ΜΕΤΑΒΟΛΕΣ ΤΩΝ ΑΚΤΟΓΡΑΜΜΩΝ ΚΑΙ ΤΟΥ ΑΝΑΓΛΥΦΟΥ ΤΗΣ ΧΕΡΣΟΝΗΣΟΥ ΤΗΣ ΠΥΛΙΑΣ (ΝΔ ΠΕΛΟΠΟΝΝΗΣΟΣ) ΤΑ ΤΕΛΕΥΤΑΙΑ 18.000 ΧΡΟΝΙΑ

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Περίληψη

Στην εργασία αυτή παρουσιάζουμε την εξέλιξη των ακτογραμμών και της μορφολογίας της χερσονήσου της Πυλίας σε τρεις διαφορετικές χρονικές περιόδους: (i) 18.000 χρόνια π.α.σ., (ii) 12.000 χρόνια π.α.σ. και (iii) 8.000 χρόνια π.α.σ.. Πριν από 18.000 χρόνια, κατά το τέλος της τελευταίας παγετώδους περιόδου, η στάθμη της θάλασσας, εκτιμάται ότι πρέπει να βρισκόταν περί τα 125m χαμηλότερα από ότι σήμερα, ενώ πριν από 12.000 χρόνια περί τα 70m και πριν από 8.000 χρόνια περί τα 20m χαμηλότερα. Στην περιοχή μελέτης η συνεχής άνοδος της στάθμης της θάλασσας μετά το 18.000 π.α.σ. είχε σαν αποτέλεσμα την ολοκληρωτική κατάκλυση μεγάλων τμημάτων της ξηράς και τη βαθμιαία μετατροπή της σε μικρότερα και μεγαλύτερα νησιά. Οι μεγάλες αυτές αλλαγές του φυσικογεωγραφικού περιβάλλοντος, που εξελίσσονται αργά μεν αλλά σταθερά σε ολόκληρο τον Αιγαιακό χώρο, έπαιξαν κυρίαρχο ρόλο στη διαμόρφωση από τον προϊστορικό κάτοικο του Ελλαδικού χώρου των διαδοχικών γενεών των Θεών της Ελληνικής Θεογονίας και των ηρώων της Ελληνικής Μυθολογίας.

THE EVOLUTION OF THE COASTLINES AND THE MORPHOLOGY OF PYLIA PENINSULA (SW PELOPONNESUS, GREECE) DURING THE LAST 18.000 YEARS

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Abstract

Through this paper, the evolution of coastlines and morphology of Pylia peninsula (SW Peloponnesus) is presented in three different time periods: (i) 18.000 years BP, (ii) 12.000 years BP and (iii) 8.000 years BP. At 18.000 years ago, that is during the end of the last glacial period, the sea level is estimated to have been approximately 125 meters lower than present, while at 12.000 years BP was 70 meters lower and at 8000 year BP 20 meters lower than present. Taking into account all the above mentioned, after the construction of palaeo-geographic maps, we get a picture of the study area much different than the present one. The continuous transgression of the land by seawater, after the end of the last glacial period, must have caused a great social and psychological stress to the prehistoric inhabitants of the Aegean area that it became the reason for the creation of their gods and heroes. Furthermore the knowledge of the environmental changes of the past leads to environmental realization, resulting in a more rational usage of natural resources.

Λέξεις κλειδιά: Παλαιογεωγραφία Μεσσηνίας, μεταβολές ακτογραμμών, Πυλία.

Key words: Messinian Paleogeography, coastline changes, Pylia.

1. Introduction

The Pylia peninsula consists the south-westernmost part of Peloponnesus. It is considered (tectonically and seismically) as one of the most active areas in Greece, due to its proximity to the Hellenic trench which represents a major subduction zone. It exhibits a composite morphotectonic structure due to the existence of numerous small morphological units of various directions (Fig. 1). The dominant mountainous bulges are Lykodimo (960m) at its north-eastern section, exhibiting a characteristic conical shape and Mavrovouni (518m) at the south-eastern part of the peninsula, which exhibits an elongated structure of NW-SE direction.

2. Geological and structural setting

The alpine nappe sequence of Pylia peninsula is comprised of a relatively autochthonous unit, the Gavrovo-Pylos unit, and an allochthonous one, the Pindos unit. The Gavrovo–Pylos unit consists of neritic carbonates and flysch and outcrops at the western part of the peninsula. On the other hand the Pindos unit occupies the eastern part of the peninsula forming a classic nappe, which has overthrusted Gavrovo – Pylos unit (Fig, 2). Pindos unit is represented with all its wellknown characteristic formations namely: the Triassic clastic formation at the bottom of the sequence, followed by pelagic limestones (Upper Triassic-Lower Jurassic), radiolarites and the so-called "first flysch" (Upper Jurassic-Lower Cretaceous), thin-bedded limestones (Upper Cretaceous) and Eocene flysch. The whole unit is intensively folded and faulted, forming successive thrusts with a general propagation direction from east to west.

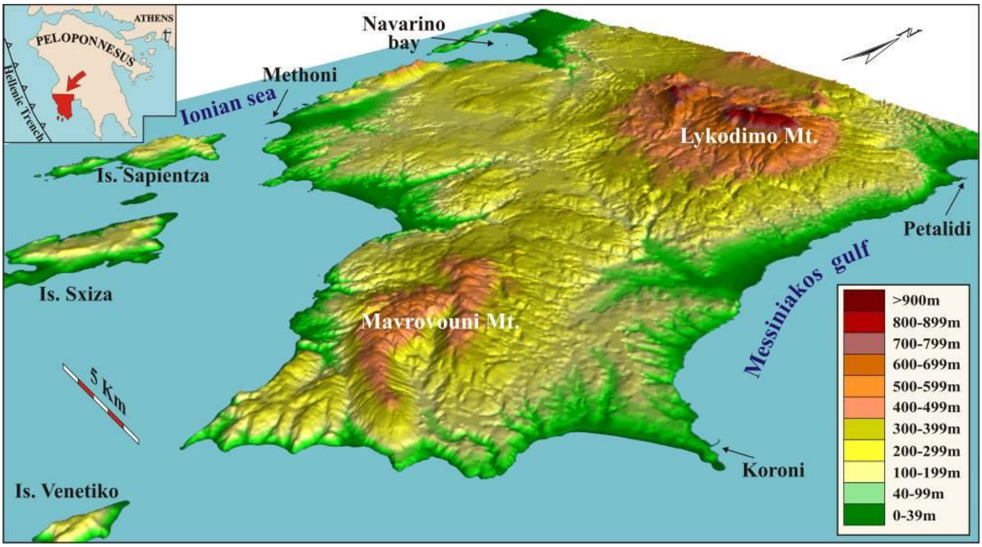

Figure 1. Location map and perspective view from the SE of the shaded relief image showing morphology of Pylia peninsula,
(azimuth of observation N130o with 45o inclination angle from the horizon).

The post alpine deposits can be distinguished into (i) marine, (ii) terrestrial and (iii) lacustrine formations. The marine deposits consist of marls, sandstones and polymictic conglomerates. They occur in all basins of Pylia peninsula but their total thickness varies from place to place. In the Falanthi basin the thickness of these sediments has been estimated, based on drilling data, as 200m at a location near the city of Koroni. In this basin the upper sequences of the marine deposits are of Early Pleistocene age or younger (Mariolakos et al. 2001). In the rest of Pylia peninsula basins (Pylos, Pydassos and Achladochori basins) according to previous studies marine sedimentation took place during Late Pliocene (Koutsouveli 1987). In our opinion, it also continued during the Early Pleistocene as indicated in the adjacent areas of Triffilia and Lower Messinia basin by palaeontological studies (Marcopoulou-Diacantoni et al. 1989, 1991).

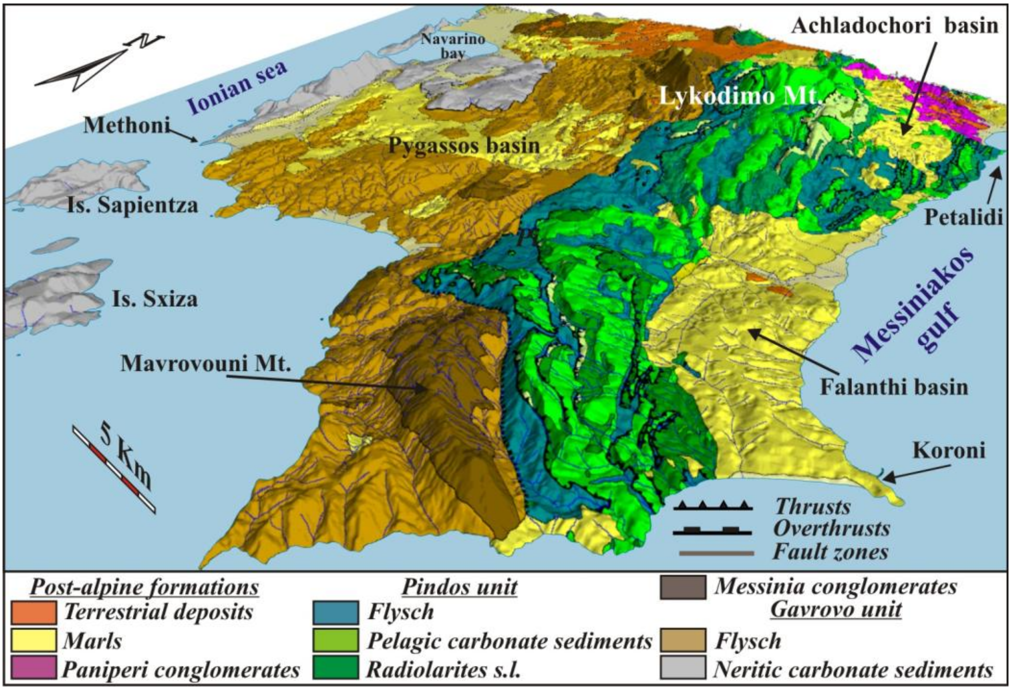

Figure 2. Perspective view of a simplified 3D geological map of Pylia peninsula. The view of observation is towards NW, (azimuth of observation N140o) with 35o inclination angle. Illumination is from the east.

The overlying continental deposits consist mainly of red-coloured siliceous sands and sandstones and of polymictic conglomerates which should be of Middle and Late Pleistocene age. It is important to mention that these conglomerates consist of pebbles originated not only from the alpine formations outcropping at Pylia peninsula but also from the metamorphic rocks of Taygetos Mt., that is from schists, quarzites and marbles, (Mariolakos et al. 2001). The Holocene is represented by alluvial deposits and talus scree. Lacustrine deposits outcrop only at the western margin of Falanthi basin consisting of marls with xylite bed intercalations. They are considered to be of Early Pliocene age (Koutsouveli 1987).

The neotectonic macrostructure of SW Peloponnesus is characterized by the presence of large grabens and horsts bounded by wide fault zones, striking N-S and E-W. The main 1st order macrostructures at the broader area are namely: (a) The Taygetos horst, (b) The Kalamata-Kyparissia megagraben, (c) The Kyparrisia Mts. morphotectonic unit, (d) The Vlahopoulo graben and (e) The Pylia Mts horst, (fig 3a).

The kinematic evolution of these neotectonic units is complicated since block rotation differentiates the uplift and subsidence rates throughout the margins of the neotectonic blocks (Mariolakos et al. 1994). At the margins or within these 1st order neotectonic macrostructures a great number of smaller structures has been recorded. These neotectonic structures of minor order strike either sub-parallel or perpendicular to the trends of the 1st order ones. They are dynamically related, as they have resulted from the same stress field but they have a different kinematic evolution. This differentiation has appeared either from the first stages of their creation, or later, during their evolution (Mariolakos et al. 1995).

Figure. 3a The 1st order Neotectonic macrostructures of SW Peloponnesus.

Figure 3b The 2nd order neotectonic macrostructures of Pylia horst. 1:Agios Nikolaos horst, 2:Pylos-Methoni graben, 3:Kynigos horst, 4:Lykodimo morphotectonic structure, 5:Pygassos basin, 6:Mavrovouni horst, 7:Falanthi graben, 8:Achladochori basin.

The study area belongs to the 1st order complex neotectonic horst of Pylia Mts which strikes N-S and is bounded to the north by a nearly E-W striking fault zone (South Vlachopoulo fault zone, SVFZ). This marginal fault zone divides the uplifted area of Pylia to the south from the Vlahopoulo graben to the north, which represents an area that was submerged below the sea level during Early Pleistocene, forming an E-W trending sea channel, whereas at the same time the greater part of Pylia megahorst continued to be above the sea level forming a separate island (or islands?), (Mariolakos et al. 1994). The reactivations of this fault zone have formed large escarpments on the morphology of the area west of Pylos town where many fault surfaces on the carbonate rocks of Gavrovo unit are covered by successive generations of tectonic breccia and scree. It traverses the whole peninsula consisting of many faults in an en-echelon arrangement. Slikensides observed on these fault surfaces indicate that they have an oblique-slip (sinistral) normal character. The 2nd order neotectonic structures that were distinguished in the Pylia Mts horst are shown in Figure 3b.

3. Climate changes

As it is known, climate changes periodically and the main causes of this periodicity are astronomical (Milankowitch theory). During the past 2 million years (Quaternary period) successions of glacier and interglacier periods due to fluctuations of solar radiation that was received by earth, have been recorded. The solar radiation that is received by the planet is not stable. The quantity of solar radiation reaching the Earth depends on the Precession of the Earth axis, the Obliquity (the change in axial tilt) and the Eccentricity. These parameters are not constant but they change periodically, the result of which is reflected on the periodic climate changes and more specifically on the change of the mean air temperature.

In fig. 4 the changes of the mean atmospheric temperature of the earth during the past 150.000 years are presented, (from the approximate start of the one before last interglacial period up to present). Similarly, in fig 5, the temperature fluctuations during the past 18000 years are presented. Around 125,000 years B.P. the climate was similar to the actual one (inter-glacial period, fig. 4). Around 75,000 years B.P. the main phase of the last glacial period begins. This period ends at 18.000 years B.P. approximately, when a new climatic era began related to the abrupt rise of the mean earth temperature, (fig. 5). At 18.000 years B.P. the mean earth temperature was at its lowest values and the glaciers had the greater distribution while during the previous 60.000 years the climate was relatively constant, with non-favourable conditions of course related to present as throughout the largest part of the earth, a continuous winter predominated.

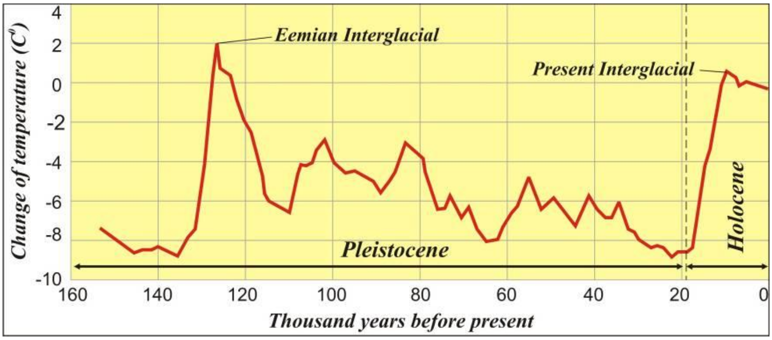

Figure 4. The changes of the mean earth temperature during the last 160.000 years.

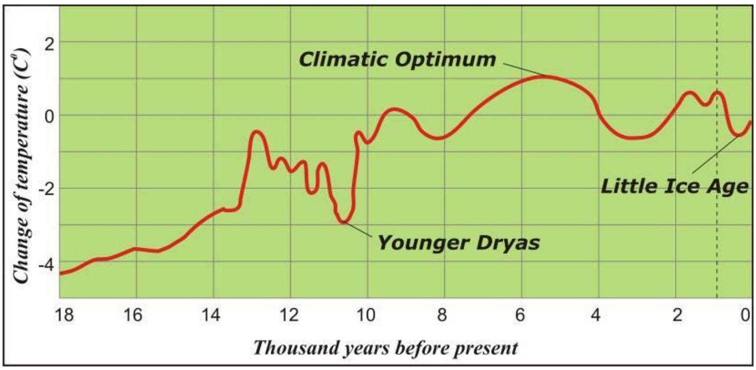

Figure 5. The fluctuations of the mean earth temperature during the last 18.000 years, (Duff 1993).

Due to the abrupt rise of the mean earth temperature, large masses of glaciers accumulated on continents, began to melt resulting in large quantities of water release. The melting of the glaciers led to the gradual rise of the sea level, which around 18.000 years B.P. is estimated to have been around 125 meters lower than present. This sort of sea level changes are known as climatic – eustatic movements.

The gradual rise of sea level had as a result the shifting of coastlines and the flooding of many coastal regions that today represent the bottom of the sea down to the depth of 125 m.

In figure 6 the sea level changes during the past 12000 years are presented. The graph shown in this figure is constructed from various curves from many regions of the planet and published by Kraft et al, 1985. From those curves we believe that the ones that represent in the most fitted way the conditions of the Hellenic region are those by Fairbridge (1961) and Morner (1971) that represent approximately the uppermost limit of the fluctuation ranges of values in figure 6. Due to the periodical climate change, the temperature variations are followed by rainfall variations. In the circum Aegean region the temperature rise is related to an increase of evaporation resulting in an increase of rainfalls.

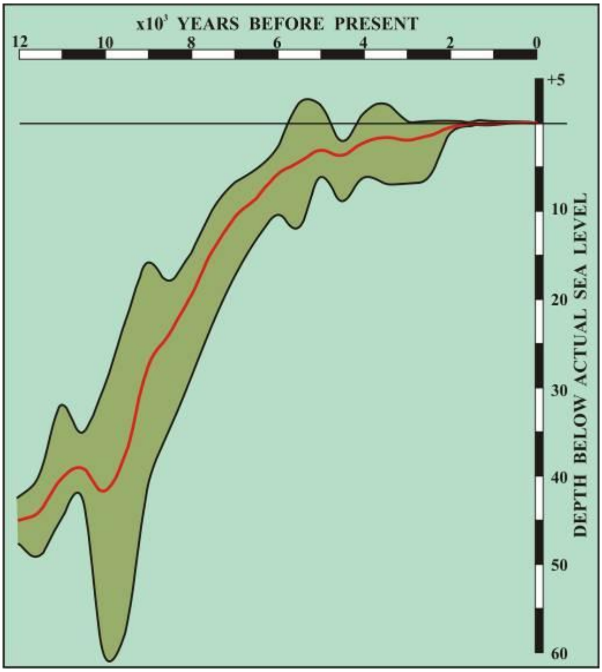

Figure 6. Sea-level changes during the last 12,000 years BP. The bold red line represents the mean curve, which has been produced from various curves published by Kraft et al., 1985. The green area represents the width between the minimum and the maximum values of these curves.

4. Coastlines evolution

Present coastlines of Pylia peninsula exhibit significant variety in morphology, alternating from rocky to sandy coasts, forming small bays and peninsulas. In the formation of these coastlines, besides the eustatic movements, an important controlling factor is the vertical movements (uplift or subsidence) due to the active fault tectonics. As Pylia is one of the most seismically active areas of the Hellenic region it includes a number of active fault zones that have been reactivated during the past 500.000 years (Middle Pleistocene to Present). This fact suggests that changes of sea level are composite and the determination of its level, during various eras, is not easy to be estimated in relation to present conditions.

Between 18.000 BP and 6.000 BP, a continuous sea level rise has been recorded that had as a result the constant change of the coastline and the gradual flooding of the coastal regions. The sea level was stabilized and reached the present levels around 6.000 BP and 4.000 BP. At the initial stage of the transgression during 18.000 – 8.000 BP, the mean sea level rise was estimated as 8-37mm/year according to Bard et al. 1989. During this period, the eustatic movements dominated while the contribution of tectonics should be limited compared to the total rise of the sea level. For this reason the paleogeographical representation diagrams have taken into account only the eustatic changes.

On the contrary, during the last stages of the sea level rise, after 8.000 BP, the mean sea level rise has been estimated as ≈ 2mm/year. According to previous studies at the Messinia Prefecture area (Mariolakos et al. 1994), it is estimated that the mean uplift rates from Middle Pleistocene until present varies between 0,375-0,625 mm/year. We therefore consider that the contribution of tectonics after 8.000 BP is critical for the evolution of the coastlines and should be taken into account in any attempt of paleo-relief reconstruction.

The coastline changes after the relative stabilization of the sea level (from ≈ 6.000 BP to present) are attributed to three factors: (a) the landscape surface processes (suspended material of streams, landslides), (b) marine processes (eustasy, marine erosion) and (c) vertical tectonic movements.

Through this paper, the evolution of coastlines and morphology of Pylia peninsula is presented in three different time periods namely: (i) 18000 years BP (figures 7&8), (ii) 12000 years BP. (figures 9&10) and (iii) 8000 years BP. (figures 11&12).

The sea level 18.000 years ago, that is during the end of the last glacier period, is estimated to have been approximately 125 meters lower than present, while at 12000 years was 70 meters lower and at 8000 year BP was estimated to have been approximately at 20 meters lower than present.

18000 years BP: As it is shown in figure 7 the coastlines at that time had a very different morphology compared to the present ones. During the Upper Pleistocene, before the melting of the glaciers, Pylia was united with all the surrounding islands that we see today, that is Sfaktiria, Sapientza, Schiza, Venetiko and the smaller islets. It comprised an area that was 65% greater than the present.

At the south section of the peninsula the cape Akritas was extending further south as Venetiko and its surrounding islets were linked with the land of the other side. At the SW end of the peninsula a second cape was formed with two ends that represented the southern end of Schiza and Sapientza islands that were also linked with each other as well as with the land at the opposite side. Between these two large capes, an elongated gulf was developed in a N-S direction, the Finikounda palaeo-bay. At the uppermost section of this bay Minagiotiko and Delimichali streams were discharging at the sea. During that time these streams had a greater size and a more evolved network.

At the western section of Pylia peninsula, the island of Sfaktiria was linked to the rest of the land and the Navarino bay was non- existent while in its location a plain existed. The western coasts had a general NNW-SSE direction and presented a series of complex gulfs that were separated by smaller peninsulas. Rivers Yiannouzagas and Xerias composed along with Xerolagado a unified fluvial system where the main branch was running through the

Navarino plain and was discharging at the Ionian Sea, further south of Sfaktiria.

To the east of the peninsula, the coastline of Messinian Bay was approximately 4 Km further to the east of the present one and was very close to the continental shelf. At the region of Koroni, a peninsula was formed that was extending in an E-W direction in the Messinian Bay. During that time, Lykodimo was comprising a mountainous mass with an approximate altitude of 1100 meters.

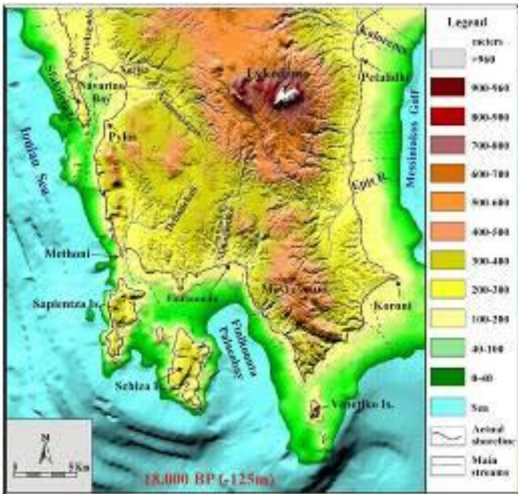

Figure 7. Shaded relief image showing morphology of Pylia peninsula 18.000 years b.p., when sea level was approximately 125 meters lower than present.

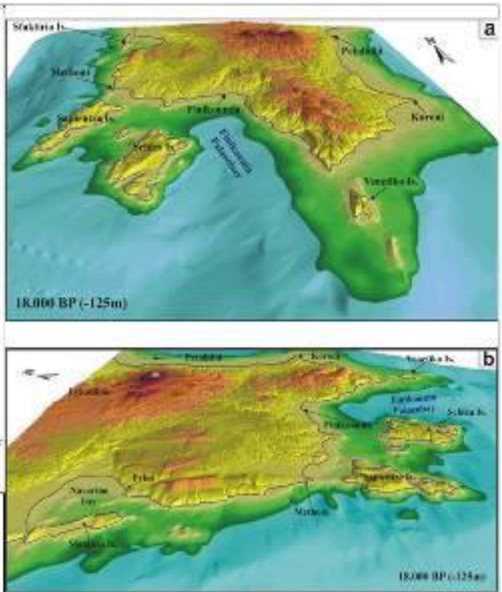

Figure 8. Perspective view of the shaded relief image of Pylia peninsula 18.000 years b.p., (a) from the south and (b) from the west.

12000 years BP: During that period significant changes at the coastal morphology were observed related to the previous period. The land distribution was reduced considerably and the Finikounda paleo-bay presented a greater development (figures 9 & 10). Schiza continued to be linked to Sapienza by a small land strip. At the western side of this peninsula the early stages of the Navarino bay began to appear, as a small and elongated bay is formed south of Sfaktiria.

Rivers Yiannouzagas, Xerias and Xerolagado formed narrow valleys with intense in depth erosion that transferred significant quantities of sedimentary material that was deposited on the lowland coastal zone north of Pylos forming an extensive alluvial plain. To the east of the peninsula, the coastline of the Messinian gulf was now approximately 2,5 Km further to the east of the present coastline forming a similar shape as the present one.

8.000 years BP: At this period the shape of the shorelines at the hole peninsula is more or less similar shape to the present ones, (Fig.. 11).The islands of Venetiko and Schiza have been separated from the mainland while Sapientza island was also separating from the opposite land as the small pass that bounded it to Methoni area started to flood. At the northwest, Navarino bay has been formed but it was opened only at the south as the northern passage was still closed. Rivers Yiannouzagas, Xerias and Xerolagado composed now separated drainage networks where the last branches were discharging at the Navarino bay.

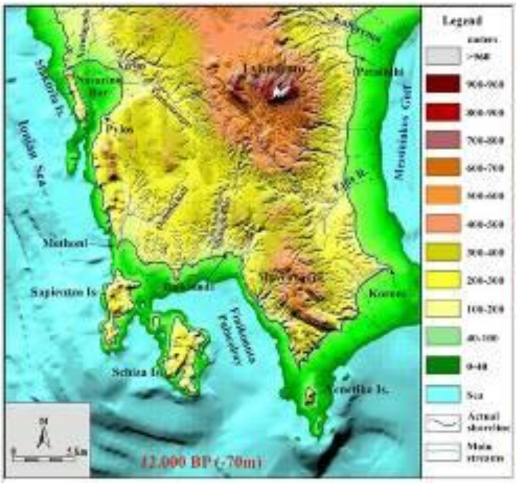

Figure 9 Shaded relief image showing morphology of Pylia peninsula 12.000 years b.p., when sea level was approximately 70 meters lower than present.

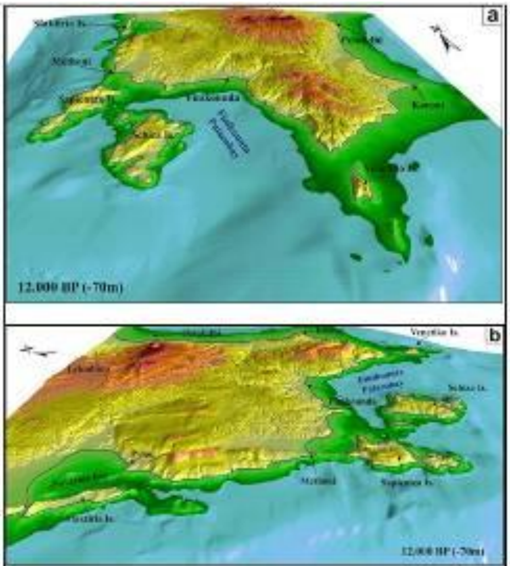

Figure 10 Perspective view of the shaded relief image of Pylia peninsula 12.000 years b.p., (a) from the

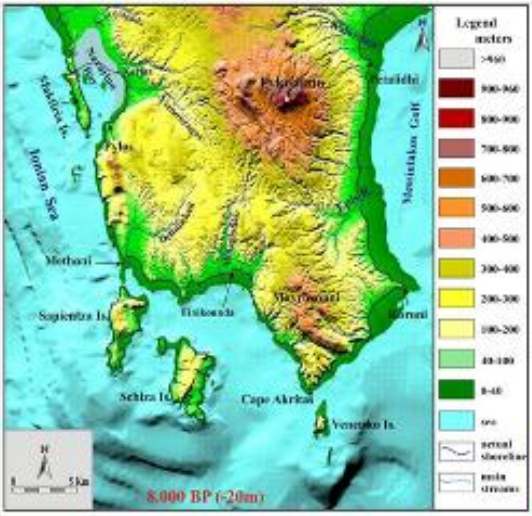

Figure 11 Shaded relief image showing morphology of Pylia peninsula 8.000 years B.P., when sea level was approximately 20 meters lower than present.

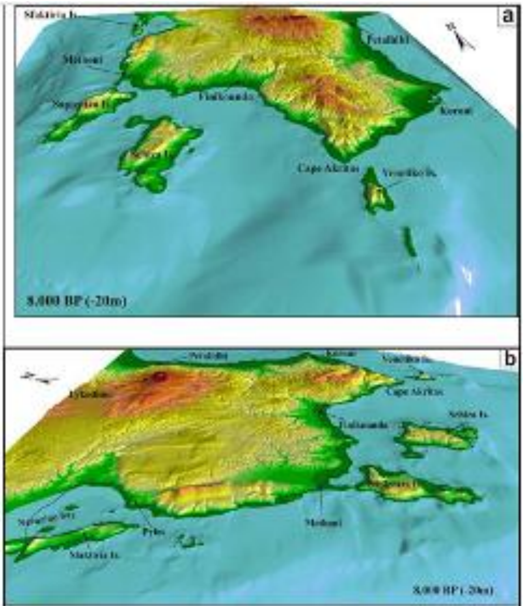

Figure 12 Perspective view of the shaded relief image of Pylia peninsula 8.000 years BP, (a) from the south

5. Conclusions

We believe that the study of the coastline evolutions and the climatic changes in general are important and can give answers in many questions related to archaeological investigations. In the study area the rise of the sea level after 18.000 BP had as a result the total flooding of large sections of land and the gradual formation of smaller and larger islands.

The habitants of the upper Paleolithic, Mesolithic and early Neolithic periods most likely did not occupied the same regions that they occupied after 6.000 BP. The prehistoric inhabitants of these societies were probably concentrating their activities in coastal karstic caves, near springs and biotopes and river deltas, areas that were flooded by the sea. Many Paleolithic, Mesolithic and Neolithic locations are presently below sea level up to a depth of 125m.

The gradual flooding of these areas by the sea had as a result the constant shifting of the prehistoric man to higher altitudes living constantly with the flood hazard. These large scale changes of the physical – geographical environment which evolved gradually for a long time period, contributed to the evolution of the prehistoric man of the Hellenic region to the successive generations of the Hellenic Theogony and the heroes of the Hellenic Mythology.

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