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Underwater morphology of the Aegean sea and natural prolongation of the Anatolian mainland

Ege Denizinin sualtı morfolojisi ve Anadolu'nun doğal uzantısı

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Abstract

Underwater morphologic structures are closely related to the structural geology. Therefore, the determination of the relationship between the actual underwater morphology and the tectonic evolution of the region is rather important in order to draw the natural prolongation of the Anatolian mainland and to draw a natural border between Anatolian and Greek mainlands. For this purpose, the actual underwater morphological structures in the Aegean Sea were determined and correlated with the available geologic and geophysical data.

The Greek and Turkish islands placed in the Eastern Aegean Sea formed the upper parts of the mountains before the subsidence of the region and the eastern part of the Aegean Sea is on the natural prolongation of the Anatolian mainland. The natural border separating the two mainlands is placed close to the coasts of the Greek mainland. These findings indicate that the islands close to the Anatolian coast are natural prolongation of the mainland.

Keywords: Aegean Sea, Natural prolongation, geomorphology

Introduction

Determination of the morphological configuration of the Aegean Sea is quite important in terms of showing that some Eastern Aegean Islands are placed on the natural prolongation of the Anatolian mainland.

Formation and paleogeographic evolution of the Aegean sea

The present tectonic features of the Aegean Sea and surrounding regions have been developed as a result of the complicated plate movements which were started in the Upper Cretaceous. Before these plate movements in the Upper Cretaceous, the Neotethys Ocean was placed between these plates and covered the whole of Anatolia. Similar to the Atlantic model, the rifting and sea floor spreading was dominant in this ocean (Brinkman, 1976; Turgut, 1987; Küleli *et al.*.1993). Beginning from the Upper Cretaceous, the Arab-African Plate started to move towards the Eurasian Plate and the northern strand of the Neotethys was closed (Mc Kenzie, 1978; Ţengör, 1979, 1980; Şengör and Yılmaz, 1983; Jackson and Mc Kenzie, 1984; Taymaz *et al.*,1991). The Menderes-Taurus and Sakarya Blocks, consisting of the Anatolian Plate, were integrated along some ridges and suture zones in the Maestrichtien. These displacements continued until the lower Oligocene and caused compressional movements in Western Anatolia and in the Aegean Sea. Consequently, large scale napes were developed in this region and the crust was thickened. An extensional tectonic regime was dominant in the middle-upper Miocene and normal faults specified the morphology. The Aegean Sea started to open in the Serravalian-Tortonian. Under the influence of extensional regime which persisted in Western Anatolia, the graben basins was evolved in the Aegean Sea and Western Anatolia. The rigid blocks in the Western Anatolia dislocated along the transform faults. The seafloor morphology of the Aegean Sea is the result of this extensional tectonic regime (Jongsma *et al.*,1977; Needham *et al.*,1977).

The pre-existed grabens continued to subside in the Messinian (late Miocene), new grabens were evolved and the amount of sediment fill increased. During this period, the ocean branch placed in the Northwest Anatolia flooded the Çınarcık Basin causing the first contact with the North Anatolian Fault Zone (NAFZ) (Görür *et al.*,1992). The paleogeography of the Upper Miocene period indicate that the Aegean Sea started to develop as a narrow and long channel. It has a NW-SE trend in the northern part; from the east of Thasos (Taşoz) Island towards south to Limni and Ayios Efstratios (Bozbaba) islands; and finally, from the west of Psara (İpsara) and Ikaria (Ahikerye) islands towards the south. In the

Pliocene, the Aegean Sea widened laterally depending on the increased subsidence caused by the NS-extensional regime, but keeping its original direction (NW-SE) (Le Pichon *et al.*,1984; Görür *et al.*,1992). A great deal of the Aegean Sea and its surroundings was inundated in this period; and the Aegean Sea basin gained a shape which was similar to the most recent geographic configuration. However, the eolian and lacustrine sediments were deposited on an important part of Western Anatolia, eastern coasts of Greece and some large Greek islands such as Rodhos (Rodos), Kos (İstanköy), Ikaria, Samos (Sisam), Khios (Sakız) and Lesvos (Midilli) (Martin, 1987). In the Pleistocene and Holocene, the Neogene grabens in Western Anatolia were invaded, the Anatolian mainland gained its present geographic status and the deltaic compositions were developed in the graben systems (Bilgin, 1969; Erinç and Yücel, 1988).

Consequently, the NW-SE trending deep tectonic event is responsible for the evolution of the Aegean Sea and the development of a narrow and long channel. This zone can be considered as the natural border between the Greek and Anatolian mainlands (Eryılmaz, 1996).

Bathymetry and underwater morphology

Trench and depressions form the seafloor of the Aegean Sea; NW-SE trending from the opening of the Gulf of Saros to the North Sporadhes (Voríai Sporádhes), NW-SE trending from North Sporadhes to the Dodecanese (Dhodhekanisos, South Sporadhes) islands and finally turning southwards at around Amorgos Island to the north of Crete (Figure 1). These S-shaped depression fields form the deepest parts (more than 1000 m in general) of the Aegean Sea (Allan and Morelli, 1971; Needham *et al.*,1973; Erinç and Yücel, 1988). The deepest points of the depression area lying from the opening of the Gulf of Saros to the North Sporadhes are 1008, 1240, 1130 and 1170 m from east to west (Books and Ferentinos, 1980; Martin, 1987; Mascle and Martin, 1990). The depths of the depression areas increase in the northern part of Crete; e.g. 2529 m west of Karpatos (Kerpe) Island and 2265 m in the northern basin of Crete. Further north of this area, in the basin surrounded by 1000 m depth contour, the maximum depths are 1485, 1451 and 1840 m. Gökova and Kuşadası Bays along the Anatolian coast form the deepest inlets with maximum depths of 620 and 1042 m, respectively.

The most common depths for the rest of the Aegean Sea vary between 100 and 500 m. From north to south, Samothraki (Semadirek), Gökçeada (Imbros), Limnos (Limni), Bozcaada (Tenedos), Lesvos, Khios, Samos and the Dodecanese (Onikiada) islands lined up on the 100 m depth contour off the Anatolian coast. There are some depressions between these islands; 801 m south of Skiros and 1042 m north of Samos (Eryılmaz, 1996).

Continental Shelf : The continental shelf is much more developed especially at the northern and eastern parts of the Aegean Sea. At the northern part, the shelf starts from the northern shelf area of the Gulf of Saros, widening toward the west up to the Akratos Point.

This broad shelf inclines gently toward the slope with a shelf break at a water depth of 110-130 m contour lines where a deep trough continues towards WSW between Bozcaada and Samothraki islands to join the 1000-1500 m-deep Anatolian Trough, which is bounded from the south by the steeply faulted (the Ganos Fault) margin of the Gallipoli Peninsula. The Samothraki and Thasos islands are located on this shelf. This area is characterised by some topographic features and old river valleys which remain from old land area. The Meriç Delta, which is placed on the Turkish-Greek border, comprise of very well developed sedimentary units with abandoned channel mouths, coastal bars and a prodelta lying on the older submarine delta far offshore with steep slopes. During the Würm glaciation, the global sea-level was lowered and consequently the Aegean Sea regressed from these areas along with the accumulation of extensive deltaic deposits. Further west, another small scale continental shelf area is placed in the Thermaikos Bay.

The shelf area on which Gökçeada and Limnos islands were placed extends up to the central axis of the Aegean and was bounded by the deep Anatolian Trough at north. This sight indicates that a relatively large shelf area was cut into parts and divided by the younger tectonically-controlled trough.

Further south, an asymmetry is in question. At the western part, the shelf area of the islands which are close to the Greek part was not fully developed and almost each island has its own shelf. Contrary, at the eastern part, the shelf area comprises of many small and big islands such as Lesvos, Kios, Samos and Kos. From this point of view, the eastern part of the Aegean Sea is the prolongation of the Anatolian Mainland up to the deep trough placed in the central part.

Continental Slope : The typical morphologic elements of oceans such as continental slope and continental rise, were not plainly and clearly developed in the Aegean Sea which bears the deep tectonically-controlled marks. The continental slope corresponds to the steep slopes of the tectonically-controlled troughs which may stretch out long distances. The steep slopes formed from old fault scarps were mainly placed in the eastern part. The sea bottom leading to the deep trough in the Gulf of Saros, displays an irregular morphology caused by ENE-faulting and sediment slumping. Because of the high deformation of the Aegean Sea, its continental slope is discontinuous and locally carries both tectonically and erosive marks.

Abyssal plain : The abyssal plains are local, discontinuous, small and placed at different depths. Some local plains were placed at different depths at the bottom of the NNE-WNW trending Anatolian trough which is bounded by rather steep slopes at the northern and eastern parts and more gradual slopes at the western part. The plain (-600 m) at the exit of the Gulf of Saros (eastern part) extends towards the south of the Akratos Point which is separated from the eastern part by a -400 m elevation. This elevation that extends between 300 and 400 m water depths was developed on another tectonic event bounding (in N-S direction) the tectonic trough between Samothraki and Thasos islands.

The NS-trending deep area forming the longitudinal axis of the Aegean Sea, even though its bottom is not flat, may be assumed as a plain extending between 300 and 450 m depths. There are depressions and hills at the depths of 600-700 m, some of them are deep more than 1200 m at the eastern part, and also individual rims, which may come up to the 150 m water depth, on this plain. These outward appearances represent an old topographic surface carrying the marks of depression and volcanism.

At the Southern Aegean, the W-E trending deep trough to the north of Crete extends perpendicular to the N-S trending trough in the central part of the Aegean Sea. Since no shelf area developed, only a continuous continental slope was placed between the Crete island and the deep depression area at 1300-1400 m water depth. The bottom of this depression is rather flat and may represent an abyssal plain.

Regarding these geomorphological aspects, the Aegean Sea, even it is tectonically subsided and broken into pieces, represents the prolongation of the Anatolian mainland. This is much more evident at the eastern part.

Reflection seismic and sediment thickness

Various works have been carried out for the neotectonic evolution of the Aegean Sea (Akkök, 1983; Brooks and Ferentinos, 1980; Dewey and Ţengör, 1979; Le Pichon and Angelier, 1981; Lyberis, 1984; Morelli *et al.*, 1975). The most prominent features of the fault tectonics in the Aegean

Sea, which started at the end of middle Miocene depending on the movements of extensional regime, are the fault trends with specific directions (Figure 2). These are generally normal or listric faults with great displacements and placed between the structures which are a few tens kilometres in length and related to each other. In some cases, the Neogene tectonics coincide with the pre and post Neogene tectonics, hence, their definition is not always possible. Tectonic styles and fault geometry need to be designated in such situations. In the Northern Aegean Sea, the Neogene fault trends close to the Turkish coasts tend to be in a NE-SW direction while they are in NW-SE direction close to Greece coasts. The NW-SE trending faults are dominant in the Central Aegean Sea. Further south, the fault systems developed in the Crete Trough, have W-E and NW-SE trends. The graben basins in the Western Anatolia are generally bounded with E-W trending normal faults. The fault systems in the Aegean Sea indicate that fault kinematics in Neogene were developed in two main directions; NE-SW and NW-SE (Figure 2).

Various depressions in the Aegean Sea were bounded with normal faults with great displacement. Some of them have strike slip component as well. The deepest reflections on seismic sections, which can be traced easily if the sedimentary units are not so thick, represent the basement. Comparably larger basins and thickest sediments, more than 3000 m, are placed in the Northern Aegean (Figure 3) where the thick sediment fill in young grabens give flat reflection patterns. These grabens were developed by active faults, reaching to the sea floor, with steep slopes. Their tectonic trends are generally in the ENE-WSW direction and concordant with the ones existing on the Anatolian mainland. On the other hand, the sediment fill become thinner in the Central Aegean Sea and the thinnest sediments are found in the Southern Aegean Sea.

The Northern Aegean Trough is formed by three separate V-shaped basins. The deepest one, placed to the north of Limnos, was exposed to dense block faulting. The others, placed further east, are NNE-WSW trending pull-apart basins. The dense mass movements observed around their north and south edges indicate a continuing faulting mechanism (Mascle and Martin, 1990; Eryılmaz, 1996).

Some active faults close to the northern coasts of Gökçeada and around Bozcaada and Gökçeada can be observed. The sediment fill is rather thick in this region. The basement becomes shallow towards Bababurnu and later controlled by an EW trending fault and deepened towards the bay.

The gulfs extending in N60°-80°E direction in general at the eastern coasts of the Aegean Sea form the western extends of the Neogene grabens in Western Anatolia and extend westward cutting the pre-existed tectonic units. The Gulf of Saros becomes deeper westward under the control of step-wise faults (Figure 4). A Miocene discordance is obvious at the western part of the gulf. The young faults in the Gulf of Saros, which are rather clear on the NS seismic sections (Çağatay *et al.*, 1998), extend in the direction of ENE-WSW (Figure 4).

Another graben forms the Edremit Trough. It is formed by two NE-SW trending asymmetric grabens at the north of Lesvos (Figure 5). A graben development, bounded by the faults to its north and south, is clear on seismic sections in Edremit Bay. The ENE-WSW trending northern fault is interpreted as a listric fault. The sediments are thicker at the northern part of the graben and the basement becomes shallow southwards (Figure 3). The recent sediments in this region can be distinguished from the Neogene and older series by their different reflection characters. A sediment filling which is placed on top of the basement (Messinian) was controlled by N10°E faults. This filling is covered by Plio-Quaternary sediments with continuous and regular reflections. The NE-SW trending faults to the NE part of this region are active. The basins between Lesvos and Psara islands, which have been generally filled by thick sediments and bounded by the N60°W fault system, form tectonically complex structures. The Upper Miocene units on top of the basement are covered by the Plio-Quaternary sediments with significant mass slides. The basin at the western part of Psara contains thinner sediment filling compared to the others. This basin is divided into two main troughs by a NE-SW trending horst. The southwestern trough indicates diapiric deformations and inner chaotic structures in the form of mass slides. Some discontinuities at the northwestern edge of the basin may indicate strike-slip movements. These structures indicate that the region is still affected by the active tectonics (Mascle and Martin, 1990). The basement could not be observed in the region to the north of the Gulf of Çandarlı. The base level which can be observed in the central part of the gulf corresponds to the top level of evaporites which was cut in the Foça-1 bore-hole (Figure 3) in İzmir Bay.

In the western part of the Kuşadası Bay, the basement can be easily traced on the seismic sections. The sediment thickness, which reaches up to 3000 m to the northern part of the graben, becomes thinner in the central and southern parts (Neogene). These thick deposits (locally 2000 m) were interpreted as the Quaternary sediments. The regional basins in the Central

Aegean Sea are small in size and their sedimentary thickness are thinner (Figure 3).

Further south, the Samos and Ikaria basins form the extend of the Menderes Neogene graben system. This asymmetric graben basin is 15 km in length and bounded by an important fault zone to its south. In this basin, the Plio-Quaternary deposits with many slumps are placed on top of the Messinian sediments, which show chaotic reflections and intercalated with evaporites. The morphological characteristic of the northern slopes of the islands indicate that the they are en-echelon faults (Figure 6).

The basement is shallow in the Büyük Menderes Bay and the thickness of the Neogene sediments are not more than 1000 m. The sediments in the Güllük and Gökova Bays are not thicker than 500 m as well. The basement close to the islands in the Southern Aegean Sea are rather shallow and occasionally reaches up to the sea floor (Figure 6). Some small scale basins also exist in this area.

Natural prolongation of the Anatolian mainland

The morphological properties of the Aegean Sea is extremely different from that of a sea bottom having an oceanic crust. The findings that the depressions in the Aegean Sea were surrounded by steep sides and their prolongation shows linearity, indicate that these depressions were formed by normal faults. The shallow parts of the Aegean Sea bear the morphological characteristics of their adjacent mainlands and they represent the submerged natural prolongation of their mainlands.

If the present sea level was lowered down to -200 m (Figure 7), the coastal structures which would come out along the western coasts of Anatolia would preserve their present morphological characteristics. The bays of Saros, Edremit, Çandarlı, İzmir, Kuşadası and Gökova would still keep their presence, but slightly shift westwards due to the sea level fall. Besides, most of the large and small Eastern Aegean Islands, e.g. Samothraki, Gökçeada, Limnos, Bozcaada, Lesvos, Khios, Samos, Ikaria, Patmos and Kos, would be connected to the Anatolian mainland. However, many bays and inlets would change into land and new bays would be evolved keeping almost similar geometric features along their prolongation. Similarly, the Cape of Ayvalık and the Biga Peninsula would shift westward preserving their present morphological characteristics. In other words, the Anatolian mainland keeps all its morphological properties down to -200 m depth contour. Progradational deltaic sequences occurring along the coasts of western Anatolia where they are found below the present day deltas suggest that the sea level was lowered up to -120 m. Their upper parts are dated by the ^{14}C method to be 14-10 Ka BP (Aksu *et al.*,1987). Such kind of sea level falls have possibly exhibited similar scenes given in Figure 7. On the other hand, the inlets and capes along the eastern coasts of the Greek mainland would preserve their present morphological characteristics with minor eastward shifts (Küleli *et al.*,1993; Eryılmaz, 1996).

Considering that the present sea level is lowered to -400 m (Figure 8), the coastal properties lose their clarity considerably but the mainlands continue down to the S-shaped depression zones. In this case, the two mainlands would come very close to each other separated by a very narrow sea. Most of the Eastern Aegean Islands would be attached to the Anatolian mainland. These assumptions indicate that the islands in the Aegean Sea are simple heights erected on the prolongation of their mainlands.

If the present sea level rose up to +200 m, some parts of the present western Anatolia would change into new islands, most of the islands would mainly be inundated and some of them would be reduced in size. The grabens would be invaded by sea, some new bays or inlets would be formed and some of them would disappear completely (Figure 9). Similar to the reconstructed islands, Khios and most of the islands having the same geomorphologic characteristics would appear to be very close to the Anatolian mainland. Briefly, this scenario indicates that the Eastern Aegean Islands belong to the Anatolian mainland (Küleli *et al.*,1993; Eryılmaz, 1996).

Sporadhes are placed in front of the Anatolian mainland. The Thasos and Samothraki islands are placed on the Thrace shelf; Gökçeada, Bozcaada, Limni and Ayios Efstratios islands are on the shelf area in front of the Strait of Çanakkale; and finally, the large and small islands between Lesvos and Samos are on the shelf area of the Asia Minor. In addition, the Dodecanese islands, except Rhodes, are placed on the shelf area, which is 90-100 m in depth, of the southwestern Anatolia,. They are not anything other than the natural prolongations of the Anatolian mainland from the point of geomorphologic and geologic views (Erinç and Yücel, 1988).

All of these islands had been forming the high mountainous parts of the western Anatolia before the Mediterranean water invasion. The low altitude areas such as plains and valleys between these high areas are the natural prolongation of the Anatolian mainland inundated after the sea level rise.

Discussion

The actual underwater morphology of the Aegean Sea has been formed of deep depressions with important discontinuities. A series of trench and depressions form a S-shaped structure from north to south in the Aegean Sea. The investigation of the faults that control these depressions and sedimentation indicates that the Aegean Sea and surrounding regions have been exposed to intense tectonic movements from Neogene to the present time. The present tectonic features of the Aegean Sea and surrounding regions have resulted from the complicated plate movements which started from Upper Cretaceous. The graben basins of western Anatolia and the Aegean Sea were evolved under the influence of extensional tectonic regime. During the Messinian, the Aegean Sea and surrounding regions gained a structural shape of grabens, bounded by normal faults. These structures gradually subsided under the influence of extensional regime and invaded by the Mediterranean waters forming the present position of the Aegean Sea. The Anatolian mainland, on the other hand, gained its present position in the Pleistocene by the invasion of the Aegean waters into the grabens on the western Anatolia. A NW-SE trending tectonic event, which is deep originated, caused the evolution of a narrow and long channel on which the Aegean Sea developed in the same direction. This zone corresponds to the series of S-shaped depressions and can be considered as the natural border in the Aegean Sea.

The faulting in the Aegean Sea are in character of listric and normal faults with great displacements. The structural frame consists of a few tens of km structures related with each other. The Neogene faulting in the Aegean Sea is almost coincident with the Neotectonic evolution. The fault systems indicate that the Neogene fault kinematics was developed in two main directions; NE-SW and NW-SE. The Neogene fault trends extend in the direction of ENE-WSW in the North Anatolian Trough, in the eastern part of the Aegean Sea and in the Western Anatolia. Some graben basins which are bounded with W-E normal faults can also be observed in the western Anatolian coasts. The fault trends are in NW-SE direction in the northern part of the North Anatolian Trough and in the western Aegean Sea (including Greece and Cyclads). In the Southern Aegean Sea, they change their directions from west to east; NW-SE (west), E-W (centre) and finally NE-SW (southwestern coasts of Turkey). The direction of fault trends along the North Anatolian Trough changes rapidly in the Northern Aegean Sea. Similarly, this alteration with a sharp turn in the west occurs along the natural border of the trough which extends NW-SE between Sporadhes and Cyclads. On the other hand, the changes of the fault trends are more gentle in the Southern Aegean Sea. A series of troughs is placed at the north of Crete. Consequently, these may indicate that a N-S extensional regime has caused the troughs in the Aegean Sea. These fault trends may possibly compose the western edge of the Anatolian plate.

The faulting is the most effective mechanism to form the highs and lows on land and on sea floor in the region. Not considering the troughs, there is no other boundary structure formed by the Quaternary faulting to disturb the integrity of the region. Hence, the islands of the Aegean Sea are placed on the prolongations of the their mainlands.

If the present sea level was lowered to -200 m, the western coasts of the Anatolian mainland would keep their characteristic features and some of the Eastern Aegean Islands would be connected with the Anatolian mainland. In addition, most of the bays along the western coasts of Anatolia would become land and new bays would be formed on their continuation. This area, which is covered by water except some small islands at present, possesses all of the characteristics of the western Anatolia in all respects.

A large exposed area of seafloor continuing down to the S-shaped depression zone and a very narrow sea between the two mainlands would exist if the present sea level was lowered to -400 m. Most of the Eastern Aegean islands would be added to the Anatolian mainland.

On the other hand, if the present sea level rose up to +200 m, the depressions on the western Anatolia would be invaded by sea, some new bays would be formed and some of them would disappear completely. Most of the islands would be reduced in size and possibly be inundated while some new islands would be developed in western Anatolia.

Consequently, these scenarios indicate that the most of the Eastern Aegean Sea islands are placed on the natural prolongation of the Anatolian mainland. The extension of the Anatolian land mass towards the Western Aegean Sea possesses the characteristics of the Anatolian Peninsula in all respects.

Özet

Ege Denizinin morfolojik yapısının ortaya konması, Doğu Ege Denizinde bulunan bazı adaların, Anadolu'nun doğal uzantısı üzerinde olduğunun saptanması açısından oldukça önemlidir. Ege Denizi'nin morfolojik özellikleri, okyanusal kabuğa sahip bir deniz tabanından son derece farklıdır. Ege Denizinde "S" şeklindeki derin (>1000 m) çukurlukların kenarlarının dik eğimli yamaçlarla çevrili olması ve uzanımlarının doğrusal karakter göstermesi, bunların eğim atımlı normal faylarla geliştiğini işaret etmektedir. Ege Denizindeki sığ kesimler, bitişik oldukları anakaraların morfolojik karakterlerini taşımakta, onların su altında kalmış devamları olduğunu göstermektedir. Bu çalışmada, eldeki jeolojik ve jeofizik verilerden bölgenin güncel denizaltı morfolojik yapısı ortaya çıkarılmış, Doğu Ege Denizindeki Yunan adalarının, deniz alanı çökmeğe başlamadan önce bölgedeki yüksek dağların üst kesimlerini oluşturduğu ve günümüzde sualtında bulunan Doğu Ege Denizinin, Anadolu'nun sular altında kalmış doğal bir uzantısı olduğu belirlenmiştir. Ege Denizinde iki ülke anakaraları arasında doğal bir sınırın daha batıda ve Yunanistan kıyılarına yakın bir yerden geçtiği saptanmış ve bu nedenle Doğu Ege Denizi Adalarının Anadolu'nun doğal uzantısı üzerinde olduğu açıkça ortaya konmuştur.

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References

Akkök, A. (1983). Structural and metamorphic evolution of the northern part of the Menderes Massif: New Data from the Derbent Area and their implications for the tectonics of the massif. *J. Geology* 91: 342-350.

Aksu, AE, Piper, DJW and Konuk T (1987). Late Quaternary tectonic and sedimentation history of outer Izmir and Çandarlı Bays, western Turkey. *Marine Geology* 76: 89-104.

Alan, T.D. and Morelli, C. (1971). A Geophysical study of the Mediterranean Sea.Bull. *Geoph. Teor. Appl.* 13/50: 99-142.

Bilgin, T. (1969). Biga Yarımadası güneybatı kısmının jeomorfolojisi, İ.Ü. Yayın No: 143, 273p.

Brinkmann, R. (1976). Geology of Turkey, 109p.

Brooks, M. and Ferentinos, G. (1980). Structure and evolution of the Sporadhes Basin of the North Aegean Trough, North Aegean Sea. *Tectonophysics* 68: 15-30.

Çağatay, M. N., Görür, N., Alpar, B., Saatçılar, R., Akkök, R., Sakınç, M., Yüce, H., Yaltırak, C. and Kuşçu, İ. (1998). Geological evolution of the Gulf of Saros, NE Aegean Sea, *Geo-Marine Letters* 18: 1-9.

Dewey, J.F. and Ţengör, A.M.C. (1979): Aegean and surrounding regions: Complex multiple and continuum tectonics in a convergent zone, Part 1, *Geol. Soc. Am. Bull.* 90: 84-92.

Eryılmaz, M. (1996). Ege Denizinde Anadolu'nun doğal uzantısının saptanmasında kullanılan yerbilimleri kriterleri, Doktora tezi, İÜ, Deniz Bilimleri ve İşletmeciliği Enstitüsü, 152s, İstanbul.

Erinç, S. and Yücel, Y. (1988). Ege Denizi, Türkiye ile komşu Ege Adaları, Türk Kültürünü Araştırma Enst. Yayını, 84, Seri VII(A.6), Ankara.

Görür, N., Oktay, F.Y., Eryılmaz, M., Bodur, M.N. and Gökaşan, E. (1992). Ege doğal uzantısı. İTÜ ve SHOD ortak raporu, SHOD arşivi, İstanbul, 45p.

Jackson, J.H. and Mc Kenzie, D. (1984). Rotational mechanism of active deformation in Greece and Iran. In Dixon, J.E. and Robertson A.H.F., (eds), The Geological Evolution of the Eastern Mediterranean. Geol. Soc. Special Pub. 17: 743-754.

Jongsma, D., Wismann, G., Hinz, K. and Garde, S. (1977). Seismic studies in the Cretan Sea. 2. The southern Aegean Sea: an extensional marginal basin without sea floor spreading, *Forschungsergebnisse Reichec*, 27.

Küleli, S., Eryılmaz, M. and Yüce, H. (1993). Ege Denizinde Anadolu'nun doğal uzantısı. Türkiye Ulusal Jeodezi-Jeofizik Birliği Genel Kurulu Bildiri Kitabı, 3-20, Ankara.

Le Pichon, X. and Angelier, J. (1981). The Aegean Sea. *Phil. Trans. Roy. Soc.* London, A 300: 357-372.

Le Pichon, X., Lyberis, N. and Alvarez, F. (1984). Subsidence history of the North Aegean Trough, In Dixon, J.E. and Robertson, A.H.F. (eds), The Geological Evolution of the Eastern Mediterranean. Geol. Soc., Blackwell Scientific Publ. Special Publication 17: 727-741.

Lyberis, N. (1984). Tectonic evolution of the North Aegean Trough. In Dixon, J.E. and Robertson, A.H.F., (eds.), The Geological evolution of the Eastern Mediterranean. Geol. Soc., London, Blackwell Scientific Publ. Special Publication 17: 709-725.

Martin, L. (1987). Structure et evolution recente de la mar Egee apports d'une etude par sismique reflexion. SNEACPJ-PAU, lab de Geody. Sous-Marine, Villefrance sur mer, Uni. Pierre et Marie-Curie, Paris.

Mascle, J. and Martin, L. (1990). Shallow structure and recent evolution of the Aegean Sea: A synthesis, based on continuous reflection profiles, *Marine Geology* 94: 271-299.

Mc Kenzie, D. (1978). Active tectonics of the Alpine-Himalayan Belt: The Aegean Sea and surrounding regions (Tectonics of the Aegean region). *Geophys. J. R. Astron. Soc.* London, 55: 217-254.

Morelli, C., Pisani, M. and Gantar, C. (1975). Geophysical studies in the Aegean Sea and in the Eastern Mediterranean. *Bull. Geoph. Teor. Appl.* 18(66): 127-178.

Needham, H.D., Le Pichion, X., Melguen, M., Pautot, G., Renard, V., Avedik , F. and Carre, D. (1973). North Aegean Sea through: 1972 *Jean Charcot* Cruise. *Bull. Geo. Greece*, 10: 152-153.

Ţengör, A.M.C. (1979). North Anatolian Transform Fault: its age, offset and tectonic significance. *J. Geol. Soc.* London. 136: 269-282.

Şengör, A.M.C. (1980). Türkiye'nin neotektonik esasları, TJK, Konferans serisi, 2, s.40.

Şengör, A.M.C. and Yılmaz, Y. (1983). Türkiye'de Tetis'in Evrimi: Levha Tektoniği açısından bir yaklaşım, T.J.K. Yerbilimleri Özel Dizisi, No:1.

Taymaz, T., Jackson, J. and Mc Kenzie, D., (1991): Active tectonics of the North and Central Aegean Sea. *Geophysics. J. Int.* 106: 433-490.

Turgut, S. (1987). Ege Denizi ve dolaylarının tektonik evrimi ve hidrokarbon olanakları, TPAO, Ankara.

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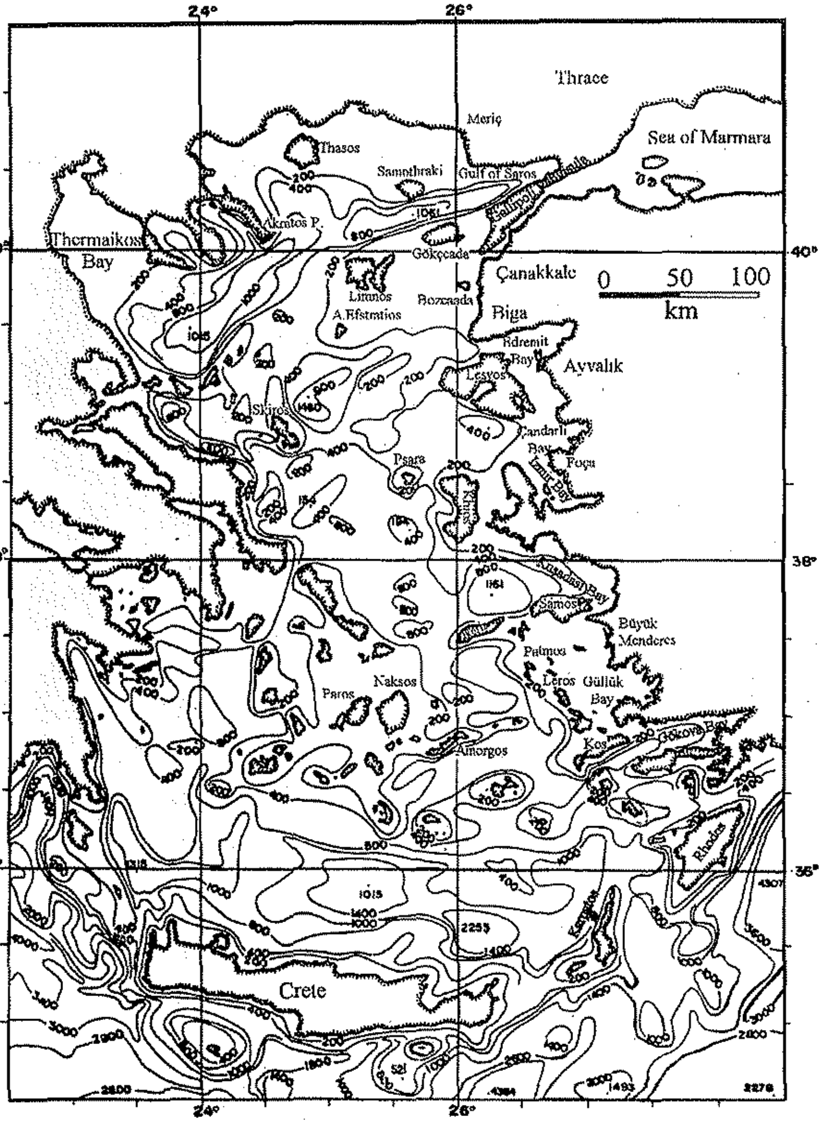

Figure 1. Bathymetric map of the Aegean Sea

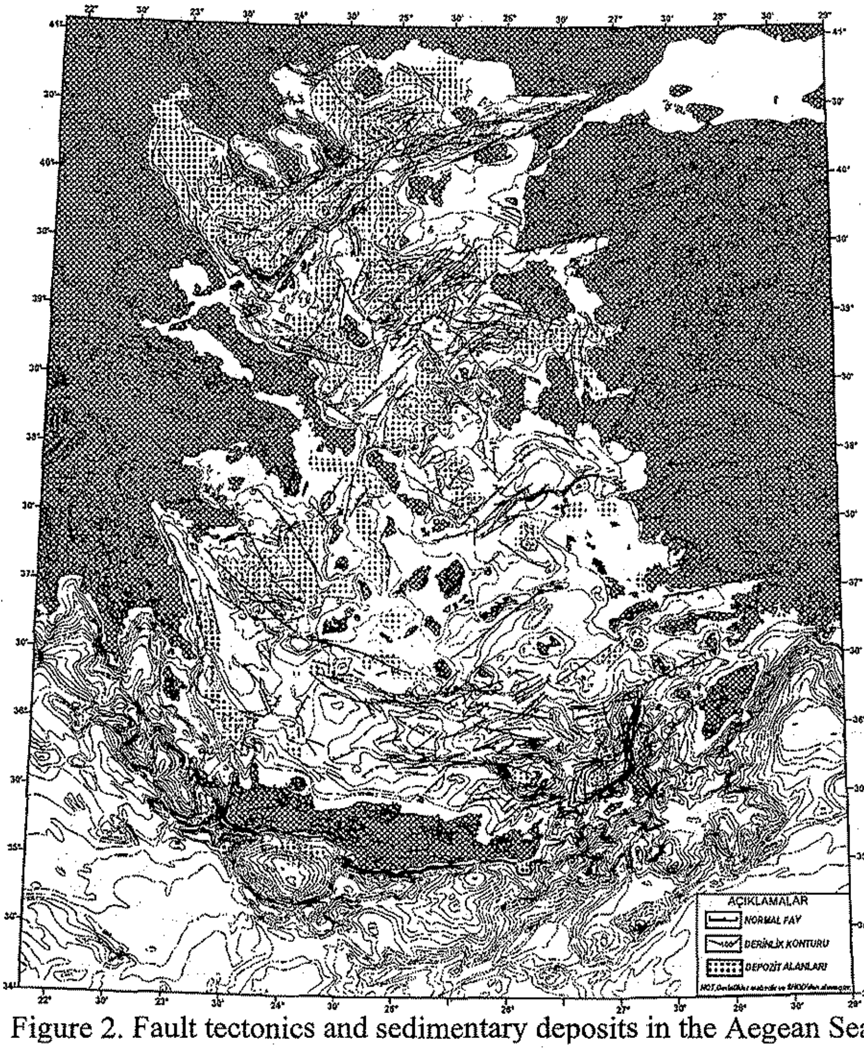

Figure 2. Fault tectonics and sedimentary deposits in the Aegean Sea.

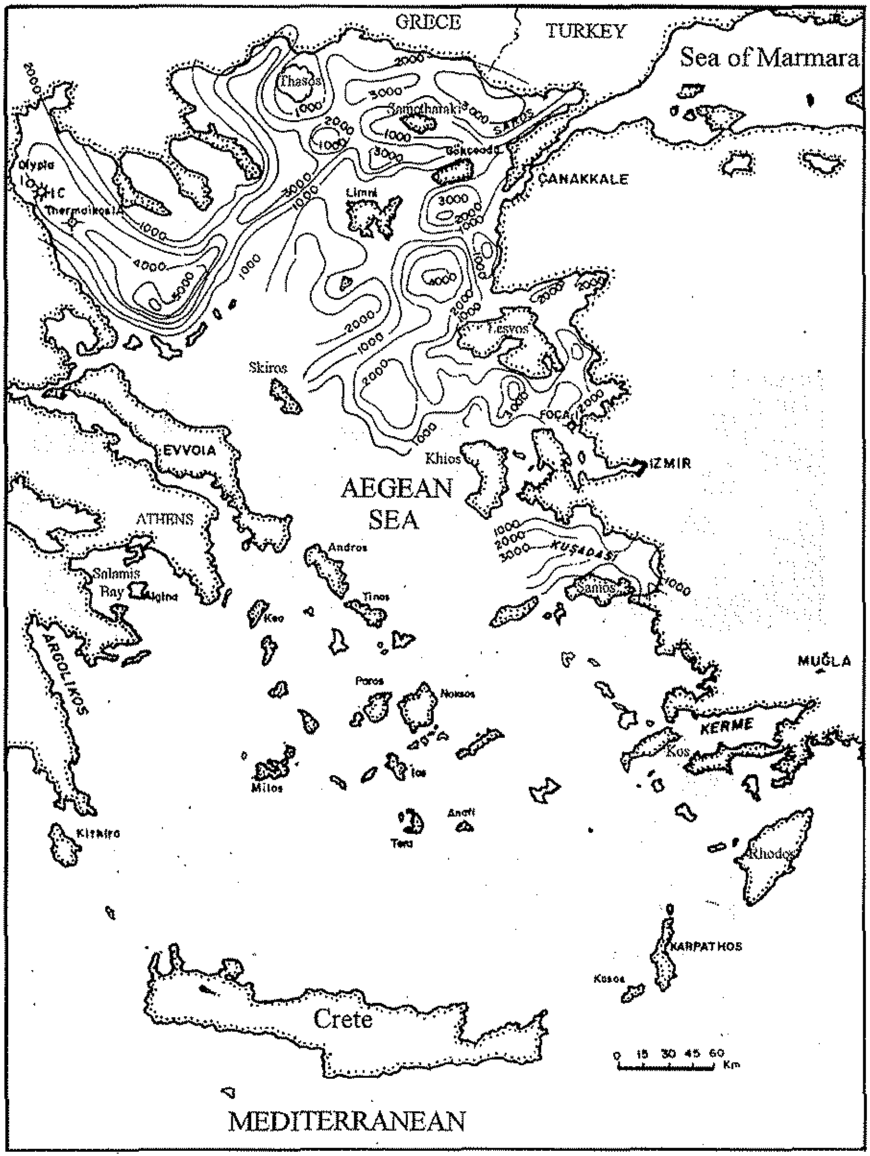

Figure 3. Sediment thickness in the Aegean Sea (Turgut, 1987).

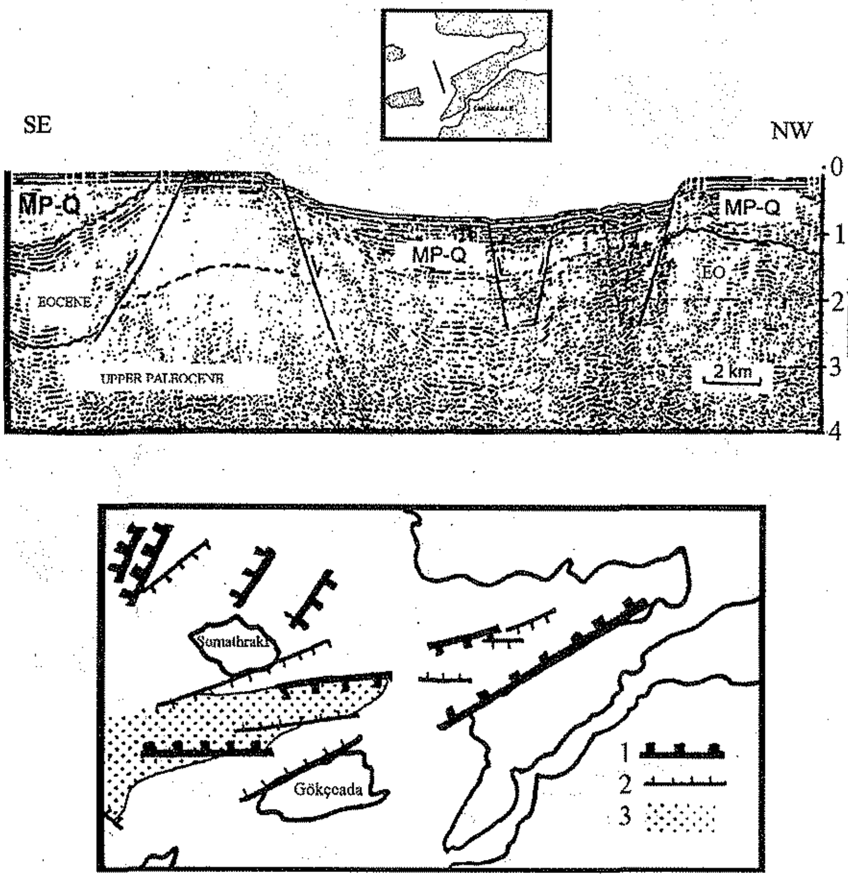

Figure 4. Seismic reflection line between Gulf of Saros and Gökçeada and simplified structural map of the area. 1. Main normal faults, 2. Normal faults, 3. Plio-Quaternary depositional areas.

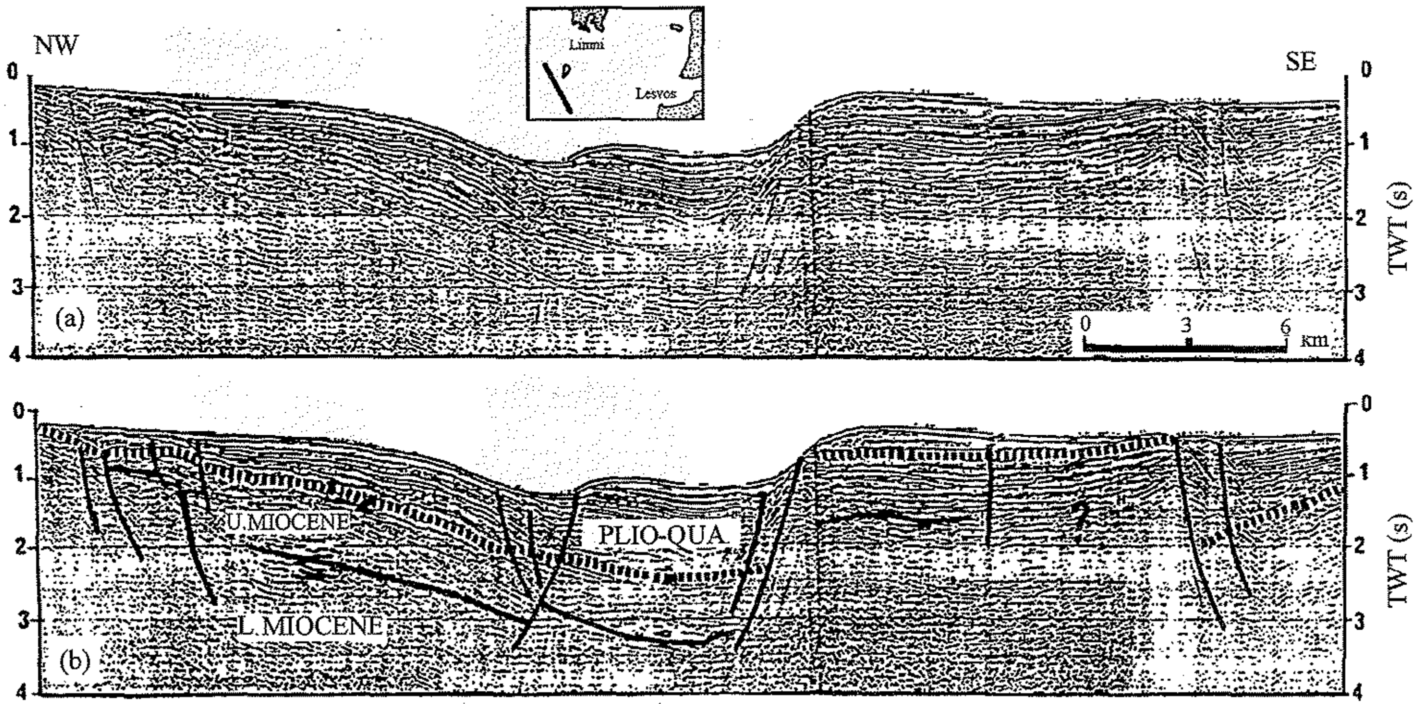

Figure 5. (a) Uninterpreted seismic section in the Middle Aegean Sea, offshore Edremit Bay (Martin, 1987), (b) Its interpretation showing graben structure and depositional sequences.

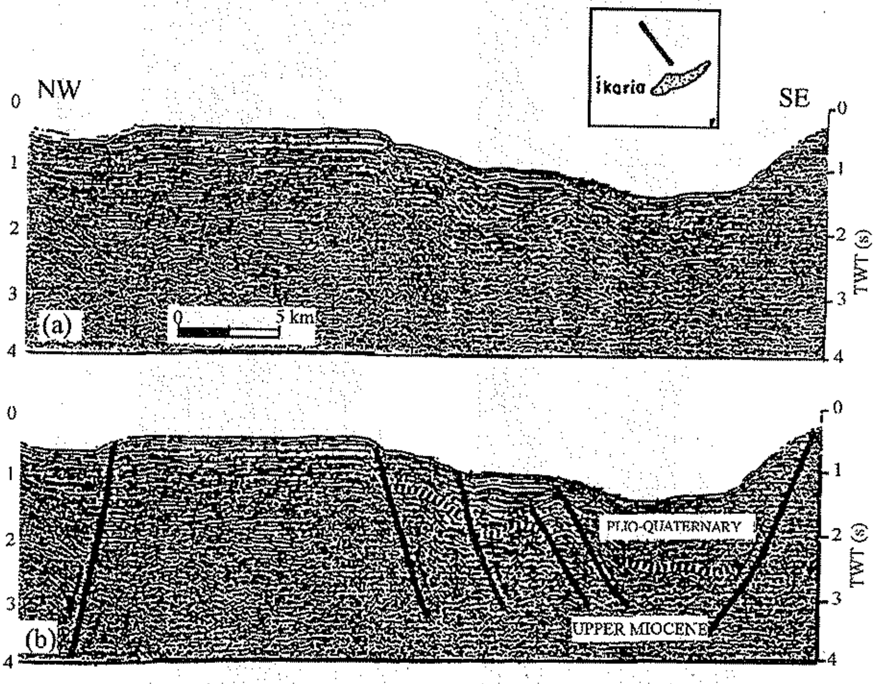

Figure 6. (a) Uninterpreted (Martin, 1987) and (b) interpreted seismic profiles showing deposits in the Samos-Ikaria Basin, extension of the Menderes Graben System in the Southern Aegean Sea.

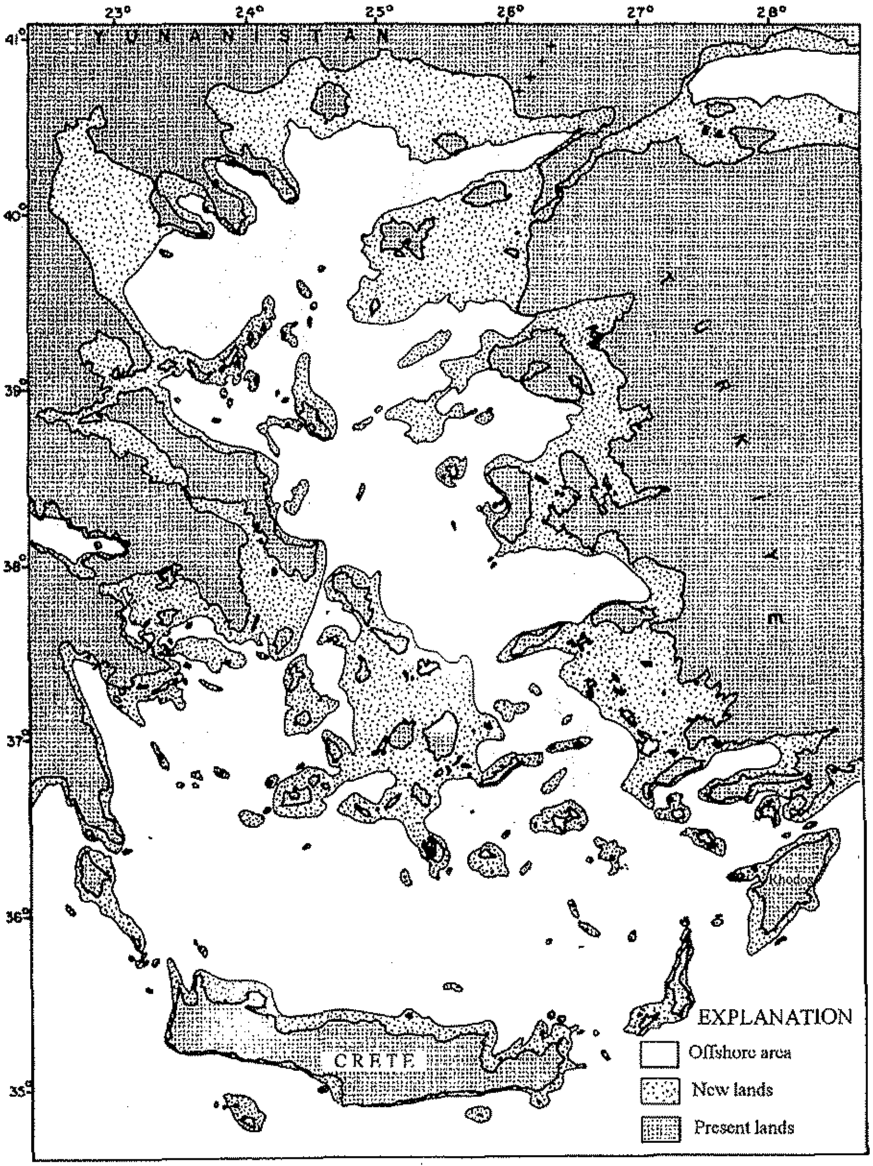

Figure 7. The case if the sea descented 200 m below the present level (modified from Küleli et al., 1993). Dotted area represents the gained lands.

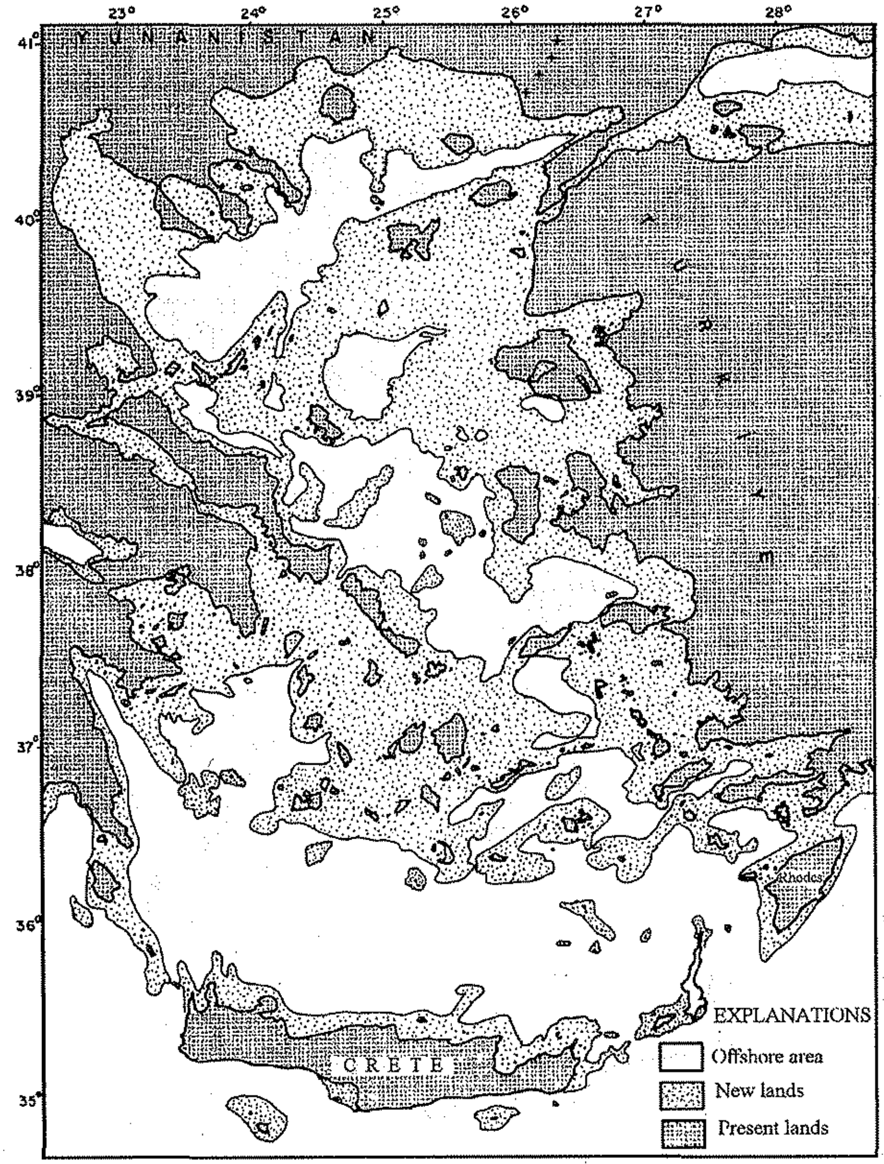

Figure 8. The case if the sea descented 400 m below the present level (modified from Küleli et al., 1993). Dotted area represents the gained lands.

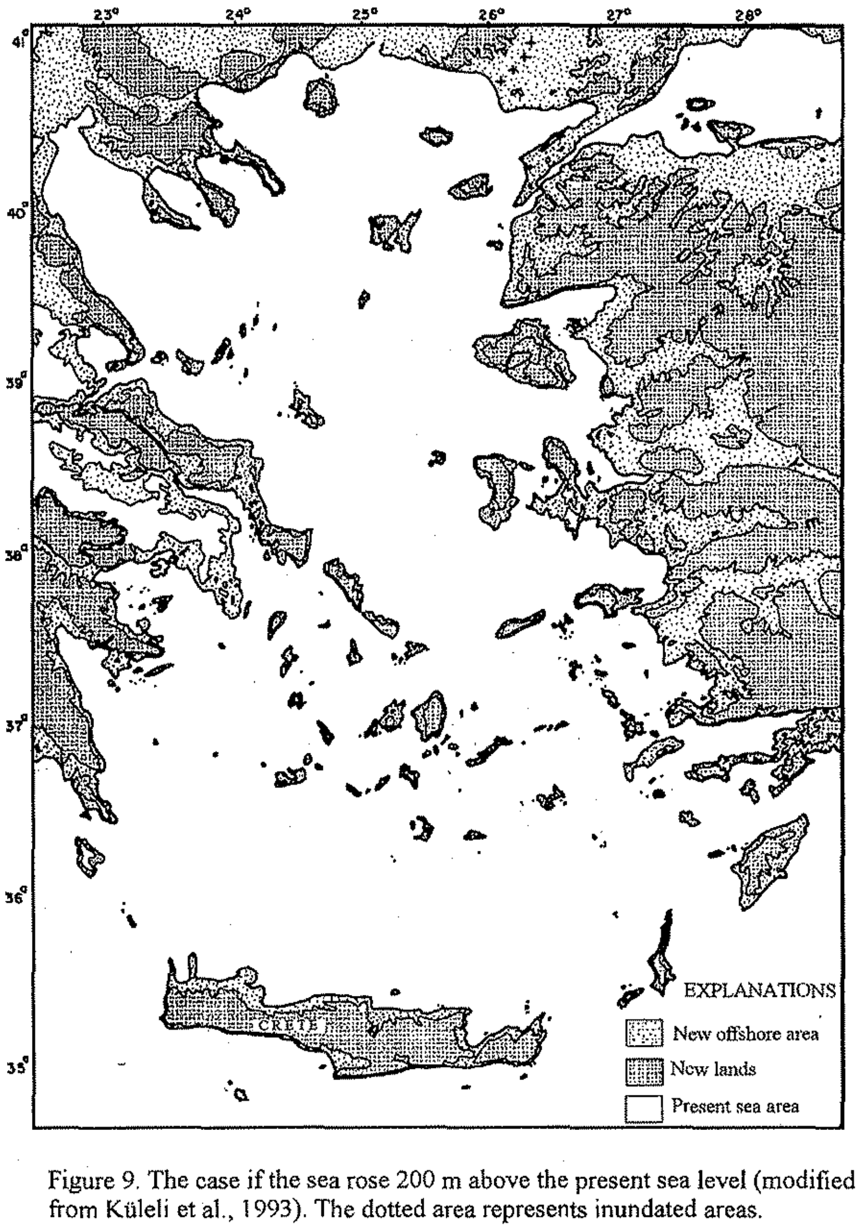

Figure 9. The case if the sea rose 200 m above the present sea level (modified from Küleli et al., 1993). The dotted area represents inundated areas.