Traditional archaeological and modern geo-archaeological methods were used to study the changes taking place in the estuaries that were predestined as anchorages and harbours and to establish where fishing villages had existed since prehistoric times (Schneider *et al*. 2010; Trog *et al*. 2013; Teichner *et al*. 2014).

One objective of the project was to understand whether the changes of the coastline were influenced by natural causes (transgression, high-energy events and climate change) or by human action. Therefore, the aim was to identify the beginning of, the chronological development of and the reasons for the erosion processes in the catchment areas and to analyze the effect of the transport of fluvial sediments on the development of the coastal areas and estuaries. A combination of sedimentological, palynological and microfossil analyses was used to reconstruct the development of the estuaries through the last 6000 years.

The second objective was to gain a better understanding regarding the location, the expansion and inner structure of the maritime settlements on the coast, with a special focus on the Roman period. For this, geophysical and traditional surface surveys, as well as large-scale excavations, were carried out, most of them in cooperation with the Universidade do Algarve (Prof. João Pedro Bernardes), the archaeological service of the city of Lagos (Dr. Elena Moran) and the Museu Arqueológico do Cerro da Vila (Filipe Henriques/Lusort). In addition, a validation of the archaeological site cadastre of the former Instituto Português do Património Arquitectónico e Arqueológico (*Carta Arqueológica de Portugal*) (Marques 1992; Marques 1995) was conducted by systematic surveys (Teichner *et al*. 2014).

In general, the results of the interdisciplinary study show that the silting up of the large estuaries on the southern coast of Portugal was, above all, due to human-caused erosion. The progressive silting up of the flooded marine estuaries began as early as the Bronze Age, although initially these were mainly fluvial deposits, and ended in the Islamic period. During this time, at the end of the first millennium, the estuaries were largely silted up so that floodplain vegetation could establish itself. Only in the larger systems was the formation of high marshes still dominant (Teichner *et al*. 2014).

Of special interest for the understanding of Roman Lusitania and its economy was the fact that the archaeological investigations showed the very strong influence of these silting up processes – at least on the estuaries of the western Algarve (Barlavento) analysed. These silting up processes took place during the time of the Roman Empire and influenced the region's settlement patterns in several aspects (harbours, fishing villages, etc.). At that time, the wide estuarial areas, still open during the Iron Age, had already been silted up. Furthermore, a change in the tree vegetation is visible for the imperial period in the palynological archives of the Algarve. There is a tendency for oak forests to be replaced by pine forests.

The study area, the settlements in focus and the applied interdisciplinary methods

During the fieldwork carried out so far, 11 Roman sites and their environment were investigated (Figure 1). Eight of these rural places have already been published and investigated by archaeological fieldwork of differing intensity, so only a brief presentation is necessary. The Roman settlements of Armação de Pera 2 (B5), Trafal (B8) and Salgados (B10), however, have been identified only during recent surface surveys and must be presented in somewhat more detail.

Martinhal (Sagres, Vila do Bispo) (Figure 1, B1)

The westernmost site investigated archaeologically during the project is located in the lee of Cabo de São Vicente, in the sheltered bay of Baleeira. The place, within sight of a small group of offshore islands (Ilhotes de Martinhal), after which it is named, is located at the eastern edge of

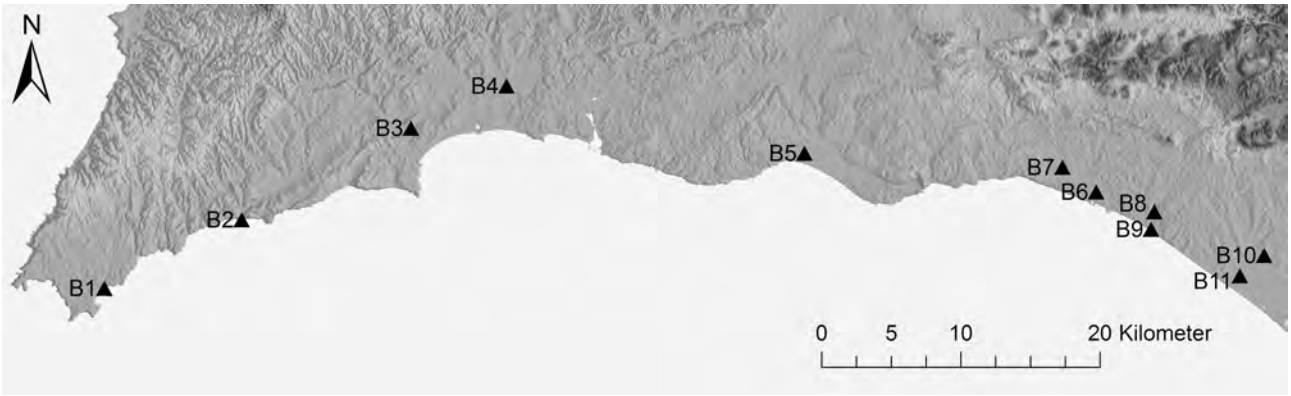

Figure 1. The south coast of Roman Lusitania and the Portuguese Algarve with the Roman maritime sites on which the project focused.
B1: Martinhal – B2: Boca do Rio – B3: São Pedro de Pulgão – B4: Abicada – B5: Armação de Pera – B6: Cerro da Vila – B7: Marmeleiros – B8: Trafal – B9: Loulé Velho – B10: Salgados – B11: Quinta do Lago. (Source: Christoph Salzmann (Marburg/Lahn)).

a bay that is characterized by the beach of Martinhal. It is situated about 10m above the present sea level, on a high shore slightly rising to the north, a place favourable for settling. The site was first mentioned in 1877 (Veiga 1910: 210) and repeatedly surveyed by Portuguese antiquarians in the following decades, confirming quickly that it was not, as initially assumed, a complex of baths ('*edifício de banhos*') but one of the largest potter's workshops in the province of Lusitania for producing coarse wares, above all the amphorae for fish products of the types late Dressel 14, Almagro 50, Almagro 51a-b and Almagro 51c (Almeida *et al*. 1971; Fabião 2004). In 1987–89, some pottery kilns were actually excavated (Silva, Coelho-Soares and Correia 1990; Bernardes 2008a; Bernardes *et al*. 2013). As a result, we know of ten ancient kilns in total, some of which are still visible in a line along the scarp face of the steep coast. Nine of them had a round ground plan and were used for producing amphorae, while a single rectangular kiln once produced building materials.

Due to its location in the natural environment, the amphora workshop (*figlina*) plays a key role in understanding the development of the coast-bound economy during the Roman imperial period. Therefore, the German team undertook archaeological research there from 2008 onwards. The field work, started by the Universidade do Algarve in the previous year, aimed at documenting those monuments that were threatened by the development of tourism and coastal erosion – the tidal range in this area amounts to 2 to 3m –, as well as at assessing the settlement's extension, its structure and development through time (Bernardes 2008b). Previously, several surveys of the site, in order to validate the Portuguese archaeological site cadastre, had been conducted by members of the project team.

During the first joint project phase, extended geomagnetic surveys were carried out on the terrace immediately north of the steep bank. Besides an already known Roman cistern (Santos 1971), several walls, either parallel or at right angles to each other, were identified, which were obviously part of a stone building oriented west-east. Surprisingly, however, no further kilns were found during the fieldwork.

A following rescue excavation by colleagues from the Universidade do Algarve resulted in the discovery of a long building, 35m in length and 11m in width, probably used as a drying and storage hall serving the ancient potter's workshop (Bernardes 2008b). No traces of buildings belonging to the workshop were found in the adjacent development area to the north outside the geophysically surveyed area, but some rubbish pits could be detected. Their ceramological analysis will allow a more detailed chronological classification of the settlement's development and end. While stray finds indicate settlement since the middle of the 1st century AD (villa or domus of the 1st to 2nd century), the production of transport vessels for exporting fish products must have started at the earliest during the course of the 3rd century AD, according to the documented groups of types, and reached its peak in the 4h to 5th century AD (Bernardes *et al.* 2013). In 2010, individual vats lined with *opus caementitium* (*cetariae*) typical of the production of fish sauces and *salsamenta* could also be identified at Martinhal for the first time (Ramos, Ferreira and Nunes 2010).

Boca do Rio (Budens, Vila do Bispo) (Figure 1, B2)

In 1878, the Roman coastal settlement of Boca do Rio, located on the Ribeira de Vale, was – like Martinhal – identified by the founder of Roman research in the Algarve, S. P. M. Estácio da Veiga (Veiga 1910; Santos 1971: 78–106). An older description had been given by the local doctor Dimas Tadeu in the 18th century, expressing his surprise about the ancient ruins that had been exposed by the heavy seaquake in 1755 (Lopes 1841: 222). Extensive geomorphologic studies conducted by British and Portuguese researchers actually prove the influence of high-energy events on the palaeo-estuary of the Ribeira de Vale (Hindson, Andrade and Parish 1999). Besides the disastrous tsunami of 1755, the smaller seaquake of 1715 also had a lasting effect on the lagoon's development (Dawson *et al*. 1995; Hindson and Andrade 1999). Further-reaching landscape-related research on human activities in this small area, which is characterized by the natural bay reaching almost 2 km inland, remained, however, a *desideratum* of archaeological research. During the Islamic period (around AD 850), a sand bar formed at the mouth of the river, which must have caused a massive change of the settlement and economic events on the banks of the estuary. Subsequently, the remaining bodies of water changed from marine to fluvial influence, making the local salt production difficult, for example (Hindson, Andrade and Parish 1999: 312).

The Roman settlement of Boca do Rio was situated on an eastern terrace of the Ribeira de Vale's estuary, protected against the rough Atlantic winds by its location. It controlled access to the estuary, which widened to the north, access that was considerably narrowed at this point by geological formations and later silted up as described above. Large parts of the stock of buildings still visible in the first half of the 20th century have now disappeared into the sea due to increasing coastal erosion. Archaeological excavations carried out by Lisbon archaeologists in 1982 and 1987 provided evidence of technical buildings for processing of seafood, subsequently resulting in the ruins receiving legal protection as an 'ancient monument' (Alves 1997). The ongoing endangerment of the site caused by coastal erosion on the one hand and unauthorized camping in the romantic bay on the other hand, suggested a continuation of the scientific documentation of the remains at the beginning of the 21st century, particularly because a correlation between the processing of seafood at Boca do Rio (B2) and amphora production at Martinhal (B1) will be highly interesting for questions regarding the economic and settlement history of this area.

The first fieldwork at the site was carried out from 2007 to 2009. The Universidade do Algarve created a micro-

topographic terrain model (Bernardes 2007; Bernardes, Martins and Ferreira 2008), while those structures visible above ground were measured. Non-invasive methods were used by the German team to survey the 3ha area of ruins. The resulting geomagnetic picture revealed a large number of walls, either parallel or perpendicular to each other, easily allowing us to reconstruct ground plans for a series of buildings. Moreover, one is able to guess an internal structure of the settlement, since the very different buildings all seem to have been arranged parallel to the slope. This supports the previously mentioned theory of Boca do Rio being not a typical *villa maritima* but rather an *agglomération secondaire* or *vicus* (Fabião 1994). As an example, we can examine a rectangular building measuring at least 35m x 30m, located in the south-east of the settlement area (Figure 2). Without a doubt, the structures visible in its interior were used for the processing of fish, since six typical vats (*cetariae*) were uncovered in preceding years in the southern half of the building. The partially intense visual noise in the geomagnetic plan seems to reflect these recent excavations. The *cetariae* had the typical long-rectangular form, with lengths of up to 1.85m and widths of 1m at a depth of 1.2m, a lining of *opus caementitium* and the characteristic quarter-round moulding at the junction of the walls and floor (Teichner 2008: fig. 315). Although the contact resistances were comparatively high because of the dry, sandy soil, a resistivity survey conducted in the summer of 2008 could also confirm the plan of the production building.

The finds from the old excavations (Santos 1971) indicate once again that the main phase of the settlement lasted from the 3rd to the 5th century AD, as the neighbouring village of Martinhal contemporaneously produced amphorae on a large scale. Pre-Roman or early imperial traces, however, have not been discovered at the site of Boca do Rio. Only modern stratigraphic excavations will be able to definitively prove this observation of the settlement's history.

São Pedro de Pulgão (Lagos) (Figure 1: B3)

In recent years, the prehistoric settlement structure at the Baía de Lagos could be understood more clearly due to a large number of important archaeological excavations. Above all, one must mention the impressive Iron Age-republican settlement on the Monte Molião on the eastern shore of the lagoon (Arruda 2007; Arruda *et al*. 2008; Arruda and Sousa 2013) and the research on the Roman industrial settlement beneath the present city of Lagos, where there is proof that the ancient enterprise of processing of fish products (*cetariae*) in the Rua Silva Lopes continued until the 6th century AD (Ramos, Almeida and Laço 2006; Ramos *et al*. 2007; Fabião, Filipe and Brazuna 2010). In 2008, indications of another Roman site were found during construction works on a small building zone in the vicinity of the Ermida de São Pedro de Pulgão, hardly a kilometre north of the Iron Age-republican settlement on the Monte Molião. It seems safe to assume that this settlement could have been connected with the neighbouring necropolis at Marateca, which dates to the 6th century AD (Pereira 2012-2013). Due to the difficult situation in terms of preserving the monument, the archaeologist in charge of the Lagos district (Dr. Elena Moran) decided to have extensive geomagnetic surveys conducted, undertaken by the company Eastern Atlas (Berlin).

The following rescue excavations were carried out by the project team in cooperation with the excavation company Arkhaios (Teichner *et al*. 2010). Below a colluvium of up to 1m in thickness, the uncommonly well-preserved foundation walls and mosaic floors of a residential building dating to the Roman imperial period were discovered. The imagery and workmanship of the mosaics found in the four documented rooms and the small finds indicate that the building was not erected before the 3rd century AD and that the settlement continued well into the 6th century at least. Due to the structure of the building, it must have been the northern part of the *pars urbana* of a Roman country estate (*villa maritima*). The geophysical survey pictures (both magnetic and radar) suggest that the residential building continued to the south. The rooms appear to be grouped around an inner courtyard (peristyle), while the entrance area seems to be located in the south-east.

In Antiquity, direct access to the Atlantic Ocean, namely the estuary of the Ribeira de Bensafrim, still existed, while the sea is presently 2km away. In the meantime, this palaeo-environmental connection could be made clearer through geomorphologic research (Arteaga and Barragan 2010). Due to natural conditions, the economic base in the vicinity of the industrial nucleus at Lagos must have been the processing of marine resources (fish products) rather than traditional agriculture. The *villa maritima* of São Pedro de Pulgão fits into the complex structure of coast-bound enterprise that included fishing, the processing of fish to sauce and *salsamenta*, as well as the production of transport amphorae.

Abicada (Mexilhoeira Grande, Lagos) (Figure 1, B4)

Unlike São Pedro de Pulgão, the villa of Abicada has been known since 1917. It is located on a spur that juts far to the south and is situated almost 8m above sea level, between the lower reaches of the Ribeira do Farelo and the Ribeira da Senhora do Verde. The residential quarter with more than 30 rooms covering 1,200m^2 and a sophisticated architectural plan with a hexagonal inner courtyard, was extensively excavated in 1937–38. Its mosaic floors have been repeatedly studied (Teichner 2007b; Teichner 2008). Therefore, the Roman villa, published in a monograph in 2008, constitutes one of the most important reference points in the western Algarve (Barlavento) regarding settlement history and chronology. A rural settlement of the early imperial period, as yet unknown in terms of structure and dimensions but obviously more modest, developed during the Tetrarchy into an imposing *villa maritima*, which opened up on an almost 50m-long porticoed façade to the sea.

In the immediate vicinity of Abicada, there are no large agricultural areas available. This means that its successful

economic development, which becomes visible in the building stock, was most likely due to the successful exploitation, processing and commercialization of maritime resources. Thanks to long-term systematic surveys in the hinterland of Alcalar, the important megalithic necropolis, we have now a clear idea of the prehistoric settlement development in the corresponding hydrographic catchment area (Moran and Parreira 2004). For the imperial period, manufacturing facilities such as the indicative vats (*cetariae*), lined with *opus caementitium*, for the macerating and fermenting of fish have been found immediately west of the *villa maritima*, on the other side of the Ribeira de Faro in the areas called Quinta da Rocha and Lameira (Teichner 2008: fig. 242).

Because of geophysical surveys in Abicada, an ancient quay could also be identified, in addition to the plan of the *pars urbana* known so far (Teichner 2008: fig. 245). Furthermore, the new investigations concentrated on describing, in terms of geomorphology, the surrounding river system that empties south of the *villa maritima* into the bay of the Ria de Alvor. Above all, the sedimentological, microfossil and palynological analyses of a drill core (ABI 05/07), extracted west of the *villa maritima*, showing the increasing silting up of the estuary since the Bronze Age, should be mentioned. During the imperial period, the silting up, in connection with rapidly decreasing tidal influence, led to brackish conditions in the vicinity of the settlement. Eventually, the sandy barriers towards the open sea (spits), which are still typical of the present Ria de Alvor, will have formed. This must have had profound effects on the availability of maritime resources, the basis of the local economy. Nevertheless, the remaining, now fluvially-fed, water runnels provided free access between the settlement site (quay) and the open Atlantic well into the post-Roman period (Trog *et al*. 2013).

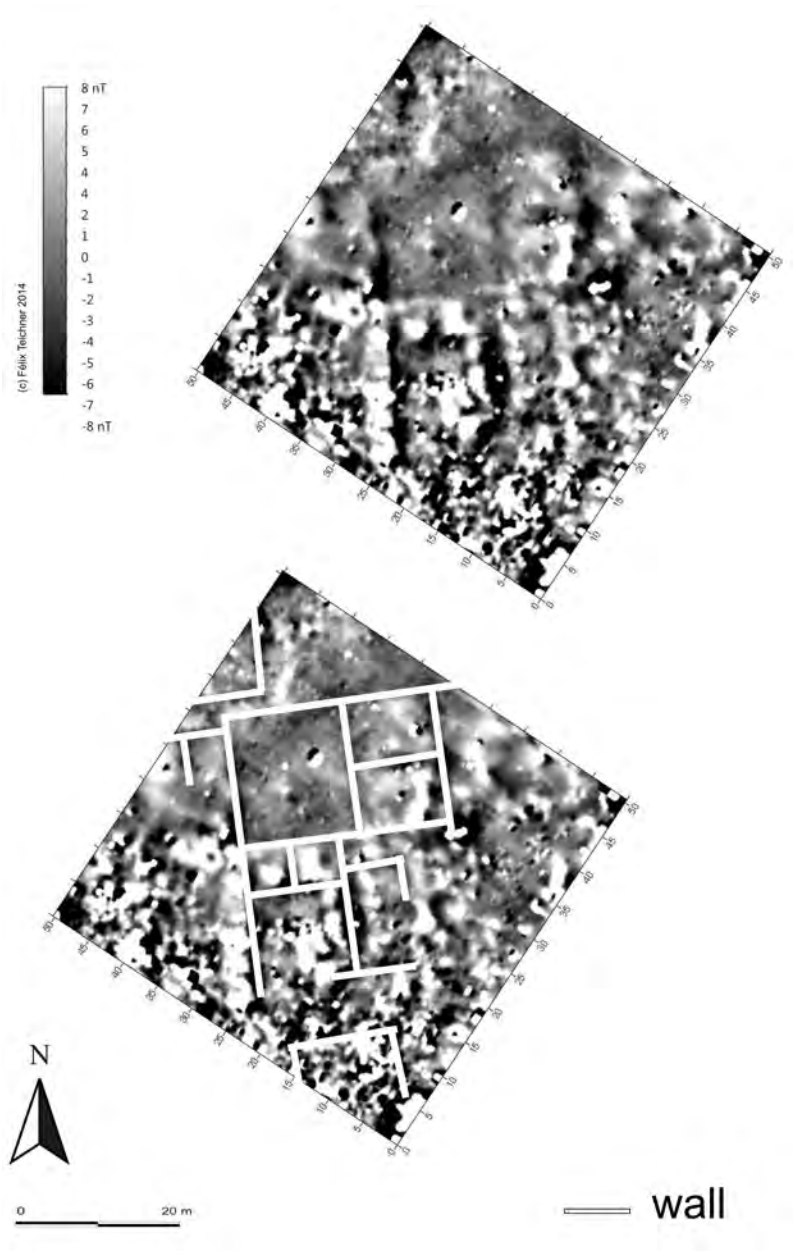

Figure 2. Detail of the geomagnetic survey carried out at Boca do Rio (B2) at the mouth of the Ribeira de Vale. Top: Geomagnetic plan (magnetogram) showing the detected structure of a Roman building with production vats (*cetariae*). Below: Building structures, interpreted from the geomagnetic plan. (Source: Teichner *et al*. 2014: fig. 6).

Armação de Pera (Portimão) (Figure 1, B5)

Immediately east of the fishing village of Armação de Pera, mentioned for the first time in the 16th century, the Ribeira de Alcantarilha and the Ribeira de Espiche form a presently mostly silted-up estuary. During the fieldwork, the thickness and the stratigraphic sequence of the lagoon sediments in this area were also systematically investigated. The scientific dating of the sediments and the resulting palynological analyses revealed an idea of the development of this estuary as well during the late Holocene. The core ADP 01/06, drilled about 1.3km inland and studied in detail, shows the development of raised freshwater marshes since at least the imperial period, as a result of decreasing tidal influence. However, the presence of riparian vegetation, proven by palynological evidence, indicates that fresh water from the hinterland continued to feed the former estuary (Trog *et al*. 2013). Therefore, using the former lagoon for fishing and landing of ships was still possible during the development of the marshes.

Until recently, Armação 1 was the only known site from the imperial period in this area, a production site for salted fish products at the eastern edge of the present waterside promenade, which operated from the 3rd to the 5th century AD. The relevant description by S. M. P. Estácio da Veiga mentioned '*tanques romanos de salga de peixe'* ('Roman basins for producing salted fish') (Veiga 1886/91 II: 369).

During the fieldwork for validating the Carta Arqueológica de Portugal, the new site of Armação 2 was discovered in the vicinity of the building of the Guarda Nacional Republicana (GNR) by members of the project in the Vila Nova development area. The existence of this site now demonstrates that the lagoon banks were already frequented at the beginning of the imperial period (Augustan). It seems that Armação 2, located on the interior shore of the ancient estuary, was only used for a short time at the beginning of the imperial period (10 BC to AD 20). Therefore, we can assume that, as in the case of the better known Ribeira de Quarteira (see below), the settlement site was relocated – namely from Armação 1 to Armação 2 – due to the increasing silting up of the estuary.

Cerro da Vila (Vilamoura) e Marmeleiros (Vilamoura) (Figure 1, B6–7)

Archaeological research in the area of the Ribeira de Quarteira palaeo-estuary, on the other hand, has quite a long tradition. By the middle of the 20th century, the Bronze Age necropolis of Vinha do Casão and the Roman rural settlement sites of Retorta and Cerro da Vila had been discovered because agriculture on the fertile soils of the silted-up wetland was being intensified (Teichner 2008: 273–4).

Once again, it was the rapid development of tourism in the 1980s and 1990s – namely the Vilamoura Resort with its own marina and extended golf facilities – that threatened the archaeological landscape and made further rescue excavations necessary. Only the foundation of an open-air museum (archaeological park) on the Cerro da Vila (Figure 1, B6), immediately west of the new marina, could preserve parts of one of the most significant ancient monuments of southern Portugal for posterity.

Towards the end of the 20th century, the Roman harbour settlement (*agglomération secondaire*), which subsisted on the processing of maritime resources (fish and dyes), was investigated by intensive archaeological fieldwork (Teichner 2008). At the same time, the recently discovered fishing station of Marmeleiros (Figure 1, B7) delivered important evidence for reconstructing the complex economic and settlement structure on the banks of the palaeo-estuary. Formerly, it reached about 5km into the hinterland and was up to 2km wide, as is today's river flood plain. Several years of geo-archaeological studies made it possible to reconstruct the morphological development of the estuary during the Holocene (Hilbich *et al*. 2005; Schneider *et al* 2010; Teichner 2008). This included both a detailed chronologically differentiated description of the silting up of the estuary – initially by marine sediments and at the latest in Roman times

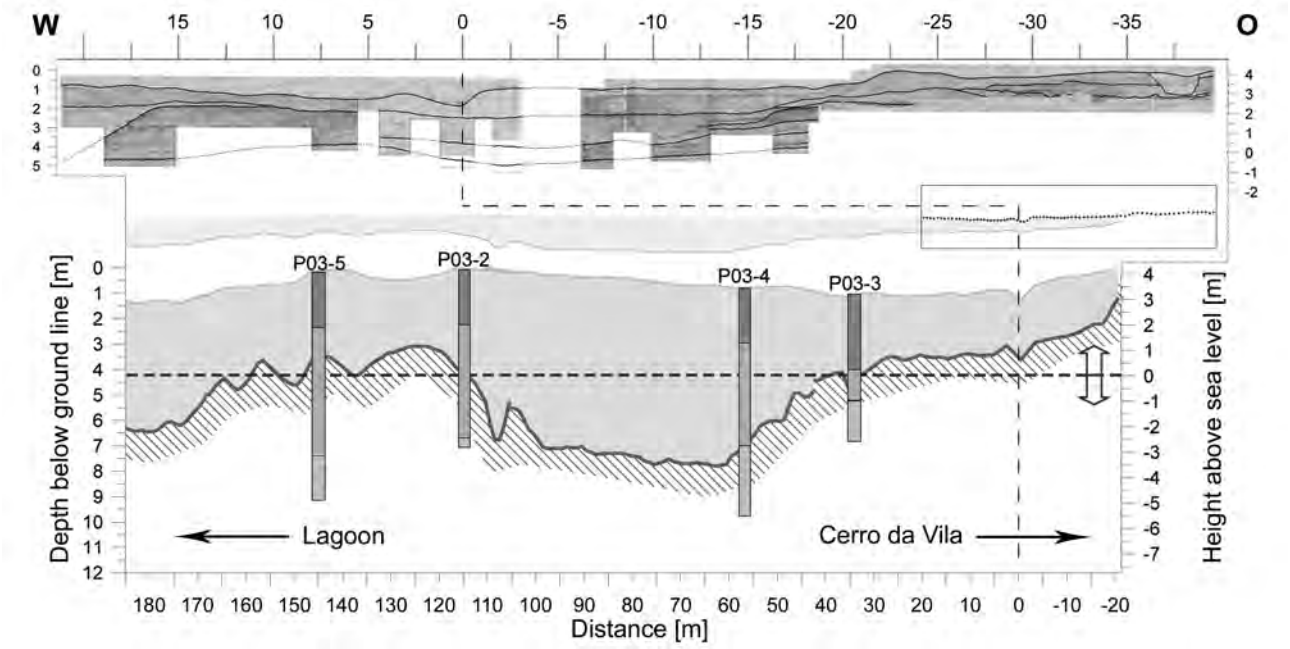

Figure 3. Modelled profile of the silted-up estuary at Ribeira de Quarteira (B7-8), based on archaeological trenches (top) and geo-radar surveys (below). For the correlation of the profiles, the modern drainage channel ('0') has been used, the Roman settlement is located on the right (east). The grey line (drawing in the middle) indicates the lowest ground limit of the marine sediments. The lower image represents the drilling cores P03/2-5 with three different levels of sediments (bottom: geological ground sediment; centre: marine sediments; top: fluvial sediments and later fillings). (Source: Christoph Salzmann (Marburg/Lahn) based on work of Felix Teichner (Marburg/Lahn) and Christin Hilbich (Zürich)).

by fluvial sediments coming from a hydrographic catchment area of 405km² (Figure 3) – and the reconstruction of the palaeo-environment on the basis of palynological archives.

The planning of the new marina (Vilamoura-2, *cidade lacustre*) opened up the possibility of interlinking the results of specific archaeological and geo-scientific analyses from the lagoon area. The planned extension of the resort demanded extended archaeological rescue excavations that were carried out by the project team. In 2007, the very first excavation year, five archaeological profiles of up to 30m in length could be excavated in the area of the silted-up estuary, starting from the limits of the already known settlement area. Because of these profiles, a branch of the Ribeira de Quarteira could be identified. Until well into modern times, this branch flowed immediately west of the eponymous Cerro da Vila to the south and into the sea. The archaeological profile documented here can now be correlated with both the transverse transect modelled by using selected drillings and refraction-seismic measurements and the depositional environments worked out in sedimentological analyses, especially grain-size statistics (Figure 3) (Teichner *et al*. 2014: fig. 14, facies I–III).

On the basis of extensive geomagnetic surveys carried out in the winter of 2007-2008 between the trial trenches, an excavation covering a larger area along the 150m of the western edge of the Cerro da Vila was undertaken in the following summer (Teichner and Winkemeier 2009). During the excavation, the ancient quay, parts of the foundation of a harbour mole (40m were uncovered) and the filling sediment of the previously mentioned palaeo-channel could be investigated (Figure 4–5).

In principle, the mole is constructed of solid Roman concrete (*opus caementitium*) based on pine stakes sunk into the ground for better anchorage. The dimensions of a rectangular building constructed right next to the quay wall correspond to those of towers described for fishing stations, used for watching hauls (θυννοσχοπεϊον: Strabon V 2, 6. 8; XVII 3,16). The development of Cerro da Vila's quay fits into the history previously reconstructed for the Roman *agglomération secondaire* (Teichner 2008; Teichner 2013): on the southern bank of the settlement, which had existed since the turn of the eras, a stone quay with corresponding harbour infrastructure developed from the Flavian period onward. After destruction during the 3rd century, the quay wall was re-built at a higher level and persisted into Late Antiquity.

On the northern bank, not needed for the landing of ships, the inhabitants had, on the other hand, started early to fill in the marshy areas of brackish water. This included the repeated elevation of the beds of the sewer channels draining the settlement area. Nevertheless, fishing boats and cargo barges could reach Cerro da Vila with its own quay wall via the described palaeo-channel of the Ribeira de Quarteira well into the mediaeval period (Al-Andalus).

East of the village of Quarteira, just before the Vale de Lobo Resort (Almancil), the Ribeira de Carcavei flows into the Atlantic. Loulé Velho, so far the only known site from the imperial period on the lower reaches of the river, was located right on the present-day seashore. Therefore, the question of a palaeo-estuary still existent in Roman times had not arisen until now (Figure 6). Massive coastal erosion, obvious even to the unaided eye, in the area of the ancient site leads to the continuous dislodging of archaeological finds and corresponding building structures, especially during the winter months. According to the photographic documentation at the early 20th century, the building remains were still more than one metre high at this time (Santos 1971: figs. 56–61), but now hardly more than the foundation layers survive. Selective rescue excavations carried out between 1994 and 2008 could document the vats in question (*cetariae*), which had been used for processing maritime resources on the immediate shoreline (Freitas 1995; Gomes and Serra 1996; Gomes and Serra 2001-2002; in summary: Bernardes 2008c). The overall architectural structure, however, could not be understood at that time. Geomagnetic surveys conducted in the meantime make some linear structures visible despite their sand covering. These linear structures, probably the walls of a corresponding production building, seem to connect the vats.

Trafal (Quarteira, Loulé) (Figure 1, B8)

As at the other archaeological sites described above, a broad range of geo-archaeological methods was also used at the Ribeira de Carcavei, included drillings with open and closed coring – the majority of the drilling locations were aligned along longitudinal transects so that geological profiles could be modelled. Data from geo-seismic and resistivity surveys were also used for this (Figure 3; Schneider *et al*. 2009). Because of this, the existence of a palaeo-estuary can now be proven with certainty for this part of the Lusitanian south coast. During the Roman imperial period, it reached at least 1.6km inland from the present coast and had a maximum width of 0.5km. In the course of the combined archaeological surface survey, a so far unknown Roman site in the Trafal area was identified.

It is situated on a settlement-friendly lynchet at the western edge of the silted-up estuary, about 1.4km away from today's shoreline (Figure 6). The surface finds indicate a settlement used from the 1st to the 5th century AD. Besides the usual architectural ceramics (*tegulae*), a greater amount of coarse ware (African kitchenware, among others) and red slip ware (especially African Red Slip Ware C) were found, so that one may expect both a production area and living quarters. Finding wasters of the amphora type Almagro 51c and parts of the kiln walls provided important evidence for the local production of this specific amphora type, thereby putting the site into the group of settlements engaged in inshore fishing and processing of fish products. Geomagnetic and geo-electrical surveys in the settlement area with the highest concentration of stray finds led to the discovery of the wing of a building oriented toward the open sea. Groups of adjacent rooms of similar size were situated around an inner courtyard. This construction is

Figure 4. Port installations at the Roman fishing site of Cerro da Vila (site B6) during rescue excavations in summer 2008. Front: reduced greyish sediments of the harbour basin; centre: quay; back: several harbour structures (*horrea, fabricae = workshops)*. (Source: Felix Teichner).

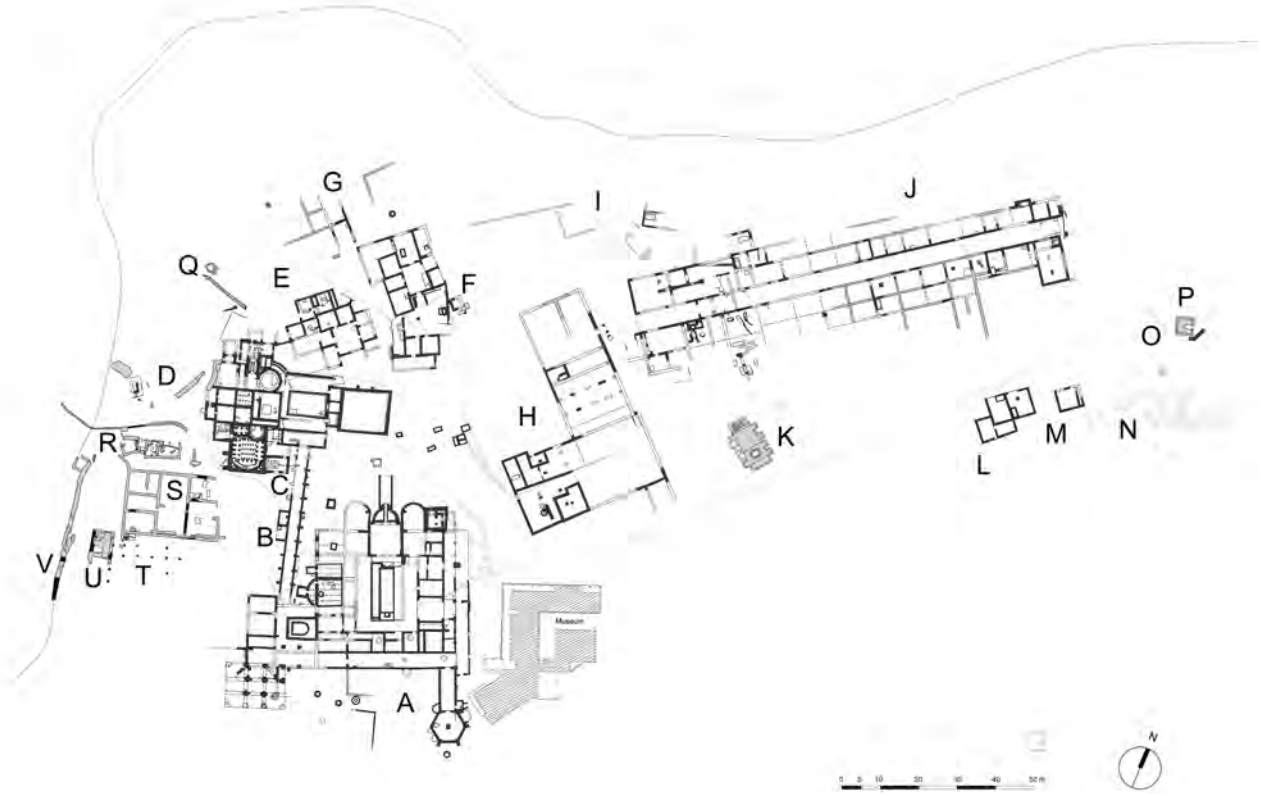

Figure 5. The Roman fishing village (*agglomération secondaire*) of Cerro da Vila (site B6) and its recently discovered port. A: Main building, *villa* – B: *porticus* – C: *thermae* – D: *triclinium/nymphaeum* – E–G and L/M: older and more recent settlement quarters, with living and working spaces - H–J: *fabricae* for the production of maritime products – K: templiform mausoleum – O: turriform mausoleum – N: necropolis – P: aqueduct – Q and U: *Nymphea* 2 and 3 – R-T: port installations (*horrea/fabricae*) – V: quay.
(Source: Christoph Salzmann (Marburg/Lahn) based on Teichner 2008: fig. 147).

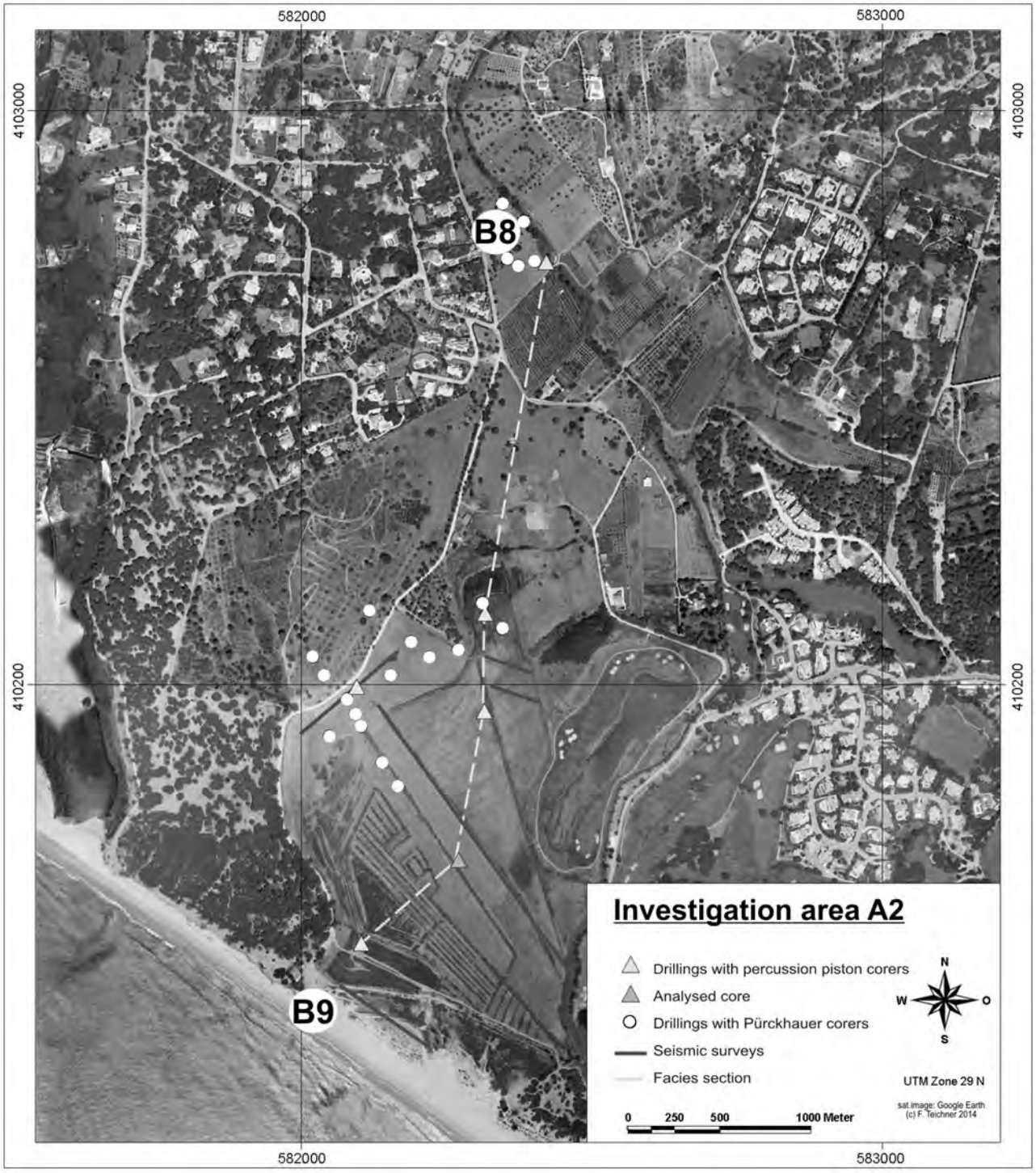

Figure 6. The coastal hinterland of Ribeira de Carcavai, between Quarteira and Faro. Marked here are the Roman production sites Trafal (B8) and Loulé Velho (B9), as well as the different geo-archaeological investigation areas. Triangles: drillings with a closed-core tube; point: drillings with an open core; lines: profiles with geo-seismic survey (solid line), dense line of small drillings (dotted line). (Source: Teichner *et al*. 2014, fig. 11).

reminiscent of buildings for processing maritime resources (Teichner 2008: fig. 305).

Quinta do Lago and Salgados (Almancil, Loulé) (Figure 1, B10-11)

At the eastern edge of the area under study, the valley of the Ribeira de São Lourenço is already situated in the sphere of influence of the Ria de Faro that is formed by the sand barrier (spit) of the Ilha de Faro. Used until well into the time of the Crusades, the harbour of Farrobilhas was, according to written sources, located in the middle of the almost silted-up lagoon (Oliveira 1977). The drillings of the lagoon sediment carried out on the lower reaches of the eponymous river once again prove an ecosystem that could, although increasingly silted-up during the Roman

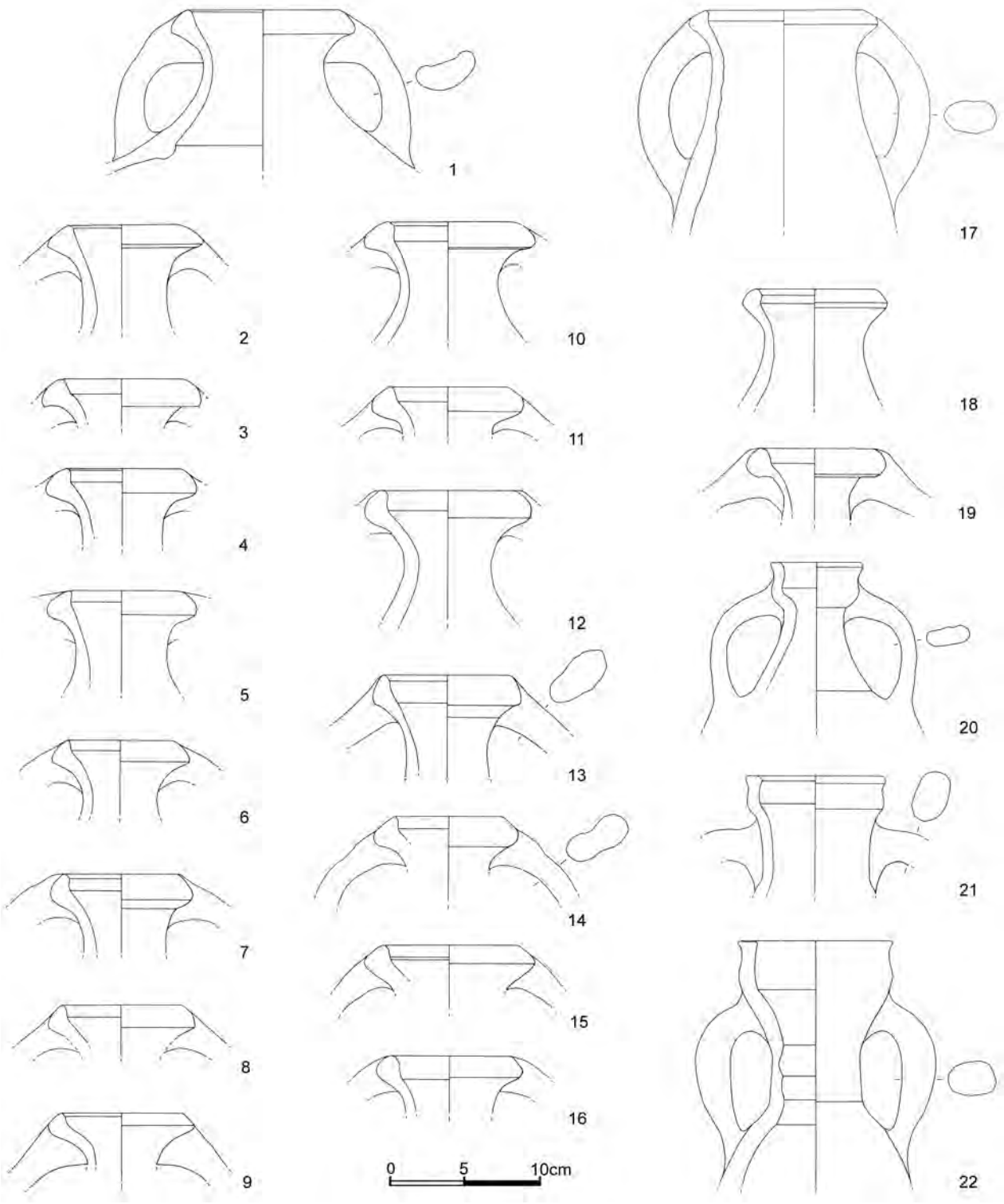

Figure 7. Roman amphora fragments recovered in the rubbish dump at Quinta do Lago, at the mouth of the Ribeira de São Lourenço, with typical Lusitanian amphora types Almagro 50 (17) and Almagro 51 a-b (20-22), the majority belonging to Almagro 51c (1-16). (Source: Helen Reinhardt/Katja Bieber (Marburg/Lahn)).

period, still be used for shipping and fishing because of its palaeo-channels. This is even more fascinating since two important pottery-production centres, São João da Venda (Fabião and Arruda 1990: fig. 57–58) and Quinta do Lago (Arruda and Fabião 1990) (Figure 1, B11), both specialized in producing amphorae for marine products, were located in the area of the hydrographic catchment area.

A third Roman potter's workshop producing amphorae had already been discovered at the beginning of the geo-archaeological investigations by students of the University do Algarve. On a terrace on the eastern bank of the river, in the Salgados area, above the now silted-up estuary, several rubbish pits were found, filled with characteristic pottery refuse (Bernardes *et al*. 2007). Altogether, the stray

finds spread over an area of about 3,000m². As expected, coarse ware and roof tiles dominated, but the presence of countless wasters and debris of kiln walls is worth mentioning. Without a doubt, these are the remains of a Roman potter's workshop in use from the 1st to the 4th century AD according to the coarse ware recovered so far. Numerous wasters of those amphorae used for fish sauces and salt fish in Lusitania (Almagro 50, Almagro 51a-b and Almagro 51c) again point to Late Antiquity as the main period of productivity.

In order to clarify the extension and structure of the Salgados workshop, geomagnetic surveys were conducted on the site during the summer of 2007, complemented by geo-electrical surveys in the following year. On the low terrace characterized by aeolian dunes, currently used for motorsport, the non-invasive surveys remained mainly without results, quite contrary to the success at other places. Artificial ski jumps and obstacles erected with construction machinery prevented extension of the survey areas on a large scale towards the terrace edge, where the respective pottery kilns are suspected. In the remaining survey area (geomagnetic) of about 1ha, set back to the east because of the obstacles, mainly the motocross track running diagonally across the area and a telegraph line could be identified. Only when comparing these results with those from the geo-electrical survey could two parallel linear structures be isolated that must have belonged to an ancient building.

At the site of Quinta do Lago, situated on the western edge of the palaeo-estuary, the non-invasive survey methods could be applied with much more success (Figure 1, B11). At the end of the 1980s, at least seven of the characteristic vats (*cetariae*) for processing the marine fruits/fish products were excavated when a golf course was laid out (Arruda and Fabião 1990: 200-201). According to the layout of the individual basins, it seems evident that these had once been situated in an interior courtyard surrounded by buildings, as has been proven for other Roman sites with large-scale excavations (e.g. Cerro da Vila, Boca do Rio). The archaeological finds from Quinta do Lago published so far again point to the 3rd to 5th century as the main period of fish sauce and *salsamenta* production. During the same time, the amphorae Almagro 50 and Almagro 51c for the export of the seafood were probably produced locally, too.

Since the excavations carried out by the Universidade de Lisboa research team, several surveys undertaken *in situ* by members of the Archaeological Association of the Algarve (AAA) - under the guidance of its former president Diana Twist - in the vicinity of the preserved *cetariae* have resulted in the localisation of an extensive rubbish dump with wasters of amphorae, namely the above-mentioned late Roman types (Figure 7). As this extensive rubbish dump, up to one metre thick, was more and more often threatened by the use of machines in the adjacent saline and bank areas, a geomagnetic survey was carried out on the initiative of the landowner, the Quinta do Lago Resorts. As a result, between the refuse site and the already known *cetariae* on the level of the low terrace, a large stone building of at least 40m in length stood out on the geophysical survey picture. Apparently, an open interior courtyard was surrounded by long wing buildings. Inside these buildings, small rectangular units seem to be visible which must have been either further fish-salting vats (*cetariae*) or levigation basins of a potter's workshop.

Results and future aspects

The geo-archaeological investigations in the south of Roman Lusitania presented here allow concrete statements, for the first time, about the formation of the coast, the determining factors regarding the conditions of human settlement in the region, and the appearance of the ancient landscape. In the process, the local 'steering' factors, especially the sediment delivery, caused by erosion processes, in the homogeneously developed hydrographic systems connecting the northern sierra with the coastline only 15 to 20km away, have turned out to be formative. At the beginning of the Holocene, the estuaries were still exposed to changes between marine and fluvial influences, but quite soon sediment delivery from the hinterland, rapidly increasing due to the human-caused reduction in vegetation, led to a decrease of the marine influence. In addition, the sand barriers (spits) forming in many places impeded the exchange of water with the open sea. The beginning of this human-caused soil erosion in the hydrographic catchment areas of the lagoons investigated here can be assumed to have started long before the Roman period, more precisely during the Bronze Age. As a result, vast lagoon areas were already silted-up in the Roman period. At the same time, mainly fluvial water channels remained alongside the marshland and the areas of brackish water, concentrating the settlements and economic activities on these channels.

Thanks to the multi-disciplinary research approach chosen, it could be made clear that above all environmental conditions and changes shaped the development of the maritime economy of Roman Lusitania, namely the production of fish sauces and *salsamenta*, alongside the well-known historical determinants: Romanization, administrative organization of the provinces, urbanization and times of crisis. A basic requirement for fishing and the commercialization and distribution of the heavy amphorae was that the settlement and production sites could be reached by ship. Therefore, the increasing silting up, particularly in the especially affected 'rear' areas of the estuaries, forced the inhabitants to give up many of the original early Roman settlements (e.g. Marmeleiros and Armação-2). Furthermore, the advancing change of marine biotopes into fluvial ones forced the fishermen to adjust, to adapt their activities to the changing fauna (fish species). The remaining brackish, marshy areas, however, also opened up new work areas, as they are ideal habitats for shells and snails. The ancient studies and archaeology have so far paid little attention to this resource, which is, for example, well-suited for producing dyes (Teichner 2007a).

It was not until the mediaeval period (Al-Andalus) that the extensive silting up of estuaries observed in the whole working area made a fundamental change to the maritime economy, which had been continued in the tradition of Antiquity up to that point (Lagos and Cerro da Vila). This led to the permanent abandonment or relocation of a large number of these rural settlement sites even before the end of the first millennium (Teichner 2008: 601).

The comparative analysis of 11 rural settlements chosen for this study allows a better understanding of the complex structures of the coast-bound maritime economy during the imperial period. In the west of the area under study, the interaction between different specialized settlements can only be vaguely outlined due to the low number of known sites: *seafood* production in Boca do Rio (B2), amphora production in Martinhal (B1), habitation in São Pedro de Pulgão (B3) and Abicada (B4) and distribution via the important industrial and economical area of Lagos.

In contrast, the high degree of functional differentiation of the individual rural settlements – even in the same hydrographic system – is evident in the east of the area under study, in particular on the lower reaches of Quarteira (B6 and 7), Carcavei (B8 and 9) and Ribeira de São Lourenço (B10 and 11). Here, small fishing stations (Marmeleiros: B7), installations for processing sea products (Loulé Velho: B9 and Quinta do Lago: B11), potter's workshops for transport vessels (Salgados: B10, Trafal: B8) and regional centres with port installations are to be found on the banks of each estuary. In the regional centres, the commercialization and shipping of the products took place alongside specialized trades (production of dyes), and the prosperity generated clearly manifested itself, too (i.e. the so-called *villa suburbana* A on the Cerro da Vila: B6).

With these results, even within the comparatively small estuary system of the Lusitanian south coast, a complex settlement and economic network structure becomes visible, such as has so far been described mainly for the extensive marine landscapes on the lower reaches of the Tejo and Sado Rivers and the area of the Circle of the Strait around Gades (Cadíz) (Étienne, Makaroun and Mayet 1994; Teichner and Pons Pujol 2008).

This obviously specialized structure of the maritime economy in southern Lusitania required affordable and easily navigable transport links between the different production units. In the end, ship traffic was not only a prerequisite for shipping the fish-sauce and *salsamenta* amphorae weighing up to 90kg to the markets in the whole Empire but also for the interaction of the different sites. Therefore, the estuaries of the Roman imperial period, protected both from the wind and more and more shielded from tidal influence, offered the best conditions.

At the same time, the export-oriented maritime economy of southern coastal Lusitania with its complexity and specialization offered a favourable basis for an increasing social differentiation and the gradual emergence of local elites. This is shown by the results of the excavations at Cerro da Vila, where a small number of large production units (*officinae*) developed from a larger number of smaller units of the early imperial period. The development of an outstanding residential building in the style of a *villa suburbana* is remarkable evidence for this. Its inhabitants had their own *balneum* at their disposal instead of the already existing public baths (Figure 5A.C; after Teichner 2008: fig. 147A.C). In general, the significant growth of the food-processing industry from the middle of the 3rd century onwards led to a greater independence of Lusitania from the then dominant Circle of the Strait. This is reflected in the emergence and development of the region's own specific transport vessels, the amphorae of the types Almagro 50, Almagro 51c and Almagro 51a-b/ Algarve 1, which dominate the production range of all amphora workshops (*figlinae)* investigated in this article.

Beyond these concrete insights into the settlement structure, the economic and social history of the coastal regions of Roman Lusitania, methodological tools for the further debate can be deduced from the presented multi-disciplinary research: considering that fishing and the secondary processing units (*cetariae, figlinae)* were bound to the coastline, especially to the palaeo-estuaries, such settlement sites with their archaeological dating can also be used as geographical and chronological indicators for the formation of the coast. Similar considerations have already been presented for some other regions, for example the central Italian Fucine Lake (Giraudi 1989; Ialonga *et al*. 2005).

On the other hand, the small, highly specialized and complex economic zones on the Lusitanian Atlantic coast were not only subject to the dynamic development of the environment but also to exceptional diluvial events as floods, deluges or even tsunamis. Evidence for several of these high energy events have been found on the Cerro da Vila especially in the *fabrica* J and its harbour area U/V (see Figure 5) (Teichner 2008: 377–385; Teichner *et al*. 2014). Recent events in Asia (Sri Lanka, Japan, etc.) have shown that such damaging marine events can bring far-reaching consequences. The economic strength of complete regions and social systems can be weakened – at least temporarily – or even a structural change brought about, the causes of which have all too often been seen only in human-influenced circumstances (e. g. the so-called 'crises of the 3rd century').

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