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Holocene variations of the shoreline between Antalya and Andriake (Turkey)

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Introduction

Evidence of holocene shorelines from Kemer to the Syrian border has already been shown by observations dating back to the 1970s and earlier (Dalongeville & Sanlaville, 1977, 1979). In the context of the programme entitled 'Evolution of coastal landscapes in the Eastern Mediterranean along the last six millenniums', it seemed to the authors that it would be interesting to carry on this first skimming and extend it to the coast between Antalya and Andriake (Fig. 1). The area indeed lies between the island of Kekova—5 km to the south-west of Andriake, affected by a significant subsidence after the earthquake of the second half of the 2nd century AD—and the coast from the east of Antalya to the Syrian border, where signs of positive relative variations of the shoreline are predominant. The authors have focused their archaeological and geomorphological observations on the sites of Phaselis, Olympos and Andriake. The presence of a submerged, ancient quarry near Andriake also provided a number of archaeological markers.

Evidence of two holocene shorelines, the actual shore lying between them

Immediately to the west of Antalya and at the far end of its gulf and of the bays of Kemer and Beldibi, large strands develop in front of dune formations. In the Bay of Kemer a set of beachrock slabs, now being dismantled, can be observed as far as 5 m ahead of the shore and down to 1 m below the surface of the water (Fig. 2). The higher level of that beachrock, which is unsubmerged, comprises in a carbonated matrix some elements of which the granulometry is very close to that of the pebbles which form the upper part of the present beach. Thus it may be inferred that this slab materializes the top of the upper midlittoral zone of the fossile beach, of which the medium level was situated about 0·5 m below the actual level.

Another beachrock can be seen above the actual beach. It consists of pieces of beachrock slabs, 40 to 50 cm long, 10 to 15 cm thick, set in the consolidated pebbled fossil beach, about 20 m behind the present beach. The consolidated beach lies in the same position as far as Antalya. The

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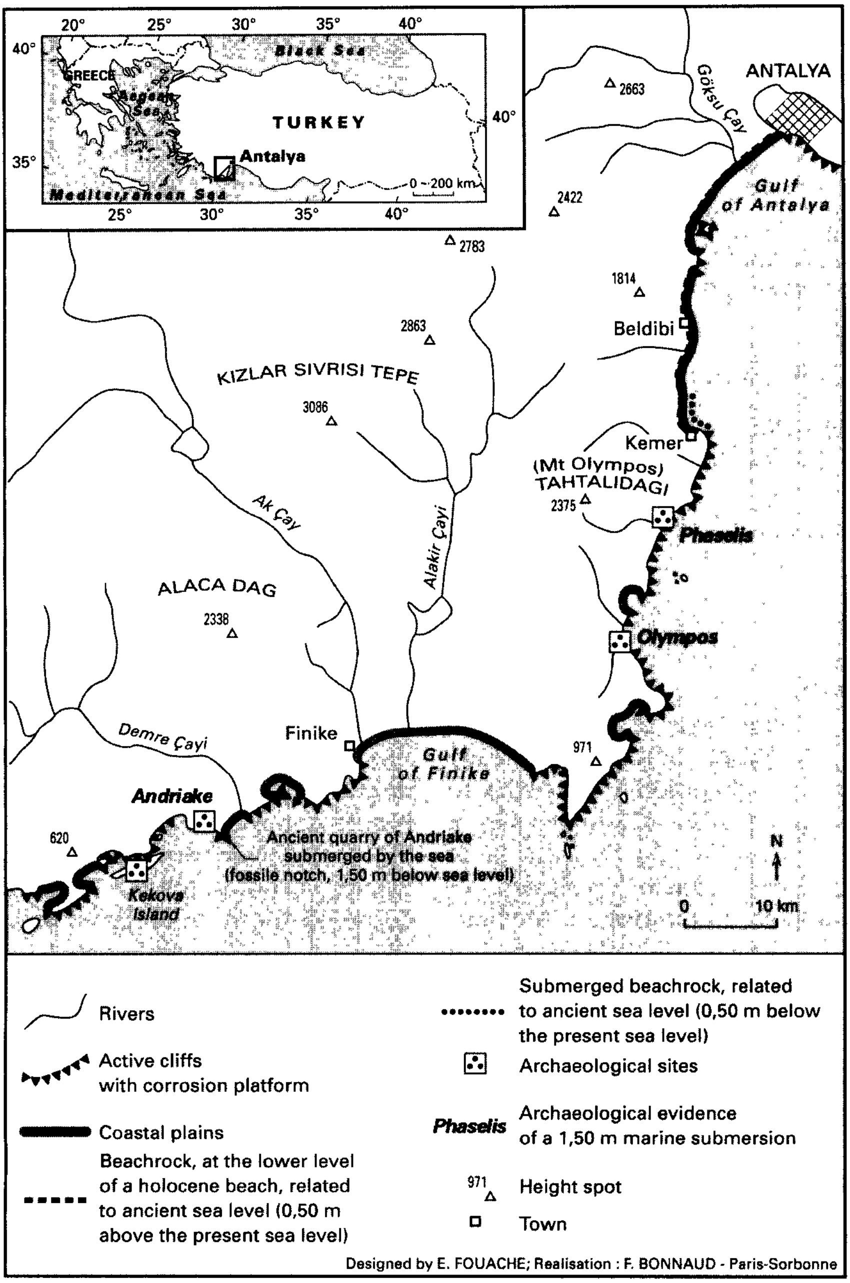

Figure 1. Holocene coastal forms between Antalya and Andriake. (Drawing: E. Fouache)

vestiges indicate that the average sea level was situated 0·5 m above the present level.

The soft formations of rocks are set in between areas of active cliffs which provide different information. At the foot of the cliff of Antalya (Fig. 3), which is 50 m high and cut in thick travertine, a notch with a bench up to 1 m wide and with a small

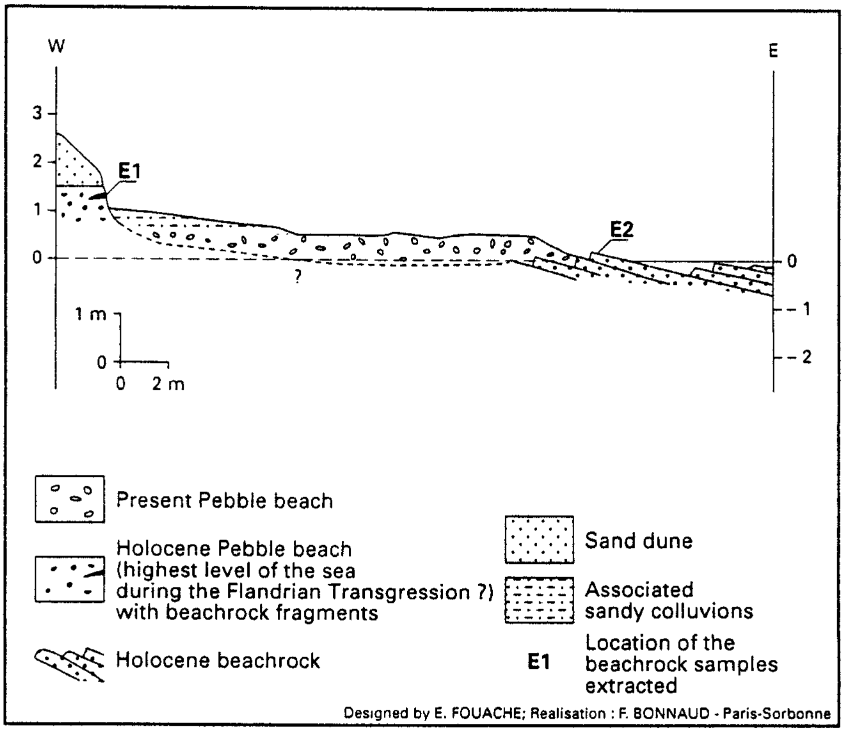

Figure 2. Fossil Holocene beach and beachrock at Kemer. (Drawing: E. Fouache)

vermeted rim has developed. To the south of Antalya, massive limestone is predominant. The actual notch with an irregular bench can be seen everywhere in the cliff areas. However the authors have never observed any fossil notch above the actual notch and which could be connected with the fossil beach identified at +0·5 m in the soft formations. On the contrary, the ancient quarry of Andriake, which was settled in an area of limestone cliff and submerged, shows a fossil notch at −0·5 m (Fig. 4).

The case of Andriake: its ancient site and quarry

The site of Andriake (Figs 5, 6, & 7), believed to be the modern port of Demre, was built on both sides of the mouth of the old Androkos River. The wide harbour was protected by the surrounding ridges and was scoured continuously by the river. South of the estuary lay tiny islands that have now become part of the mainland. They provided defence against both waves and enemies. Andriake was inhabited from the Hellenistic to the late Byzantine periods, and was one of the main harbours along the grain route connecting Egypt to Rome.

The quarry itself (Fig. 8) is located west of the harbour and south of a rocky promontory. Ancient travellers designated this promontory as Pyrgo, which would correspond with the *Isium* of the *Stadiasmus*, according to Leake (1824). Access to the quarry was either via the promontory or by sea, but no ancient trails have been identified thus far.

Little is known historically about the quarry, but archaeological evidence of stone extraction on the cliff face suggests that it may have been exploited as early as

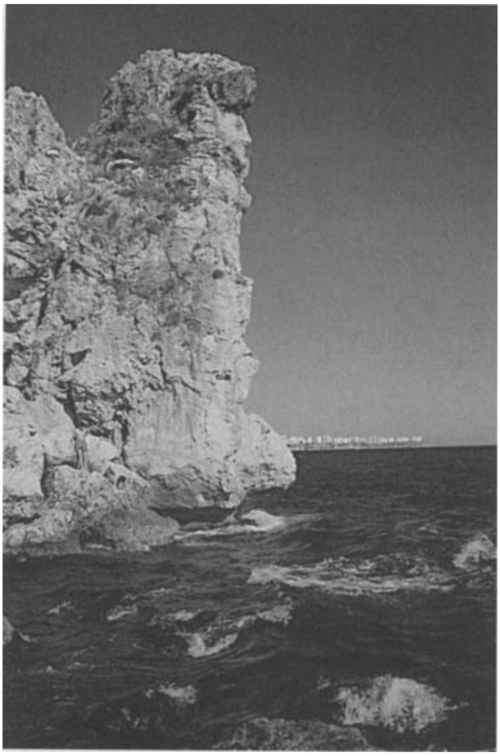

Figure 3. Actual notch with a vermeted rim at the foot of the travertine cliff of Antalya. (Photo: authors)

the Roman Period. The use of at least two different types of picks is indicated by toolmarks (Bessac, 1988). The first type was trapezoidal in profile (Fig. 9) and its cutting edge formed a W shape. It was forged from a narrow iron hoop and fitted to a long handle. It was intended for cutting narrow grooves and invariably left perpendicular marks on the rock which, because of the height of the cliff, form a chevron pattern on the face. The second type of pick used in only one area was swollen at its centre and fitted to a long wooden handle. Both tips were pyramidal in shape. This pick was used to cut trenches, and left curved and concentric grooves (Fig. 10). Both types were familiar to the Greeks, but were used more commonly by the Romans, which period coincides with the most prosperous time at Andriake. Most of the surface remains of the site (namely granaries, warehouses, and quays) were constructed by the Romans. Other tools may have been used at the quarry. Iron extraction picks would normally have been employed to dig

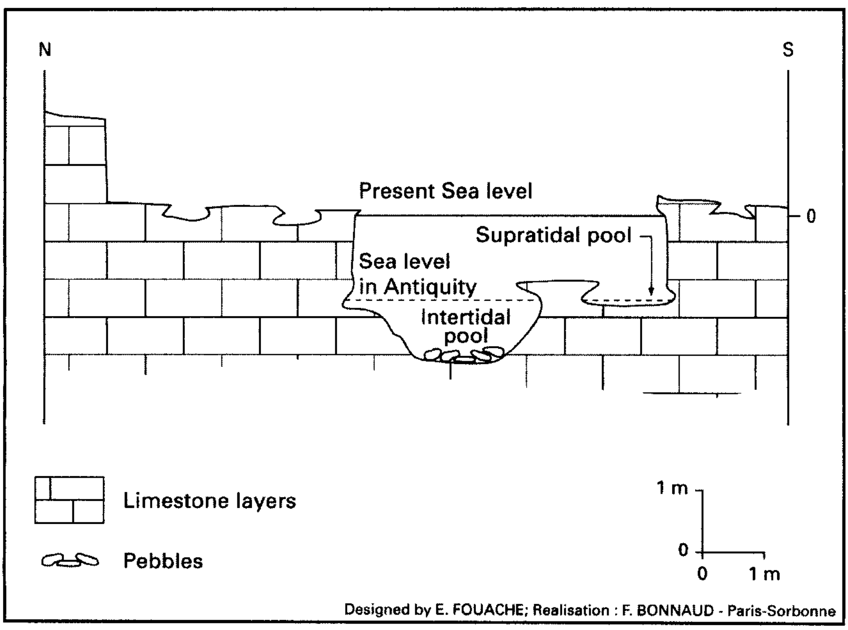

Figure 4. Submerged ancient quarry of Andriake. (Drawing: E. Fouache)

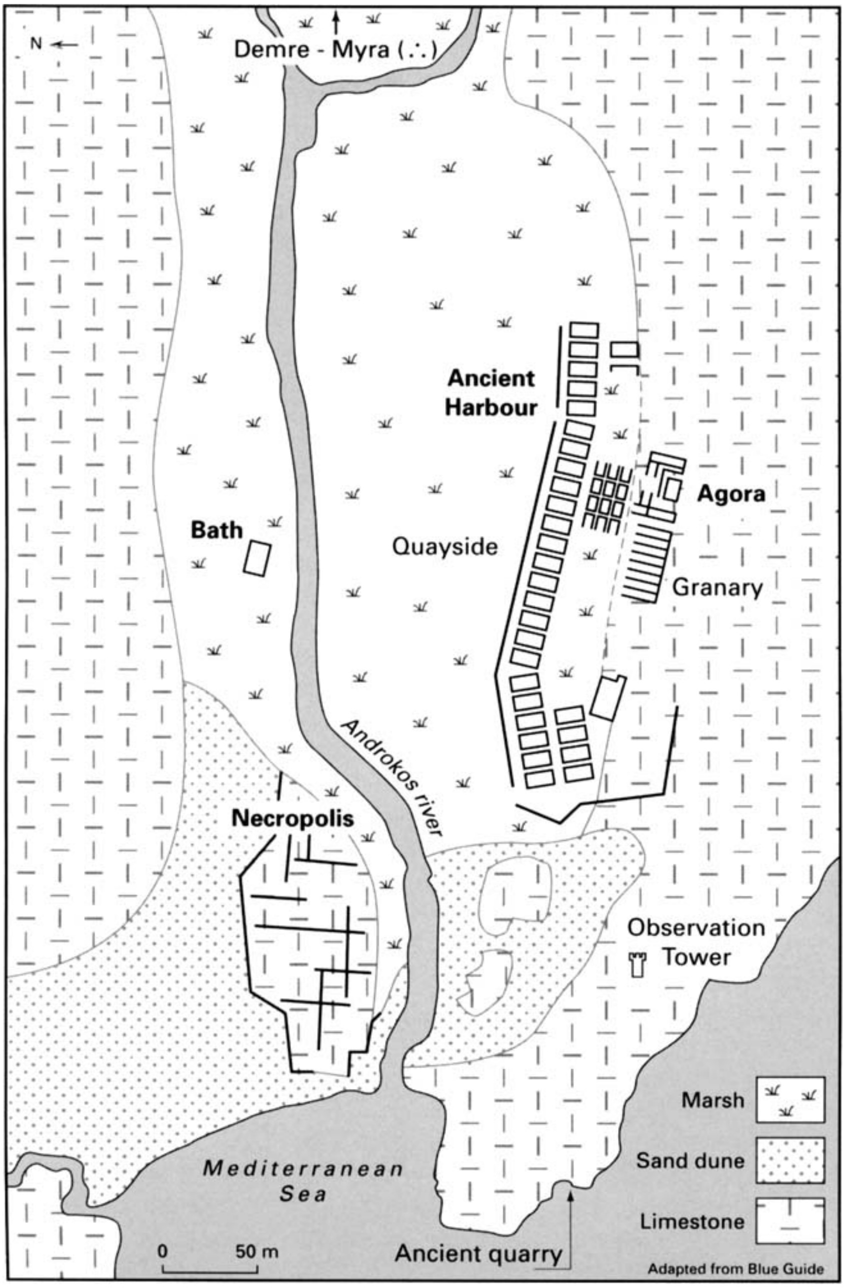

Figure 5. The site of Andriake. (Drawing: adapted from Blue Guide, 1996, p. 444)

vertical trenches around blocks, but no tell-tale toolmarks were detected. It is likely that blocks extracted here were used in the construction of at least some of the buildings at the site, but quarry stones may have been exported as well.

Figure 6. The site of Andriake built at the mouth of the old Androkos river to each side of the bay. The isle of Kekova can be seen in the distance. (Photo: authors)

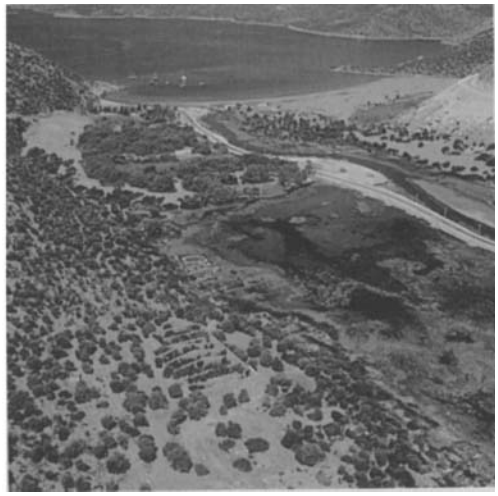

Figure 7. Granaries of Andriake in the foreground; location of the port in the swamp area. (Photo: authors)

A fossil notch at − 1·5 m in the ancient quarry of Andriake

The quarry, which was cut directly into the cliff, thus benefiting from the inclination of the rocks towards the sea, allowed the limestone blocks to be exported directly by boat. Several border zones of exploitation now invaded by the sea prove that the sea

Figure 8. Ancient submerged quarry of Andriake. The quarry is located south of a rocky promontary, situated west of the harbour. (Photo: authors)

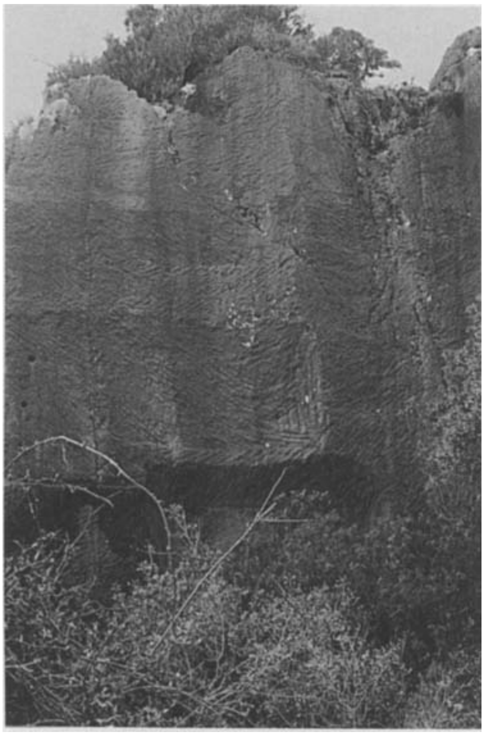

Figure 9. Tool marks: pick with narrow hoop-iron and long wooden handles. Grooves exhibit perpendicular impact on rock. (Photo: authors)

level has risen relatively since the quarry was abandoned. Diving at the foot of those zones allowed us to observe a fossil notch 1·5 m below the actual sea level. As has already been observed in an ancient quarry in Tunisia (Paskoff *et al.*, 1981), the exact position of the ancient sea level is all the more precisely located in height since it necessarily lies in the passage between a morphology of intertidal pools—infralittoral enclaves in the midlittoral zone—and a morphology of supratidal pools—specific of the supralittoral zone—above the same notch. That former level corresponded to a position of the midlittoral zone which enabled the lower parts of the quarry to be exploited. Therefore it may be interpreted as being the level contemporaneous with the exploitation of the quarry in the Roman Period. Thus there is a relative submergence of the shoreline posterior to that period, which had much influence on the port settlements of the area.

Archaeological indications of the relative rise of the sea level: Phaselis and Olympos

Phaselis (Fig. 11) was founded in 690 BC as a Rhodian colony. It disappears from the historical record after its conquest in 1158 by the Seljuks. Phaselis was built on a narrow peninsula, and from its earliest period was known for its three harbours and a *limne*, or marshy lake. The three harbours are clearly defined: a large bay south-west of the peninsula, a small enclosed harbour just north of the acropolis, and another bay directly north of that harbour. The south harbour (A) was protected from the south-east winds by a breakwater of stone blocks and rubble that formed an extension of a natural finger of land (Blackman, 1973b: 358–362). The breakwater subsided at some point in time, with its outer edge now submerged some 5–6 m. Evidence for a pier built from the breakwater is still partly visible. Neither construction can be dated precisely, but the first written reference to them by Scylax would make them no younger than the 4th century BC. It is likely that this was the first harbour to be developed.

A mole was constructed on either side of the central harbour (B), and a partly-preserved quay is also visible on its south-western side. Remains of bollards are present along this quay, but only one is complete. The bollards have been set horizontally rather than in the typical vertical position. This peculiar arrangement does not appear to have any parallels, but suggests to us that these blocks may have been reused. In 1973 Blackman (1973b: 360, 362 & fig. 17) stated that in antiquity the upper surface of this quay would have been *c.* 4 m above sea-level, but the basis for this estimate is obscure and leaves us unable to verify it. The statement seems questionable considering that the bollards are at the

Figure 10. Tool marks: this second type of pick is only attested in one area. It is swollen at its centre and has a long wooden handle. Its extremities are pyramidal in shape. Employed to cut trenches, its grooves are curved and concentric. (Photo: authors)

upper surface of the quay. The entrance to the harbour is only 18 m wide, so the ships entering were probably small to medium in size and would have had difficulty reaching the top of the quay. This harbour requires investigation at least to determine its original depth, as it is now heavily silted up. The main period of use is unknown, but it may have started in the 1st–early 2nd century AD, which would correspond to the laying out nearby of the site's main street and agoras (Bean, 1968).

The northern harbour (C) is an open bay that is protected on the north-eastern side by a natural barrier that the Phaselians improved. The upper surface of this breakwater is now submerged 1 m. Along the western side of the bay run the remains of a pier that once supported a Roman aqueduct. This harbour may have been in use from the Hellenistic Period onwards. The proximity of the water to the remaining supports of the aqueduct gives some indication of the relative rise of the sea level here. Phaselis was abandoned for a number of reasons both historical and economic. The nearby marsh was also probably a source of sickness for the inhabitants. The geomorphological shift in the area should also be considered as a factor contributing to the town's demise.

The first written reference to Olympos is in the 2nd century BC (Plutarch & Scylax), when it was a member of the Lycian Confederation, which included some 23 cities. After several periods of prosperity and decline the site was finally abandoned in the 15th century. Situated at the mouth of a small torrential river, Olympos was one of the main harbours along the south-western coast of Turkey (Fig. 12). Much of the river appears to have been channeled, as stone slabs were laid across its bed allowing boats to travel up into the heart of the city. A bridge crossed the river, of which one course of stones survives,

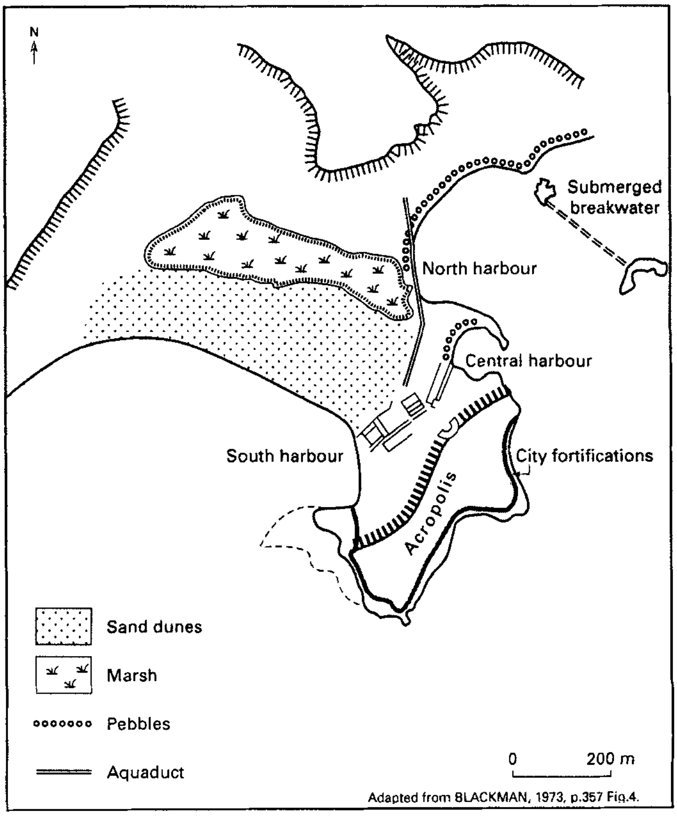

Figure 11. The site of Phaselis. (Drawing: adapted from Blackman, 1973a, p. 357, fig. 4)

constituting the bridge footings (Fig. 13). A section of quay dating to the Hellenistic Period is located along the river's southern bank. There is evidence of repairs from the Roman and Byzantine periods. The quay is accompanied inland by a warehouse. The harbour was silted up progressively due to a combination of the irregular flow of the river and the rise in sea-level.

Discussion and conclusions

That the highest holocene shore (+0·5 m), which was well preserved in the sedimentary areas, should have left no trace in the cliff areas raises a number of problems. Because of its position and geomorphological context, an indurated beach covered by a dune, it is obviously a trace of the oldest holocene shoreline. Thus it seems to be linked to the level corresponding with the peak of the Flandrian Transgression, around 3500 BC.[1] To account for the fact that this high level has not marked the foot of the cliff, it is assumed that, at that time, there was a beach in front of the cliffs which covered their foot. The dune fields behind the present strands would be the remains of such a beach, preserved only at the far end of the bays. Such a situation can be observed on the site of, for example, Guverdjine Kaya in Syria (Dalongeville *et al.*, 1993; Fouache & Dalongeville, 1998) but also nearer to our area, to the east of Antalya, at the level of Hotel Incekum.[2] There the shore, which developed in massive limestone, clearly shows that the making of a higher notch (at +0·6 m) was preceded by a burial beneath a beach; the

Figure 12. The port of Olympos in a rocky inlet, at the outlet of a torrent. The location of an ancient bridge is marked by the pillar which can be seen in the middle of the channel. (Photo: authors)

Figure 13. Detail of the pillar of the ancient bridge set up in the middle of the channel. (Photo: authors)

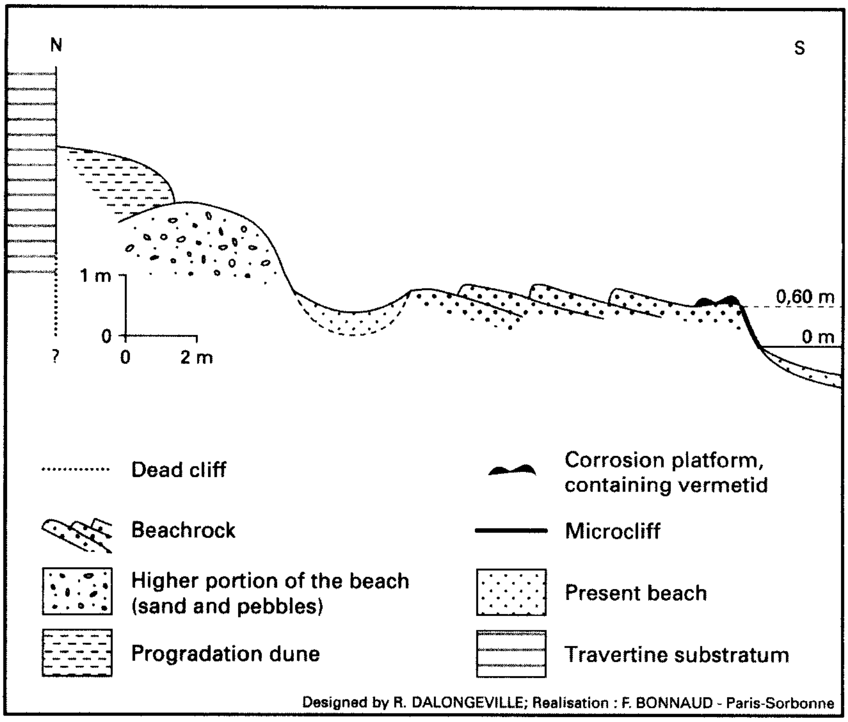

Figure 14. Fossil Holocene beach and beachrock at the foot of the travertine cliff east of Antalya. (Drawing: R. Dalongeville)

pools of the lower supralittoral zone were filled in, then reopened more recently by corrosion, when the sea came in again at a slightly higher level (a relative movement) and cut the +0·60 m notch. To the east of Antalya even, at the foot of the travertine cliff, the recession of the beach let a beachrock appear. The latter was formed during a phase of progradation, in which a dune eventually covered the embedded beach. The slabs which were closest to the sea were cut into a bench-like vermeted rim at +0·60 m (Fig. 14).

The second difficulty stems from the discontinuity of the geomorphological evidence lining the holocene shore, lower than the actual one, between Antalya and Andriake, and from the variations in the vertical amplitude between the upper and the lower sea levels. The submerged beachrock of the Bay of Kemer corresponds to a level between − 0·50 m and − 1 m while the fossil notch of the submerged quarry of Andriake reaches − 1·50 m. The absence of an intermediary notch in the quarry of Andriake implies a link in the two levels. In that case, since there could not have been a dissymetric eustatic rise, a tectonic movement may have generated the building up of the present shoreline. The regional neotectonic context reinforces this interpretation (Fig. 15) (Glover & Robertson, 1998). However, there is no element to allow a decision on whether the relative variation of the sea level (between − 1 m and − 2 m below the highest holocene level) which led to a lowering of the shoreline, was of eustatic or tectonic origin. The absence of shells in the beachrocks observed prevented radiometric datations but the observation of the ancient harbour structures of the ports of Phaselis, Olympos and Andriake, allows a chronology to be established.

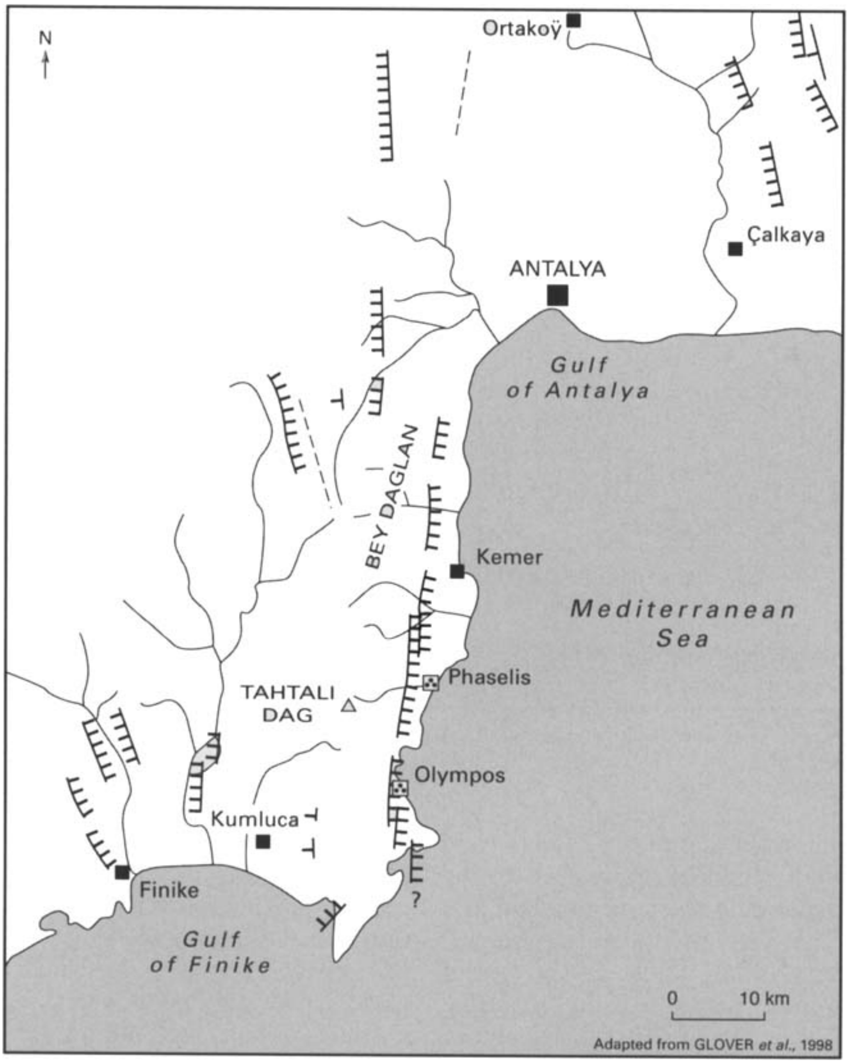

Figure 15. Main neotectonic lineaments. (Drawing: adapted from Glover & Robertson, 1998)

The establishment of an ancient sea level situated between −0·50 m and −1·50 m below the actual sea level provides an explanation for the submersion of archaeological structures which were, undoubtedly, originally on dry land, such as the aquaduct pillars of the northern harbour of Phaselis, or the sheds along the quay in Andriake, not to speak of the quarry itself. This level would thus correspond with that according to which the port structures were built. The recent geomorphological evolution of the site of Olympos can also be clarified. Indeed the port was set downstream from a small torrential river, in the site of a rocky inlet, which opens into the Bay of Daliktas at the southern end. Nowadays this inlet is barred by a pebble barrier (Fig. 16) in which medieval buildings have been partly fossilized by the top of the beach. The relative rise in the sea level, while it straightened the bar,

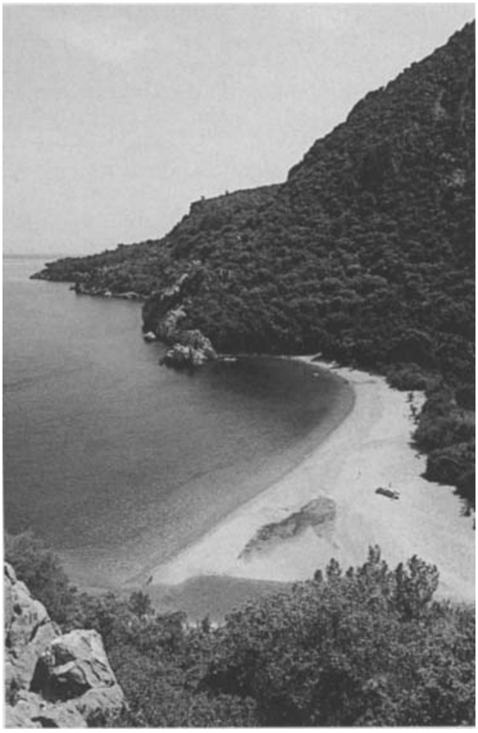

Figure 16. Strand on the site of Olympos, of which the pebble barrier blocks access to the ancient harbour. (Photo: authors)

encouraged the erosion of the coast by the sea and the massive supply in pebbles which, carried away by the longshore drift, gradually migrated south and eventually blocked the entrance to the harbour, thus encouraging its filling up by heavy torrential load insufficiently evacuated towards the sea. Such a situation was already in place in the 11th and 12th centuries when the Venetians and Genoese fortified the port directly in the bay.

Since the tectonic origin of the movement which led to present level is now being established, it would be tempting—and this is what the archaeological chronology is aiming at—to locate this period of tectonic uprising within the 'Early Byzantine Tectonic Paroxysm (EBTP)' (Pirazzoli *et al.*, 1996), between the 4th century and the middle of the 6th century AD. The coastal area between Antalya and Andriake would thus lie in an intermediary position between the shore of Alanya and the Syrian border, where traces of higher holocene sea levels are predominant (Kelletat & Kayan, 1983; Erol & Pirazzoli, 1992), and Kekova where the post-byzantine subsidence exceeds 1·50 m.

Acknowledgements

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Notes

[1] An equivalent level in Syria can be found in Guverdjine Kaya, at +1·2 m and dates back to 5900–5600 BP (Dalongeville *et al.*, 1993).

[2] As observed by R. Dalongeville and P. Sanlaville in 1976. Their observations have not been published.

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