A new biostratigraphically significant calcareous nannofossil species in the Early Pliocene of the Mediterranean

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ABSTRACT: Here we describe *Reticulofenestra cisnerosii* nov. sp. a rounded species of "Reticulofenestrid" with a well defined stratigraphic distribution in the Mediterranean Neogene. The first occurrence of this new taxa is placed in the middle part of subchron Thvera (C3n4n); in the subzone CN10b (Okada and Bukry 1980); and the last occurrence is observed into the subchron C3n1r, middle part of subzone CN 11a (Okada and Bukry 1980), just before the regular record of *Discoaster asymmetricus.* In the region studied, this species is linked with warm, moderately saline and relatively fertile waters. This species has also been observed in the equatorial Pacific.

INTRODUCTION

Reticulofenestra is a common genus in the geological record through the Paleogene and Neogene (including the Quaternary). Several events based on different species of *Reticulofenestra* have been used as biostratigraphic markers (Backman 1980; Pujos 1987; Driever 1988; Gallagher 1989; Young 1990; Rio et al 1990; Raffi and Flores 1995; Kameo and Takayama 1999; Okada, 2000; Marino and Flores 2002, among others). Lancis (1998) carried out a qualitative and quantitative study of Neogene materials from the Bethic region (figure 1) mainly based on Reticulofenestrids, with a focus on biostratigraphic and paleoecological reconstuctions. Lancis (1998) used both standard and regional biozonations (Martini 1971; Okada and Bukry 1980; Rio et al. 1990; Raffi and Flores 1995; Fornaciari et al. 1996) for calibration of several newly defined events. One of the most characteristic events in the lower Pliocene is the record of rounded forms of *Reticulofenestra* (from 4 to 8µm) which occur just after the first occurrence of *Ceratolithus acutus* (Gartner and Bukry 1974), in the Messinian-Pliocene interval. These forms are clearly different from *Pseudoemiliania lacunosa* (Kamptner 1963; Gartner 1969) and *Reticulofenestra pseudoumbilicus* (Gartner 1967; Gartner 1969), both of which are abundant in this interval. Morphological and stratigraphic criteria are used to distinguish these specimens from others with similar characteristics.

TAXONOMY

CLASS Prymnesiophyceae Hibberd 1976
FAMILY Noelaerhabdaceae Jerkovic 1970
GENUS Reticulofenestra Hay, Mohler and Wade 1966 emend. Gallagher 1989

Reticulofenestra cisnerosii Lancis and Flores **n. sp.**
Plate 1, figures 1-10

Etymology: "In memoriam" Professor Daniel Jiménez de Cisneros y Hervás teacher in *Instituto de Segunda Enseñanza* of Alicante between 1904 and 1933 and pioneer palaeontologist in Alicante (Spain).

Description: Circular to subcircular placoliths with a well developed collar with a distal part of proximal shield elevated, defining a prominent collar with high brightness when observed under crossed nichols. The central opening constitutes at least one third of the total diameter. The distal shield is similar in thickness at the collar but less birefingent. Periphery is slightly jagged.

Size between 4 and 8µm.

Occurrence: Reticulofenestra cisnerosii have their first occurrence in the early Pliocene, after the first occurrence of C*eratolithus acutus*, in the Thvera chron (C3n4n- middle part of Subzone CN10b); and their last occurrence in the middle part of Subzone CN11a, just before the first record (scattered) of *Discoaster asymmetricus* Gartner 1969 in chron C3n4n. Based on Berggren et al. (1995), this represents an interval between 5.23 and 4.48 Ma.

Preliminary studies carried out in the equatorial Pacific (Ocean Drilling Project Site 202) show a similar distribution.

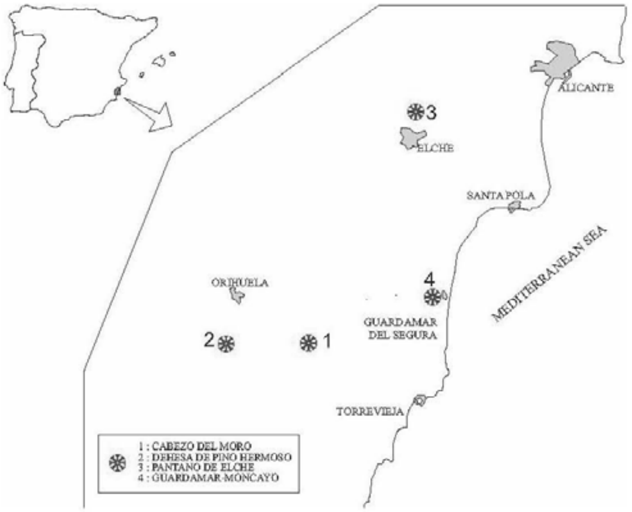
Type locality: Dehesa de Pino Hermoso. (Alicante) Spain.

Section DPH. Holotype: sample DPH20 (fig. 1a,b)

Paratypes: Samples DPH 14 (fig. 2a,b; 3a,b), DPH 15 (fig. 6), PTEL 4 (fig. 4a,b), PTEL 6 (fig 7-10), PTEL 9 (fig. 5a,b).

Depository: Laboratorio de Geología de la Universidad de Alicante (Spain).

Remarks: A narrow distal shield with a prominent collar as well as circular-subcircular form allow us to differentiate *R. cisnerosii* from *R. pseudoumbilicus*. *Reticulofenestra rotaria* (Theodoridis 1984=*Reticulofenestra pseudoumbilicus* var. *rotaria* sensu Young 1990) is similar in morphology, but this species is characteristic from the Messinian in the Bethic sections. *Reticulofenestra asanoi* (Sato and Takayama 1992) is also similar to *R. cisnerosi* but their record is exclusively Pleistocene (Sato and Takayama 1992; Wei 1993). Kameo and Takayama (1999) and Kameo and Bralower (2000) observed in Deep Sea



TEXT-FIGURE 1
Geographic situation of the studied sections.

Drilling Program Sites 606, 607 and 610 (North Atlantic) and ODP Sites 998, 999 and 1000 (Caribbean Sea), respectively, a similar morphology named *R. minutula* var. A (circular form) larger than 5 mm, but they occur in the lower part of zone CN12a. *R. cisnerossi* is easy to distinguish from *Reticulofenestra pacifica* Nishida 1979 due to their eliptical form.

Paleoecological remarks

Based in the nannofossil assemblage, Lancis (1998) interpreted *R. cisnerosii* (morphotypes now named in this way) as being more abundant in warm, moderately saline and relatively fertile waters, due to low proportions of *R. pseudoumbilicu*s and high proportions of small and medium *Reticulofenestra* (*R. haqii/minutula* and *R. minuta*) and Helicosphaera, as well as and regular presence of sphenoliths, asteroliths and *Calcidiscus* spp.

Comments

As noted, the presence of circular species is recurrent during the late Neogene. In several cases, such as with *R. rotaria*, these morphologies are frequent to abundant under conditions of ecological stress in semi-closed basins (Flores et al., 2005), although they are also present in open ocean (Raffi and Flores 1995) in minor proportions. This species is abundant at the base of the Pliocene in the Mediterranean region immediately after the Messinian Salinity crisis, returning to normal oceanic conditions but still under certain restriction due their semi-closed basin characteristic. At this time an intense seasonality under relatively warm conditions were the dominant environmental conditions (Lancis 1998). Other taxa, such as *R. minutula* var. A or *R. asanoi*, developed this rounded morphology synchronously in the ocean.

This intriguing evolutionary behaviour raises several questions: Do these forms respond to a common strategy? Can they be considered ecophenotypic modifications? How can this study be approached?

For us, the repetition of this circular morphology represents a case of iterative evolution, from the common branch of *R. pseudoumbilicus*. This process occurs at different intervals: Messinian, lower Pliocene, late Pliocene and middle Pleistocene, responding to equivalent selective pressure. Stressing conditions where intense seasonality could play a crucial role favours the development of circular forms. These changes seem to occur in relatively simple ecophenotypical features such as the coccolith morphology. These kinds of characteristics are probably controlled by a reduced number of genes with a common regulation. The appearance of weak modifications in the coccolith morphology or in the amount of calcite produced in the collar only would imply punctual mutations with high probability of success. The possibility of selection of these changes is linked to favouring environmental conditions. The repetition of these conditions towards the Neogene seems to be the reason of this iteration.

We note that, however, that specimens with intermediate morphology between *R. cisnerosii* and *P. lacunosa* (occasional presence of few small windows in the distal shield) have been observed. These characteristics, strictly morphological, raise the possibility that some forms of *P. lacunosa* evolved from *R .cisnerosii*. In any case, the morphological variations in shape and size observed in this species (e.g., Young 1990; Driever 1988) suggest a poliphiletic origin. Additional studies are necessary to clarify these ideas.

We are conscious that this is the beginning of a challenge to decipher this peculiar variability, but at the same time we consider that identification and calibration of these forms in the sedimentary sequence constitutes a useful biostratigraphic tool.

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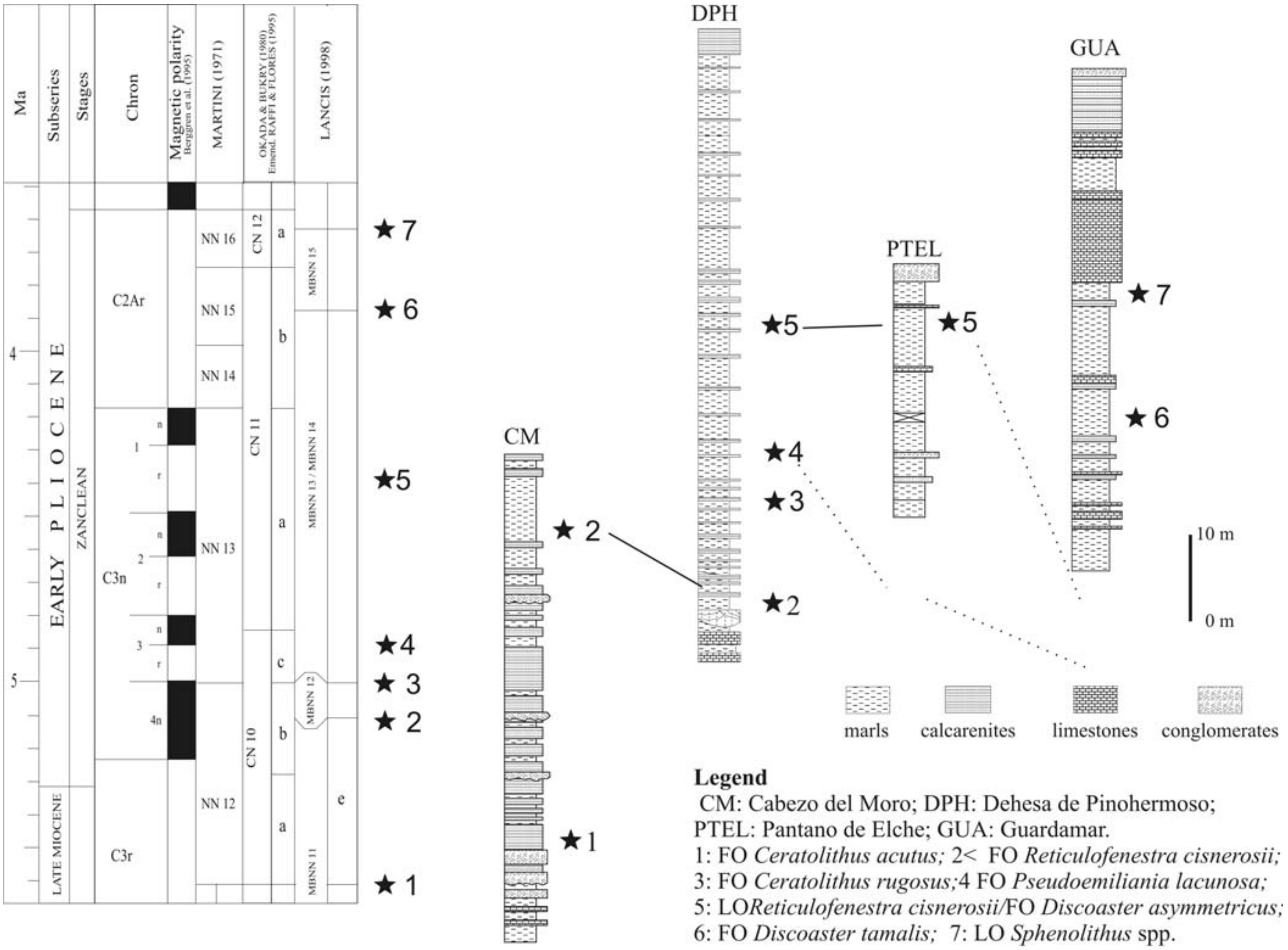

TEXT-FIGURE 2
Stratigraphic correlation panel. Lithology and situation of calcareous nannofossil biostratigraphy events: FO and LO of *Reticulofenestra cisnerosii* nov.sp. and their relationship with the geomagnetic and calcareous nannofossil bisotratigraphy standard scales. FO- first occurrence; LO- last occurrence.

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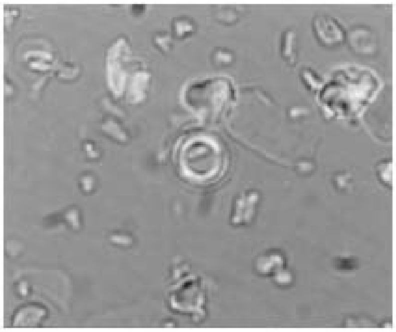
PLATE 1

Reticulofenestra cisnerosii. Magnification ×1500.
1-5, Petrographic microscope: a, parallel nichols and b crossed nichols.

1a,b Holotype; sample DPH 20.
2a,b Paratype; sample DPH 14.
4a,b Paratype; sample PTEL 6.
5a,b Paratype; samples PTEL 9.

6-10 — Scanning electron microscope. Paratype; sample PTEL 6.



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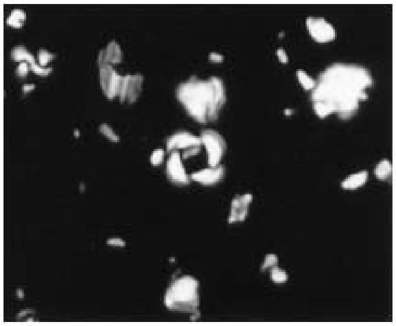

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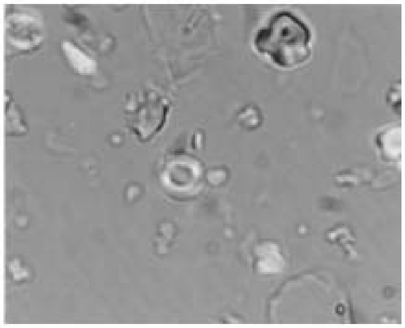

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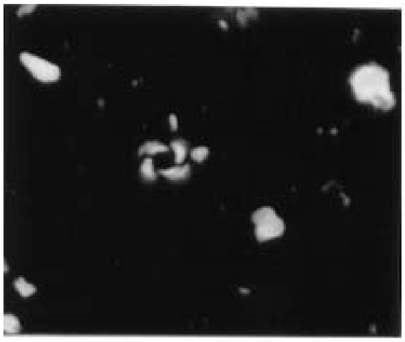

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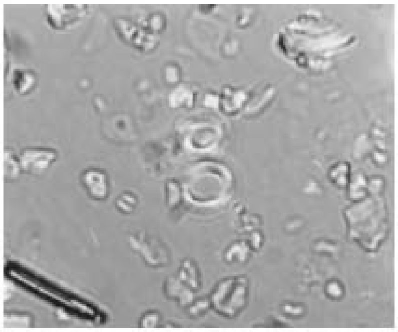

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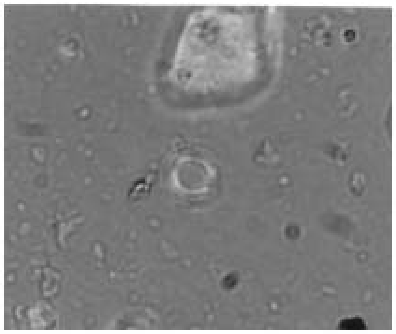

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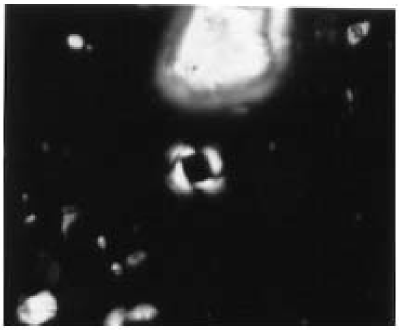

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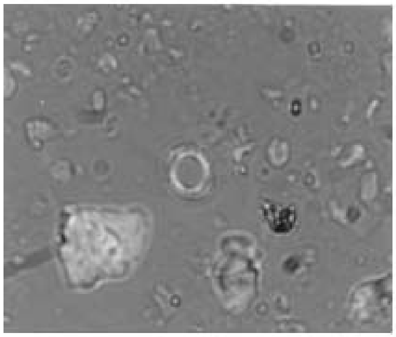

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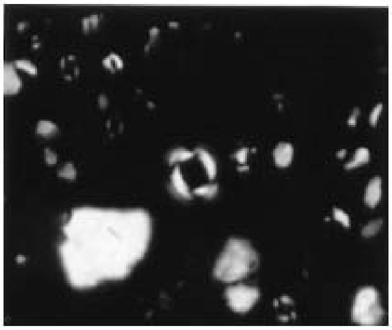

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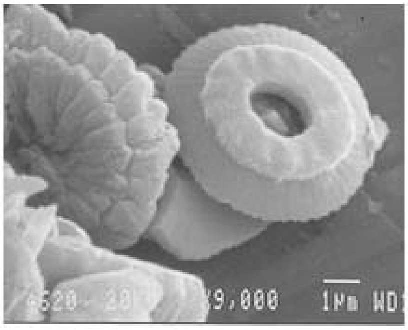

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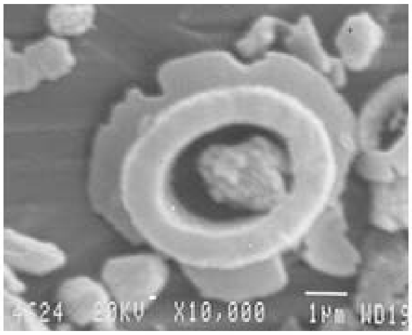

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