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1 The graben of the Isthmus of Ierapetra is bounded to the west by the Dikti mountain range and to the east by the imposing and inaccessible mountains of Sitia, which essentially isolate far eastern Crete from central Crete. The Ishtmus of Ierapetra, from Pachia Ammos on the north coast to Ierapetra in the south, just 12 km in length, was historically an overland trade route connecting the Sea of Crete to the Libyan Sea. This facilitated the transport of goods through a fertile valley at a time when circumnavigation was extremely dangerous (Fig. 1).

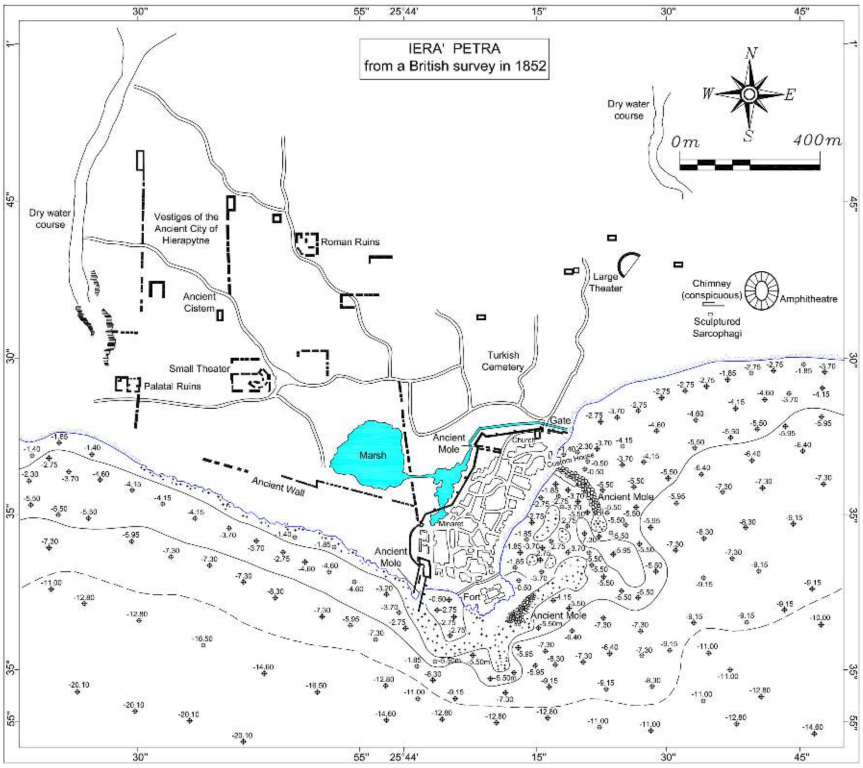
Fig. 1 - Location map of Crete

Sites with evidence for city status in the Roman period are indicated. Gortyna was the Roman capital of Crete and Cyrenaica (after SANDERS, 1982).

2 Roman Ierapetra (or Hierapytna) was largely destroyed by the modern city developed on top of it (ZOIS, 2002). The widespread destruction, in conjunction with the lack of systematic archaeological excavation, has deprived historical researchers of the possibility of reconstructing one of the most important towns of Roman Crete. The seafront of the ancient town has also suffered considerable damage due to construction of the modern port. The contemporary breakwater rests on the rockfill of the ancient western breakwater of which only the westernmost end is preserved below the sea level. The ancient eastern breakwater, unlike the western one, is preserved along its entire length, thus demarcating the eastern boundary of the Roman harbour. Moreover, the contemporary dredging of the modern port's access appears to have destroyed a significant part of the geomorphological sea-level indicators which were incorporated into the ancient port facilities.

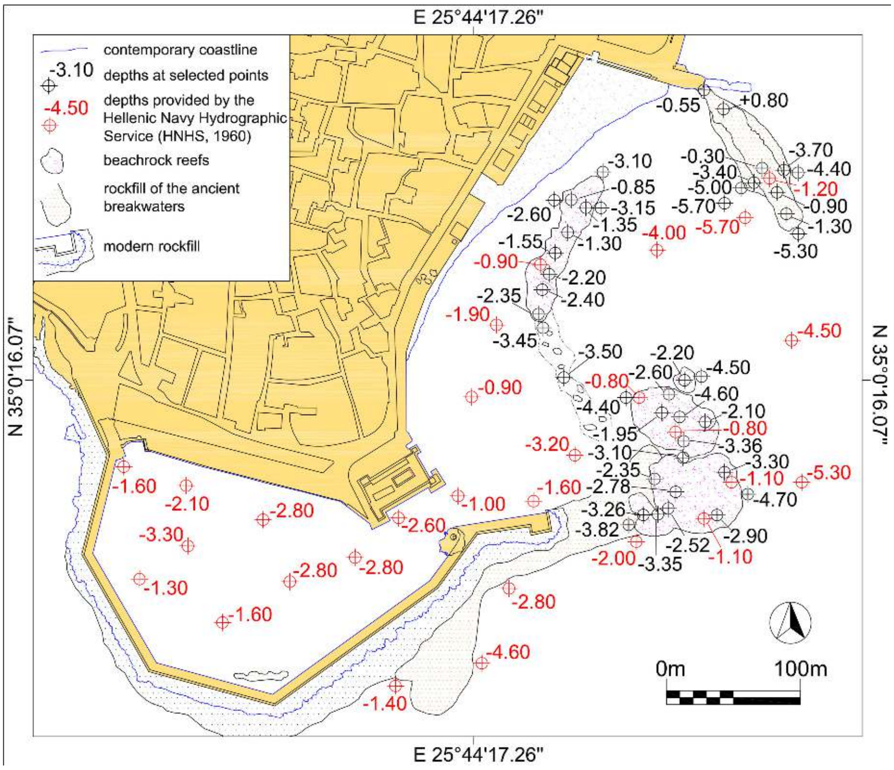
3 Therefore, our efforts to reconstruct the ancient coastline of Roman Ierapetra (Fig. 1) were based on the accounts, maps and drawings of 15th and 18th centrury travellers (Fig. 2), on the Hellenic Navy Hydrographic Service (HNHS) nautical chart issued in 1960, prior to significant dredging of the harbour basin, and on underwater surveys of archaeological and geomorphological indicators (Fig. 4).

Fig. 2 - British survey map of Ierapetra (1852)



That was originally drawn by SPRATT, was found in FLOURIS and DIDIKAS (2012) and is redrawn here.

Fig. 4 - Plan of the Ierapetra seafront



Excerpt from the Hellenic Navy Hydrographic Service (HNHS) nautical chart issued in 1960 prior to significant dredging of the harbour basin. Red numbers: depths from the HNHS nautical chart, Black numbers: depths measured during this study.

4 In the Late Roman period, the AD 365 severe seismic event (PIRAZZOLI, 1986; STIROS, 2001; STIROS and DRAKOS, 2006; SHAW *et al.*, 2008) split the island along the neotectonic graben of Spili and its northern and southern prolongations. During this period, sea level was -1.25 ± 0.05 m lower than at present (MOURTZAS, 2012a, b; MOURTZAS *et al.*, 2016). However, this significant tectonic event did not affect sea level along the coast of central and eastern Crete, which remained stable at -1.25 ± 0.05 m until the earthquake of 1604 (MOURTZAS *et al.*, 2016).

5 In this paper we reconstruct the palaeogeography of the Roman coastline at the Ierapetra in relation to the relative sea-level changes that have occurred during the last 2,000 years.

1 - Historical evidence

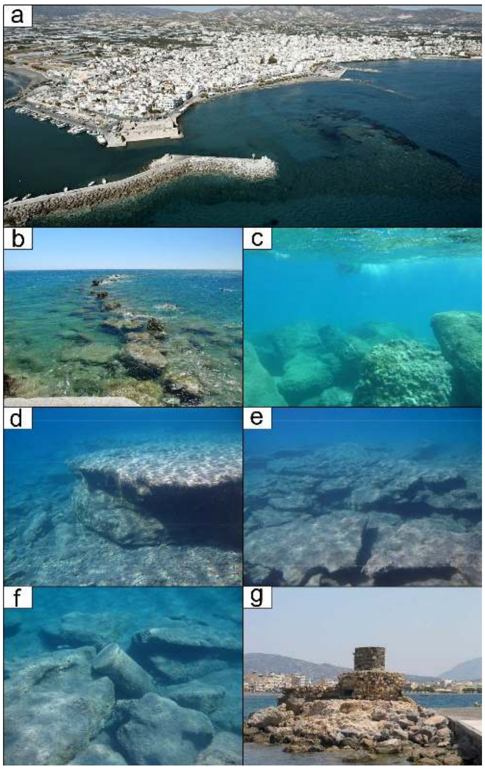
6 After the fall of Ierapetra in 67 - 66 BC, the extremely violent conquest of Crete by the consul Quintus Caecilius Metellus and his legions was completed. The town was totally destroyed by the Romans, but was rebuilt shortly afterwards. Taking advantage of its strategic location for trade with the Eastern and Southern Mediterranean, it became an important naval base. The town grew in population, experienced an economic and cultural expansion and evolved into one of the richest Cretan cities with its own cosmopolitan character, currency and many important public buildings, including

temples, aqueducts, large public baths, an amphitheatre, two theatres, and a ‘naval battle’ (PAPADAKIS, 1986) (Fig. 2).

7 During the early Byzantine times (AD 330 - 824), Ierapetra was not well-known in the empire. Furthermore, it suffered serious damage during the AD 796 earthquake, with a magnitude 7.5 on the Richter scale (SPANAKIS, 1991). The destruction was completed by raids and looting of the Saracen corsairs in 824 (SPYRIDAKIS, 1990).

8 Venetian rule in Crete lasted from the 13th to the 17th century. The fortress Kales at the entrance to the modern port was built in 1212 by the Venetians to protect the small harbour (Fig. 2, 5a).

Fig. 5



- (a): aerial photo of the seafront of Ierapetra, view from the south (from: https://www.tripinview.com/en/presentation?layer=overview&datasetId=55830&id=59067),
- (b): the blocks of the eastern breakwater that project from the sea and the outline of the submerged section,
- (c): the submerged top of the eastern breakwater,
- (d): the massive eastern seaward end of the inner beachrock reef,
- (e): the fragmented outer beachrock reef,
- (f): the fragmented western end of the inner beachrock reef with a column piece on its top,
- (g): the rocky islet incorporated into the modern jetty.

9 An earthquake razed the town once again, on either May 29 (PLATAKIS, 1950) or June 4 of 1508 (PAPADAKIS, 1986). It had an estimated magnitude of 7.2 on the Richter scale, and in addition to its impact on Ierapetra, it caused serious damage in Sitia and Candia (today Iraklion) where only four or five houses survived (PLATAKIS, 1950). After several years, the town was rebuilt in the mid-16th century as a village with a small fortress. After falling to the Turks in 1647, it was again downsized to a simple settlement (TOURNEFORT, 1717).

2 - Materials and methods

10 Reports of the submerged archaeological and geomorphological structures at Ierapetra's seafront were first published by MOURTZAS (1990) and were further surveyed over the course of this study.

11 The geomorphological features and the ancient harbour installations were mapped using satellite images (Google Earth, 2012) and high-resolution orthophotos at a scale of 1:500 (Ktimatologio SA). During the underwater survey, the depths at characteristic points of the ancient constructions related to former sea levels were measured in order to precisely define their functional elevation. The beachrock reefs were also surveyed, and their depths were measured.

12 All measurements were collected during calm sea conditions using mechanical methods. To account for tides, observational data have been reduced for tide values at the time of surveys with respect to average sea level, using tidal data from the nearest tide-gauge stations. All records were corrected for tides, using data from the Hellenic Navy Hydrographic Service (HNHS) for the closest tide-gauge station at Iraklion.

13 The formation of beachrocks in the intertidal zone along the coast of Crete, suggests that these are indicative of specific sea level positions and therefore they are valid indicators of sea level change (DERMITZAKIS and THEODOROPOULOS, 1975; NEUMEIER, 1998; NEUMEIER *et al.*, 2000). They are formed during periods of eustatic and tectonic stability by cementation of beach sediments between the low tide level and the swash limit of the constructive waves. The cementation occurs in the intertidal and supratidal zone, both presenting a similar, indistinguishable diagenesis (BERNIER and DALONGEVILLE, 1996; NEUMEIER, 1998). For this reason, the intact seaward end of the beachrock that forms in the intertidal zone can be used as an indicator of the mean sea level at the time of the beachrock formation. Therefore, the base of their intact seaward end coincides with the low tide level of the corresponding sea level. Different beachrock bands represent different sea level stands, whereas sandy strips between them reflect periods of rapid change in relative sea level.

14 NEUMEIER (1998) studied the beachrock formation just west of Ierapetra harbour, which stretches for 400 m along the exposed coast. Cement samples were analyzed by various methods in order to identify the cementation pattern and define the environment of formation. NEUMEIER (1998) concluded that beachrocks were formed in the intertidal zone in the broadest sense, including the tidal and swash zones. Regarding their composition, it comprises sands, detritic gravels (quartz, carbonate, metamorphic and volcanic lithoclasts) and less than 10 % bioclasts, cemented by magnesium calcite. The fluid is mainly marine water with probable fresh water influence. The cement comprises two components. The Mg-calcite micritic (MgMi) brownish gray cement, which is a principal early marine cement and the most common cement in the Mediterranean and also Crete. The micrite crystal size ranges from 0.5 μm to 4 μm. It is characterized by an unusual undulating structure, similar to the form of microbialites at a smaller scale and it is only of microbial origin. The MgMi cement is followed by an orange micrite cement (MiOr), brown orange to bright orange in colour, rich in organic material, whose formation is linked to microbiological activity. Its distribution is discontinouous, observed either on the surface or up to a depth of 0.40 m - 0.50 m. During diagenesis it

can be transformed into Mg-calcite undulating micrite, and the decomposition of the organic material could jointly intervene in its mineralization. It corresponds to the recent diagenesis phase, still biologically active (NEUMEIER, 1998).

3 - Historical evidence concerning the ancient coastline and harbours

15 According to SPRATT (1865), Roman Ierapetra seems to have had two harbours, both damaged and filled with sediment and debris at the time of his visit. SPRATT (1865) believed that the natural morphology of the coast, supplemented by artificial structures formed the ancient outer harbour. Its landward side was surrounded by a curved Ottoman wall, while the modern town occupied a significant part of its area. The second, inner harbour was within the walls. Because it was separated from the sea, it formed a marsh and was a cause of serious diseases for the local inhabitants. SPRATT also described the ruins of two ancient theatres and the amphitheatre, which were still visible at the time.

16 On a British survey map (1852), SPRATT presented the two breakwaters of the ancient harbour: the eastern breakwater running NW-SE and 185 m in length and the western breakwater running NE-SW and 115 m in length (Fig. 2). According to his detailed bathymetric measurements, the basin was 2 m to 5.5 m deep, and he also noted the existence of shallow reefs inside the harbour. He placed the Roman military battle harbour, which he characterized as an inner harbour, at the western end of the town at the southern extension of the Ottoman wall. Spratt postulated that the ancient harbour basin was filled in to accommodate the new town. On land within 160 m of the coast at the northern extension of the town, he noted an ancient structure 70 m in length running E-W, which he characterized as an 'ancient mole'. The extensive marsh, now dried, seems to extend almost the entire length of the town's western boundary (Fig. 2).

17 SPRATT (1865) referred to the 1586 manuscript (then lost) of Onorio Belli, extracts of which were published by FALKENER (1854). Belli travelled to Crete at the end of the 16^{th} century and as stated by SPRATT (1865) visited Ierapetra in 1590. According to Belli's description, Ierapetra had three ports; one of these was the military battle port or inner harbour. This was the basin where condemned criminals or slaves, pretending to be sailors, re-enacted historical naval battles. The naval battle basin was located on the western side of the town, and when Belli visited Ierapetra, it was already filled in. He could not precisely define the other two harbours, since the modern town was built exactly in the centre of the main harbour and the Venetian fortress was built on its periphery. However, within the urban fabric of the town, he could distinguish some massive foundations of moles or quays. On the compact western mole, built of stones with pozzolana, he distinguished five or six perforated blocks that projected from its sides to receive the ships' moorings. These were visible at the end of the 16^{th} century near the extreme southern part of the wall of the modern city, which, for a short distance, was built on this mole. Belli referred to the severe 1508 earthquake, which was also described by Girolamo Donato, Duke of Candia (today Iraklion), as stated by FALKENER (1854) in SPRATT's book (1865). The town was then razed and, after that event, it was reduced to a hamlet with only a small castle.

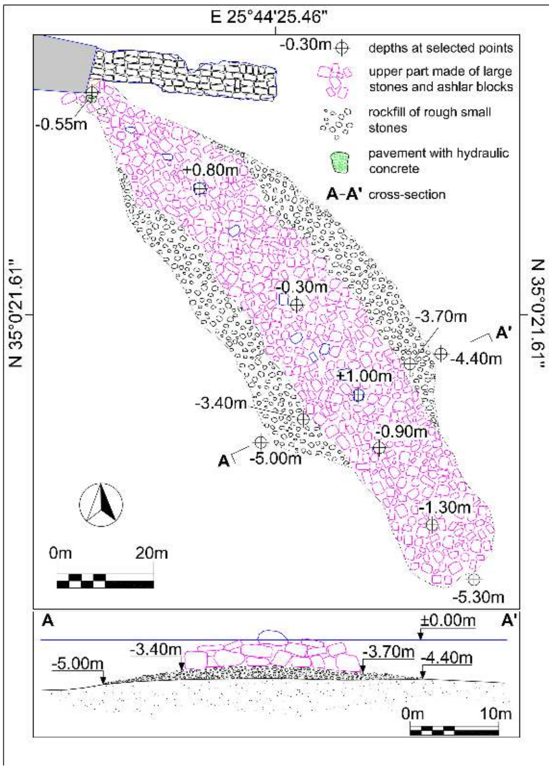
18 According to SANDERS (1982), only a few ancient remains are now visible from a town once embellished with a naval battle basin, an amphitheatre, two theatres, temples, thermae and aqueducts. However, it is still possible to distinguish the relics of the western and eastern breakwaters of the outermost of the three harbours. The plan provided by SANDERS (1982) shows the outer harbour between the Venetian fortress and the submerged Roman breakwater to the east.

19 ZOIS (2002) identified the central harbour between the Venetian fortress and the submerged Roman eastern breakwater, the eastern harbour along the east coast where there are the 'shipsheds' described by the author and the breakwater to the west of the Venetian fortress in the area of the 'Wall Harbour', where he also placed the 'naumachia'. West of the Venetian fortress, he located the main harbour basin that was thought to have been formed by dredging. Vessels arrived and were moored on the southern side of the 'Wall Harbour', which is now on land within 120 m of the coastline (Fig. 2).

4 - The submerged ancient harbour installations and geomorphological features

20 The ancient eastern breakwater (Fig. 3, 4, 5a, b, c) runs SE for 130 m from the coast to the open sea, with a maximum width of 35 m in the central part. It consists of the lower rockfill with a visible thickness of 1.5 m in the central part; it is made of small rough stones up to 0.4 m in size.

Fig. 3 Plan and cross-section of the eastern breakwater of the outer harbour of Roman Ierapetra.



21 The upper part, which rests on the rockfill, has a thickness of 3 m to 3.5 m, and comprises large stones and parallelepiped ashlars up to 3 m to 3.5 m in size (Fig. 3). Apart from 13

boulders that slightly project from the sea (Fig. 3, 5b), the top of the breakwater is at -0.8 m to -1.3 m (Fig. 3, 5c), depths similar to those of the HNHS nautical chart (1960) (Fig. 4). On the landward end of the breakwater, at -0.55 m, the probable remains of a pavement with hydraulic concrete were found (Fig. 3).

22 The majority of the ancient western breakwater (Fig. 4, 5a) is buried under the modern pier. It ran ENE for 145 m between the outer reef and the rocky islet, which is currently incorporated into the modern pier (Fig. 5g). Then, it turned NW for 125 m to its western end. Most probably, it ran further west, since within 90 m of its western end inside the modern basin the remains of rockfill have been identified. The rockfill of the ancient western breakwater, between the end of the modern pier and the outer rocky reef, apparently has been removed and used as material for the construction of the modern pier (Fig. 4, 5a).

23 The two extensive rocky reefs consist of massive beachrocks, with a total thickness of 1.8 m to 2.5 m (Fig. 4, 5a). The elongated inner beachrock reef grows parallel to the coastline in a NNE-SSW direction for 115 m, and it is 20 m wide. Its intact eastern part is up to 1.8 m thick, and the top and the base are at -1.3 m and -3.15 m, respectively (Fig. 5d). The remainder is very fragmented, probably because the basin was dredged in the 1960s (Fig. 5f). The depths of the top and base in the fragmented part are -2.2 m and -3.45 m, respectively. The HNHS nautical chart (1960) produced prior to the dredging shows that the beachrock top was at -0.90 m (Fig. 4).

24 The outer reef is located at the extension of the western breakwater and runs in a NW-SE direction for 115 m. It is 65 m wide and appears very fragmented because of the harbour dredging (Fig. 5e). The base of the beachrock is at -4.6 m and the top at -2.1 m, whereas the depth of the beachrock top shown on the HNHS map is -0.8 m to -1.1 m (Fig. 4).

25 Pieces of beachrock, structural blocks and column fragments are scattered around the seabed between the two reefs down to a depth of -3.5 m (Fig. 4, 5f).

5 - Sea-level markers

26 MOURTZAS *et al.* (2016) have identified four distinct beachrock generations on the coast of eastern Crete, with a mean seaward depth of the bases of the three earlier generations at -6.55 ± 0.55 m (generation IV), -4.3 ± 0.2 m (generation III) and -3.1 ± 0.3 m (generation II), and the seaward depth of the top of the younger beachrock (generation I) at -1.35 ± 0.2 m. MOURTZAS *et al.*, (2016), comparing the seaward depths of the base of the various beachrock generations with the depths of the successive tidal notches and sea erosion platforms, as well as with the functional elevation of archaeological indicators, concluded that these had a good match and corresponded to former sea levels. By dating the past sea levels on the basis of archaeological indicators, MOURTZAS *et al.*, (2016) attributed the following ages: 2200 BC to 1900 BC for the beachrock generation IV, 1900 BC to 1600 BC for beachrock generation III, 1450 BC and the 4th century BC to beachrock generation II and the 4th century BC to AD 1604 to beachrock generation I.

27 By collating the seaward depths of the beachrock bases in Ierapetra harbour, we find that the depths of the outer beachrock reef at -4.55 ± 0.15 m coincide with those of the beachrock generation III and the depths of the inner beachrock reef at -3.25 ± 0.2 m with those of the beachrock generation II. Accordingly, the depth of the top of the beachrock reefs at -1.3 ± 0.05 m coincides with that of the beachrock generation I. Therefore, we

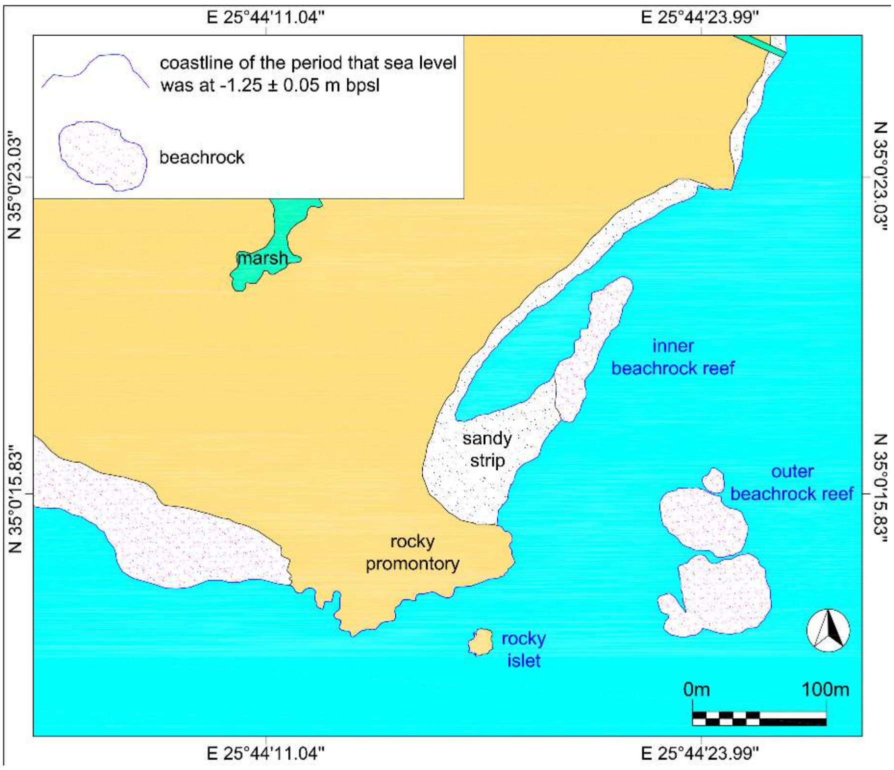
suggest that the various beachrock generations have been formed by cementing the coast deposits that overlap with each other, so that the total thickness (around 2 m) of the resulting beachrock far exceeds the local tidal range (mean 0.15 m).

6 - Palaeogeographic reconstruction

28 Using all the available data, including the depths of the current position of geomorphological and archaeological indicators measured during the present underwater survey, depths from the HNHS bathymetric map, historical evidence and plans, archaeological assessments and the previously defined and dated sea level when the harbour was operational (MOURTZAS, 1990, 2012a, 2012b; MOURTZAS *et al.*, 2016), we attempt a palaeogeographic reconstruction of the Roman coastline of Ierapetra and the intervening relative sea-level changes.

29 When the sea level was -1.2 m and -1.3 m lower than at present, from the 4th century BC to AD 1604, as determined and dated by MOURTZAS (1990, 2012a, 2012b) and MOURTZAS *et al.*, (2016), the Roman legions that conquered Ierapetra would have found the seafront quite exposed to the open sea. The two beachrock reefs would have protruded slightly from the sea, and the inner beachrock reef most likely would have been joined to the opposite coast by a sandy strip. The rocky islet within 40 m from the opposite rocky promontory was aligned with the outer beachrock reef (Fig. 6).

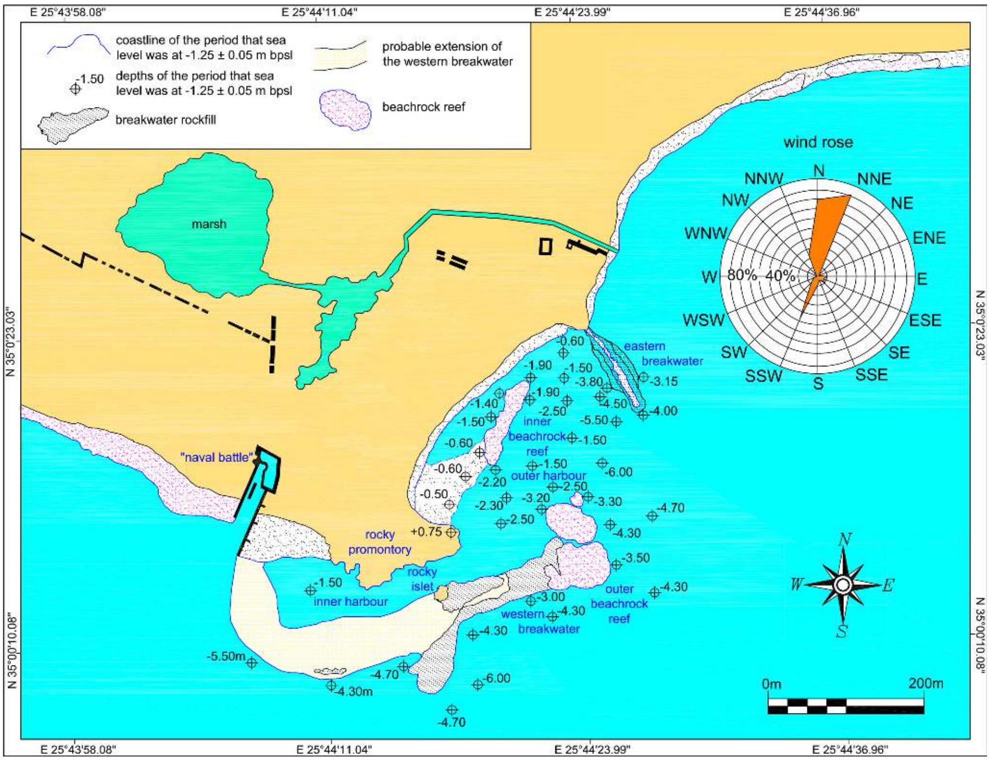
Fig. 6 - Palaeogeographic reconstruction of the Ierapetra seafront prior to the Roman period



30 The Romans constructed the eastern breakwater that would have had to protrude from the then sea level by around 0.1 m to 1.0 m in order to form a sheltered harbour (Fig. 3). The western breakwater was constructed by joining the outermost beachrock reef to the islet, possibly extending it even further west and joining it to the shore, as indicated by

the rockfill remains within the modern port. Therefore, the inner harbour would have been nearly the same size as the modern port (Fig. 7).

Fig. 7 - Palaeogeographic reconstruction of the coastline of Roman Ierapetra



31 The outer harbour was probably bounded by the western artificial breakwater and the inner and outer beachrock reefs, which projected from the sea by 0.1 m to 0.5 m. According to SPRATT's (1865) bathymetric map, the depths of the basin of the outer harbour should have ranged from 1.5 m to 5.5 m, while those of the inner harbour seem not to have exceeded 1.5 m. The naval battle seems to be located just west and outside the inner harbour, as shown in SPRATT's (1865) plan (Fig. 2, 7).

32 Given that the sea level during the Roman period was -1.25 ± 0.05 m lower than at present, and assuming that this level had not changed when Belli visited Ierapetra, we believe that in the late 16th century the morphology of the coast was not radically different to today. The assumptions that the harbour basin during the Roman period occupied part of the current urban fabric of the town and that the structure indicated by SPRATT (1865) at the northwest boundary of the then town is an ancient mole (Fig. 2) are not supported by any currently available data.

7 - Conclusions

33 From Venetian rule through the Ottoman conquest to recent times, the urban fabric of Ierapetra developed at the same site where the ancient town existed (SANDERS, 1982; ZOIS, 2002). The seafront and harbour facilities of Roman Ierapetra followed the story of the destruction of the ancient town. The ancient western breakwater of the Roman harbour is mostly buried under the modern jetty, rockfill from its eastern end was removed, and the beachrock reefs were fragmented. The relative rise of the sea level by

1.3 m, which has occurred since the Roman period, has altered the ancient coastline and distorted the ancient harbour installations.

34 The 1586 descriptions of Onorio Belli as presented in the manuscript of SPRATT (1865) with its descriptions and drawings provided us with important information on both the location of the Roman relics outside the town's limits and of the ancient harbour installations that seem to have been used until the 18th century without having undergone major interventions. Also, the HNHS nautical chart (1960), which was apparently drawn prior to the harbour dredging, enabled us to reconstruct the depths of the harbour basin.

35 During the underwater survey, we measured the current depth of the ancient harbour installations and the submerged geomorphological indicators of former sea levels, such as the beachrock reefs (Fig. 3, 4). Based on the newly collected data and utilizing historical and recent bathymetric maps, we attempted a palaeogeographic reconstruction of the Ierapetra seafront with respect to the relative sea level changes over the past 2000 years (Fig. 6, 7).

36 In the Roman period, the coast of Ierapetra, which was exposed to southerly winds, needed large technical constructions to form a harbour and provide protection from unclement weather. It was then that the eastern breakwater that bounded the harbour basin on the east side was constructed. The inner and outer beachrock reefs were the north and south boundaries of the basin, respectively. To construct the western breakwater, the outer beachrock reef and the islet were utilized. The inner harbour was formed by extending the western breakwater further west and joining it to the shore (Fig. 7).

37 The relative sea level rise that occurred in the early 17th century, initially by 0.7 m and then by 0.55 m (MOURTZAS *et al.*, 2016), submerged the ancient harbour installations and the natural coastal morphology.

BIBLIOGRAPHY

BERNIER P., DALONGEVILLE R., (1996), Mediterranean coastal changes recorded in beach-rock cementation, *Zeitschrift für Geomorphologie* N.F., Suppl.-Bd. 102, p. 185-198.

DERMITZAKIS M., THEODOROPOULOS D., (1975), Study of beach-rocks in the Aegean Sea, Observations on occurrences in SE Crete, Rhodes and Metopi, *Annales Geologiques des Pays Helleniques*, 1 (26), p. 275-305.

FALKENER E., (1854), *Description of some important theatres and other remains in Crete: from a ms "History of Candia by Onorio Belli in 1586"*, London.

FLOURIS P., DIDIKAS G., (2012), *Analysis of electric tomography measurement with gradient method in the region of Ierapetra*, Dissertation, Technological Institute of Crete, Dept. Natural Resources and Environment, Lab. Geophysics and Seismology.

MOURTZAS N.D., (1990), *Tectonic Movement of the Coasts of Eastern Crete during the Quaternary*, PhD Thesis, N.T.U.A, Athens.

MOURTZAS N., (2012a), Archaeological indicators for sea level change and coastal neotectonic deformation: the submerged roman fish tanks of the gulf of Matala, Crete, Greece, *Journal of Archaeological Science*, 39, p. 884-895.

MOURTZAS N., (2012b), Fish tanks of eastern Crete (Greece) as indicators of the Roman sea level, *Journal of Archaeological Science*, 39, p. 2392-2408.

MOURTZAS N.D., KOLAITI E., ANZIDEI M., (2016), Vertical land movements and sea level changes along the coast of Crete (Greece) since Late Holocene, *Quaternary International,* 401, p. 43-70.

NEUMEIER U., (1998), *The Role of Microbial Activity in Early Cementation of Beachrocks (Intertidal Sediments)*, PhD thesis, University of Geneva (Terre et Environment).

NEUMEIER U., BERNIER P., DALONGEVILLE R., OBERLIN Ch., (2000), Holocene sea-level changes underlined by beachrock features and diagenesis: example from Damnoni (Crete), *Geomorphologie: relief, processes, environment*, 4, p. 211-220.

PAPADAKIS N.P., (1986), *Ierapetra: Bride of the Libyan Sea, A Historical, Archaeological and Cultural Guide*, Ierapetra.

PIRAZZOLI P., (1986), The early byzantine tectonic Paroxysm, *Zeitschrift für Geomorphologie N.F.*, Suppl.-Bd 62, p. 31-49.

PLATAKIS E., (1950), The earthquakes of Crete, *Kretika Chronika*, 4, p. 463-526.

SPANAKIS S., (1991), *Towns and villages of Crete over the centuries*, V. I-II, Detoraki Eds, Herakleion.

SANDERS I.F., (1982), *Roman Crete: An Archaeological Survey and Gazetteer of Late Hellenistic, Roman and Early Byzantine Crete*, Aris & Phillips, Warminster.

SHAW B., AMBRASEYS N.N., ENGLAND C.P., FLOYD A.M., GORMAN J.G., HIGHAM G.F.T., JACKSON A.J., NOCQUET J-M., PAIN C.C., PIGGOTT D.M., (2008), Eastern Mediterranean tectonics and tsunami hazard inferred from the AD 365 earthquake, *Nature Geoscience*, 1, p. 268-276.

SPYRIDAKIS S., (1990), *Ierapytna, Amaltheia*, 21, 38-44.

SPRATT T.A.B., (1865), *Travels and Researches in Crete*, Vol. I, 254-264, John Van Voorst, London.

STIROS C.S., (2001), The AD 365 Crete earthquake and possible seismic clustering during the fourth to sixth centuries AD in the Eastern Mediterranean: a review of historical and archaeological data, *Journal of Structural Geology*, 23, p. 545-562.

STIROS S., DRAKOS A., (2006), A fault-model for the tsunami-associated, magnitude 8.5 Eastern Mediterranean, AD 365 earthquake, *Zeitschrift für Geomorphologie*, 146, p. 125-137.

TOURNEFORT J.P. de, (1717), *Relation d'un voyage du Levant*, Imprimerie Royale, Paris.

ZOIS A.A., (2002), Roman Ierapetra: an unknown imperial city, the hub of the eastern Mediterranean, *Apodeixis: Archaeological Studies, Theory and Praxis*, 25, Athens.

ABSTRACTS

In this paper, we reconstruct the palaeogeographical evolution of the ancient seafront of Roman Ierapetra, using historical evidence, maps and new bathymetric data. Modern human interventions in the coastal zone have significantly altered the primary data necessary for determining past sea levels. During Roman times, when the sea level was 1.30 m lower than it is at present, major technical interventions were needed in order to form a safe harbour on the coast of Ierapetra, which was exposed to southerly waves. It was then that an elongated eastern breakwater was constructed that bounded the basin of the outer harbour to the east. The inner and outer beachrock reefs were the southern and northern boundaries of the basin, respectively. The western breakwater was constructed by using the outer beachrock reef and a small islet aligned with it. The inner basin was formed by extending the western breakwater further to the west and joining it to the coast.

Dans cet article, nous présentons l'évolution paleogéographique du front de mer de Ierapetra à l'époque romaine, en utilisant des données historiques, cartographiques et bathymétriques. Des aménagements récents de la zone littorale ont malheureusement détruit les indicateurs de paleo-niveaux marins. À l'époque romaine, quand le niveau marin était ca. 1,30 m sous le niveau actuel, des constructions ont été nécessaires afin de protéger les bassins portuaires des houles du Sud. Ainsi, un môle protégeait le port du côté oriental. Des affleurements de *beach-rock* limitaient le bassin au Nord et au Sud, tandis qu'un môle occidental était aménagé en profitant de la présence d'un banc de *beach-rock*.

INDEX

Keywords: Ierapetra, Crete, Roman period, sea-level change, sea front, beachrock, harbour installations, palaeogeography, geoarchaeology
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