

CONTRIBUTION TO THE STRATIGRAPHY OF MIOCENE SEDIMENTS OF KASSOS ISLAND (SOUTH SPORADES)*

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ABSTRACT

The stratigraphy of the Miocene deposits of Kassos island (South Sporades) is described. Special attention is paid to the study of the bio- and chronostratigraphic assignment of calcareous nannoplankton and planktonic foraminiferal associations and their correlation with mollusc biozones. Marine sediments overlying unfossiliferous conglomerates can be assigned to the Messinian. A reviewed invasion of the sea occurred in the Tyrrhenian (late Pleistocene).

ΣΥΝΩΣΗ

Η Στρωματογραφία των Μειοκαινικών αποθέσεων της νήσου Κάσσου (Νότιες Σποράδες) περιγράφεται στην εργασία αυτή. Ιδιαίτερα μελετάται η βιοστρωματογραφική και χρονοστρωματογραφική εξέλιξη των συγκεντρώσεων του ασβεστολιθικού ναννοπλαγκτού και των πλαγκτονικών τρηματοφόρων σε συσχέτισμό με τις κοινότητες των προσδιορισθέντων μαλακίων. Η προσπάθεια αναπαράστασης και ερμηνείας της παλαιογεωγραφικής εξέλιξης της περιοχής, δείχνει ότι αυτή έχει επηρεαστεί σημαντικά από ευρύτερες τεκτονικές κινήσεις.

* Συμβολή στη Στρωματογραφία των Μειοκαινικών ιζημάτων της νήσου Κάσσου (Νότιοι Σποράδες).

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INTRODUCTION

Kassos, is the southernmost island of the South Sporades (Dodecanese), (latitude 35° 23 N, longitude 26° 56 E). The larger part of the island is composed of preneogene rocks ; and the Neogene deposits are mainly restricted to the southwestern part of the island. (Fig.1)

The main goal of this study is on the one hand to redefine the biostratigraphical and chronostratigraphical position of the Neogene sediments, and on the other hand to correlate planktonic foraminifera, calcareous nannoplankton and molluscs biozones, on the basis of an integrated analysis. This was achieved by a detailed analysis of the micro- and macrofauna of the Kokkino Rema Section, which is represented of the Miocene of Kassos.

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The fieldwork was performed in the context of a stratigraphical study of the Upper Cenozoic of the South Aegean island by the department of Historical Geology and Paleontology of Athens University.

GEOLOGICAL AND STRATIGRAPHICAL FRAMEWORK

The Geology of Kassos has been the subject of several studies from the 19th century. BUKOWSKY (1889) supplied the first geological map of the island (scale of 1:175.000), NELLI (1910) gave a well known account of the Neogene fauna, and concluded that the age of the sediments was Middle

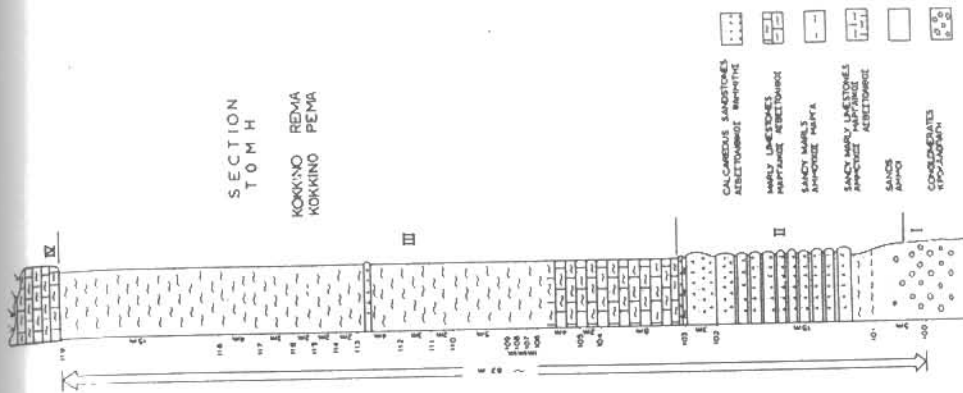


Fig. 2

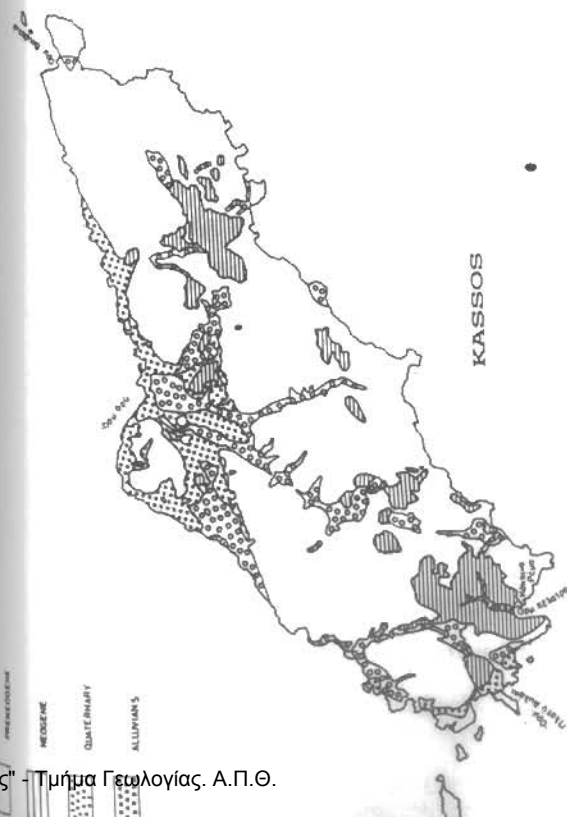


Fig. 1

Fig. 1 Geological sketchmap of Kassos island with the distribution of Neogene and Quaternary formations (simplified after BARRIER, 1979 and own observations).
Fig. 2 Lithostratigraphic column of section Kokkino Rema, southern part of Kassos island.

Miocene. DESIO (1931), expressed several conclusive remarks about the Geology and Geomorphology of the island, based on previous studies and his own observations. He determined four lithostratigraphic units: i) hypocrySTALLINE bedded limestones with red and green schist intercalations, ii) flysch of Eocene age, iii) Miocene limestone deposits and iv) Pleistocene clastic sediments.

FLORIDA (1932) determined, in the limestone intercalations of the flysch formations of Kassos, the following Nummulite species: *Nummulites atacicus* LEYN, *Nummulites laevigatus* BRUC, *Nummulites perforatus* DE MONTF, *Nummulites girehensis* FOZKAL, *Nummulites fabiani* (PREVEL), *Asterigerina rotula* (LAUFMANN), and from this he concluded a Lutetian - Priabonian age.

The Neogene marine deposits, of Kassos island are mainly exposed i) at the location Ag. Georgios-Hadion - Hilatros and ii) at the coastal zone of the Argos settlement.

BUKOWSKY had already referred (1889) to the existence of the following species: *Pecten besserii* ANDRZ, *Pecten latissimus* BR., *Gryphaea cochlear* POLI, *Clypeaster alticostatus* MICH, *Clypeaster aff. altus* LK. This fauna, let him consider these rocks of Miocene age.

ANAPLIOTIS (1969) studied the fossiliferous deposit located east of Aghios Georgios Hadion Monastery and concluded to a "Vindobonian" Age (concerning not only the "Helvetian facies", but the "Tortonian" as well).

At the second fossiliferous region of the Argos settlement, the Neogene depositions are of negligible thickness, and there CHRISTODOULOU (1961) determined the larger foraminifer *Neoalveolina melo* (FICHTEL & MOLL), and also representatives of Miliolidae, Rotaliidae and Elphidiidae. On the basis of the species *Neoalveolina melo*, the same author considered these sediments of Middle Miocene age.

During the past 20 years several geoscientists carried out researches in Kassos island. KUSS (1969) studied the Pleistocene fossilized mammals, AUBOUIN and DERCOURT (1970) discussed the problem of the Plattenkalk Series, THORBECKE (1976) has redefined the Priabonian flyschoid sediments, and placed them in the Gavrovo - Tripolis series, and BARRIER (1979), in his neotectonic study of Karpathos and Kassos islands, referred also to the solution of stratigraphical subjects concerning Kassos in his published geological map of the island, (scale 1:50.000).

SECTION KOKKINO REMA

Section Kokkino Rema is located east of Aghios Georgios Monastery, at the site of the Kokkino Rema torrent, to which the section owes its name.

This section can be subdivided into four lithological units (from bottom to top). (Fig.2)

Unit I. Reddish conglomerates

It is impossible to estimate the precise thickness of this unit, due to the fact that it is not well bedded and also covered by scree (Fig.3). Nevertheless, we can assume that it is not less than 60m thick. The conglomerate consists of pebbles of various size - in specific places they appear as blocks - which are of similar lithology and are "floating" in a reddish matrix. The components were most likely derived from the nearby located formations of greyish Cretaceous limestones. Locally, especially in the upper part of this unit, the conglomerates show a more pronounced imbrication of the pebbles, which also appear more flattened, as compared to the lower part of the unit. Due to this imbrication this unit shows an indistinct stratification when viewed from a distance. The conglomerates are

entirely devoid of fossil remains .

Unit II. Sands, sandstones.

After a transition of interval consisting of approximately 6m of sands - which at the lower part contain pebbles of similar lithology as the ones of unit I, and at the upper part finely bedded clayey intercallations - we pass into a unit consisting of calcitic sandstones. (Figs. 4,5)

This unit is about 16m thick and includes calcitic sandstones and less diagenetified layers of sand, more than 10cm thick. Altogether 11 sandstone layers, which thicknesses vary between 1 and 3m, have been observed. The sandstone layers contain rich mollusc-, corral-, calcitic sponge- and scaphopod associations, which display a high degree of diagenetic alteration. The amount of fossils is higher in the lower than in the upper part of the unit. From these associations we determined the following species:

Bivalves

Glycymeris sp., *Pecten praebenedictus* TOURN, *Pecten revolutus* MIGHT., *Pecten* (*Flab.*) *besseri* ANDRZ., *Chlamys* (*Macrochlamys*) *latissima* (BROCC.), *Chlamys multistriata* POLI, *Chlamys* (*Aequiepecten*) *scabrella* (LK), *Chlamys spinulosa* (MUNST), *Spondylus gaederopus* L, *Ostrea* (*Ostrea*) *lamellosa* BROCC., *Neopycnodonta navicularis* (BROCC), *Cardium* (*Discors*) *spondyloides* (Von HAUER), *Cardium* (*Ringicardium*) *kunstleri* COSSMAN & PEYROT, *Meretrix* cf. *islandicoides* LAMARCK, *Thracia* cf. *pubescens* PULTIN .

Gastropods

Conus sp.

Scaphopods

Dentalium (*Antale*) *novemcostatum mutabile* DODERL

Corrals

Helliastrea reussana M. EDW.



Fig. 3. A view of the section Kokkino Rema from the lowermost part of the Miocene sequence, with the reddish conglomerates.



Ψηφιακή Βιβλιοθήκη "Θεόφραστος" - Τμήμα Γεωλογίας, Α.Π.Θ. lithostratigraphic unit of the Kokkino Rema Section. The picture shows the contact between the reddish conglomerates and the bedded, white-greyish marly sandstones.

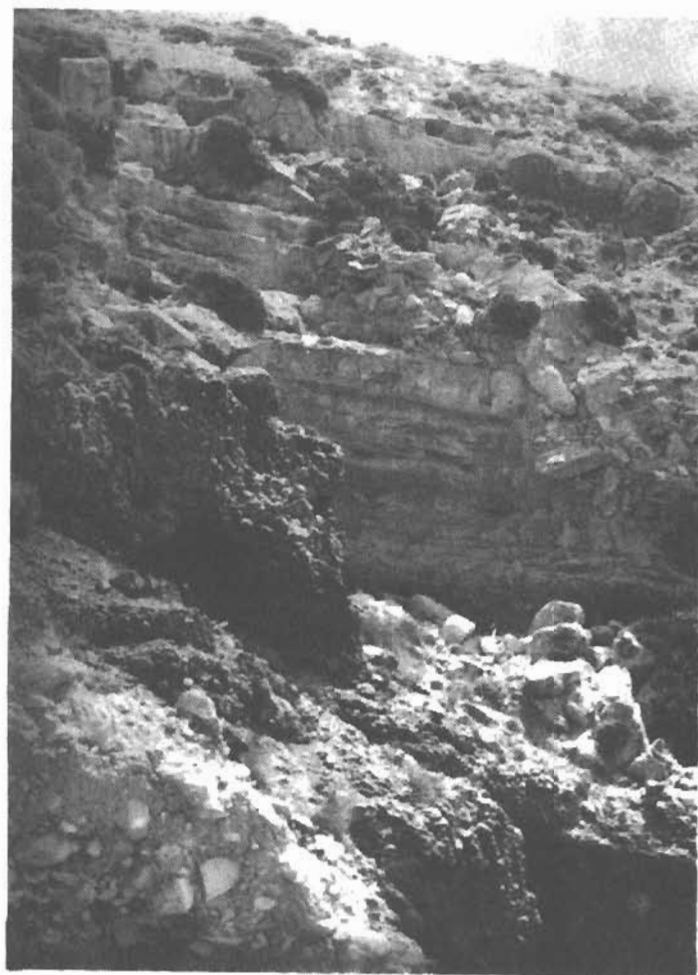


Fig.5 A detailed view of the previous picture with the contact between reddish conglomerates of Unit I and marly and calcitic sandstones of Unit II.

Ψηφιακή Βιβλιοθήκη "Θεόφραστος" - Τμήμα Γεωλογίας, Α.Π.Θ.

Unit III. Sandy - marly limestones and marls.

This unit, which thickness is approximately 60m, consists of marly sediments, which display more intense diagenetic effects in the lower parts, where also sandy and marly limestones, approximately 16m thick, occur. The rest of this unit consists of less indurated sandy marls, bearing high sand contents. Thin beds of sandstones are also sporadically present. Small bivalves, such as *Arca pectinaria* LK, *Neopycnodonta navicularis* BROCC, *Ostrea lamellosa* BROCC, *Chlamys fasciculata* LM, discontinuous corral masses and echinoids, (*Clypeaster portentosus* DESM.) can be seen locally. As a result of the less compact lithology the relief is low.

Unit IV. Marly limestones

The upper part of the section consists of unfossiliferous greyish marly limestones, which unconformably overlie the previous unit. The thickness of this unit, (which is probably also present in section Aghios Georgios), is not known due to the intense erosion. Unit IV unconformably overlies the other three units.

Probably the Kokkino Rema region was a basin during the late Miocene transgression which emerged, due to fault activity, and for that reason, either the younger marine sediments were deposited and then eroded, or during that time the whole area was above sea level. Finally there exists the unit IV unconformably overlying the other three previous mentioned units.

BIOSTRATIGRAPHY AND CHRONOSTRATIGRAPHY

The Section Kokkino Rema was sampled in detail, in order to establish a biostratigraphic subdivision of the Neogene of southern Kassos. The

Planktonic Foraminifera

The studied samples contain rather ill-preserved associations. The associations derived from the sand - sandstone succession above the reddish conglomerates allow a tentative correlation with the planktonic foraminiferal standard zonation of BLOW. However the occurrence of *Globigerina quinqueloba* together with *Neogloboquadrina humerosa* allows a correlation with the *Globorotalia conomiozea* Zone of ZACHARIASSE (1975) and with Zone N17 of BLOW.

Consequently these sediments may be considered of Middle -Upper Messinian Age.

Calcareous Nannoplankton

All associations were studied in smear slides under the light microscope only. Most of the samples contain moderately to badly preserved associations but age diagnostic species could be recognised.

Our samples are very poor in calcareous nannoplankton assemblages, due to the bad preservation of the flora because of the type of lithology and also to the impoverished type of the flora, which is characteristic for the Messinian.

Reticulofenestra spp is present through the whole Section, as also *Coccolithus pelagicus* (WALLICH), *Helicosphaera carteri* (WALLICH) KAMPTNER em., *Geminilithella rotula* (KAMPTNER) BACKMAN, *Sphenolithus abies* DEFLANDRE, *Calcidiscus leptoporus* (MURRAY & BLACKMAN) LOEBLICH & TAPPAN.

In the upper part of the section *Rhabdosphaera procera* MARTINI, *Geminilithella jafari* (MULLER) BACKMAN, *Calcidiscus cf premacintyreii* THEODORIDIS, *Eu-discoaster variabilis* (MARTINI & BRAMLETTE) THEODORIDIS appear more frequently; *Amaurolithus primus* (BUKRY & PERSIVAL) GARTNER & BUKRY is present in one sample only. There is a barren interval located at about the middle part of the section.

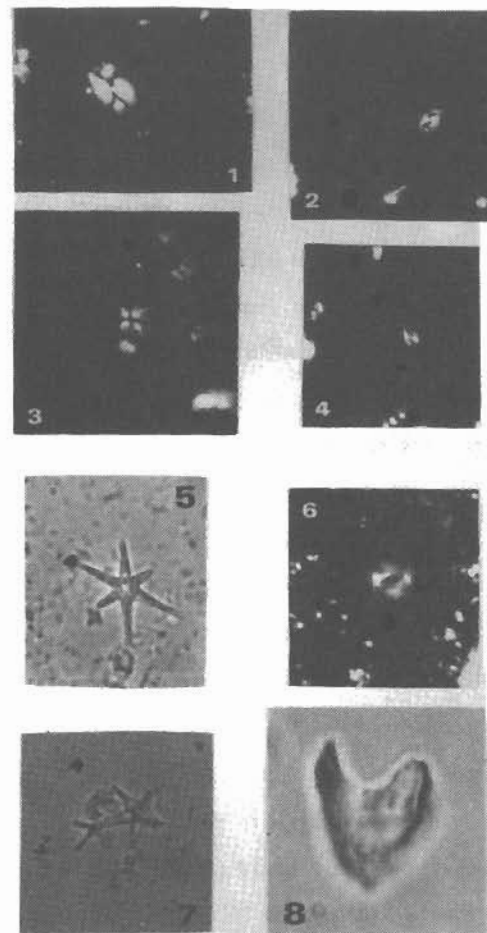
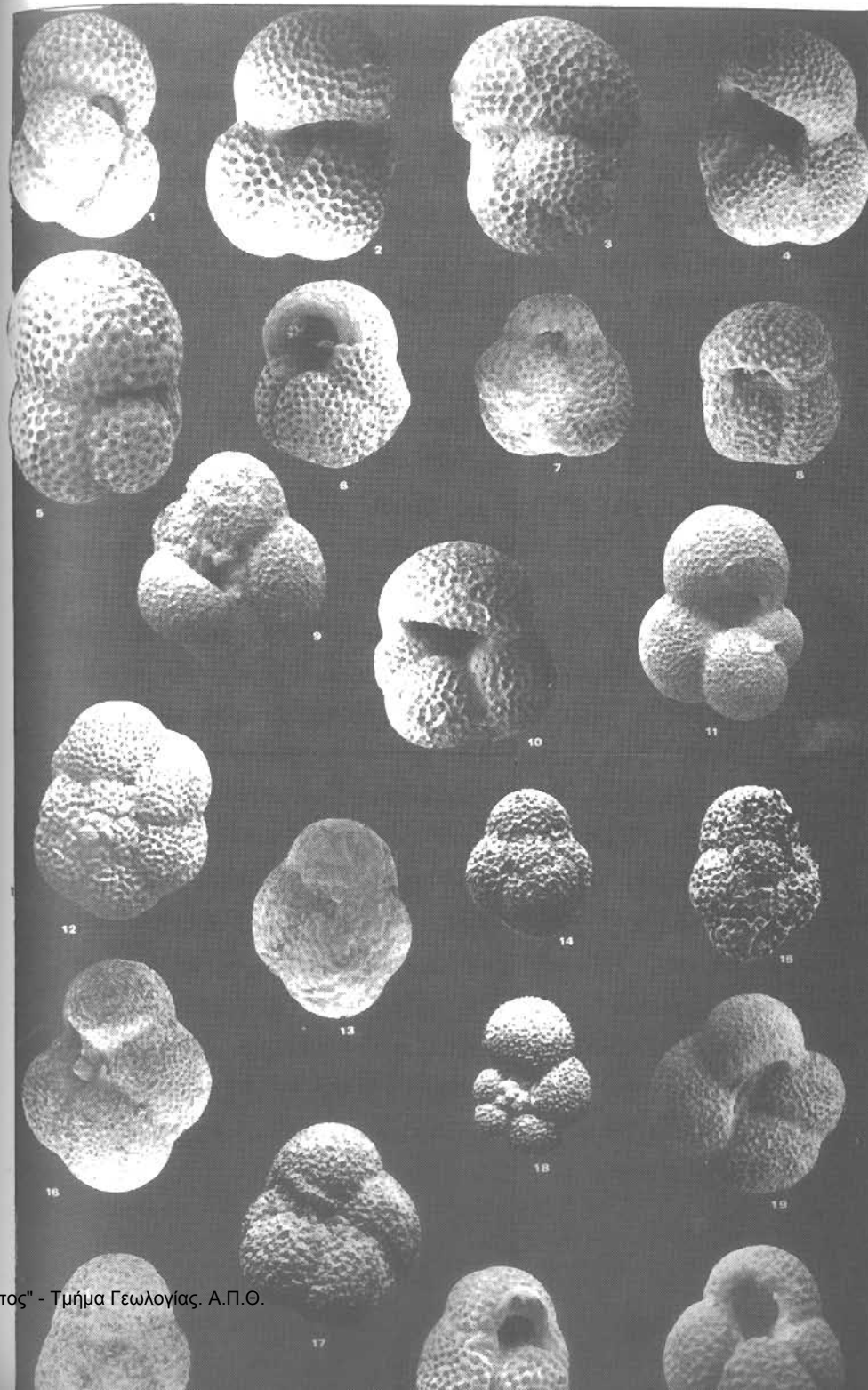


Fig.7 1. *Helicosphaera carteri* (WALLICH) KAMPTNER x1500
2. *Helicosphaera stalis* THEODORIDIS x1500
3. *Sphenolithus abies* DEFLANDRE x1500
4. *Helicosphaera stalis* THEODORIDIS x1500
5. *Eu-discoaster brouweri* (TAN SIN HOK em. BRAMLETTE & RIEDEL) THEODORIDIS x1500
6. *Calcidiscus cf premacintyreii* THEODORIDIS x1500
7. *Eu-discoaster misconceptus* THEODORIDIS x1500
8. *Amaurolithus primus* (BUKRY & PERSIVAL) GARTNER & BUKRY x2000

- Fig. 8 1. *Globigerinoides trilobus immaturus* (LE ROY) x160
 2. *Globigerinoides trilobus immaturus* (LE ROY) x160
 3. *Globigerinoides trilobus trilobus* (REUSS) x160
 4. *Globigerinoides obliquus* BOLLI x160
 5. *Globigerinoides trilobus immaturus* (LE ROY) x160
 6. *Globigerina apertura* CUSHMAN x130
 7. *Globigerinoides obliquus* BOLLI x110
 8. *Globigerinoides obliquus* BOLLI x110
 9. *Globigerina bulloides* D'ORBIGNY x130
 10. *Globigerina bulloides* D'ORBIGNY x130
 11. *Globigerina praebulloides* BLOW x130
 12. *Neogloboquadrina humerosa* (TAKAYANAGI & SAITO) x130
 13. *Globigerina falconensis* BLOW x120
 14. *Globigerina druryi* AKERS x110
 15. *Globigerina nepenthes* TODD x120
 16. *Neogloboquadrina acostaensis* (BLOW) x160
 17. *Neogloboquadrina acostaensis* (BLOW) x160
 18. *Globigerinella siphonifera* D'ORBIGNY x110
 19. *Globigerina bulloides* D'ORBIGNY x160
 20. *Neogloboquadrina acostaensis* (BLOW) x130
 21. *Globigerinoides obliquus* BOLLI x130
 22. *Globigerina apertura* CUSHMAN x160



The absence of the species *Reticulofenestra rotaria* THEODORIDIS, *Helicosphaera stalis* THEODORIDIS (present only in the lower part of the section), *Helicosphaera orientalis* BLACK, and the presence of *Amaurolithus primus* may allow the assignment of our section to the *Calcidiscus leptoporus* Zone (Subzone A) of THEODORIDIS (1984), which corresponds to Zone NN11 of MARTINI & WORSLEY (1970) and to Zone CN9b of OKADA & BUKRY (1980). This points to a Late Messinian Age.

PALEOGEOGRAPHIC INTERPRETATION

According to BARRIER (1979) two series are represented on Kassos island, the Ionian (relatively autochthone) and the Gavrovo - Tripolis (s1).

We can observe on the island the following sequence of various events during the interval between L. Oligocene and Upper Miocene.

- Deposition of a thick calcitic series (Ionian) which ends with the flysch, possibly at the L. Oligocene.
- Metamorphism and folding of the Ionian series.
- Overthrust of the upper units.
- Curvature of the whole tectonic complex, under the influence of tangential tectonism.
- Fault activity, representing a main N-S strike fault, which caused a downthrow of Karpathos in relation to Kassos. Until the Upper Miocene the most of the allochthone tectonic complex of Kassos was practically disappeared, due to the erosion, a possibility that is also proved by the fact that on Kassos the molassic deposits overlie the ionian marbles.
- Upper Miocene transgression.

The molassic basins are actually tectonic trenches with a N-S orientation.
- Possible emersion owed to fault activity, with a vertical slip more than a 1000m.

Above the Upper Miocene, no marine deposits are visible till the late Quaternary. So it is possible that the island, during that period, was above sea level, partially, at least.

CONCLUSIONS

Having in mind the biostratigraphical and chronostratigraphical, previous mentioned, results we come to the conclusion, that the age of the Neogene sediments exposed on the island of Kassos corresponds to the lower part of the Upper Messinian (according to THEODORIDIS, 1984 biozonation).

Our results suggest that Kassos was probably above sea level due to uplifts caused by fault activity, until Late Messinian. There is also the possibility that some sediments older than Messinian were deposited but subsequently eroded, prior to the Messinian onlap. The outcrops of the Kokkino Rema sequences allow us to conclude that during Late Messinian time Kassos was at least in part below sea level. The younger marine sediments must have been eroded, due to a possible emersion (partially at least) of the island, which lasted till Late Quaternary time, when the Tyrrhenian marine sediments were deposited.

The references on mammal fossils on Kassos island (DERMITZAKIS & SONDAAR 1978), may suggest that Kassos and Karpathos were connected during the Lower-Middle Pleistocene time span.

REFERENCES

- ANAPLIOTIS, K., (1968), Contribution à la connaissance du Neogène de l'île de Kassos. *Prakt.Akad.Athen.*, v. 43, p. 276-283
- AUBOUIN, J. & J.DERCOURT, (1970), Sur la géologie de l'Égée, regard sur la Dodécanése méridionale (Kassos, Karpathos, Rhodes), *Bull. Soc. Geol. France* (7) XII, p. 455-472, 2 fig
- BARRIER, E., (1979), Etude néotectonique des îles de Karpathos et Kassos. Etude géologique de l'île de Kassos (Dodécanése, Grèce). Travaux du Depart. de Géotectonique. Thèse 3e cycle. *Univ. Pierre et Marie Curie*. Paris.
- BARRIER, E., MULLER C., & J.ANGELIER, (1979), Sur l'abondance du Quaternaire marin ancien dans l'île de Karpathos (arc hellénique, Grèce) et ses conséquences tectoniques. *Bull. geol. France*
- BUKOWSKI, G. (1889), Der geologische Bau des Insel Kassos. *Sitzungsberichte. Kai. Akad. Wiss. Wien Math. nat.* Cl. 98 1: 653 -669 Wien.
- CHRISTODOULOU, G. (1960), Geologische und mikropalaeontologische Untersuchungen auf der Insel Karpathos (Dodekanese) *Paleontografica*, 115, p.1-143 Stuttgart.
- CHRISTODOULOU, G. (1961), The occurrence of *Neovalveolina melo* (Fichtel & Moll) in Miocene formation of Kassos island and some remark on the geology of that island *Bull. geol. Soc. Greec* 1:156 - 162, Athens
- DERMITZAKIS, M.D. (1969). Geological investigations of the Ierapetra district Crete. *Ann. Geol. pays hell.* 21, p 342-484 Athènes.
- DERMITZAKIS, M.D. (1978). Stratigraphy and Sedimentary History of the Miocene of Zakynthos island. *Ann. Geol. pays hell.* vol. 29, 1, p47-186. Athènes. Cum. lit.
- DERMITZAKIS, M.D. & P.Y.SONDAAR (1978). The importance of fossil mammals in reconstructing Paleogeography, with special reference to the Pleistocene Aegean Archipelago. *Ann. Geol. d. Pays Hellén.* vol. 29, 2, p. 808-840. Athènes.
- DERMITZAKIS, M.D. & E.GEORGIADIS-DIKEOULIA (1979). Makrofauna and Planktonic Foraminifera of the Armenopetra section in Keratokambos-Viannou area (E. Crete). *Ann. Geol. pays hell. Tome hors serie, fasc. 1* p 309-314, Athènes.
- DERMITZAKIS, M.D. & S.A.THEODORIDIS (1978). Planktonic Foraminifera and Calcareous Nannoplankton from the Pliocene of Koufonisi island (East Crete, Greece). *Ann. Geol. pays hell.* vol. 29 p. 630-643. Athènes.
- DERMITZAKIS, M.D. & E.GEORGIADIS-DIKEOULIA (1984). Biostratigraphic and chronostratigraphic correlations of the Late Cenozoic Bivalves of the hellenic area. *Ann. Geol. pays hell.* XXXII, p. 186-194, Athènes.
- DERMITZAKIS, M.D. & E.GEORGIADIS-DIKEOULIA, (1987). Biozonation of the Neogene Invertebrate Megafauna of the Hellenic area. *Ann. Inst. Geol. publ. Hung.* vol. LXX. Budapestini
- DESIO, A. (1931). Le isole italiane dell'Egeo (Studi geologici e geografico-fisici) *Memoire descriptive della carta geologica d'Italia* vol. XXIV, Roma. 534p.
- FLORIDA, G.B. (1932). Alcuni nummuliti dell'isola di Caso (Dodekaneso) *Boll. soc. geol. Italia* A, 289, 1362, p. 405-458
- GEORGIADIS-DIKEOULIA, E. (1979). Repartition Stratigraphique des Pectinides et d'autres Mollusques du Néogène dans l'île de Crète. *Ann. Geol. pays hell.*, tome hors serie fasc. I., p. 457-460 Athènes.
- GEORGIADIS-DIKEOULIA, E. & P.MULLER (1984). Paleoeology of a messinian dolomite from Iraklion (Greece) with description of a Crab species. *Ann. Geol. pays hell.* XXIII, p. 220-227, Athènes.
- KUSS, S.E. (1969). Die erste pleistozäne Saugertierfauna des Insel Kassos (Griechenland) *Ber. Naturf. Freiburg i Br.*, 59. 169-177 Freiburg.

- MARTINI, E. & T. WORSLEY (1970). Standard Neogene calcareous nannoplankton zonation. *Nature* 225, pp. 289-290.
- MUTTI, E., G. OROMBELLI, & R. POZZI, (1970) Geological studies on the Dodekanese Islands (Aegean Sea) IX Geological map of the island of Rhodes (Greece) Explanatory notes *Ann. Geol. Pays Hell.* 22, p. 77-262.
- NELLI, B. (1910). Fossili Miocenici di Kaso nel mare Egeo *Boll. Soc. Geol. Ital.*, 29, p. 369-377, Roma.
- OKADA, H. & D. BUKRY (1980). Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation. *Mar. Micropal.*, 5, pp. 321-325.
- STEININGER, F. F., RÖGL F. & M. D. DERMITZAKIS (1987). Report on the round table discussion: "Mediterranean and Paratethys Correlations" Proceedings of the VIIIth RCMNS Congress *Ann. Inst. Geol. publ. Hung.*, vol. LXX. Budapestini.
- SYMEONIDIS, N. (1965). Das Miozän in Bereich von Boliones (Landkreis Rethymnon, W. Kreta). *Ann. Geol. Pays Hell.* 16, s. 249-314, Athènes.
- THEODORIDIS, S. (1984). Calcareous nannofossil biozonation of the Miocene and revision of the Helicoliths and Discoasters. *Utrecht Microp. Bull.* 32, 272 pp., Utrecht.
- ZACHARIASSE, W. J. (1975). Planktonic foraminiferal biostratigraphy from the late Neogene of Crete (Greece). *Utrecht Microp. Bull.* II, 171 pp., Utrecht.