SHORT NOTE ON THE OCCURRENCE OF SMALL *GEPHYROCAPSA* SPECIES AND BIREFRINGENT CERATOLITHS IN MESSINIAN DIATOMITES (GAVDOS ISLAND, SOUTHERN GREECE)

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Abstract: The occurrence of small *Gephyrocapsa* species, along with sporadic birefringent ceratoliths and *Amaurolithus tricorniculatus*, has been documented from Gavdos Messinian diatomites. This is the first time this assemblage has been observed in the Greek region.

Introduction

Gavdos Island forms the southernmost extension of the S Aegean arc, and is located approximately 23 miles S of Crete (Figure 1). The Neogene sediments covering most of the surface area of the island are subdivided into two lithostratigraphic formations, the Potamos and the Metochia (Anastasakis *et al.*, 1995).

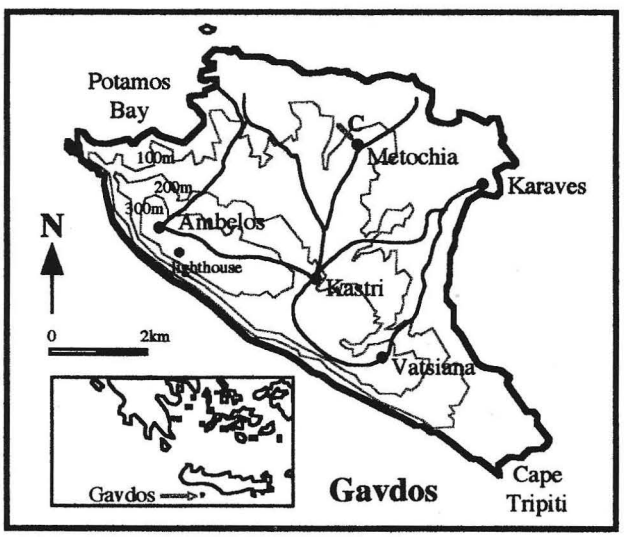

Figure 1: Location of the Metochia C section, Gavdos Island.

Thinly-bedded diatomites are located at the top of the Metochia C section (Metochia Formation). Hilgen *et al.* (1995) correlated these with the lithostratigraphic unit of the Tripoli diatomites and have astronomically-dated the base of the pre-evaporitic sequence at 6.70Ma. Additionally, Triantaphyllou *et al.* (1999) correlated the upper part of the diatomite sequence, through nannofossil biostratigraphy, with CN9b (of Okada & Bukry, 1980), with the upper part of NN11 (of Martini, 1971), and with the *Calcidiscus leptoporus* Zone (of Theodoridis, 1984), giving it a Late Messinian age.

The present study records the occurrence of small *Gephyrocapsa* spp., along with sporadic birefringent ceratoliths and *Amaurolithus tricorniculatus*, from the Gavdos Messinian diatomites. This assemblage is reported for the first time from the Greek region, and the aim of the present study is an attempt to understand the biostratigraphic significance of the nannoflora.

Material and methods

Fifteen samples from the upper 12m of the diatomite sequence of the Metochia C section were analysed (Figure 2). The distribution of calcareous nannofossil taxa was determined by LM, and additional detailed SEM analysis was applied to several samples. Both observational techniques were used in order to get the maximum amount of information from the studied material. Preparation of smear-slides for light microscopy, and of the samples for the SEM analysis followed standard procedures (Bown & Young, 1998). Semiquantitative analysis (presence of the species in 40 fields of view under 1250x magnification) was used to estimate the abundances of the discoasterid and rare ceratolithid forms.

Small *Gephyrocapsa* spp.

The genus *Gephyrocapsa* was once considered to be restricted to the Quaternary. In the Mediterranean region, Dermitzakis & Theodoridis (1978) and Müller (1978) reported small *Gephyrocapsa* from the Lower Pliocene (NN13), whilst Pirini Radrizzani & Valleri (1977) and Lohmann & Ellis (1981) described new species from the Lower Pliocene, observing an increase in size towards higher stratigraphic levels. Raffi & Rio (1979) observed these below the last occurrence (LO) of *Amaurolithus delicatus*, and Driever (1988) also reported several forms from the Lower Pliocene.

Rio (1982) pointed out that small *Gephyrocapsa* in the Mediterranean appear near the LO of *Globorotalia margaritae* or the first occurrence (FO) of *Pseudoemiliania lacunosa*, reaching a maximum size of 3.5μm. The FO of *Gephyrocapsa* has been established near the Lower/Upper Pliocene boundary, whereas small *Gephyrocapsa* specimens are usually common in the lower part of NN16 (Young, 1998), *i.e.* the Lower Pliocene. However, the precise stratigraphic distribution of the genus still remains uncertain, since *Gephyrocapsa* representatives have been reported in Miocene sediments from the Pacific and Atlantic Oceans (Pujos, 1987; Jiang & Gartner, 1984). In the Mediterranean, Bonci & Pirini Radrizzani (1992) have noted the presence of small *Gephyrocapsa* in the Upper Miocene

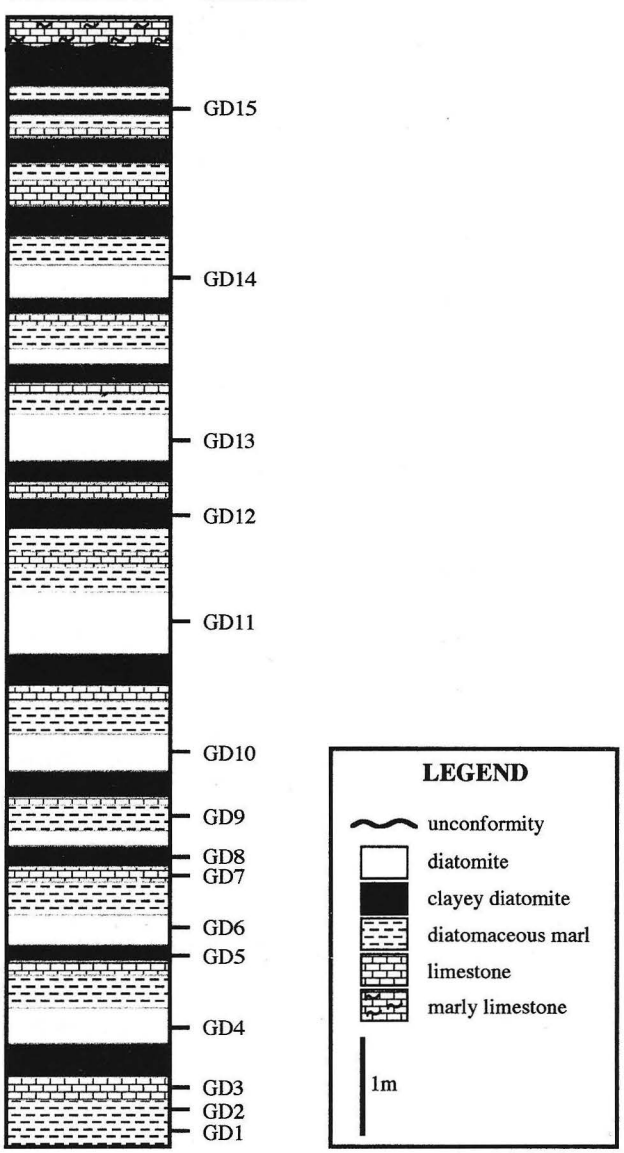

Figure 2: Lithostratigraphic column of the upper diatomaceous sediments, Metochia C section.

diatomaceous levels of the Capella Montei section (Alessandria, Italy).

The presence of small *Gephyrocapsa* specimens in Mediterranean Miocene sediments is supported once more through the present study. In particular, while investigating this material with the SEM, the presence of small, but characteristic, gephyrocapsid forms (Plate 1, Figure 13) was detected, which leaves no doubt about the presence of the genus *Gephyrocapsa* in the Messinian pre-evaporitic diatomites of Gavdos. The example shown in Plate 1 possesses an overall length of ~3.8μm, whereas the central opening measures 1.5μm on the proximal side, a fact that makes the observation of a bridge extremely difficult by means of light microscopy, due to the resolution limit of the LM.

Birefringent ceratoliths

The earliest birefringent ceratoliths are represented by *Ceratolithus acutus* and *C. rugosus*. The FO of *C. acutus* was used by Bukry (1975) for the definition of the *C. acutus* Subzone, corresponding to the upper part of NN12. The FO of *C. acutus* was reported to have been found 6m above the base of the Zanclean at Capo Rosselo by Cita & Gartner (1973). However, Flores (1986) reported *C. rugosus* together with *C. cristatus* as the first ceratoliths to appear in the Pliocene of SW Spain.

Mazzei *et al.* (1979) reported the FO of *C. acutus* at DSDP Site 397 (NE Atlantic, NW African margin) at between 5.23Ma and 5.94Ma, and Müller *in* Rögl *et al.* (1991) reported the sporadic presence of *C. acutus* in the Upper Messinian of the Mediterranean. Raffi & Rio (1979) also reported ‚horseshoe-shaped' coccoliths which, being strongly birefringent, could belong to the genus *Ceratolithus*. Additionally, Mazzei *in* Benson & Rakic El Bied (1996) reported the presence of *C. acutus* well into the Messinian, in the Moroccan section, Bou Regreg, placing its FO near the base of Chron Gilbert.

In the present material, although extremely rare, birefringent ceratoliths are definitely present (Plate 1, Figures 5-8). It must be noted that they do not resemble *C. acutus* but they may represent morphovariants of *C. rugosus*. Rio *et al.* (1990a) considered that the FO of *C. rugosus* in the Mediterranean appeared to be a migration event, strongly diachronous with respect to the open-ocean sections.

The rest of the nannoflora observed in the Gavdos diatomaceous sediments is particularly characterised by the presence of *Amaurolithus delicatus*, *A. primus*, *A. amplificus*, *A. tricorniculatus*, *Discoaster quinqueramus*, *D. pentaradiatus* and *D. berggrenii* (Figure 3; Plate 1, Figs 1-4, 9-12). *A. tricorniculatus* is often recorded as appearing in CN9b (*e.g.* Berggren *et al.*, 1995), although Rio *et al.* (1990b) have observed its later appearance, within CN10a/CN10b. The contemporaneous presence of *A. tricorniculatus*, *D. quinqueramus*, *D. berggrenii* and birefringent ceratoliths in the Gavdos pre-evaporitic diatomites enables us to conclude that the first representatives of the birefringent ceratoliths were already present in the Late Messinian.

Discussion and conclusions

The occurrence of small *Gephyrocapsa* specimens in Gavdos Messinian diatomites contributes to the limited knowledge about the precise stratigraphic and geographic distribution of these early representatives of the genus in the SE Mediterranean region, and offers palaeoecological implications suggesting the possibility of a sudden arrival of cooler surface-waters in the diatomaceous depositional environment, since small *Gephyrocapsa* assemblages imply intensified upwelling conditions (Gartner, 1988).

The presence of birefringent ceratoliths in the Late Messinian supports earlier observations of diachroneity, even within the Mediterranean region.

Both topics require further detailed investigation in order to provide an accurate time-framework for these events.

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SAMPLES	TAXA	*Amaurolithus amplificus*	*Amaurolithus delicatus*	*Amaurolithus primus*	*Amaurolithus tricorniculatus*	*Discoaster berggrenii*	*Discoaster brouweri*	*Discoaster intercalaris*	*Discoaster pentaradiatus*	*Discoaster quinqueramus*	*Discoaster surculus*	small *Gephyrocapsa* spp.
GD15												
GD14						R	A	A	A	R	C	F
GD13												
GD12		R	C	R		R	A	A	A	R	C	R
GD11		R	C	R		R	A	A	A	R	C	F
GD10												
GD9						R	A	A	A	R	C	F
GD8					R	R	A	A	A	R	C	F
GD7												
GD6			C	R	R	R	A	A	A	R	C	R
GD5			C	R			A			R	C	R
GD4												
GD3												
GD2			C	R			A	A			C	F
GD1							A	A		R	C	R

Figure 3: Distribution of the nannofossils in the Gavdos diatomaceous sediments. A = abundant, C = common, R = rare, F = few.

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PLATE 1

Full taxonomic references can be found in Perch-Nielsen (1985) or Bown (1998)

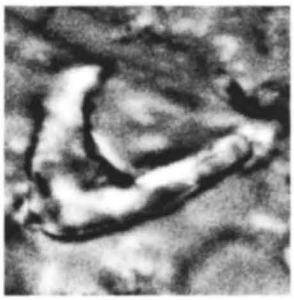
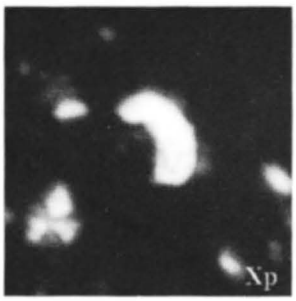


Fig.1: *A. amplificus*
Sample GD6

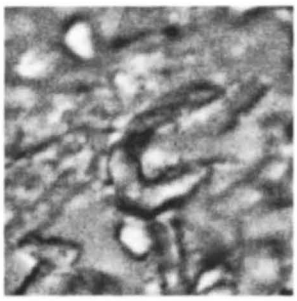
Fig.2: *A. primus*
Sample GD6

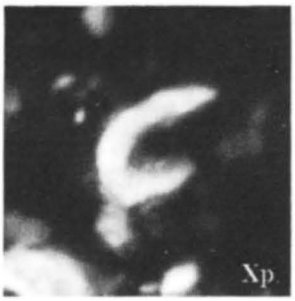
Fig.3: *A. tricorniculatus*
Sample GD6

Fig.4: *A. delicatus*
Sample GD6



Figs 5, 6: *Ceratolithus* sp.
Sample GD6





Figs 7, 8: *Ceratolithus* sp.
Sample GD6

Figs 9, 10: *D. quinqueramus*
Sample GD6

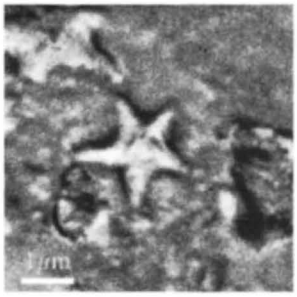


Fig.11: *D. berggrenii*
Sample GD1

Fig.12: *D. pentaradiatus*
Sample GD6

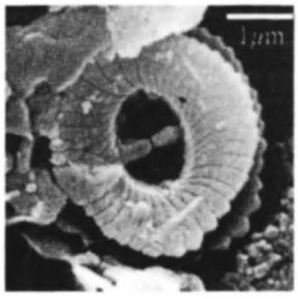


Fig.13: Small *Gephyrocapsa* sp.
Sample GD5