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Phytoplankton dynamics in the eastern Mediterranean Sea during Marine Isotopic Stage 5e

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Abstract

Calcareous nannoplankton, diatoms and organic-walled dinoflagellate cysts from seven eastern Mediterranean sediment cores were investigated to clarify the climatic and paleoceanographic conditions that influenced the deposition of sapropel S5 during Marine Isotopic Stage 5e. Warming of surface waters during S5 deposition is indicated by the high abundance of the calcareous nannofossil "small" *Gephyrocapsa* group, the presence of the dinoflagellate species *Spiniferites mirabilis*, *Spiniferites pachydermus*, *Lingulodinium machaerophorum* and *Polysphaeridium zoharyi*, and the tropical–subtropical diatom *Pseudosolenia calcar-avis*, *Chaetoceros* resting spores, Rhizosolenids and *Thalassionema* group. Increased productivity accompanied S5 deposition as evidenced by a general decrease in abundance of calcareous nannofossil superficial species and a coeval increase of dinocysts and diatoms. The productivity increase is further supported by an increase of the deep dwelling calcareous nannofossil species *Florisphaera profunda*. Stratification of near-surface waters is recorded by the presence of the dinocyst species *L. machaerophorum* and *P. zoharyi* together with the co-occurrence of the diatom *Chaetoceros* resting-spore group, *Thalassionema frauenfeldii*, and *Thalassionema nitzschioides* var. *parva*, which reflect transport of neritic waters off-shore, and by the presence of some freshwater and transport-related diatom taxa (*Cyclotella*, *Diatomella* and *Diploneis*). Gradual shoaling of the nutricline and a gradual weakening of water stratification at the end of S5 deposition is indicated by an increase in the deep dwelling calcareous nannoplankton species *Gladiolithus flabellatus*, which suggests a less-deep niche compared to the deeper dwelling *F. profunda*. Time transgressive variations in the distribution of the calcareous nannofossil *Emiliana huxleyi* and changes in the abundances of *Gephyrocapsa oceanica*, small *Gephyrocapsa*, *G. flabellatus*, and of the dinocysts *P. zoharyi* and *L. machaerophorum* lead to paleocirculation considerations, as they always reflect the main current path. Moreover, the occurrence of upwelling-related diatom and dinocyst taxa, such as *Chaetoceros* resting spores and *S. pachydermus*, suggests the presence of a former gyre structure south of Crete that was active during S5 time.

Keywords: Eemian; Sapropel; Calcareous nannoplankton; Diatoms; Dinoflagellate cysts; Eastern Mediterranean Sea

1. Introduction

From the Pliocene through the Quaternary the eastern Mediterranean Sea experienced periodic depo-

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sition of organic carbon-rich sediments called sapropels. These peculiar deposits, strongly connected to important changes in paleoclimatic and paleoceanographic conditions (cf. Kallel et al., 2000; Rohling, 2001; Corselli et al., 2002; Weldeab et al., 2003), are in phase with orbital cycles and usually coincident with precession minima (Lourens et al., 1996). In this study, we focus on sapropel S5, which was deposited in the Eemian during Marine Isotopic sub-Stage 5e, in the interval between 124 and 119 kyrs BP (Bar-Matthews et al., 2000; Cane et al., 2002; Rohling et al., 2002).

Phytoplankton assemblages respond to changes in water column conditions that can be inferred from changes in the abundance of indicator species. Studies have revealed how calcareous nannofossils (Lototskaya et al., 1998; Negri et al., 1999; Negri and Giunta, 2001; Corselli et al., 2002; Giunta et al., 2003), diatom frustules (Schrader and Matherne, 1981; Kemp et al., 1998, 1999, 2000; Pearce et al., 1998; Corselli et al., 2002) and dinoflagellate cysts (e.g., Zonneveld, 1996; Sangiorgi et al., 2002, 2003) reflect changes in paleoceanographic conditions during sapropel deposition.

The aim of this study is to employ changes in the distributional patterns of these three phytoplankton groups to characterise the paleoecosystem dynamics during sapropel S5 deposition. We therefore selected seven sediment cores collected along a west–east transect from the Ionian Sea to east of the Napoli Dome in the eastern Mediterranean Sea in which the sections of interest showed good microfossil preservation, evidence of high sedimentation rates based on the thickness of their sapropel layers, and the presence of a laminated sapropel S5. We studied those phytoplankton species that are considered the most sensitive to parameters such as temperature, salinity, and nutrient content. This provides the best signals for revealing climatic and oceanographic changes, including variations in surface circulation and in environmental parameters related to global and/or local changes. Another important aim of our study was to identify local or basin-wide variations during the Eemian time and to determine if the local forcing affected sapropel S5 deposition throughout the whole eastern Mediterranean basin.

2. Material and methods

For this study we selected six gravity cores (GC) and a piston core (PC) collected in the eastern Mediterranean Sea during different oceanographic cruises (Table 1 and Fig. 1). According to the calcareous nannofossil biostratigraphy that permits recognition of the *Emiliana huxleyi* zone (Rio et al., 1990), the age of the cores spans the Late Pleistocene, and lithological analyses identified the sapropel S5 (Table 2 and Fig. 2). This sapropel in fact is different from all the others occurring in the *E. huxleyi* zone because of its darker colour, greater thickness and often fine lamination. We are aware of the problems related to the definition of sapropel if based only on color, and for this reason we also consider the extension of the sapropel S5 corresponding to the interval where the benthic microfauna dramatically drops or disappears (Table 2).

Samples were taken every 1 cm in all the cores in the interval spanning the sapropel layer.

2.1. Calcareous nannofossils

Detailed calcareous nannofossil analyses were performed on the seven cores (Table 1 and Fig. 1). For sample preparation, we tested a method that assured a uniform distribution of the sediment on the cover glass. For this purpose, 1 mg of sediment was suspended in 10 ml distilled water adjusted to pH 8. After 30 s, 1 ml of the suspension was collected with a micropipette and put on a cover glass to dry at 50 °C. This methodology was tested by performing three replicas of the same sample and comparing the result with a standard smear slide preparation. The result of this test (Giunta, unpublished data) shows that the method does not show selective settlement of species or distortion of the association. This preparation, in which the weight of sediment, the surface over which the sediment is homogeneously extended and the observed area are controlled, allows estimation of the number of coccoliths per surface areas (coccoliths/mm^2) (Flores et al., 1997). In addition, Baumann et al. (1998) showed that all major abundance features using coccoliths/mm^2 instead of percentages are reproducible although there can be some differences in the absolute size of the individual peaks. Although this method does not allow estimating the dilution effect caused by variations in terrigenous input that could affect the primary signal, it yields data that can be considered

Table 1
Location and depth of the studied cores

Studied cores	Latitude	Longitude	Depth (m)	Cruise
BD02-GC01	37°33.90′N	17°48.32′E	2470	BIODEEP 2002
SIN97-GC05	34°55.63′N	17°04.07′E	1075	SINAPSI 1997
BAN84-GC27	33°20.99′N	23°13.26′E	2026	BANNOCK 1984
BAN89-GC09	33°37.98′N	24°43.29′E	2011	BANNOCK 1989
BAN82-GC16	32°34.42′N	26°50.85′E	3008	BANNOCK 1982
SIN97-GC01	35°49.01′N	22°42.04′E	933	SINAPSI 1997
UM94-PC17	35°13.94′N	21°24.71′E	3224	PALEOFLUX 1994