

**Physical properties of beachrocks on the coasts of
Gelibolu Peninsula and their contribution to the
Quaternary sea level changes**

**Gelibolu Yarımadası kıyılarındaki yaşıtaşlarının
fiziksel özellikleri ve Kuaterner deniz seviyesi
değişimlerine katkısı**

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Abstract

Beachrock formation developed at two different localities at the coasts of Gelibolu Peninsula. Geomorphological, geological, and tectonic properties of the coastal area have been considered in this study. All beachrock localities have been investigated in detail considering their material types, sequences, structures and depositional localities. It was concluded that the beachrocks observed in a distance of 8 to 15 meters from the present shoreline were found under the present sea and they have been tectonically uplifted. Sea level changes and tectonic activity of the coastal area have been explained owing to the properties of these young formations.

Keywords: Beachrock, Sea level change, Gelibolu Peninsula, Gulf of Saros, Strait of Çanakkale.

Introduction

Beachrock is a type of layered sandstone or conglomerate including sand, pebble, mineral pieces, and also artificial material such as brick and glass fragments. All these components connected by carbonate cement results in the formation of beachrocks. It is generally accepted that fundamental formation environments of beachrocks are tropical and subtropical coastal regions. In addition, beachrocks are widespread in the latitudes of 30° to 40°, where the sea water temperature is ranging between 15°C and 30°C (Erinç, 2000). The beachrocks are used to reveal the ancient sea level traces. Thus, it becomes possible to comprehend the paleo-bathymetric conditions along coastal zones.

Number of investigations on the beachrock formations on the coasts of Turkey increased in last two decades (Goudie, 1966; Erol, 1971; Erinç, 1973; Bener, 1974; Avşarcan, 1997; Yalıtırak et al., 1998 a,b; Yalıtırak et al., 2000; Sakınç et al., 2001; Ertek and Erginal, 2002). The coasts of İznik Lake (Kayan, 1993) and the coasts of Western Black Sea (Şile) (Ertek, 2001) have recently been described as other well-known beachrock localities. A recent investigation has also shown that the coasts of Western Black Sea constitute a different beachrock locality in Karaburun-Kilyos coastal area (pers. comm. to H. Turoğlu 2002). Thus it is comprehended that the beachrocks have formed in almost all coasts of Turkey, and they have lithologically and structurally distinctive properties.

Gelibolu Peninsula is located between the northern latitudes of 40° 02' to 40° 36' (Fig. 1). Beachrocks on the coasts of the peninsula have been studied by considering all of their observable physical properties. It was aimed to explain their relations both to the Quaternary sea level changes and the tectonics of the Gulf of Saros and Gelibolu Peninsula. In addition, the origin areas of carbonates and clastics within the beachrocks have been examined since the lithology of the peninsula is partly responsible for beachrock formation (Fig. 2). The beachrock localities in the study area have been classified in two groups.

1. Localities of the Gulf of Saros:

1.a. Arıburnu (L1)

These beachrocks containing sandstone and limestone pebbles cemented by carbonate shafe firstly been determined by the authors near Arıburnu site (Fig. 3 A, Photo 1 A,B). The beachrocks are dipped about 10° to the northwest. The stratum direction is measured SW-NE in beachrock strata. Beachrocks are found 20 cm above the sea level and continue about 15 m towards offshore. The beach sands cover these beachrocks. Finally, marine terrace, which is 5 m above the mean sea bounds the beachrock zone at the back.

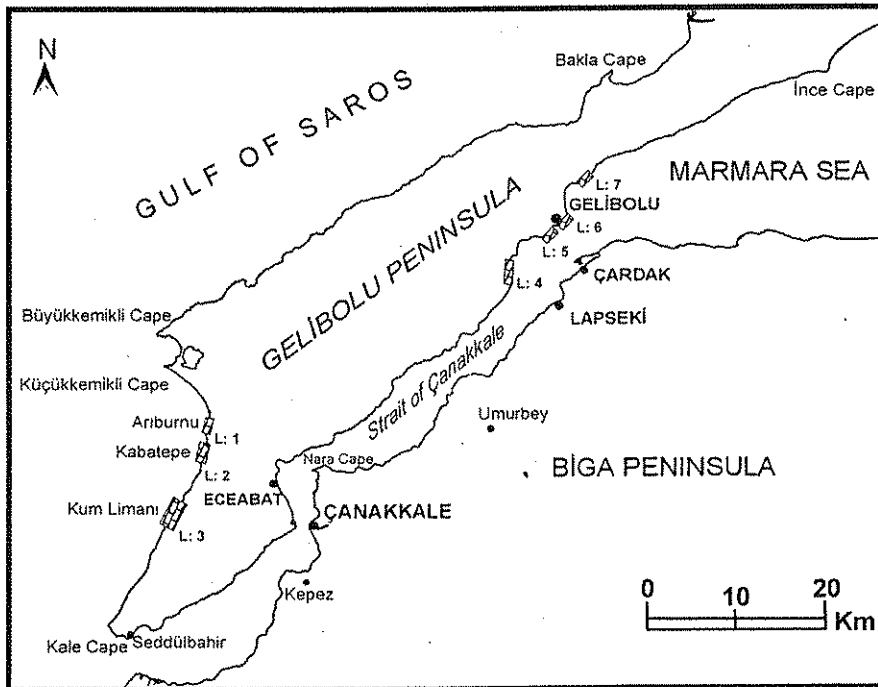


Figure 1. Beachrock localities at the coasts of Gelibolu Peninsula.

1.b. North of Kabatepe (L2)

A beachrock formation zone near the sea level has been observed to the north of Kabatepe site (Fig. 3 B, Photo 2). This locality was first discovered by Erol (1971). The length of the beachrock zone in

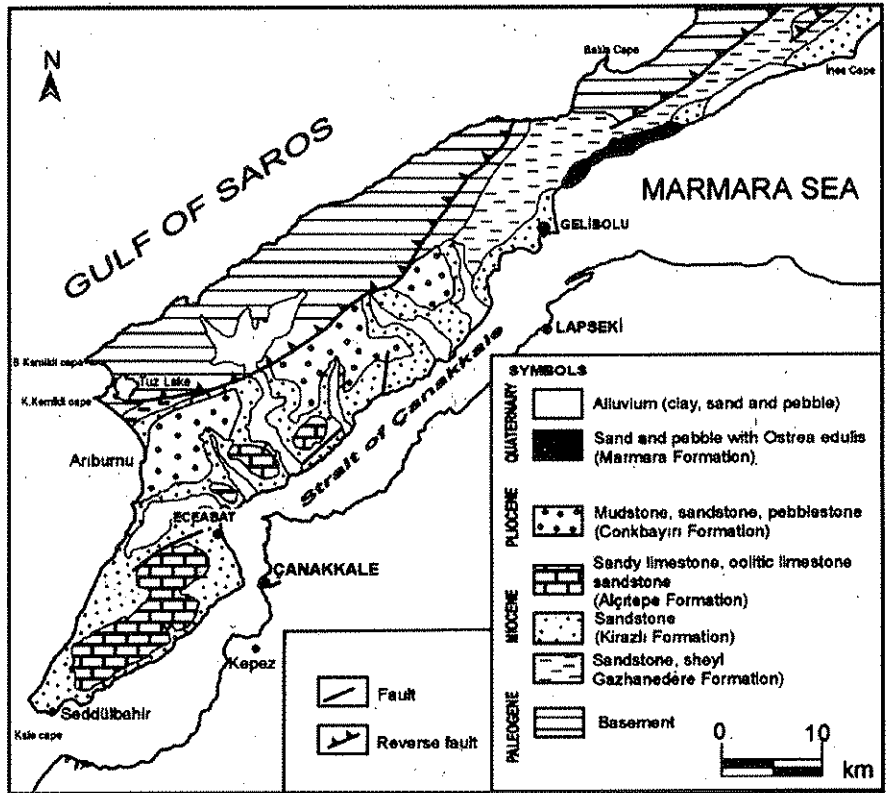


Figure 2. Geological map of Gelibolu Peninsula.

N-S direction is 100 m and its width is about 15 m in average. According to our measurements, 36 cm of the formation, in average, is found above the sea level, whereas, the thickness of those remained beneath the sea level was observed to be 48 cm. Beachrocks have a dip angle of 25° to ENE. The stratum direction is SSE-NNW in general. The average thickness of beachrock strata ranges from 2 to 7 cm. Deformation caused by the wave activity is evident and fracture systems of miscellaneous directions might have been resulted from tectonic movements. Beachrocks covered with mosses continue northward about 1 km under the sea.

1.c. Kum Limanı (L3)

This beachrock locality is situated 4 km south of the Kabatepe site (Fig. 3 C, Photo 3 A,B). The most conspicuous beachrock formation in Gelibolu Peninsula is observed in this locality. Erol

(1971) first clarified some features of the beachrocks considering other coastal landshapes around Kum Limanı.

The beachrocks extend about 650-700 m along the shoreline at a direction of N-S. The 2-meter-level coastal sand dunes bound the beachrocks at the onshore. Coarse sand and pebbles of radiolaria, quartzit, limestone and shells are found within the sequence. The height of the beachrock zone reaches up to 50 cm towards the Semer Cape to the north. The dip direction in this beachrocks is 15° westwards. The stratum direction has been measured as NNE-SSW. Beachrocks terminate at the mouth of a small creek to the south where a placer formation existed in a local area.

It is concluded that this fine-developed beachrock zone along the N-S oriented shoreline is composed of sand and pebbles. This zone should have developed as a coastal spit prior to the cementation processes, which occurred according to a former sea level. This coastal spit extends from north to south. The gradual growing of the pebble sizes towards the north indicate that the coastal spit was beginning from the Semer Cape and it progressed southwards in the course of time. Diminishing of the material sizes towards the south also support this idea. As a matter of fact, this condition is contrary to the northward trending present current system. Thus, due to the existence of an old bay with 250 m width, the current system converted to southward. As result, the beachrock formation in Kum Limanı site developed in this direction.

At the southern parts of the sequence, huge pebble zones have been observed. These are found at the east side of the beach. This condition might be caused by the high wave energy. During these periods, waves might have reached the storm sets, causing the the formation of gaps along the coastal spit. The complex fracture systems possibly resulted from tectonic movements should have been enlarged by the wave activity coming from the west. When waves passed the storm sets, water channels were formed behind the coastal spit and thin materials have probably been deposited along this N-S aligned shallow channels. This is evident from the fine sandy materials observed among the pebble layers.

2. Localities of the Strait of Çanakkale:

2.a. North of Munipbey Delta (Gelibolu) (L4)

Beachrock formation have been observed at the north of the delta of Munipbey stream (Fig. 4 A, Photo 4 A,B), which has one of the most important drainage catchment areas in Gelibolu Peninsula. Carbonate-cemented beachrocks in this locality display two different forms. The first one is composed of blocks and pebbles, while the second one is formed by thinner materials including abundant of shells.

As seen in many of beachrock localities in Gelibolu Peninsula, beachrocks in this locality are also bounded by marine terraces at the back. Upper Miocene marls are covered by marine terraces with a thickness of about 19,5 m. Since the observable thickness of marls was measured as 3 m above the sea level. Thus, it is concluded that the uplift rate behind the beachrocks can be assumed to be about 22 m. Carbonate input has been supplied by Miocene marls and dense "ostrea edulis" zone (Yaltrak et al. 1998) at the back. In addition, we presume that the Kirazlı formation including sandstone ones with carbonate cement might have produced the conjunctive material all along the shoreline (Figure 2).

The stratum dip of marine terraces is 15° ENE and the stratum direction is NNW-SSE. These measurements are parallel to those of beachrocks. The wave break zone shows that beachrocks continue about 8.5 m offshore. Beachrocks have been observed up to 60 cm depth below the sea level. The maximum level has been measured as +60 cm. Beachrocks are broken due to the wave activity.

Fragmented shells have played an important role in cementation. They appear to be same with those observed within the marine terraces. Thus, it verifies that the carbonate input from marine terrace was considerably high and the beachrock formation occurred along a narrow beach in front of the marine terrace deposits. That is, beach material composed by sand, pebbles and blocks cemented with debris fragments, resulted in beachrock formation. Marl,

sandstone, quartz, serpentine and shells form the components of the sequence.

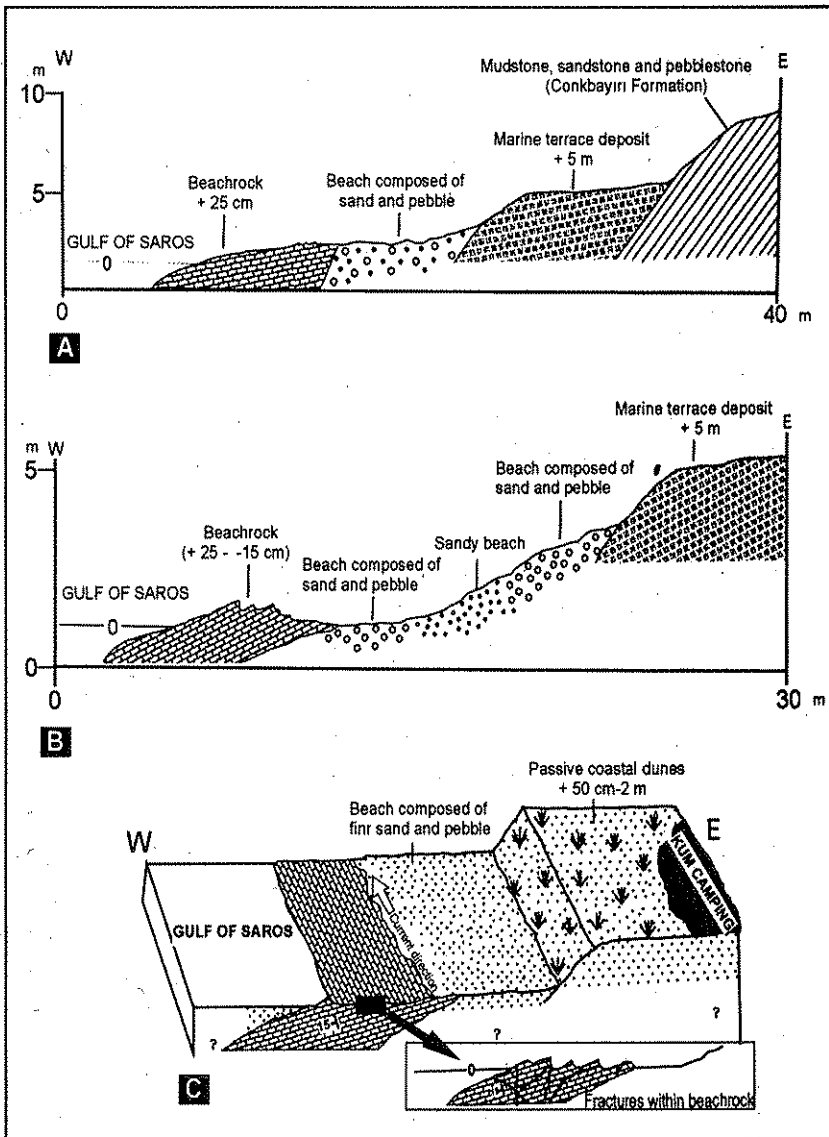


Figure 3. Coastal profiles at the Saros localities A: Arıburnu locality B: North of Kabatepe site C: Kum Limanı site

Finally, good reaction with hydrochloric acid (HCl) was observed on the present beach material, demonstrating a recent constitution along the beach.

2.b. The site of Gelibolu-Officer's club (L5)

In this locality, average elevation of beachrocks reaches up to 140 cm. Beachrocks have a ESE-dip of 15° toward the Strait of Çanakkale (Fig. 4 B, Photo 5 A,B). The stratum direction is NE-SW. The components in sequence formed by flat and rounded pebbles, which are composed by quartz, limestone, green schist. Abundant shells are mixed with the pebbles. Thickness of beachrocks ranges from 3 cm to 13 cm upwards. Abrasional platforms having a width of 10-15 m have also formed on the stratum planes of beachrocks. Beachrocks are observed at - 60 cm depth below the sea level and have tectonically-induced fractures. In addition, corrosional pits and bioconstructive forms have developed over the beachrocks.

2.c. The site of Gelibolu-Teacher's guest house (L5)

Beachrocks in this locality have an average elevation of 140 cm. They have been fragmented to pieces because of wave activity. Corrosional notches, natural bridge are formed on beachrocks, which are composed of radiolaria and serpentine blocks (Photo 5 B). The dip measurements indicated a ESE direction with a value of 20° - 90° . Stratum direction is NNE-SSW. Some indentations toward the land have been observed on beachrocks. This is because of the fractures of 7 m long. These fractures are perpendicular to the stratum direction and have been expanded by wave activity. The sequence includes abundant of shells. It is seen that the beachrock zone is bounded by marine terraces (Yaltrak et al., 1998). The distance between offshore and onshore parts of beachrocks is about 40 m, implying the former shore line over which the beachrock formation developed. The continuation of the beachrock zone towards the land should have later been covered by asphalt road. Additionally, a piece of brick has been determined indicating a historical record. Finally, bio-constructive forms developed on the beachrocks in part. The beachrocks observed at the south of Hamzakoy site show almost the same physical characteristics. Their

dip is 65° toward NW and they have 140 cm elevation from sea level. They are also found – 65 cm depth at 20 m offshore.

2.d. The site of Yıldırım Kışlası(L6)

This locality is situated at the north of Hamzakoy site (Fig. 4 C, Photo 6). The beachrocks which are bounded by a marine terrace to the west have a dip of $75-80^\circ$ ESE.

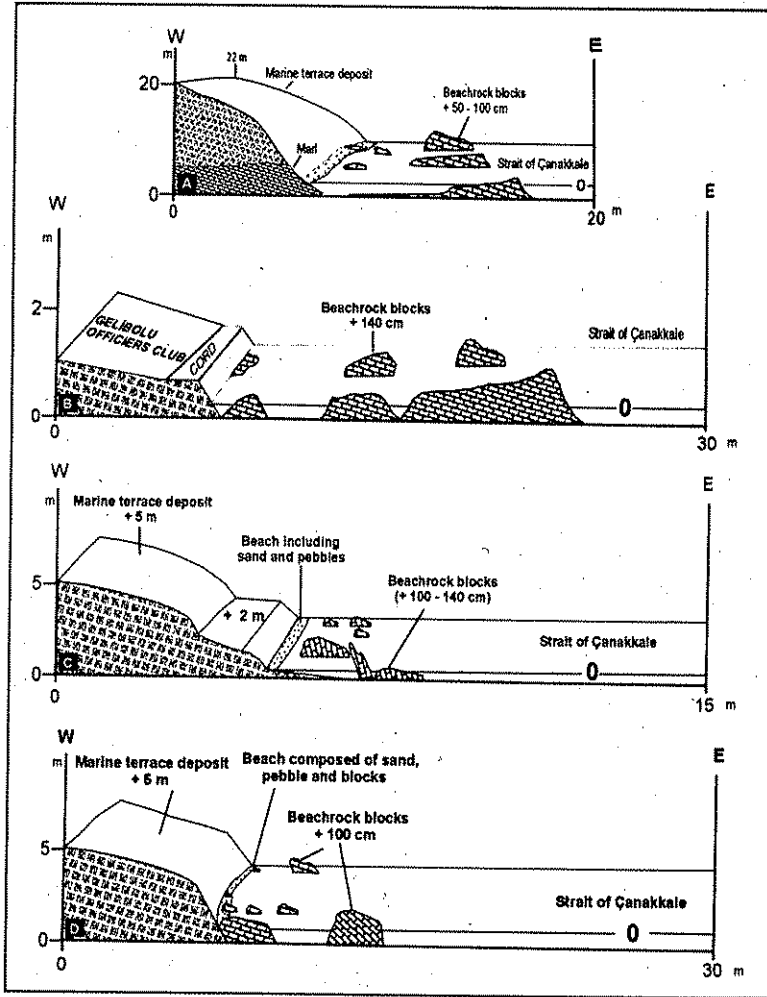


Figure 4. Coastal profiles at the Gelibolu localities A: North of Münibbey Delta. B: Site of Gelibolu Officer's Club. C: Site of Yıldırım Kışlası. D: Site of Çakırağa Çiftliği.

In other words, they separate the marine terrace from the sea, which demonstrates that the beachrock formation was developed in a belt of 40-50 m width. Nevertheless, pumices have been observed along the present beach at the north of this site.

2.e. The site of Çakırağa Çiftliği (L7)

Along the narrow beaches at this site, beachrocks are found in front of a marine terrace, which creates a 5 m morphologic step (Fig. 4 D, Photo 7 A,B). They continue offshore and reach up to 100 cm in altitude. The amount of shells reduces and small pebble-dominated composition is characteristic in beachrocks. As a matter of fact, two types of beachrock are observed along the shoreline. First one, which has a dip of 25° SSE and a stratum direction of NE-SW, is composed of coarse sand and pebbles of limestone and quartz. Calcite fillings are present at stratum spaces. The general thickness of the sequence is 7-13 cm.

The latter consists mainly of sandy bands and pebbles of metamorphic and carbonate rocks. Dip of the sequence is 40° SSE and the direction is ENE-WSW. The average stratum thickness is 6-8 cm.

Results

Beachrock formations placed at both sides of the Gelibolu Peninsula, Gulf of Saros and the Strait of Çanakkale were studied. These formations have different characteristics in terms of elevation, texture, structure, material composition, stratification and inclination. Formation of beachrocks is based on a few factors. For instance, sandstones of carbonate cement forming Conkbayırı and Kirazlı formations in the locality of the Gulf of Saros might have played an important role. Whereas, Gazhane Formation including carbonate cement around Gelibolu city appears to be effective on producing connective material. In addition, the Marmara Formation has a great influence on beachrock formations in the study area due to the fact that its high shell content held producing carbonate input. Especially, the closeness of marine terraces to the sea might have been responsible for rapid cementation all along the Gelibolu localities (L4-7 in Fig. 1).

It was comprehended that each beachrock locality is not found at river mouths on the contrary to the general concept accepted so far. The beachrocks in the peninsula are bounded by marine terraces in general. Thus, they might have developed in front of narrow and high shorelines.

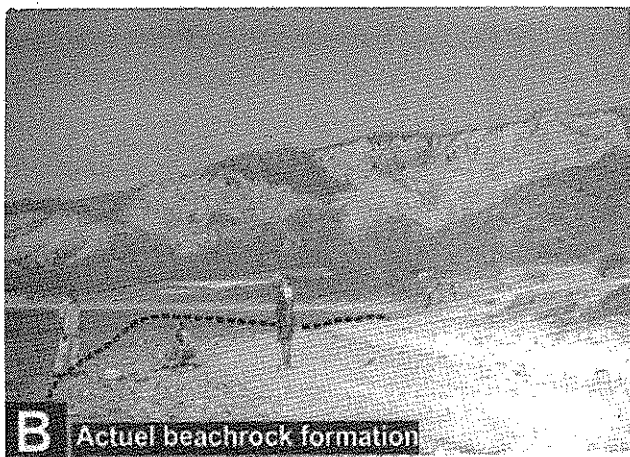
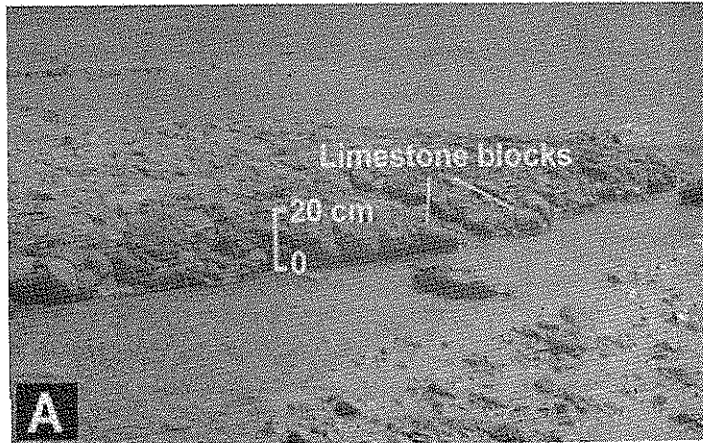


Photo 1 A-B: Actual beachrock formation on the Arburnu coasts (L1 in fig. 1)

Beachrocks situated at the Gulf of Saros localities (L1-3 in Fig. 1) have been dip $10-15^\circ$ eastward. These are found at the levels near the normal formation environment, -65 cm to $+50$ cm. But they are found between the levels of -65 cm and $+140$ cm in Gelibolu

localities, which indicates that they have been uplifted. These are slanted 10-75° towards the Strait of Çanakkale. Thus, it is concluded that the coasts of Gelibolu Peninsula might have been deformed differently at two sides, resulted from the uplift of the peninsula along its SW-NE axis. Inclinations towards the each side might likely be related to the graben formation at the Gulf of Saros to the west and at the northeast part of the Strait of Çanakkale (Demirbağ et al, 1998).

As comprehended from the arrangement of materials from the west to the east, the long beachrock zone at Kumlimanı locality (L3 in Fig. 1) has been assested here as an ancient coastal spit. Beachrocks in this locality formed in close front of the present shoreline, extending 8-15 m far. The coastal current, which enabled the formation of beachrock, might have been similar present condition.

The marine terraces have been evaluated as prime factor for producing beachrocks. Indeed, the plentiful carbonate content of the terraces enabled the loose beach materials to be cemented in the study area. High "*Ostrea edulis*" content in these terraces should be assested as the principle factor. The sandstones of Kirazlı Formation and limestones of Alçitepe Formation can be considered as other carbonate sources.

The beachrocks we studied have been formed 8-15 m offshore from the present coastal line, which shows the sea level during the depositional period. The water depth along this band varies between 40 and 65 cm. This depth is assumed to be the paleo-shoreline during 3660 and 3660±157 BP. The calculations of Yaltrak et al (1998), who were dated the marine terraces situated Gelibolu and İyisu localities, was considered to draw this conclusion.

Beachrocks in Gelibolu localities have been uplifted up to 140 cm due to the rising of the peninsula. According to the calculations of Yaltrak et al (1998 a), it was explained that an uplift of 40,5 m in Gelibolu and 26 m in İyisu marine terrace localities occured. Thus we concluded that the beachrocks have totally been rised about 0.73 m, indicating an uplift of 0.2 mm per year.

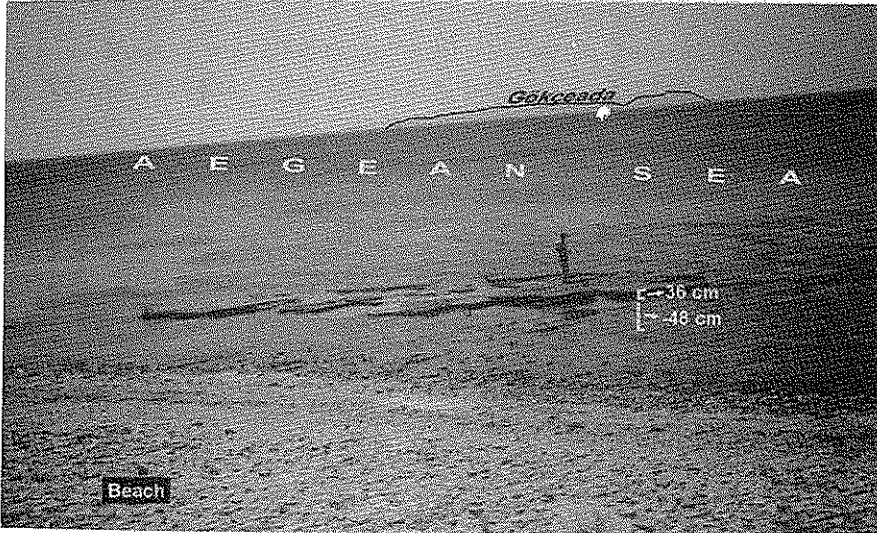


Photo 2: Beachrock zone at Kabatepe Site (L2 in fig. 1)

In this study, some exotic pebbles and blocks, which are not included in the lithology of the peninsula, have been determined.

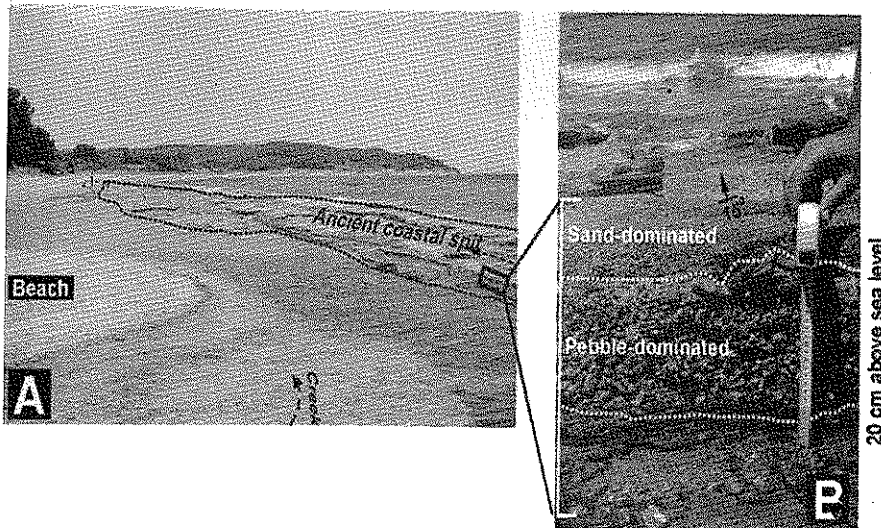


Photo 3 A-B: Beachrock zone (A) and sequence view (B) at Kumlimanı site (L3 in fig. 1)

The pebbles of metamorphics, serpentine might have been carried by the paleo-currents. Much of these materials are placed at the Biga Peninsula (Fig. 2. The exotic materials are not determined at Saros localities (L1-3 in fig. 1).

Thus, it is questionable that the water linkage along the Kabatepe-Eceabat corridor was existing, at least, during the deposition of beachrock formations. Now that we observed the external limit of the Kumlimanı beachrock zone at about 8-15 m offshore, there was no connection when the sea level was at the depth of -65 cm.

There should be a correlation between the beachrock zone and abrasional platform observed up to 15 m offshore along Kumlimanı locality, since this platform extends up to the same limit with beachrock zone, the ancient coastal spit. Consequently, it is concluded that the date of beachrock formation might be correlated to the coastal regression, relatively. Finally, Avşarcan (1995) implied that the beachrocks in Turkey are slanted $2-7^{\circ}$ in general. In this study, we determined the degrees between $10-75^{\circ}$, which might be related to the tectonic activity of the area.

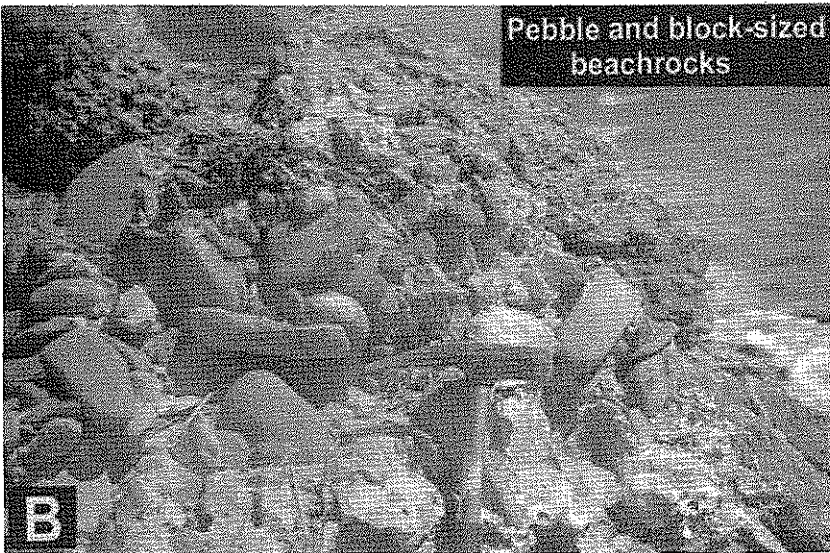
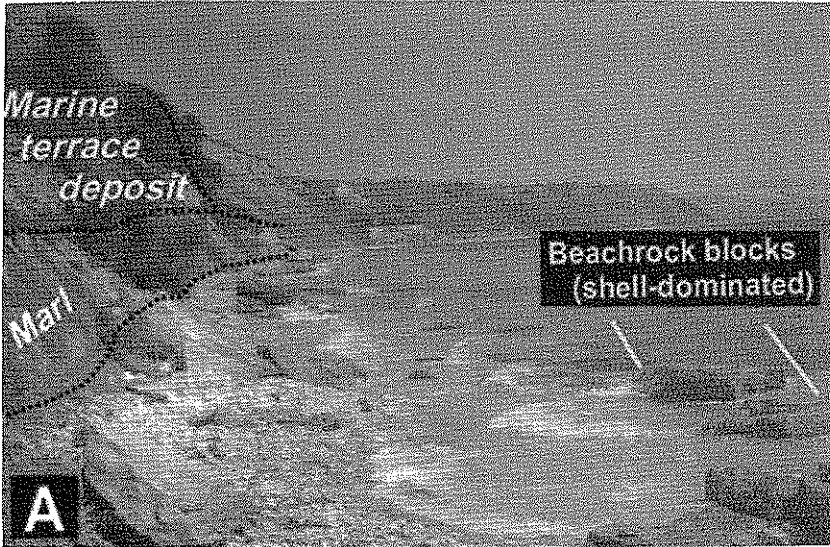


Photo 4 A-B: Beachrocks at the north of Münipbey delta. (Looking to north (A) and sequence composition (B) (L4 in fig. 1).

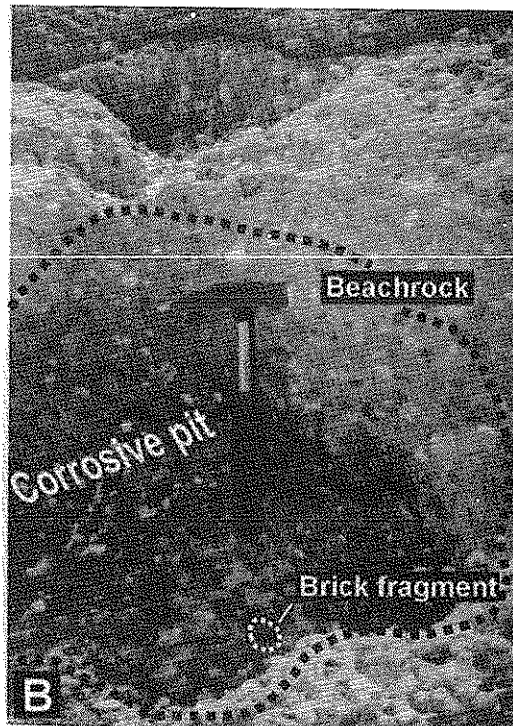
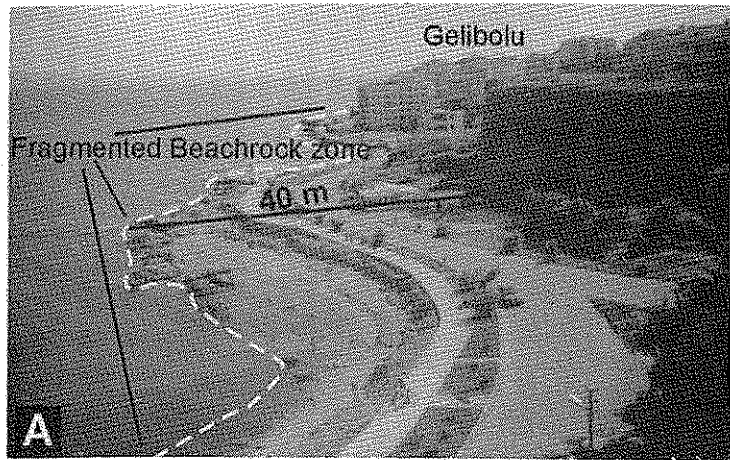


Photo 5 A-B: Fragmented beachrock zone(A) and sequence view(B) between Gelibolu Officer's club and Hamzakoy site (L5 in fig. 1).

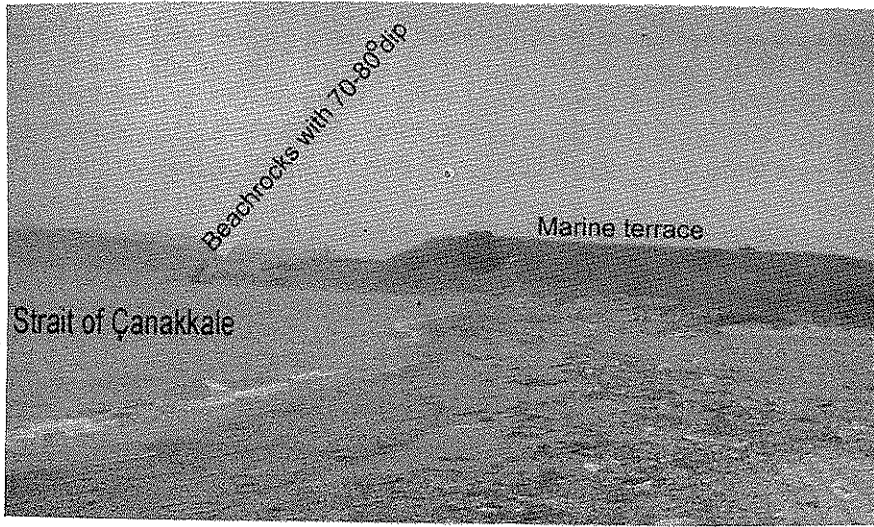


Photo 6: Beachrocks at Yıldırımkişlası site (L6 in fig. 1).

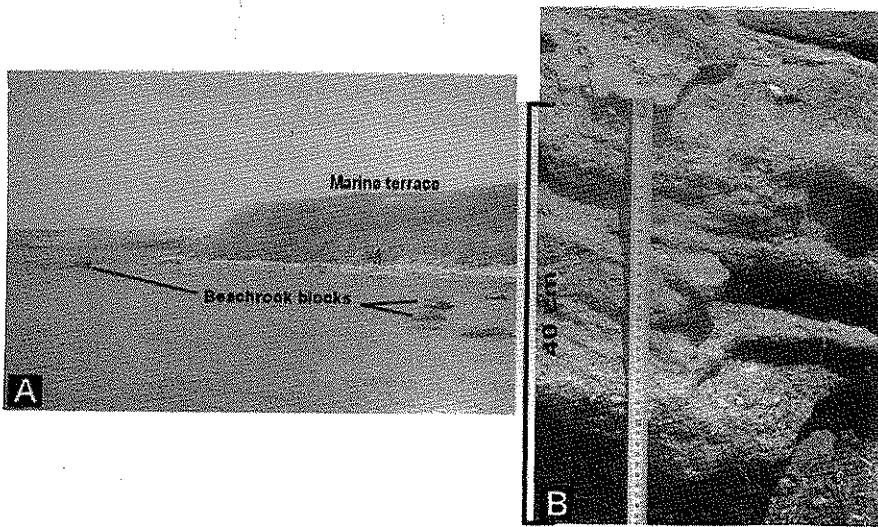


Photo 7 A-B: General view of fragmented beachrocks in Çakırağa Çiftliği locality (A) and sequence view (B) (L7 in fig. 1).

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Özet

Bu çalışmada Gelibolu Yarımadası'nın Saros Körfezi ve Çanakkale Boğazı her iki kıyısındaki yalıtışları ele alınmış ve bu genç oluşukların fiziksel özellikleri tanıtılarak gelişimleri üzerinde durulmuştur. Unsur içerik ve boyutları, bağlayıcı madde, yükselti, tabakalaşma gibi özellikleri ile oluştukları eski deniz seviyesi gibi özellikleri ele alınan yalıtışlarının bölgenin aktif tektoniğinden kaynaklanabilecek yapısal unsurlara sahip oldukları görülmüştür. Yalıtışlarının Gelibolu Yarımadasındaki kubbeleşme ve yarımadanın her iki yanındaki çökme rejimlerinden etkilendiği anlaşılmış, ayrıca oluşum senaryoları üzerinde durulmuştur. Bu konuda en ilgi çekici olan Kumlımanı lokalitesinde çalışılan yalıtışı zonunun eski bir kıyı okunun yalıtışı konumuna geçmesidir. Ayrıca özellikle boğaz kıyısındaki yalıtışlarının içerdiği yabancı çakıllar günümüz akıntı şartlarına aykırı oluşumlar olarak dikkat çekmekte, bu durumda kuzeydoğuya doğru yönelen eski bir akıntı sistemi ortaya çıkmaktadır. Çalışma sonucunda yalıtışlarının, Çanakkale Boğazı'ndaki denizel taraçaların yaşlandırma sonuçlarına dayanarak günümüzden 3660 ± 157 yıl öncesinde oluşmaya başladıkları ortaya çıkmaktadır.

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