RECENT UPLIFT IN NORTHERN CYPRUS[1]

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ABSTRACT

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Geomorphological, geological and archaeological evidence suggest that the coast of Northern Cyprus has undergone about 1 m of uplift since the Byzantine period (330-1100 A.D.). This movement forms part of the intermittent uplift that has affected the area since the Pliocene and that has produced a series of intertidal platforms and terraces.

INTRODUCTION

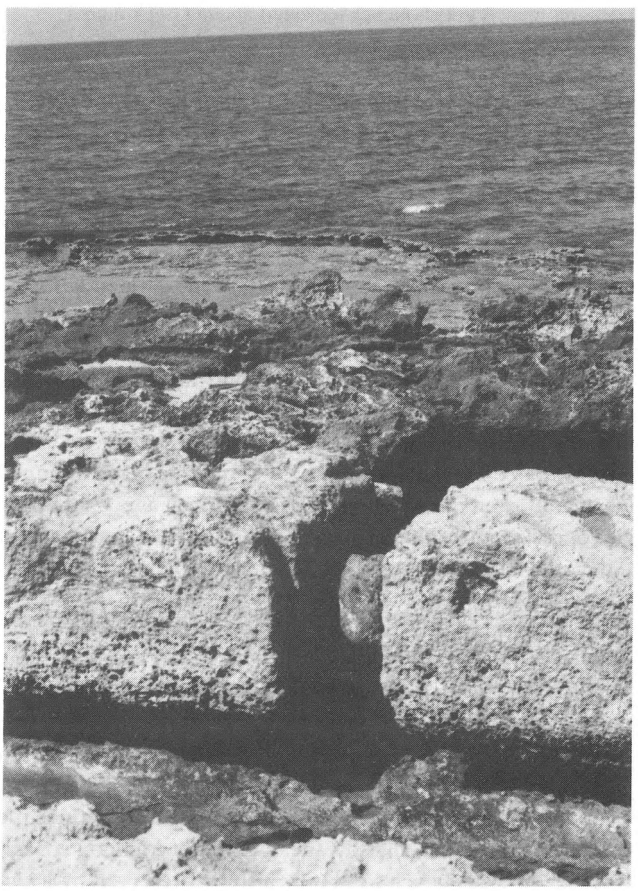
The aim of the study reported in this paper was to discover whether the north coast of Cyprus shows unambiguous evidence of vertical movements during historical and late Pleistocene times. Geologists have long postulated that uplift has been taking place in the area since the Pliocene, and ascribed marine terraces and deposits at various elevations to the Pleistocene. In view of the problems posed by stratigraphical dating of such features, it was decided to restrict the investigation to features whose age could be estimated by archaeological methods. Care was taken to record sea-level indicators at higher elevations in the hope that their dating would in due course prove possible.

GEOLOGICAL SETTING

The Girne (Kyrenia) mountain chain of northern Cyprus stretches for 175 km near Cape Kormakiti in the west to Cape Andreas in the east (Fig. 1). It has been suggested that in early Pliocene times the range was an arcuate chain of islands lying north of the island massif of Troodos, and that intermittent emergence subsequently led to the formation of a series of marine terraces flanking the Girne range (MOORE, 1960).

Two rock formations now dominate the coastal geomorphology: the Kythrea Flysch of Middle Miocene age, and the Plio-Pleistocene calcarenites that cap the terraces. The total thickness of the Kythrea Flysch is estimated to be 2000-3000 m. It is a typical turbidite displaying rhythmic series of alternating marls and sandy beds, load, flute and groove casts, and in places a series of massive greywacke sandstones. The Kythrea Flysch was subjected to intense orogenic pressure, probably in late Miocene times. Consequently, we find the flysch strongly folded, but it is remarkable that in very few places along the coast folds are visible. Instead, we have a monotonous homoclinal structure with northward dips of 30-45°. After folding, the beds were eroded and on their upturned edges the first marine beds of calcarenite were laid down.

The calcarenites are granular limestones whose matrix is largely made up of Foraminifera. They are littoral deposits: the seashore at the time was often bordered by sand dunes which were later consolidated into aeolianite similar in texture and in matrix to the calcarenite. What is often mistaken for current bedding is actually the sedimentary structure of a



Roman fish pond and sluice gate near Lâpta.

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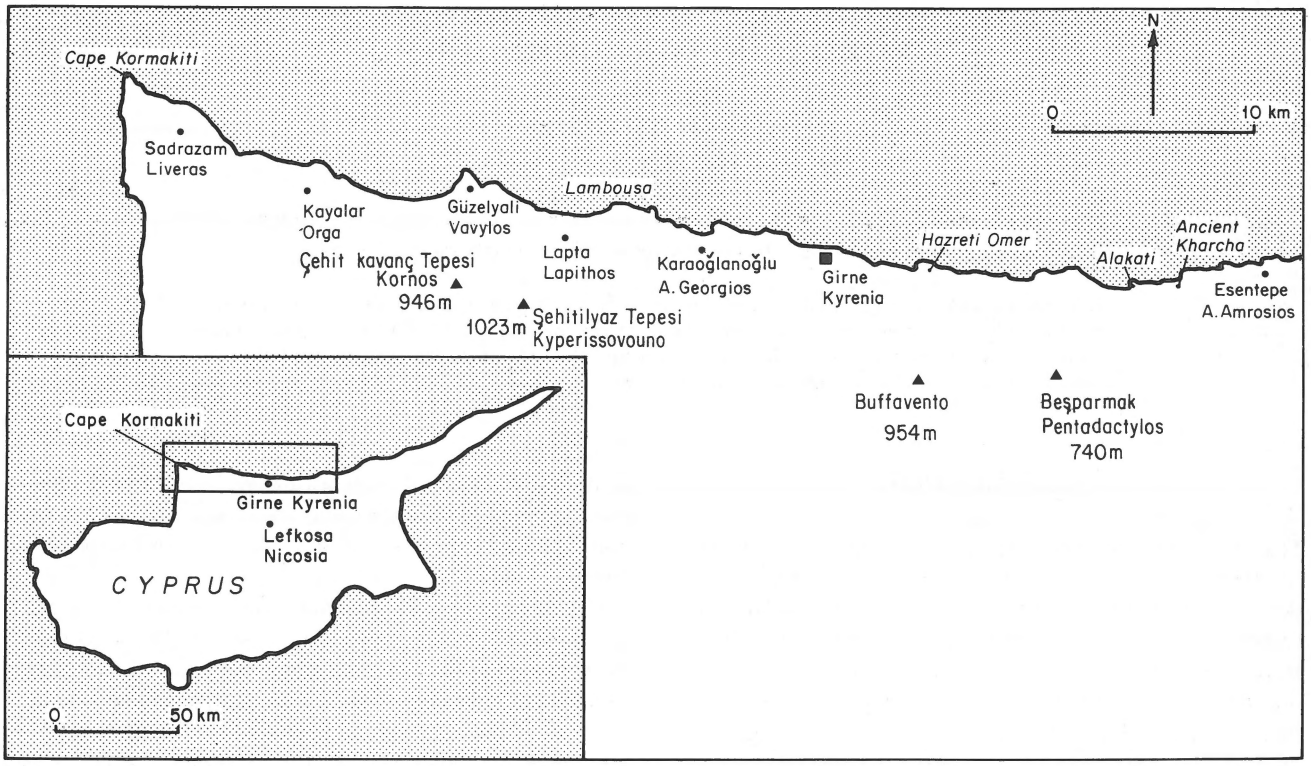

Fig. 1.
Location map; Turkish names indicated above Greek names.

large dune, which causes much variation in the micromorphology of the cliffs. The calcarenite, though a competent rock, is usually riddled with primary voids of biogenic origin, and these cavities are widened by solution. The local term *poropetra* for this rock is a very apt one.

Inland, the calcarenite surface is covered with a calcrete crust, common in most parts of Cyprus and termed *kafkalla* (PANTAZIS, 1973). Within reach of sea spray, this calcrete is rapidly destroyed. Seaside hotels that have built swimming pools close to the seashore find that only after two years the entire surface cement cover is lost.

The calcarenite rests with near-horizontal structures on the upturned beds of the Kythrea Flysch, but this plane of angular unconformity lies at elevations of as much as 300 m. Some geologists identify the higher calcarenites with the Pliocene Athalassa Formation that occurs in other parts of Cyprus (MOORE, 1960).

Rainwater rapidly sinks through the vertical joints of the cap rock to reach the flysch marls below, and issues forth as springs. This leads to an overhang with cave formation; thus not all caves and raised notches are of marine origin. The spring line also acts as a lubricated surface along which the competent blocks of calcarenite slide down to the sea to form a seashore barrier of large blocks of rock protecting the cliffs from wave attack, so that the 'dead cliff' is a common coastal feature. Ancient beach lines may also be preserved by a cap of tufa. Where the cap rock is entirely removed, subaerial erosion of the exposed flysch marls is rapid.

The sites shown in the map were selected on geomorphological and archaeological grounds. It was decided to investigate locations lying at different distances from the main axis of the Kyrenia range to establish whether variation in uplift was related to distance from the axis. Unfortunately the military situation made it impossible to examine recent changes of sea level on the shores of the Cape Kormakiti and Karpas peninsulas.

RECENT COASTAL LANDFORMS

Parallel strips of coarse conglomeratic beach rock, sometimes three or four in number and dipping seaward at about 30°, are to be seen in shallow water at depths of not more than 1 m. Good examples occur on the foreshore of the wide bay where the Geçitköy (Panagra) gorge reaches the sea, and it is reasonable to infer that the gravel in the beachrock is fluviatile in origin. Beachrocks composed of lithified sands are also found, as between Sadrazam (Liveras) and Cape Kormakiti, with the individual beds dipping 20-40° seawards. The sand was probably derived from the Morphon Bay area, on the western side of Cape Kormakiti.

Where beachrock is absent the sea has locally eroded a smooth pavement in the calcarenite rock which is often concealed by fallen chunks of the cap rock. It extends seaward

for about 20 m and is always covered with a few centimetres of water, even in conditions of calm weather. The tidal range here is from 10 to 20 cm. The remarkable smoothness of these marine pavements is no doubt due to wave action at a near constant level on the homogeneous calcarenite. These pavements are riddled with circular to oval holes less than 1 m in diameter. Their vertical sides and flat bottoms indicate a solution process in their formation, but close examination of the rims shows an ecosystem of algae and zooplankton eating into the rock. As a result there is a slight overhang to the rim, and its outward growth is radial and fairly equal in all directions. Thus, as the holes expand biogenetically, their circular shape is maintained, until coalescence with others is reached. On emergence, the riddled pavement is subjected to subaerial processes of karstification, but this merely accentuates the cavities and preserves them. Soil accumulates in the cavities and its colonization by herbaceous plants produces 'flowerpot terrain'. At higher levels, however, karstification tends to erase the cavities except where they are preserved by kafkalla.

In general, the coast is rocky because of the subaerial disintegration of the cap rock on the cliff tops. The large chunks of calcarenite stand in the water and invariably have a notch all round the base. At first glance one might attribute this to wave action, but the incipient process is biogenic. The exposed toadstool rocks are 'dead' because the marine organisms attacking the rock are active only below water level, and the subsequent wave action serves merely to accentuate the undercut. The toadstool rocks can be matched with notches formed at the cliff base on the beach which after only slight emergence have become enlarged by natural processes; some of the notches were converted into tombs in the Byzantine period. It is rare to see elevated notches in the form of caves above 25 m because the cap rock soon becomes unstable.

The marine pavement is often bordered by small platforms which have been sculptured into the calcarenite and which commonly lie at elevations of 3, 5 and 10 m. They are thought to represent ancient intertidal platforms, and it is noteworthy that the cavities in the 10 m level have been filled by windblown soil now colonised by plants. Much more prominent is the 20 m surface on which stands the town of Girne; often more than 1 km in width, this terrace terminates in steep calcarenite cliffs.

Although the search for ancient beach conglomerate on the lower tidal platforms is on the whole not very rewarding, a good display of ancient beach conglomerate may be seen at a height of 3.5 m, 14.5 km west of Girne. This deposit is only partly lithified and its cover of recent alluvium is now being eroded. At higher levels, more especially at the top of the 20 m (Girne) terrace, beach conglomerates are easy to find and a good example is found at the cliff edge at Alakati, 21 km east of Girne, where a coarse conglomerate containing bivalves and gastropods at the cliff top grades below into homogeneous calcarenite. A similar feature occurs at a site 2.2 km west of Kayalar (Orga) where a small remnant of a calcarenite conglomerate terrace rests on the Eocene Lapithos white chalk into which the terrace was cut. The terrace lies at an elevation of 60 m and is tilted about 20° seaward away from the main crest of the range, which is here only 500 m distant.

HISTORICAL CHANGES

The beachrock formations provide a time scale for an advance of the sea that has occurred within historical times. Near Geçitköy and at Sadrazam near Cape Kormakiti there are at least four strips of beachrock lying at equal intervals off shore. All the strips show the same facies, size and dip, and the sequence is interpreted as an advance of the coast in four stages. At Geçitköy the formation nearest to the beach yielded Byzantine pottery sherds. Unfortunately the three outer strips could not be examined closely, and it is not yet clear whether they too are post-Byzantine in age. At other sites, only one or two strips of beach rock can be seen, but this may be due to storm destruction which varies with the orientation of the various bays.

At the Roman (Byzantine) site of Lambousa there are several ancient fish ponds which were excavated into the calcarenite of the intertidal platform. Neither the inflow nor the outflow channels of these ponds now operate efficiently because the site shows a retreat of the sea of about one metre since the period 400-700 A.D. Dr. Kyriakos Nicolaou, curator of the Nicosia museum (pers. comm.), believes that the orientation of these stone-cut channels was used to ensure an inflow of water into the pond with a strong NW wind, another channel allowing outflow in periods of calm, low water. At two other localities, one km east of Girne Castle and 2 km west of Lambousa, there are similar channels connected with ancient fish ponds, and here there is evidence of a regression exceeding one metre.

A Neolithic site at Troulli, 16 km east of Girne, has a stone jetty thought to date from the period of occupation. According to DIKAIOS & STEWART (1960) the site dates from about 5000 B.C. The stones forming the jetty were placed on the intertidal platform, and have since then been eroded into toadstool rocks. The undercuts responsible for this effect are no longer active and new ones are forming below the edge of the platform in about one metre of water.

At the important coastal site of ancient Kharcha, 4.5 km west of Esentepe, an ancient road leads down to a jetty. The shoreline has apparently been displaced downwards by 1 m during the last 1500 years. Most of these coastal Byzantine towns are said to have been deserted by the 9th century, but discussion with visiting archaeologists leads the author to believe that Kharcha was occupied up to the Middle Ages.

DUCLOZ (1968) has recognized depositional terraces at 230 m, 185 m, 140 m, 50 m, 25 m and 5 m in the Arapköy (Klepini) region. His chronology was to large extent based on altimetric correlation with other Mediterranean areas. Ducloz

assigned the 25 m (Girne) terrace to the Tyrrhenian 2 stage of the Pleistocene, in agreement with MOSHKOWITZ (1966) and PANTAZIS (1966) who had dated this terrace as middle Pleistocene by means of its macrofossils. Ducloz also compared the 5 m Koupia terrace with the 6 m terrace of the coasts of Syria and Lebanon in which have been found remains of *Rhinoceros merckii* and artifacts of the Levallois-Mousterian tradition. With the aid of C-14 ages he dated the 5 m terrace to about 52,000 year B.P. SAUCIER & MAJOR (1963) recognised marine terraces at 4 m, 12 m and 21 m in their geological survey of the Karpas peninsula. These levels correspond well with the author's observations some 100 km to the west of Karpas.

Underwater archaeology in northern Cyprus has been greatly stimulated by the excavation of an ancient Greek shipwreck in 25 m of water off the coast of Girne. Considerable work on the relation of ruins to present sea level has been done by FLEMMING (1969) in the Aegean and the western coast of Turkey. His general conclusion is that the net eustatic change over the last 2,000 years has been minimal. Further investigation led him to the view that the sea level lay within a few centimetres of its present position 2,000 years ago, dropped slowly to – 30 cm about 500 A.D., and then rose to modern datum.

Recent work in marine archaeology in northern Cyprus was done by GREEN & JEREMY (1973) in the Cape Andreas area of the Karpas peninsula. In their preliminary report they reported no evidence of sea-level changes 'in recent geological time.'

The Neolithic coastal settlement of Ayios Epkitikos (Catalköy) Vrysi lies on the 10 m terrace which is here at 13 m. In his report, PELTENBERG (1975) suggests that the settlement (3500 B.C.) was abandoned because the rising sea level caused erosion of the cliffs on which the houses were built.

DISCUSSION

The assumption is made that the negative changes of sea level along this northern coast of Cyprus have been due to uplift of the land. A tectonic rather than a eustatic process is favoured, simply because the area of study is in an orogenic zone.

The beachrock formations indicate that in about the last 1500 years a positive change of sea level of about one metre has occurred. Since these formations are often found in equally spaced lines it is suggested that each linear formation corresponds to a stillstand period while the spaces between represent a more rapid advance.

There appears to be some discrepancy in the results concerning ancient Kharcha and Lambousa. In the former, the evidence of an emergence of about one metre since Byzantine times is quite clear, but at Lambousa the evidence for this is somewhat obscured by a positive change of sea level associated with beachrock formations some 8 km to the west.

Elevated notches and toadstool rocks can be seen in many parts of the coast and all point to an uplift of about one metre. The Neolithic site at Troulli would be a type area. Here, however, the emplacement of large stones for a harbour by the Neolithic occupants of this site remains to be proved.

There are many areas along the coast showing the excavations by Byzantine and later quarry workers, whose methods of grooves and wetted wood were similar to those practised in ancient Egypt. In no case have quarry workings been discovered below the present sea level, and they are to be found on the 3 m, 5 m and 10 m terrace. In many places the workings were converted into catacombs or coastal settlements, where ancient jetties can still be seen. There is an extensive area showing all these uses to which the quarries were put, one km east of Girne Castle. These ancient jetties could be of any post-Roman date up to A.D. 1570, when the last major additions to the castle were made.

A relief section along the longitudinal axis of the Kyrenia range reveals the form of a low asymmetrical dome. As it is about 175 km in length and only averaging 4 km in width, it can be likened to a gigantic wave on the earth's crust: the cymatogen concept of KING (1962). This is the best proof of uneven uplift of the range since the Pliocene, for marine deposits of this age are found at 600 m in the central portion while further to the western extremity at Kayalar (Orga) the same deposits are at 340 m. Hence it is reasonable to suggest that the uneven uplift that has occurred in historical times is merely a continuation of this phase of orogenesis.

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