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The Upper Miocene sediments of Anoghia: their Significance for the Tectonic Evolution of Crete, Greece.

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Crete lies close to the convergence boundary of African and Euro-Asiatic continents (Fig.1.C) and consists of a series imbricate tectonic units (nappes), which consist of Alpine formations (Creuzburg and Seidel 1975, Bonneau 1976, Fig. 1A, B). These formations were formed in different palaeo environments but each unit has its own deformational and metamorphic history. Except these sediments there occur post-alpine sediments where the Neogene sediments dominate. The nowadays configuration of Crete is the result of several tectonic processes. The main processes are:

a) A compressional tectonic phase which accumulated the tectonic nappes and caused the metamorphism of some units under HP/LT conditions in Oligocene (Seidel et al., 1982),

b) The consequent fragmentation of the emergent areas due to the extension, which caused the formation of trenches and horsts and the deposition of Neogene sediments. (Meulenkamp et al., 1994).

c) The post-Miocene warping of the crust, which led to the exhumation of metamorphic complex of Crete and the formation of detachment faults. (Fassoulas et al., 1994).

The Neogene sediments south of Anoghia

The Neogene sediments south of Anoghia are limited along the way from Anoghia to Nida plateau (fig.1D) and their outcrop is relatively small as well of small thickness. In Vathia area 1.5 Km south of Anogia the thickness of Neogene ranges from 10 to 50 cm and they comprise well-cemented micro conglomerates masse and brown yellow marls with numerous small size limestone pieces. In fact they are unconformably overlying the carbonates of Crete-Mani unit or the tectonic contact of Tripolis and Crete-Mani carbonates. The ages of Upper Miocene –L.Pliocene are indicated. Southwards the thickness and width of the outcrop increases. The conglomerate-breccia with clay-sandstone matrix dominates. They are well cemented and overlying unconformably both Crete-Mani and Tripolis carbonates as well as phyllite-quartzite horizons.

Biostratigraphically, the most important Neogene sediments outcrop is the one next to the chapel St. Marina close to the spring of the Zomythos. Their thickness is about six meters and from depth to the upper surface the following members can be distinguished (fig. 2): (i) An alternation of thin-layered sandstones, marls saprophytes and fine grained conglomerates of total thickness 1.5 meters (sample D2 is part of thin-layered marls), (ii)Microbreccia of total thickness 20 cm. At its base yellow marls of 5cm thickness occur (sample D3), (iii) Carbonate breccia of 2 m thick in a sandstone-marl matrix, (iv) Alternation of thin layered microbreccia yellow marls and well cemented sandstones (sample D4), (v) 2m polymixed breccia with lateral transition to coarse-thin grained alternation of sandstones (sample D5) phyllitic marls and microbreccia. In the proximity of St. Marina the Neogene sediments overlie unconformably phyllite-quartzite series and near the spring “Zomythos”, partly cover the tectonic contact of Tripolis carbonates and phyllite - quartzite series. Southwesterly of the spring, the Neogene sediments overlie unconformably the contact of the meta-flysch of the plattenkalk and the phyllite -quartzite series (sample D1).

Biostratigraphical data

The results of the study of samples D1-D5 of the previous section can be seen in tables P1 and P5 (see also fig. 3). Combining the results of tables P2 to P5 leads to the Neogene sediments age determination that is Messinian. (biozones NN11a-b, NN11b). From table P1 it is concluded that sample D1 determines the biozone NN11b. Our biostratigraphical analysis was partly based on the previously published data of Schmidt (1979) and partly on present observations. Unfortunately, the later author has not differentiated between the various Helicosphaera and furthermore he did not identify any circular Reticulofenestrids or Reticulofenestra rotaria. Moreover, he reported the FAO (First Absolute Occurrence) of Amaurolithus delicatus long before that of Discoaster quinqueramus, the latter species shown very scarce distribution in the published charts. It is known for defining the homonymous calcareous nannoplankton zone (NN 11) sensu Martini (1971) or alternatively in the scheme of Okada & Bukry (1980) the base of the equivalent CN9 Zone is defined by the FO of both D. berggrenii and D. Surculus and the top by the LO of D. quinqueramus. Therefore and due to the scarcity of the nominate species, although present to the top of the section, the nannofossill assemblage of Anogia was originally placed in the NN11, or CN9 zones and it was impossible further refinement with the presently available data set (cf. Schmidt, 1979 as well). New events like the re-occurrence of R. pseudoublilica are important, because the large variety (>7μm) has been used as an additional event for subdivision of the NN11 a, b (CN9a, b) subzones. A re-entrance of this large variety is placed within the R.rotaria zone of Theodorides (1984), below the FO of A. amplificus (CN9Bb subzzone) and immediately after the absent interval of R. pseudoumbilica (sensu Raffi & Flores, 1995).

For the lower stratigraphic interval of Anogia section, truncation of bimodality between the two varieties is present at 6 μm, while for the upper part it was estimated at ca. 7μm. Considering a constant and relatively uniform occurrence of the large variety (R.pseudoumblilica >7μm), one can use this subordinate event in distinguishing firstly the CN9b (NN11b) subzone. Occurrence of R. rotalia points to the Tortonian/Messinian boundary of the Late Miocene and to the homonymous zone sensu Theodoridis (1984) and Young et al. (1994) various biostratigraphic data compilation for the Neogene. Key species: Discoaster quinqueramus (FAD, marks the base of CN9 or NN11), Amaurolithus delicatus (FAD) marks the base of the NN11b subzone.

Discussion-conclusions

The aforementioned observations show that this is the first time that marine Neogene deposits are found at high altitudes, south of Anoghia.

The age of these sediments, based on their microfauna and nannoplankton content is Late Tortonian to Middle-Late Messinian (NN11a-b or CN9a-b biozones). It is also highly likely that their age is even younger, reaching up to the Lower Pliocene.

The fact that these outcrops have limited extent and thickness, in respect to other isochronous deposits in other, lower-lying areas of Crete, suggest either a pause in sedimentation (owing to emergence of the broader area), or high, post-emergence erosion rate.

The occurrence of these deposits at such altitude is indicative of the magnitude of the uplift that took place in post-Messinian times.

Such uplift cannot be attributed to normal faulting (in which case the cumulative fault throw should exceed 1,400 m), but must be related to a regional doming at the area of Crete, and close to the accretionary prism, possibly related to an abrupt change in the geometry and/or the volume of the subducting African plate.

Such doming, which is also held responsible for the formation or the reactivation of large detachment faults and is connected to the exhumation of the metamorphic complex in Crete, is believed to have lasted well after the deposition of the Messinian sediments at Anoghia.

Thus, we suggest that the tectonic and structural post-alpine history of Crete should be reconsidered, by incorporating these new data.

References

Alexopoulos, A., Markopoulou – Diakadoni, A.. 1996. La presence du Calabrien au plateau Impros (Crete occidentale, Greece) et sa signification pour l'evolution tectonique de Crete. Revue de Paleobiologie, 15, 349-355.

Bonneau, M. 1976. Esquisse structurale de la Crète alpine. Bulletin de la Société géologique de France, 18, 351-353.

Creutzburg, N., Seidel, E. 1975. Zum Stand der Geologie des Präneogens auf Kreta. Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen, 141, 259-285.

Fassoulas, C., Kilias, A., Mountrakis, D. 1994. Postnappe staking extension and exhumation of high-pressure/low-temperature rocks in the island of Crete, Greece. Tectonics, 13, 127-138.

Gartner, S., J. (1973). Absolute chronology of the Late Neogene calcareous nannofossil succession in the Equatorial Pacific: Geol. Soc. Am. Bull., 84, p. 2021-2034.

Meulenkamp, J. E., Van Der Zwaan, G. J., Van Wamel, W. A. 1994. On Late Miocene to resent vertical motions in the Cretan segment of the Hellenic arc. Tectonophysics, 234, 53-72.

Martini, E., 1971. Standar Tertiary and Quaternary calcareous nannoplankton zonation: Second Plank. Conf. Proc., Roma 1970, v.2, p.739-785.

Müller, C., 1972. Kalkiges Nannoplankton aus Tiefseekernen des Ionischen Meers: "Meteor" Forsch-Ergebnisse, Reihe C, v.10, p. 75-95.

Okada, H., Bukry, D., 1980. Supplementary modification and introduction of code numbers to the low-latitude coccolith biostratigraphic zonation (Bukry, 1973, 1975). Mar. Miicropaleontol., 5 (3): 321-325; Amsterdam.

Raffi, I., Flores, J.-A. (1995). Pleistocene through Miocene calcareous nannofossils from eastern Equatorial Pacific Ocean. In: Pisias, N. G. Mayer, L. A., Janecek, T.R., Palmer-Julson, A & van Andel, T. H. (eds), Proceedings of the O.D.P., Sci. Results, 138: 233-286: College Station, Tx (Ocean Drilling Program).

Raffi, I., Rio, D., 1981. Coccolithus pelagicus (Wallich): a paleotemperature indicator in the late Pliocene Mediterranean deep sea record. In: Wezel, F.C. (ed.), "Sedimentary Basins of Mediterranean Margins": 187-190; C.N.R. Italian Project of Oceanography, Tectoprint, Bologna.

Raffi, I., Backman, J., Rio, D., Shackleton, N.J., 1983. Plio-Pleistocene nannofossil biostratigraphy and calibration to oxyden isotope stratigraphiew from Deep Sea Drilling Project Site 607 and Ocean Drilling Program Site 677. Paleoceanography, 8 (3): 387-408; American Geophysical Union.

Schmidt, R., R., 1973. A calcareous nannoplankton zonation for Upper Miocene-Pliocene deposits from the southern Aegean area, with a comparison to Mediterranean stratotype localities: Kon. Ned. Akad. Wettensch. Proc. Ser. B, v. 76, p. 288-309.

Seidel, E., Kreuzer, H., Harre, W. 1982. A late Oligocene/Early Miocene high pressure belt in the External Hellinides. Geologisches Jahrbuch,, E23, 165-206.

Stradner, H., 1973. Catalogue of calcareous nannoplankton from sediments of Neogene age in the eastern North Atlantic and Mediterranean Sea. In Ryan, W. B. F., Hsu K. J., et al., Initial reports of the Deep Sea Drilling Project, Volume 13; Wasington (U.S. Government Printing Office), p. 1137-1199.