

Late Quaternary morphological changes along the western coast of the Lakonic gulf (Peloponnesus, Greece) based on geomorphological and archaeological data*

Kalliopi Gaki-Papanastassiou¹, Hampik Maroukian¹ & Georgia Tsartsidou²

¹Department of Geography and Climatology, University of Athens, Panepistimiopolis 15784, Athens, Greece, e-mail: gaki@geol.uoa.gr

²Ephoreia of Palaeoanthropology – Speleology, Ardittou 34B, 11636 Athens.

ABSTRACT: The study area extends along the western coast of the Lakonic gulf, in southeastern Peloponnesus. Morphotectonically, the gulf and its northern extension form an asymmetric graben situated between Taygetos and Parnonas mountain masses.

Fault tectonism has played an important role in the coastal configuration of the study area in the Late Quaternary period forming a series of embayments with pocket beaches. A Tyrrhenian terrace including Strombus bubonius and Palaeolithic finds has been traced up to 3 meters.

The Holocene coastal morphological sequence includes barrier beaches at the base overlain by sand dunes and incorporating in places beachrock formations. Roman and Byzantine ruins observed between sand bars and dunes delimit chronologically their evolution.

Key-words: Coastal geomorphology, geoarchaeology, West Lakonic gulf, Greece, Late Quaternary, Tyrrhenian.

ΠΕΡΙΛΗΨΗ: Η περιοχή μελέτης εκτείνεται στις δυτικές ακτές του Λακωνικού Κόλπου, ΝΑ Πελοπόννησος. Μορφοτεκτονικά, ο Λακωνικός Κόλπος και η προς τα βόρεια προέκτασή του είναι μια ασύμμετρη τεκτονική τάφρος μεταξύ των ορεινών όγκων του Ταύγετου και του Πάρωνα.

Ο ρηξιγενής τεκτονισμός διαδραμάτισε έναν σημαντικό ρόλο στη διαμόρφωση του παράκτιου ανάγλυφου κατά το Ανώτερο Τεταρτογενές σχηματίζοντας σειρά από κολπίσκους με μικρές παραλίες. Μια Τυρρήνια αναβαθμίδα εμπεριέχουσα Strombus Bubonius και παλαιολιθικά ευρήματα χαρτογραφήθηκε στα 3 m.

Η παράκτια Ολοκαινική μορφολογική σειρά συνίσταται από μια αμμιολωρίδα στην οποία επίκεινται θίνες και ακτόλιθοι κατά θέσεις. Ρωμαϊκά και Βυζαντινά ερείπια παρατηρήθηκαν μεταξύ της αμμιολωρίδας και των θινών καθορίζοντας χρονολογικά την εξέλιξή τους.

Λέξεις-κλειδιά: Παράκτια Γεωμορφολογία, Γεωαρχαιολογία, Λακωνικός Κόλπος, Ελλάδα, Τυρρήνιο.

INTRODUCTION

The recent coastal history of the Mediterranean coastlines has been affected by the global eustatic changes but also by local tectonic vertical movements. The study area, located in southeastern Peloponnesus, extends along the western coast of the Lakonic gulf. Morphotectonically, the gulf and its northern extension form an asymmetric graben situated between the mountain masses of Parnonas (1935 m) in the east and Taygetos (2407 m) in the west.

The Alpine lithology is composed of marbles, flysch, phyllites, volcano-sedimentary rocks and limestones (Fig. 1). The post-Alpine formations are Plio-Pleistocene marls, conglomerates and sandstones together with Upper Quaternary alluvial and coastal deposits (DUFAYRE, 1970; KELLETAT & GASSERT, 1975; KOWALCZYK *et al.*, 1992).

Regarding the tectonics, en echelon normal faults having NW-SE directions and dipping to the NE are observed in the west, giving rise to an indented shoreline

with five pocket beaches.

In this study, geomorphological and archaeological data have been used in order to determine the changes that have taken place in the western coast of the Lakonic gulf since the Tyrrhenian period. For this purpose, aerial photographs interpretation was utilized in the laboratory and detailed geomorphological mapping at a scale 1:5.000 was performed in the field.

GEOMORPHOLOGICAL OBSERVATIONS

The general morphology of the coasts is determined by the recent tectonic activity of en echelon normal faults dipping to the NE. Consequently, the faulted blocks dip to the SW. Thus, at the eastern side of each coastal block we have the outcropping of calcareous formations at Valtaki, Selinita, Stomio, Epiano Vathi and Kato Vathi bays, forming pocket beaches with recent coastal sediments extending west of these outcrops (Fig. 2).

* Μορφολογικές μεταβολές κατά μήκος των δυτικών ακτών του Λακωνικού Κόλπου (Πελοπόννησος, Ελλάδα) κατά το Ανώτερο Τεταρτογενές σύμφωνα με γεωμορφολογικά και αρχαιολογικά δεδομένα.

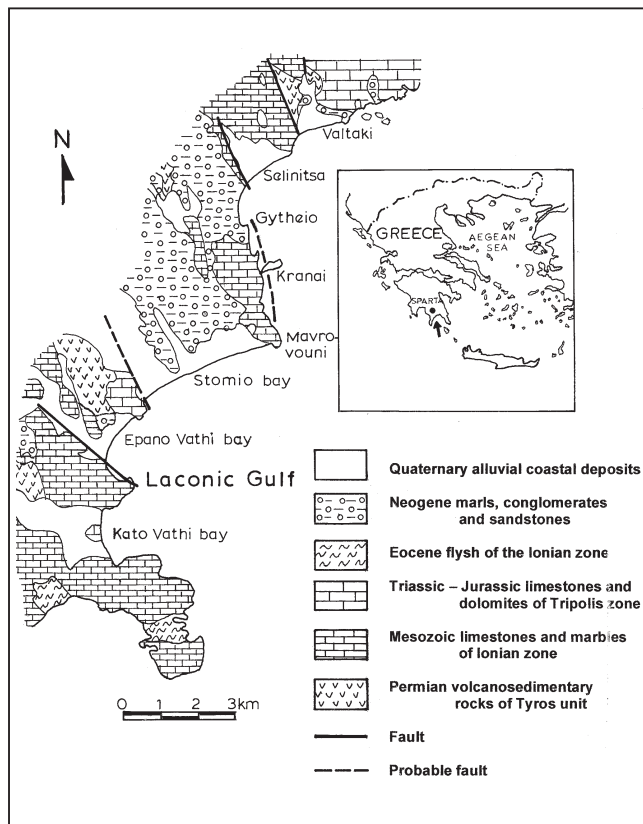


Fig. 1. Geologic map of the study area.

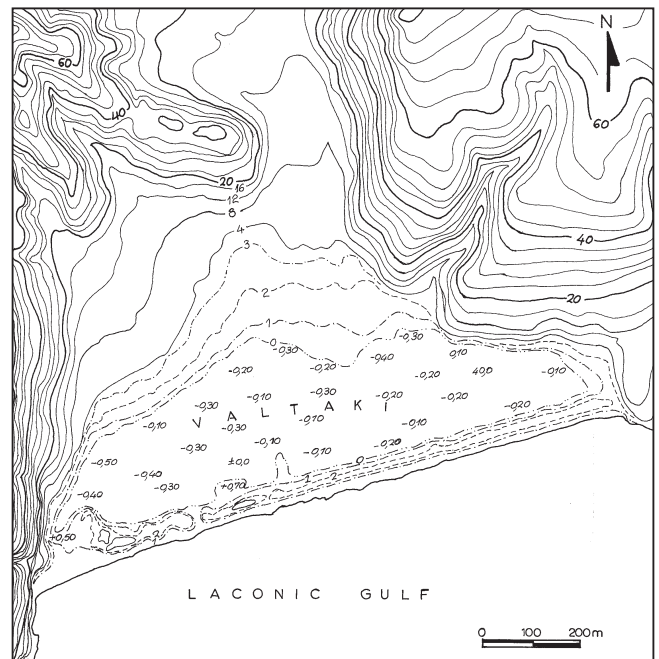




Photo 1. Panoramic view of the Valtaki pocket beach. Arrow points to the Late Roman structure (see photo 2).



Photo 2. A closer view of the Late Roman structure, located underneath the coastal sand dunes and reaching into the sea down to -1.5 m.



Photo 3. Outcrop of the Tyrrenian terrace at the eastern end of Stomio bay, showing the thick deposit of coarse material, rich in fossils with *Strombus bubonius*, overlain by aeolianites.

gulf, both of them are 1-3 m above sea level. The first at the archaeological site Lakonis, at the northeast end of Selinita bay, and the second at the east end of Stomio bay (Photo 3). The beach conglomerate at the first site (Lakonis) is covered by travertine, which is underlying a 7 m sequence of terrestrial strata with archaeological findings. U-series measurements on the travertine that covers the beach conglomerate yielded an age of 94 ± 14 Ka, while ^{14}C dates from the uppermost terrestrial strata are between 35-40 Ka (PANAGOPOULOU *et al.*, 2002).

Three submerged notches have been found at the rocky coast at the eastern end of Selinita (Lakonis) the first notch at -0.5 m accompanied with lithophaga boreholes, a second one at -1 m and a third one at -2 m.

The second terrace site is located at the eastern end of Stomio bay (Fig. 4). The sequence of this deposit starts at the base, near present sea level, with a coarse grained conglomerate which laterally becomes finer. This formation is overlain by a layer consisting of a meter of mixed sand, followed by a thick layer of coarse sand with pebbles; it is also rich in fossils including the characteristic

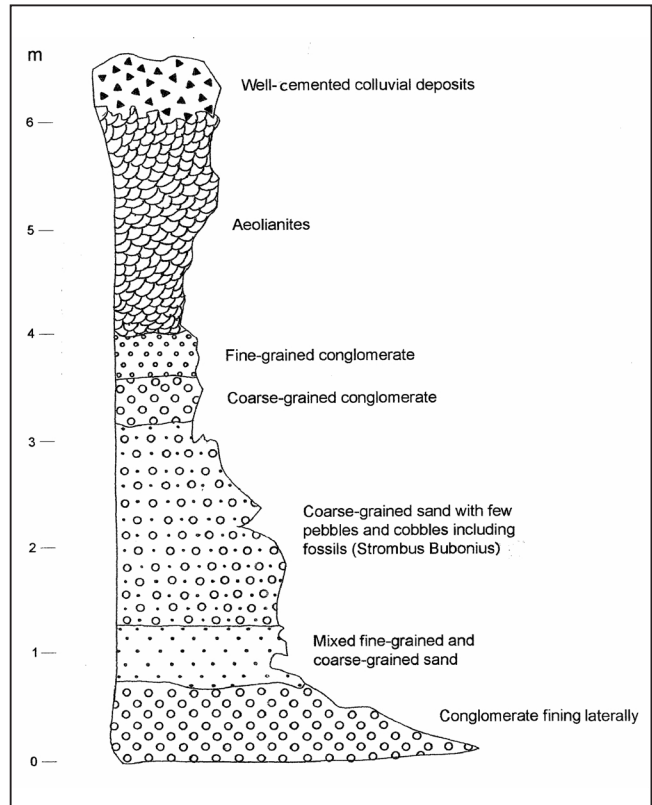


Fig. 4. Schematic profile of the Tyrrenian terrace at the eastern end of Stomio bay.



Photo 4. Close up of *Strombus bubonius* found in coarse sand deposit which include pebbles as well.

TABLE 1
Greek chronological time table.

120000 - 40000 BC	MIDDLE PALEOLITHIC
40000 - 10500 BC	Upper Paleolithic
10500 - 6800 BC	Mesolithic
6800 - 3200 BC	Neolithic
3200 - 2150 BC	Early Helladic
2150 - 1600 BC	Middle Helladic
1600 - 1100 BC	Late Helladic (Mycenaean)
1050 - 700 BC	Geometric
700 - 480 BC	Archaic
480 - 323 BC	Classical
323 - 30 BC	Hellenistic
30 BC - 300 AD	Roman
300 - 630 AD	Early Byzantine
630 - 1204 AD	Middle Byzantine
1204 - 1453	Late Byzantine
1453 - 1821	Ottoman
1821 - today	Modern

Strombus bubonius (Photo 4). On top of this, there is about a meter of coarse grained deposit followed by fine grained conglomerate. That is covered upwards by a two meter formation of cross bedded aeolianites. Finally, the sequence is topped by more recent well-cemented colluvial material.

Several scientists have dealt with sites having Tyrrhenian deposits around Peloponnesus. IMPERATORI (1962) observed *Strombus bubonius* at Portarakia in Dyros bay (SW Peloponnesus) at an elevation of up to 2 m and at Korinthos. KERAUDREN (1971, 1972) found Tyrrhenian strata at two locations: at Elide (Katakolon), Eutyrrhenian in age and between 1 and 2 m elevation and in the area of Nafplion at an elevation of about 1 m. DUFAURE (1972) studying the coastal area of Xyli (Eastern Laconikos gulf), has reported marine terraces at an elevation of 25 m including *Strombus bubonius*

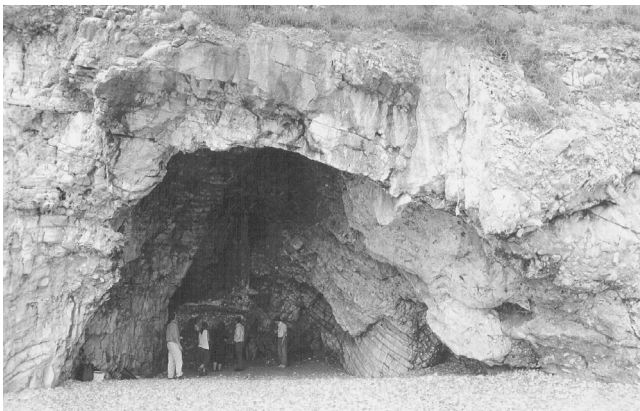


Photo 5. View of coastal cave at Lakonis archaeological site.

(Eutyrrhenian) and a Neotyrrhenian beach at elevations from 0 to 2 m with sporadic finds of *Strombus bubonius*. KOWALCZYK (1992) found *Strombus bubonius* at Stomio (western Laconikos gulf), between 1.5 m and 3m. PIRAZZOLI (1991) has presented a series of world wide sea level curves including some of the Aegean and gulf of Corinth areas. PIRAZZOLI *et al.* (1994), in their study of Perachora peninsula attributed of shore lines to Holocene times.

ARCHAEOLOGICAL EVIDENCE

The archaeological remains of the study area range from the Middle Palaeolithic to the Early Byzantine period testifying areas of human exploitation through time. Table 1 is presented for a better visualization of prehistoric and historic time periods which are in effect for Greece.

Valtaki: There are archaeological remains at the western end of Valtaki, which extend into the sea one meter below sea level and are covered by eroding beachrocks. Ruins are also found under the sand dunes and behind them down to forty centimetres below m.s.l. The age of these ruins is believed to be Late Roman to Early Byzantine. In the same area there is a ceramic pipe which seems to belong to an Early Byzantine building located inland (HOPE-SIMPSON & WATERHOUSE, 1960, 1961).

Lakonis: The archaeological site of Laconis located just west of Valtaki, belonging to the Middle Paleolithic (120.000 B.P. - 40.000 B.P.) is a cave complex at the beach (Photo 5). The main site is an east – facing collapsed shelter preserving a sequence of lithified sediments more than 7 meters thick in the form of a rather steeply inclined wave – eroded remnant at an elevation of about 0.5 m indicating a co-seismic uplift. Part of the sequence is submerged together with a spring located immediately below the site. The lowermost exposed unit includes remnants of a beachrock indicating a former sea level and a coastal environment very similar to the present one. Overlying these culturally sterile formations is a sequence with bone breccia layers, crudely stratified stony layers consisting of angular roofspall and finally layers with overlapping hearths containing successive, lithified ash lenses and other burnt remains (PANAGOPOULOU *et al.*, 2002).

The deposits are chiefly assigned to the Middle Palaeolithic and contain extremely rich cultural remains. The lithic assemblages are made of local raw material (volcanic rocks, quartz and flint) and are manufactured mainly with the Levallois technique indicating morphological affinities with the Balkan and Eastern Mediterranean sequences (PANAGOPOULOU *et al.*, 2002).

A Neanderthal tooth associated with Initial Upper Palaeolithic assemblages was found on the topmost part of the sequence. The associated layers were radiome-

trically dated to ca. 40 Ka. The tooth adds to the very small number of taxonomically diagnostic human fossil material from Early Upper Palaeolithic European contexts (HARVATI *et al.*, 2003).

The faunal evidence indicates that hunting was the prime method of animal food extraction. Fallow deer are common, with red and roe deer specimens in smaller numbers. Sus, bos and rhinoceros are also present. A mosaic landscape combining open grassland/parkland conditions, marshy expanses and some woodland is indicated for the main part of the last glacial period. The faunal evidence indicates foraging in topographically mild lowland territories in the vicinity of animal paths. (PANAGOPOULOU *et al.*, 2002). Evidence from the study of wood charcoal confirms that open plant formations dominated the area. Based on the global characteristics of the Last Glacial, colder and drier conditions prevailed and were tolerated by *Prunus* (PANAGOPOULOU *et al.*, 2002).

Gytheio used to be an important port of Sparta during Classical and Hellenistic times and it became a Roman conquest after 195 B.C. Unfortunately the modern city has been built on the classical one leaving no traces of the latter. A small theater from the Late Hellenistic/Early Roman period (CAVANAGH *et al.*, 1996) is preserved and several roman buildings are under excavation testifying the glory of the city during the Roman period. Some of the buildings (according to FORSTER (1906) they are baths) are semi-submerged down to -0.50 m. According to SCOUFOPOULOS-STAVROLAKIS (1985) several wall like structures have been traced down to a depth of 5 m.

Kranai: the small island connected nowadays to the mainland preserves only surface sherds from Mycenaean to the Ottoman period (SCOUFOPOULOS-STAVROLAKIS, 1985).

Ageranos: at the south end of Epano Vathi bay there is a long harbor structure (30 m x 3 m), which is traced underwater at 0.40-1.30 m (TSARTSIDOU *et al.*, 2002). Its long shape implies that this could be a quay. The material and method of construction, attributes this structure to the Roman period.

Kamares: Roman villas preserved up to the roof have been located on the beach of Kamares village. In addition there are several remnants of Roman buildings in the fields suggesting a serious exploitation of the area by the Romans.

CONCLUDING REMARKS

The Late Quaternary morphologic evolution of the coastal environment of the western coast of Lakonic gulf is mainly controlled by fault tectonism of the area forming a series of embayments which led to the development of today's pocket beaches. A Tyrrhenian marine terrace has been traced at two sites between 1 and 3 meters above present sea level and includes the characteristic fossil *Strombus bubonius* and archaeological Palaeolithic finds.

The Holocene coastal morphological evolutionary

sequence starts with marine transgression due to the sea level rise which formed the deep embayments of Valtaki, Sellinita, Stomio, Epano and Kato Vathi. Subsequently, followed the development of barrier beaches, blocking the newly formed embayments, creating marshes behind them. Eventually the marsh areas have filled with fluviotorrential and colluvial deposits leaving only a few remnants of marshes.

The next step in this evolutionary cycle is the development of sand dunes on top of most beach barriers. In between beach barriers and dunes, Roman and Byzantine ruins have been found, determining the chronological limits of their evolution. Parts of these archaeological remains extend into the sea down to a depth of about 1.5 meters, indicating a relative sea level rise of about 2 meters in the last 1500 years. The most recent natural feature is the beachrock which in some places covers Late Roman – Early Byzantine ruins; this landform is eroding today indicating that there is either sediment starvation and/or a farther sea level rise, or both.

ACKNOWLEDGEMENTS

This research was partly financially supported by ELKE of the University of Athens, to whom we express our deep thanks.

REFERENCES

- CAVANAGH, W., CROUWEL, J., CATLING, R.W.V. & G. SHIPLEY, (1996). Continuity and change in a Greek rural landscape: The Lakonia survey. II Archaeological data. *British School at Athens*, Suppl. Bd. 27.
- DUFAURE, J. (1970). Niveaux d'abrasion marine quaternaire autour du Péloponnèse. *Annales de Géographie*, 79, 322-341.
- FORSTER, E.S. (1906). Lakonia: Topography. *Annual of the British School at Athens*, 13, 218-259.
- GAKI-PAPANASTASIOU, K., MAROUKIAN, H. & D. PAPANASTASIOU, (2001). Recent coastal changes in the northern Lakonic gulf, Greece, based on geomorphological and archaeological evidence. *Proceedings of the 36th CIESM Congress*, Monte Carlo, 24.
- HARVATI, K., PANAGOPOULOU, E. & P. KARKANAS, (2003). First Neanderthal remains from Greece: The evidence from Lakonis. *Journal of Human Evolution*, 45, 465-473.
- HOPE-SIMPSON, R. & S.H. WATERHOUSE, (1960). Prehistoric Lakonia, *Annual of British School of Athens*, Part 1, 55, 67.
- HOPE-SIMPSON, R. & S.H. WATERHOUSE, (1961). Prehistoric Lakonia, *Annual of British School of Athens*, Part 2, 56, 114.
- IMPERATORI, L., (1962). Livelli quaternari nel golfo di Corinto e nel sud del Peloponneso. *Quaternaria*, V, 131-133.
- KELLETAT, D. & D. GASSERT, (1975). Quartarmorphologische Untersuchungen im kustenraum der Mani-Habinsel, Peloponnes. *Zeitschrift für Geomorphologie*, Suppl. Bd., 22, 8-56.
- KERAUDREN, B. (1971). Les formations Quaternaires marines de la Grece. *Bulletin du musee d'Anthropologie prehistorique de Monaco*, 17, 87-169.
- KERAUDREN, B. (1972). Les formations Quaternaires marines de la Grece. *Bulletin du musee d'Anthropologie prehistorique de Monaco*, 18, 245-279.

- KOWALCZYK, G., WINTER, K.P., STEINICH, G. & L. REISCH, (1992). Jungpleistozaene Strandterrassen in Suedost-Lakonien, (Peloponnes, Griechenland). *Schriftenreihe für Geowissenschaften*, 1, 1-72.
- PANAGOPOULOU, E., KARKANAS, P., TSARTSIDOU, G., HARVATI, K., KOTZABOPOULOU, E. & M. DINOU, (2002). Late Pleistocene archaeological and fossil human evidence from Lakonis cave, southern Greece. *Journal of Field Archaeology*, 29 (3-4), 323-349.
- PIRAZZOLI, P.A. (1991). World Atlas of Holocene sea level changes. *Oceanography*, Ser. 58, Elsevier, Amsterdam.
- PIRAZZOLI, P.A., STIROS, S.C., ARNOLD, M., LABOREL, G., LABOREL-DEGUEN, L.F. & S. PAPAGEORGIOU, (1994). Episodic uplift deduced from Holocene shorelines in the Perachora peninsula, Corinth area, Greece. *Tectonophysics*, 229, 201-209.
- SCOUFOPOULOS-STAVROLAKIS, N. (1985). Ancient Gythion, the Port of Sparta: History and survey of the submerged remnants. *In: Harbour Archaeology, Proceedings of the 1st International Workshop on Ancient Mediterranean Harbours, Caesare Maritima*. A. RABAN (Ed.), 49-62.
- TSARTSIDOU, G., GAKI-PAPANASTASIOU K. & H. MAROUKIAN, (2002). Coastal evolution of the inner Lakonic gulf in the Late Pleistocene–Holocene period. *Proceedings of the 6th Panhellenic Geographical Congress, Thessaloniki 3-6th October, I*, 380-387.