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Journal of Asian Earth Sciences 27 (2006) 835–846
Journal of Asian Earth Sciences
www.elsevier.com/locate/jaes

Pleistocene–Holocene calcareous nannofossil biostratigraphy of core samples from The Northeastern Sea of Marmara, Fenerbahçe–Pendik, NW Turkey

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Received 20 September 2004; received in revised form 27 June 2005; accepted 28 July 2005

Abstract

Pseudoemiliana lacunosa, Gephyrocapsa oceanica and *Emiliania huxleyi* (Ionian) (Pleistocene–Holocene) calcareous nannoplankton zones were identified from 82 samples of 14 cores taken from 8 locations in the northeastern Sea of Marmara. The investigation indicates that the identified biozones have been alternated by tectonic activity in the 1, 5 and 6 core locations. The study area has been affected three times by tectonic activity during the Pleistocene–Holocene time interval. The first activity occured during the Early Pleistocene and the others during Holocene.

Keywords: Biostratigraphy; Nannofossil; Pleistocene–Holocene; Sea of Marmara; Turkey

1. Introduction

The area studied covers approximately 180 km^2 between Fenerbahçe and Pendik. It is located in the northeastern part of the eastern basin of the Sea of Marmara (Fig. 1). Geologically, the Marmara Basin owes its evolution to the interaction between the NW Anatolian graben system (western extension of the North Anatolian Fault Zone) and the N-S extensional tectonic regime of the Aegean (Şengör et al., 1985; Crampin and Evans, 1986; Barka and Kadinsky-Cade, 1988; Wong et al., 1995; Görür et al., 1995, 1997. An east-west trending deep Marmara Basin trough, the western extension of the North Anatolian Fault (Şengör et al., 1985; Taymaz et al., 1991), separates the narrower northern shelf (<10 km) from the wider southern shelf (<30 km). This trough consists of three small sub-basins (fault-bounded pull-apart basins) with maximum water depths of 1300 m (Wong et al., 1990; Görür, 1997. Several canyons or other valley-like features connect these deep basins to the Dardanelles and Bosphorus, e.g. 'Ergin et al. (1991)'. Therefore, the Sea of Marmara forms a transition zone between the Black Sea, the world's largest anoxic basin, and the Aegean Sea. The hydrography of the Sea of Marmara is well defined (Millier, 1983; Beşiktepe et al., 1994) and is characterised by two-layer water flow. The low salinity (18 ppt) Black Sea surface waters enter the Sea of Marmara from the Bosphorus, and higher salinity (38 ppt) Mediterranean sub-surface waters enter from the Dardanelles. Thus a permanent pycnocline occurs at depths of about 25 m, serving to separate these two distinct water masses. Sea-level differences between the Black Sea and Aegean are low (approximately 42 cm) (Bogdanova, 1969). Numerous studies on the general geology, palaeontology, sedimentology, geochemistry, mineralogy and seismology in the Sea of Marmara and nearby areas have been carried out by a number of authors (Abdüsselamoğlu, 1963; Stanley and Blanpied, 1980; Yanko, 1990; Ergin et al., 1990, 1993, 1994, 1996; Bodur and Ergin, 1994; Eryılmaz et al., 1995; Meriç et al., 1995; Seymen, 1995; Smith et al., 1995; Öztürk and Shimkus, 1995; Yalçın and Bozyaka, 1995; Çağatay et al., 1996; Nazik et al., 1996; Toker et al., 1996; Tunoğlu and Duru, 1996; Görür, 1997; Yıldız et al., 1997; Yıldız, 2001; Yıldız and Toker, 2001; Toker and Yıldız, 2002). None have previously studied the area considered here. The main purpose of this work is to establish the biostratigraphic zonation of the study area on the basis of

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1367-9120/$ - see front matter
doi:10.1016/j.jseaes.2005.07.010

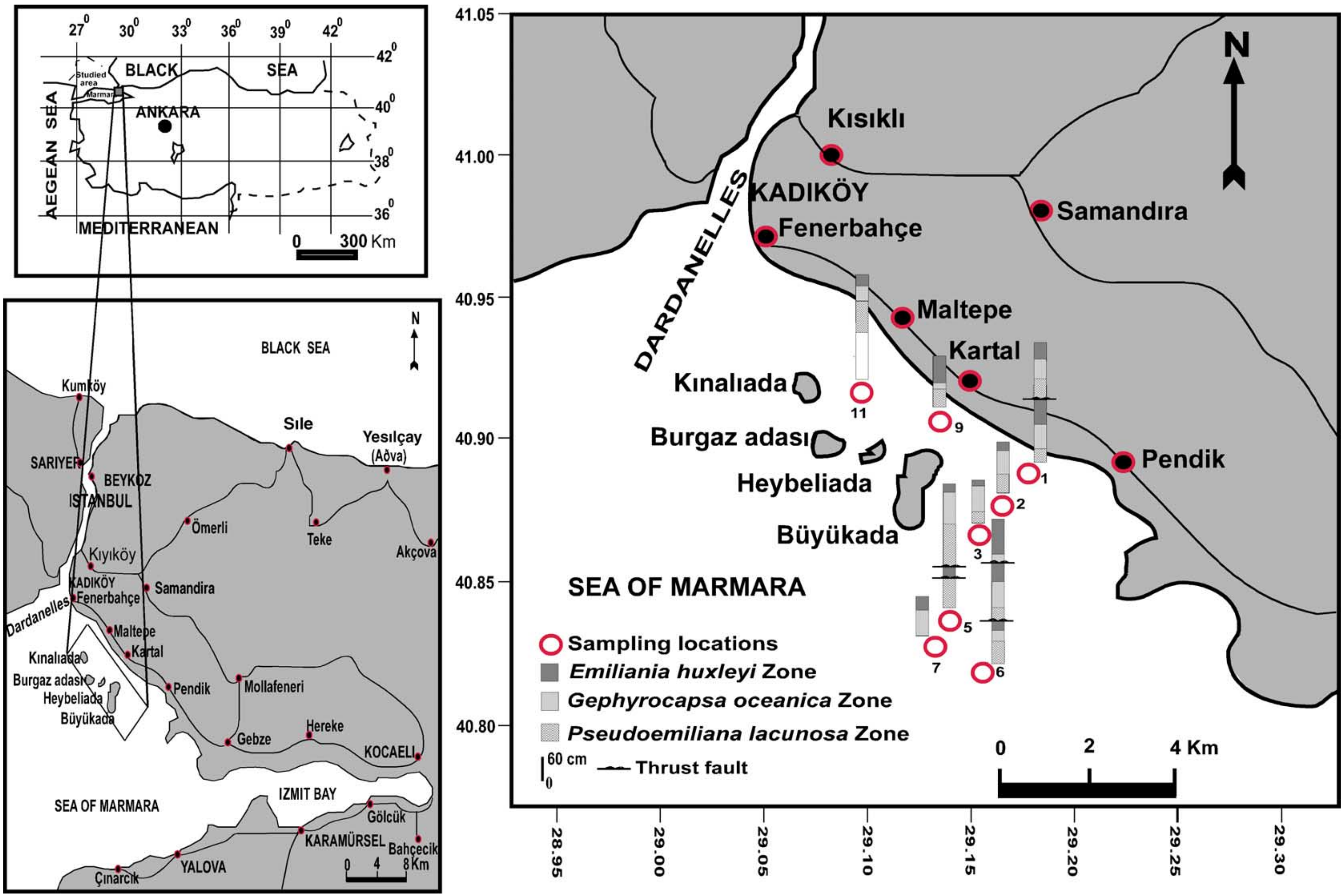

Fig. 1. Map and distribution of the core locations and calcareous nannofossil biozones in the studied area.

species of calcareous nannoplankton. A secondary goal is to evalute the relationship between the distribution of biozones and structural properties of the sea bottom and determine the time of various tectonic activity in the study area during the Pleistocene–Holocene period. We have also attempted to interpret changes in the temperature of the sea-surface water at the time of deposition (during the Pleistocene–Holocene interval), based on the distribution and percentage of temperature-sensitive calcareous species.

2. Material and methods

Eights-two core samples were taken from 8 locations in the northeastern Sea of Marmara in the 1997 Summer Season during a cruise by R/V MTA Sismik-1. For calcareous nannoplankton analysis smear, slides were prepared from raw samples. No specific techniques were applied to clean or concentrate the biogenic fraction in order to maintain the original composition of the nannofossil assemblages. Smear slides were examined with an Ortholux polarizing microscope using an oil-immersion objective at a magnification of ×1600. Relative abundances of the nannoplankton were estimated using the scheme of Wei (1988). Based on this method, the presence of one or more taxa in each field of view was considered as abundant, one taxa in 2–10 fields as common, one taxa in 11–50 fields was described as a few, and one taxa per 51–200 fields was regarded as rare. In addition, the distribution of nannoplankton abundance and the percentage of temperature-sensitive calcareous nannoplankton groups (per sample) were calculated, and are shown graphically (Figs. 2–9).

3. Calcareous nannofossil biostratigraphy

The biostratigraphic subdivision of core samples, using calcareous nannoplankton, was based on the zonations of Raffi and Rio (1979) for the Western Mediterranean and Castradori (1993) for the Eastern Mediterranean. The determined biozones were correlated with the zonations of Martini (1971) (Fig. 10).

3.1. *Pseudoemiliana lacunosa* Zone

Definition: Interval from the last occurence of *Discoaster brouweri* (Tan) to the last occurrence of *Pseudoemiliana lacunosa* (Kamptner).

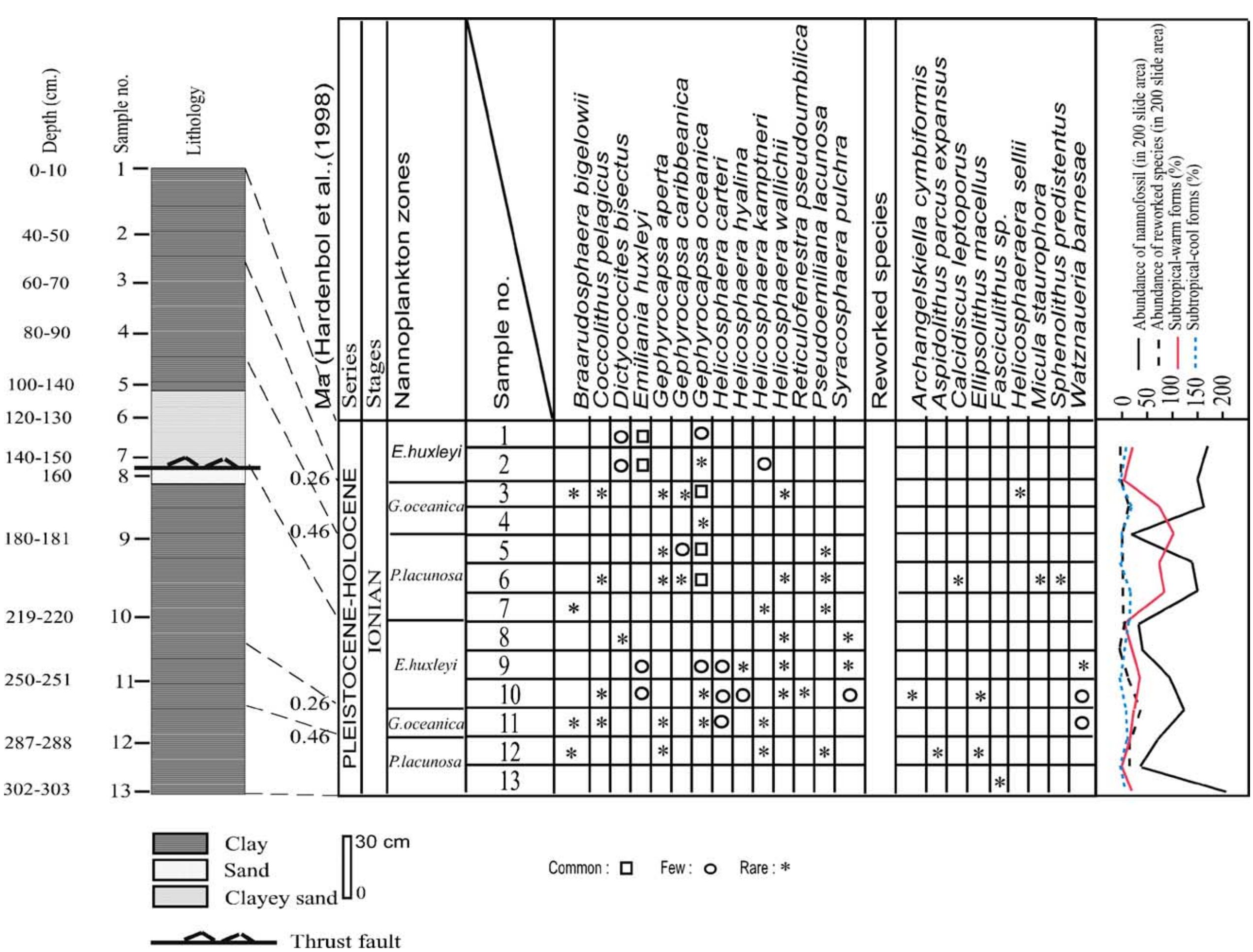

Fig. 2. Distribution of the calcareous nannofossil species and biozones of the samples from core 1.

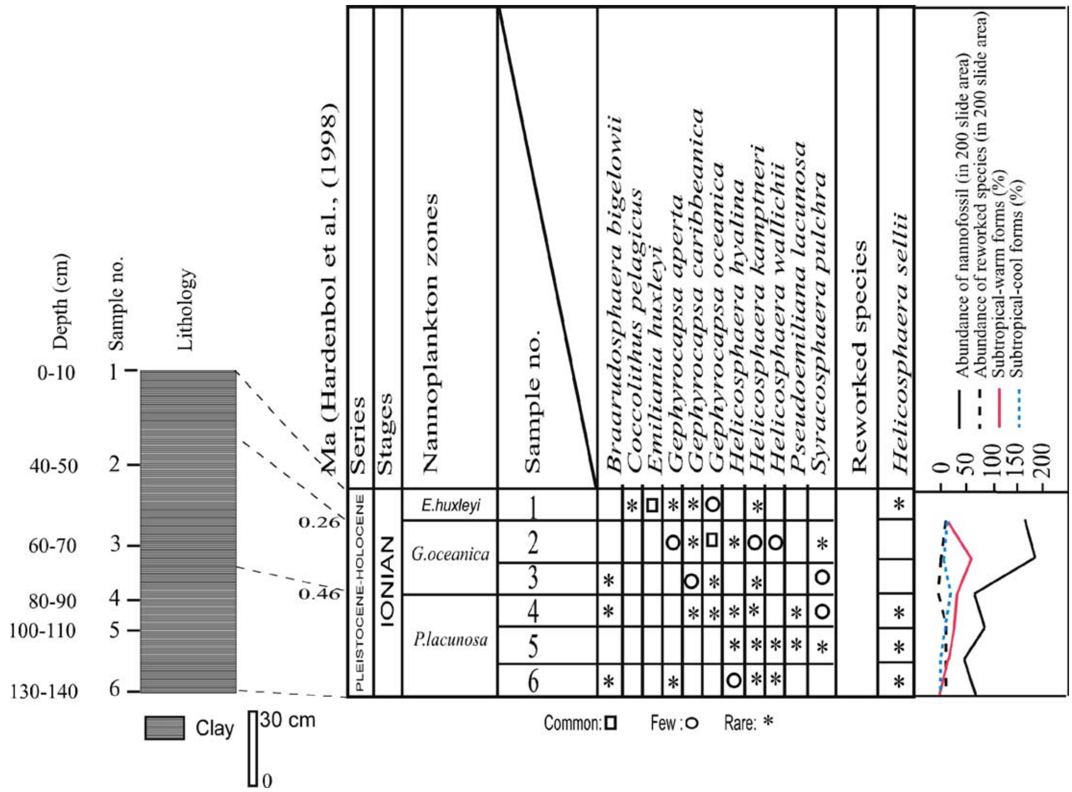

Fig. 3. Distribution of the calcareous nannofossil species and biozones of the samples from core 2.

Author: Martini, 1971.

Category: Concurrent range zone.

Age: late Gelasiyen–Ionian (Early Pleistocene).

Fossil association: *Braarudosphaera bigelowii* (Gran and Braarud), *Coccolithus pelagicus* (Wallich), *Helicosphaera carteri* (Wallich), *Helicosphaera hyalina* Gaarder, *Helicosphaera kamptneri* Hay and Mohler, *Helicosphaera wallichii* (Lohmann), *Gephyrocapsa aperta* Kamptner, *Gephyrocapsa caribbeanica* Boudreaux and Hay, *Gephyrocapsa oceanica* Kamptner, *Pseudoemiliana lacunosa* (Kamptner),

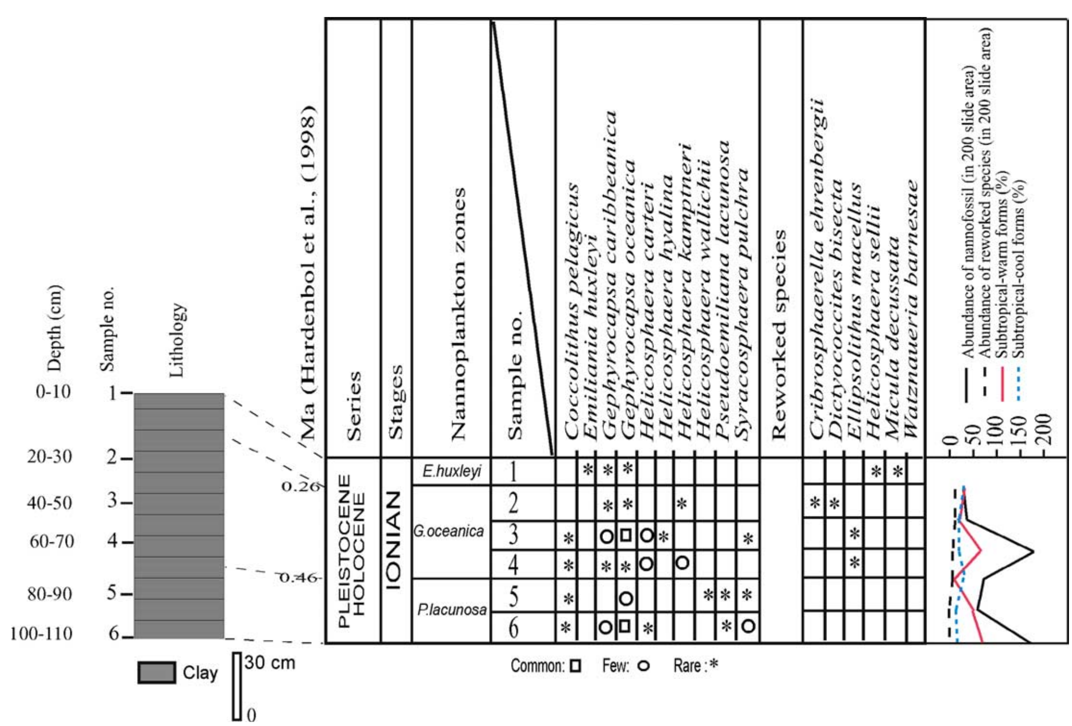

Fig. 4. Distribution of the calcareous nannofossil species and biozones of the samples from core 3.

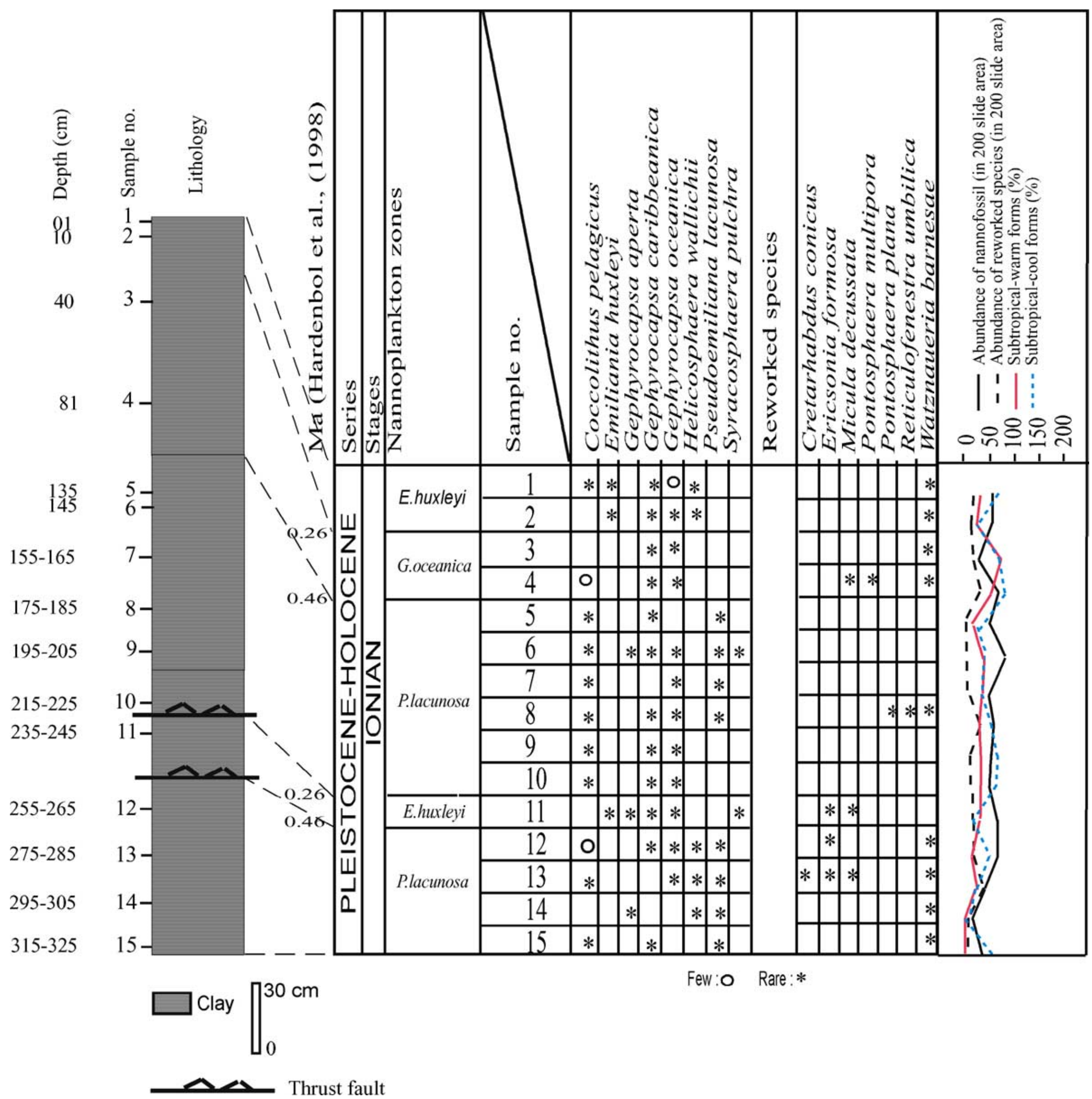

Fig. 5. Distribution of the calcareous nannofossil species and biozones of the samples from core 5.

Rhabdosphaera inflata Bramlette and Sullivan, *Syracosphaera pulchra* Lohmann (Figs. 2–6, 8–9, 11).

Correlation and interpretation: This biozone was defined by Martini (1971) (in Standard zonation) as NN19. It was defined at the following levels in the cores: samples 5–7, 12 and 13 were collected between 93 and 147 cm, and between 264 and 303 cm at core location 1; samples 4–6 occurred between 95 and 140 cm at core location 2; samples 5 and 6 between 80 and 110 cm at core location 3; samples 5–10 and 12–15, between 109 and 223 cm, and between 225 and 325 cm at core location 5; samples 9, 10, 13 and 14 between 224 cm, and 254, and between 314 and 365 cm at core location 6; samples 5–7 between 82 and 130 cm at core location 9, and samples 5–8 between 61 and 124 cm at core location 11 (Figs. 2–6, 8–9).

This biozone has been defined by Yıldız et al., (2003) during a previous investigation in the Mut area (SE Turkey). It is represented stratigraphicaly at the same level, with upper levels containing the *Coccolithus pelagicus* and *Pseudoemiliana lacunosa* zones of Raffi and Rio (1979) in the Western Mediterranean, and also *Calcidiscus macintyrei, Helicosphaera sellii,* large *Gephyrocapsa,* small *Gephyrocapsa, Pseudoemiliana lacunosa* zones of Castradori (1993) in the Eastern Mediterranean (Fig. 10). The base of the biozone has been determined by Martini (1971) as the last occurence of *Discoaster brouweri* (Tan). *Discoaster brouweri* (Tan) was not recovered in samples from the area studied here, and for this reason the bottom level of the *Pseudoemiliana lacunosa* Zone has not been identified in this investigation.

The recognized *Pseudoemiliana lacunosa* Zone, correlates well with the upper levels of the *Pseudoemiliana lacunosa* Zone of Martini (1971) and Raffi and Rio (1979). Therefore, this zone is assigned to the Early Pleistocene (Ionian) in the area under investigation (Fig. 10).

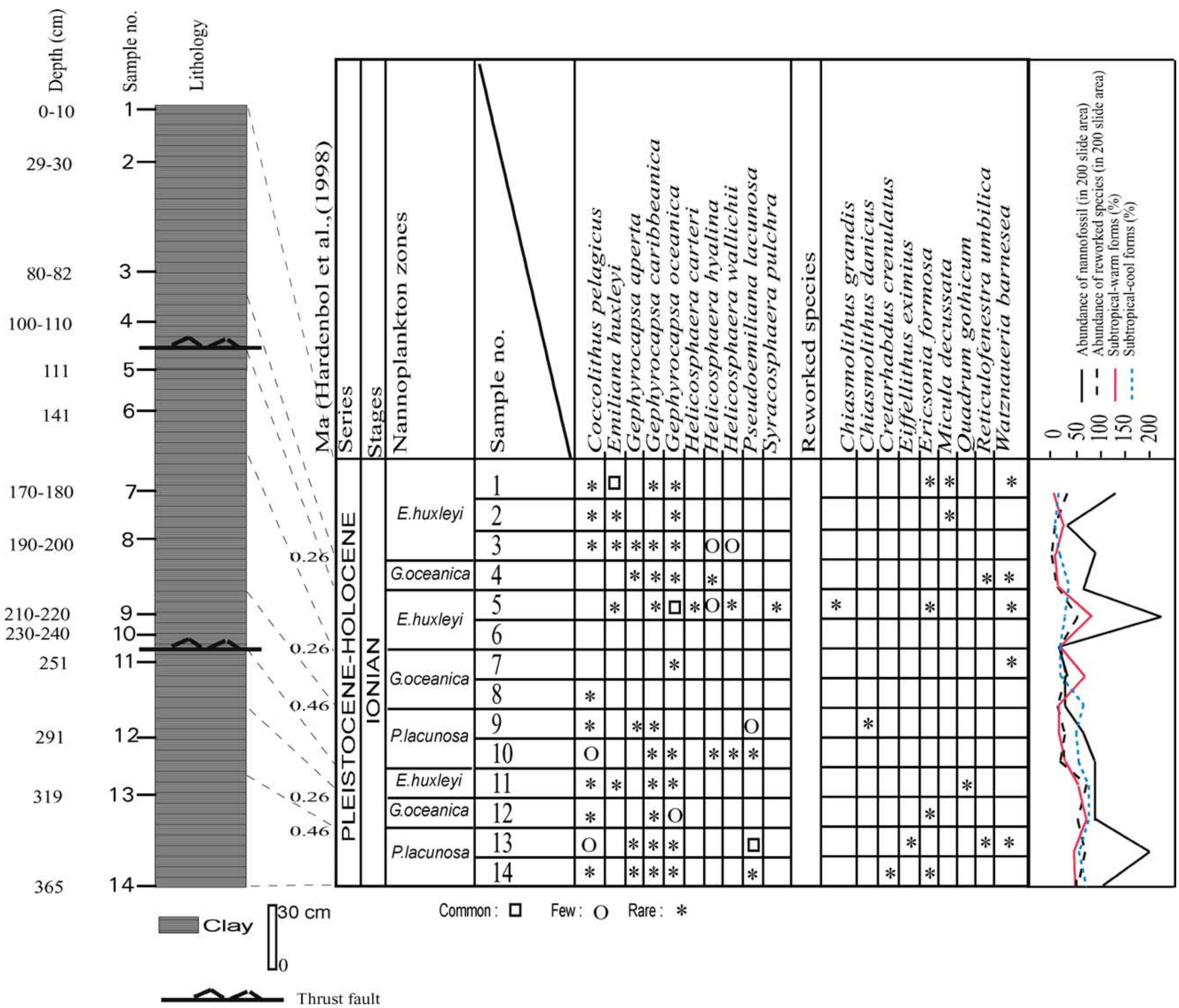

Fig. 6. Distribution of the nannoplankton species and biozones of the samples from core 6.

3.2. *Gephyrocapsa oceanica* Zone

Definition: Interval from the last occurence of *Pseudoemiliana lacunosa* (Kamptner) to the first occurrence of *Emiliania huxleyi* (Lohmann).

Author: Martini, 1971.

Category: Concurrent range zone.

Age: Ionian (Late Pleistocene).

Fossil association: *Braarudosphaera bigelowii* (Gran and Braarud), *Coccolithus pelagicus* (Wallich), *Helicosphaera carteri* (Wallich), *Helicosphaera hyalina* Gaarder, *Helicosphaera kamptneri* Hay and Mohler, *Helicosphaera wallichii* (Lohmann), *Gephyrocapsa aperta* Kamptner, *Gephyrocapsa caribbeanica* Boudreaux and Hay, *Gephyrocapsa oceanica* Kamptner, *Rhabdosphaera inflata* Bramlette and Sullivan, *Syracosphaera pulchra* Lohmann (Figs. 2–9, 11).

Correlation and interpretation: This biozone was defined by Martini (1971) (in Standard zonation) as NN20. It was defined at the following levels of cores: samples 3, 4 and 11 were collected between 48 and 93 cm, and 231–264 cm at core location 1; samples 2 and 3 between 35 and 95 cm at core location 2; samples 2–4 between 20 and 80 cm at core location 3; samples 3 and 4 between 40 and 109 cm at core location 5; samples 4, 8, 7 and 12 between 95 and 116 cm, 161–224 cm and 275–314 cm at core location 6; samples 3–6 between 30 and 96 cm at core location 7; sample 4 was collected between 58 and 82 cm at core location 9, and samples 3 and 4 between 25 and 61 cm at core location 11 (Figs. 2–9).

Therefore, this zone is assigned to the Late Pleistocene (Ionian) in the area investigated (Fig. 10).

3.3. *Emiliania huxleyi* Zone

Definition: Interval above the first occurence of *Emiliania huxleyi* (Lohmann).

Author: Castradori, 1993 (Boudreaux and Hay in Hay et al., 1967)

Category: Range zone.

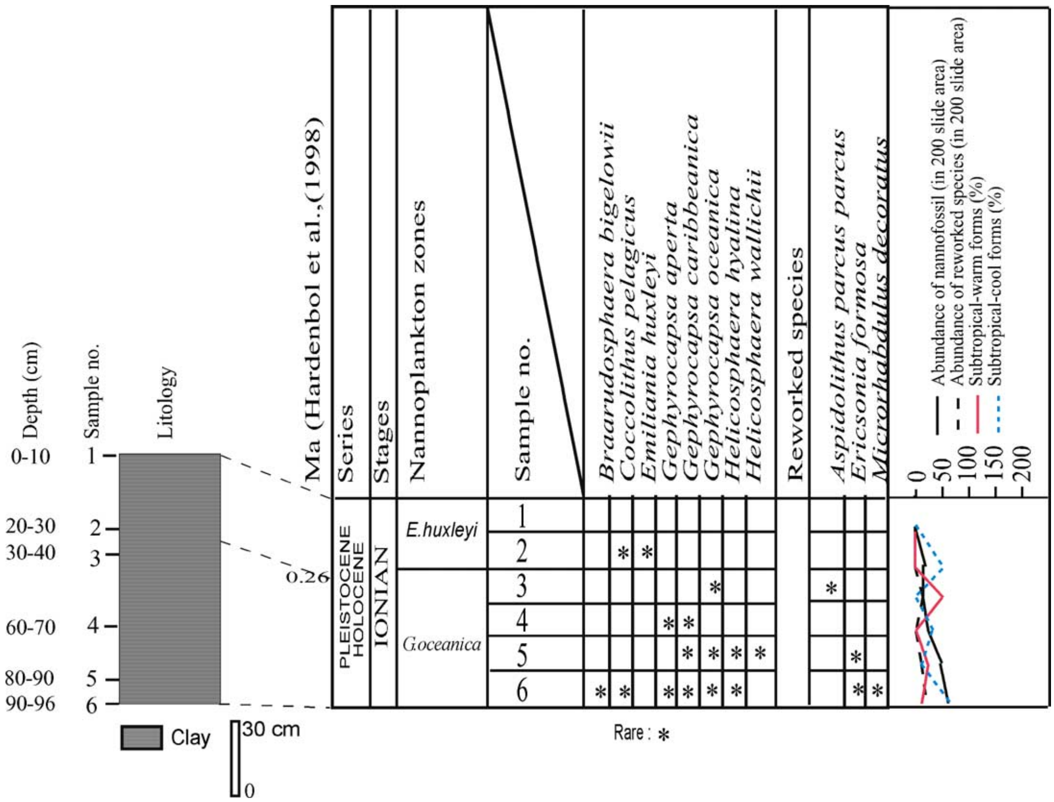

Fig. 7. Distribution of the calcareous nannofossil species and biozones of the samples from core 7.

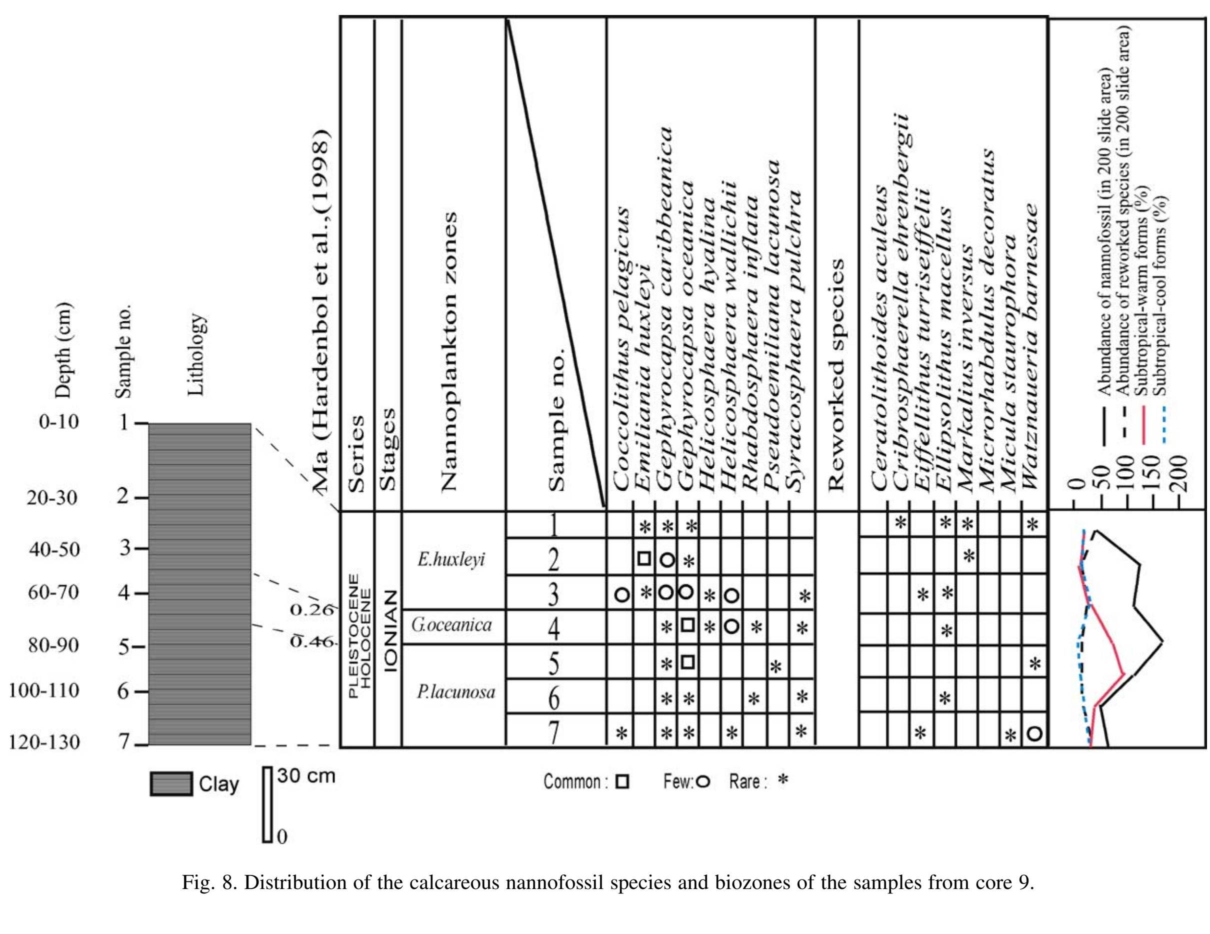

Fig. 8. Distribution of the calcareous nannofossil species and biozones of the samples from core 9.

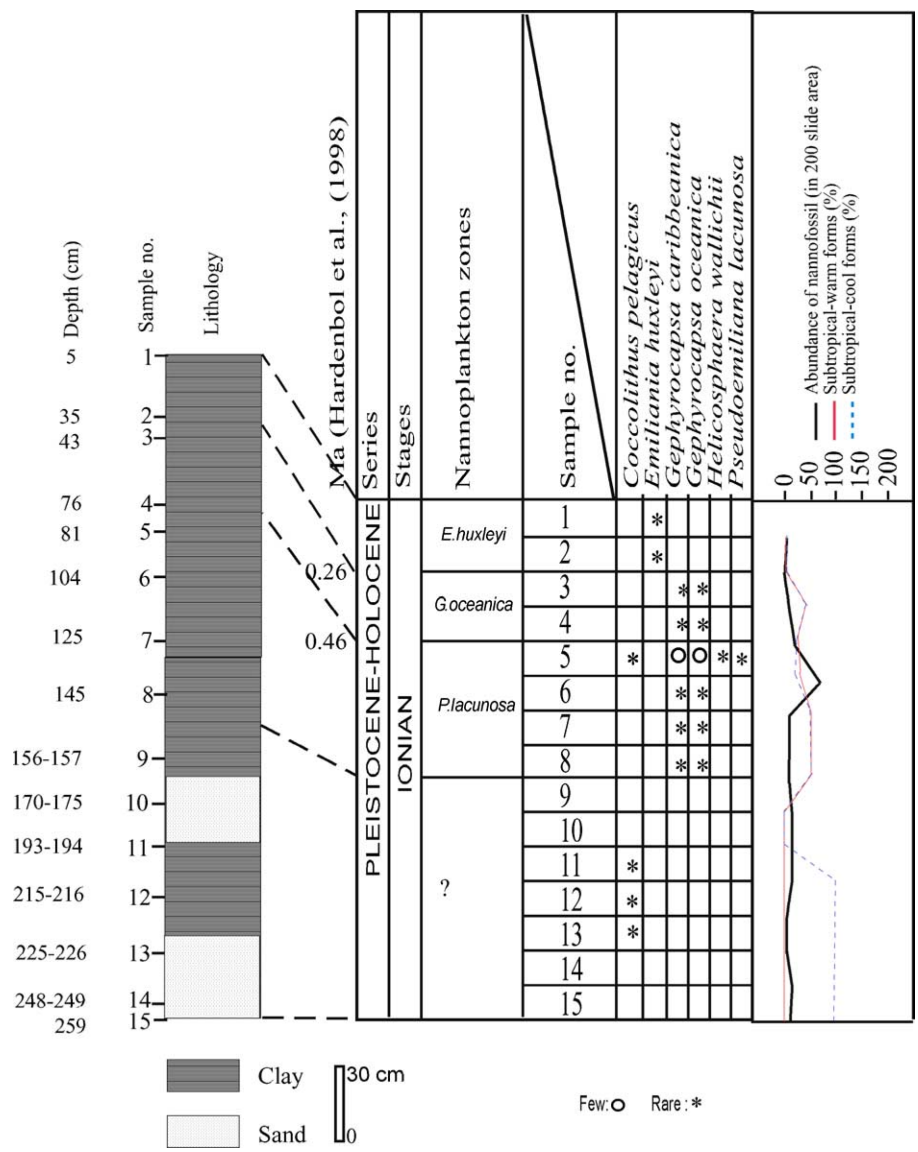

Fig. 9. Distribution of the calcareous nannofossil species and biozones of the samples from core 11.

Age: Ionian (Late Pleistocene–Holocene).

Fossil association: *Coccolithus pelagicus* (Wallich), *Dictyococcites bisectus* (Hay, Mohler and Wade), *Emiliania huxleyi* (Lohmann), *Helicosphaera carteri* (Wallich), *Helicosphaera hyalina* Gaarder, *Helicosphaera kamptneri* Hay and Mohler, *Helicosphaera wallichii* (Lohmann), *Gephyrocapsa aperta* Kamptner, *Gephyrocapsa caribbeanica* Boudreaux and Hay, *Gephyrocapsa oceanica* Kamptner, *Reticulofenestra pseudoumbilica* (Gartner), *Syracosphaera pulchra* Lohmann (Figs. 2–9, 11).

Correlation and interpretation: This biozone was defined by Martini (1971) (in Standard zonation) as NN21. It was defined at the following levels of cores: samples 1–2 and 8–10 collected between 0.0 and 48 cm, and 147–231 cm at core location 1; sample 1 at 0.0–35 cm at core location 2; sample 1 between 0.0 and 20 cm at core location 3; samples 1,2 and 11 between 0.0 and 40 cm, and 223–253 cm at core location 5; samples 1–3,5,6 and 11 between 0.0 and 95 cm, 116–161 cm and, 254–275 cm at core location 6; samples 1 and 2, between 0.0 and 30 cm at core location 7; samples 1–3 were collected between 0.0 and 58 cm at core location 9, and samples 1 and 2 between 0.0 and 25 cm at core location 11 (Figs. 2–9).

This zone is assigned to the Late Pleistocene–Holocene (Ionian) in the area under investigation (Fig. 10).

4. Conclusions

In this study, 16 calcareous nannoplankton species belonging to 11 genera and 3 biozones have been determined within the Pleistocene–Holocene (Ionian) interval (Figs. 1–10, 11).

It was observed that the identified biozones were altered by tectonic activity at core locations 1, 5 and 6. It is suggested that there were thrust faults at these locations. The alternation

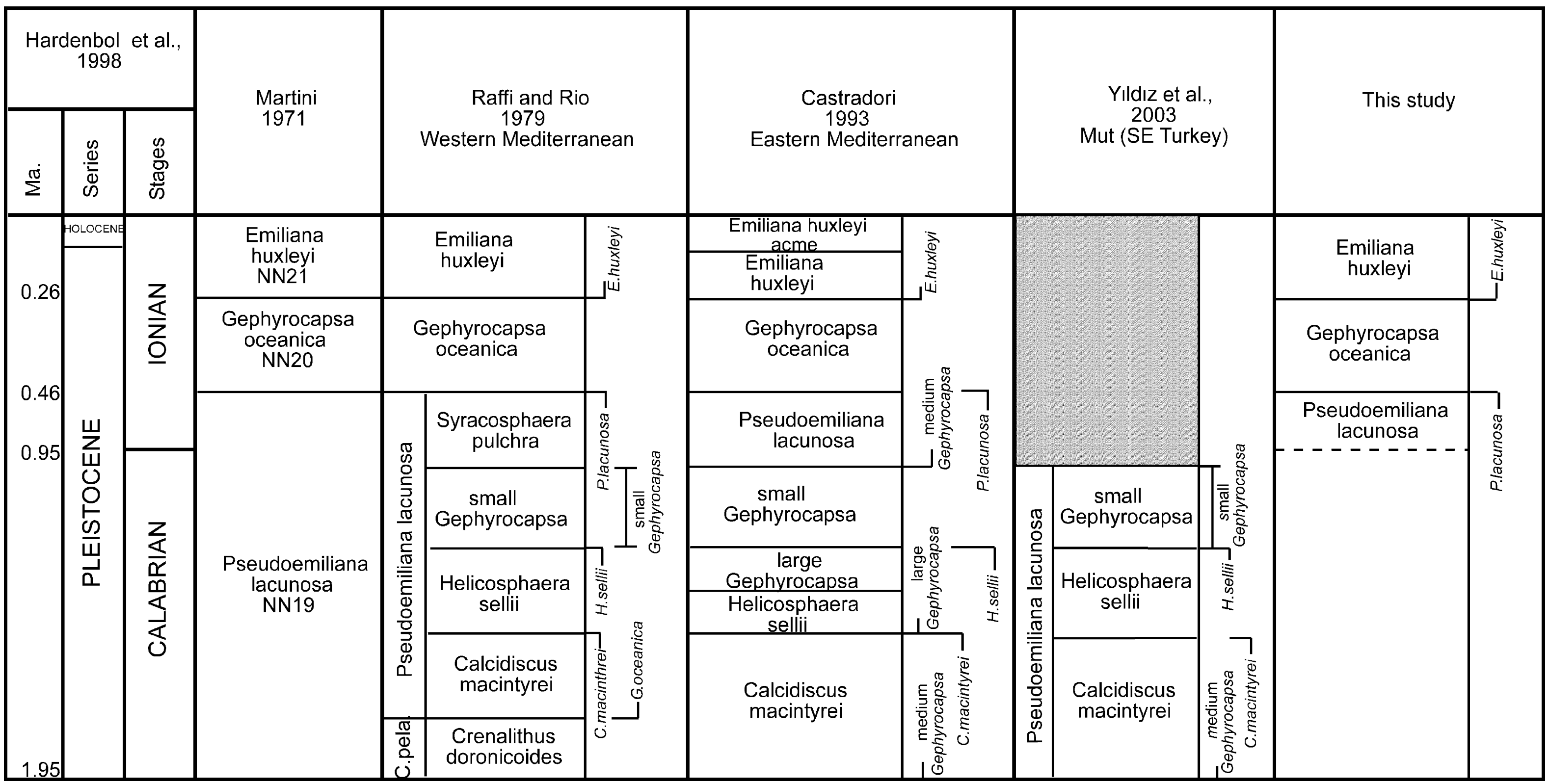

Fig. 10. The correlation of the determined calcareous nannofossil biozones from the studied area with the other studies.

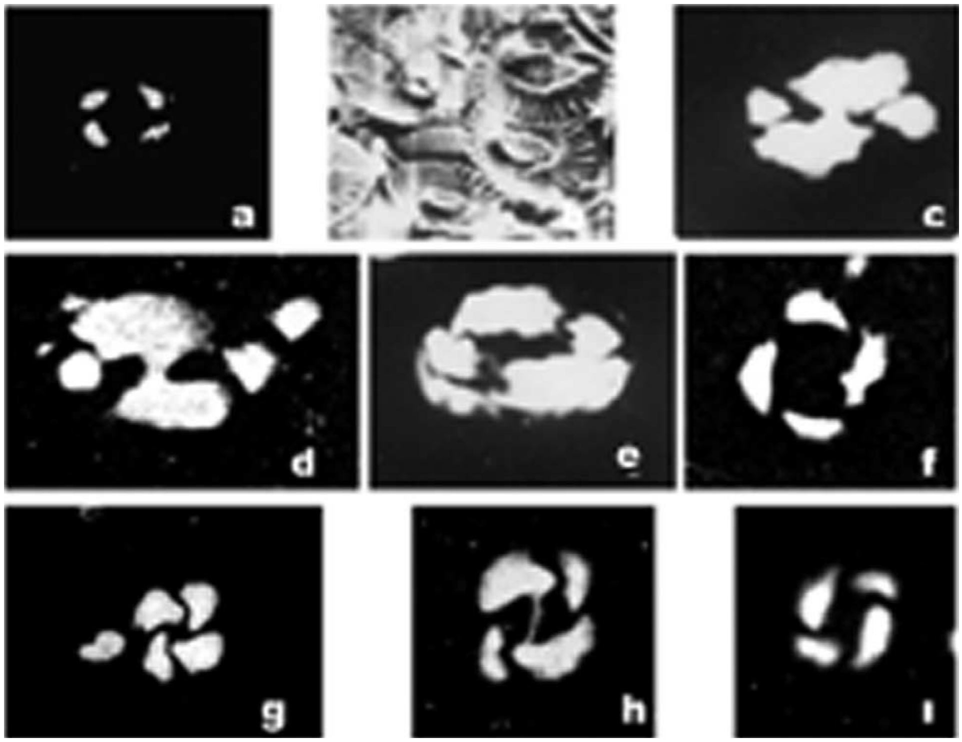

Fig. 11. (a) *Emiliania huxleyi* (Lohmann), Cross-Polarized, X7500, Core 2, Sample no.1; (b) *Emiliania huxleyi* (Lohmann), (SEM), X3200, Core 2, Sample no.1; (c) *Helicosphaera kamptneri*, Hay and Mohler, Cross Polarized, X2920, Core 2, Sample no.1; (d) *Helicosphaera sellii*, Bukry and Bramlette, Cross Polarized, X2940, Core 3, Sample no.1; (e) *Helicosphaera hyalina*, Gaarder, Cross Polarized, X2900, Core 2, Sample no.2; (f) *Pseudoemiliana lacunosa* (Kamptner), Cross Polarized, X2830, Core 2, Sample no.4; (g) *Gephyrocapsa caribbeanica* Boudreaux and Hay, Cross Polarized, X2900, Core 1, Sample no.3; (h) *Gephyrocapsa oceanica* Kamptner, Cross Polarized, X3750, Core 1, Sample no.1; (ı) *Gephyrocapsa oceanica* Kamptner, Cross Polarized, X4290, Core 2, Sample no.4.

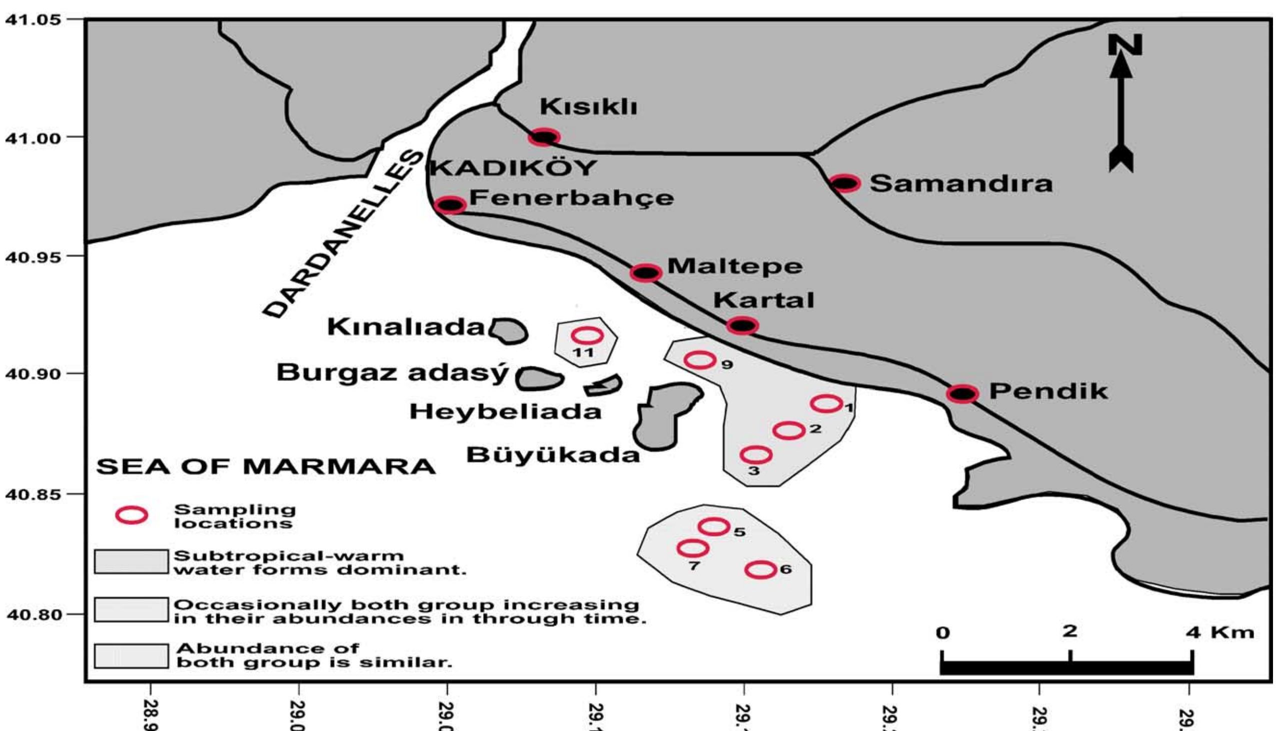

Fig. 12. Distribution of the temperature-sensitive calcareous nannoplankton groups in the study area.

occurred once at core location 1 after deposition of the Emiliana huxleyi Zone (Holocene), and twice at location 5, the first after deposition of the Pseudoemiliana lacunosa Zone (Early Pleistocene) and later after the deposition of the Emiliana huxleyi Zone (Holocene). At the core 6, the alternation, the alternations occurred twice after deposition of the Emiliana huxleyi Zone (Holocene). According to these data, we can say that, the study area has been affected three times by tectonic activity during the Pleistocene–Holocene time interval. The first occurred during the Early Pleistocene and the others during Holocene time. These data also indicate that, the North Anatolian Fault Zone continues within the Sea of Marmara and the North Anatolian Fault was active during the Early Pleistocene-Holocene time interval in the study area (Figs. 1, 2, 5 and 6).

The relative abundance of nannofossils in the samples increases at core locations 1, 2, 3 and 9, and is probably affected by water depth, sea-surface water temperature, and also water currents (Figs. 2–4, 8). Among the identified species, *Gephyrocapsa oceanica* Kamptner and *Syracosphaera pulchra* Lohmann are subtropical-warm water forms, while *Coccolithus pelagicus* (Wallich), *Gephyrocapsa caribbeanica* Boudreaux and Hay prefer subtropical-cool waters (McIntyre and Bé, 1967; McIntyre et al., 1970; Okada and Hanjo, 1975; Braarud, 1979; Okada and McIntyre, 1979; Nishida, 1979, 1986; Prell et al., 1980; Weaver, 1983; Mitchell-Innes and Winter, 1987; Matsuoka and Okada, 1989; Houghton and Guptha, 1991; Ushakova and Blyum, 1991; Giraudeau, 1992; Houghton, 1993; Cachão and Moita, 1995; Samtleben et al., 1995; Jordan et al., 1996; Cheng and Wang, 1997; Wells and Okada, 1997; Flores et al., 1999).

In the study area, the distribution and abundance of the temperature-sensitive calcareous nannoplankton species display significant differences based on warm and cool water currents. While the subtropical-warm water forms are generally dominant (25–100%) in core samples 1–3 and 9, the occasionally subtropical-warm water forms (0.0–70%) and subtropical-cool water forms (0.0–75%) of samples 5–7, increase in abundance over the same interval of time. The abundance of both groups is similar (0–50%) at core location 11 (Figs. 2–9, 12).

Acknowledgements

We are grateful to Dr Meral Doğan (Hacettepe University, Department of Geological Engineering) to give permission to use the samples for calcareous nannoplankton investigation.

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