Upper lower Eocene calcareous nannoplankton from the Las Pocitas core (Tepetate formation), Baja California Sur, Mexico

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ABSTRACT

Sixty species of calcareous nannoplankton from the Tepetate formation were recovered from a drill hole near Las Pocitas, Baja California Sur. In spite of its low abundance and erratic distribution throughout the sedimentary column, the great amount of reworked species, as well as the absence of traditional index fossils representing the standard tropical biozonation, the co-occurrence of Reticulofenestra dyctioda, Rhabdosphaera crebra, R. pinguis, Micrantholithus flos, Pontosphaera pectinata and Lanternithus minutus situates the studied stratigraphic column at the Discoasteroides kuepperi CP12a Subzone of Okada and Bukry, dated between 49.5 and 49 Ma at the top of the upper lower Eocene.

The population structure as well as the lithological features of the sedimentary package, suggest a temperate open-sea deposit, which confirms interpretations based on other marine fossils at arroyo Datilar, El Conejo, Salada, Colorado y Las Pocitas, where rocks of the lower middle Eocene Tepetate formation crop out.

Key words: biostratigraphy, calcareous nannofossils, Tepetate formation, Eocene, Baja California Sur, Mexico.

RESUMEN

Sesenta especies de nanoplancton calcáreo provenientes de la formación Tepetate fueron recuperadas de un pozo exploratorio perforado en los alrededores de Las Pocitas, Baja California Sur. A pesar de su baja abundancia y distribución errática a través de la columna sedimentaria, la alta frecuencia de especies retrabajadas así como la ausencia de fósiles índice tradicionales de las biozonaciones tropicales estándares, la presencia de Reticulofenestra dyctioda, Rhabdosphaera crebra, R. pinguis, Micrantholithus flos, Pontosphaera pectinata y Lanternithus minutus sitúa la columna estratigráfica estudiada dentro de la subzona CP12a de Discoateroides kuepperi de Okada y Bukry calibrada entre 49.5 y 49 Ma en la parte final del Eoceno inferior.

La estructura de la población, así como las características litológicas de los paquetes sedimentarios sugieren condiciones de depósito de mar abierto en un ambiente templado, confirmando interpretaciones previas basadas en diversos fósiles marinos provenientes de los arroyos Datilar, El Conejo, Salada, Colorado y Las Pocitas, donde afloran rocas del Eoceno inferior de la formación Tepetate.

Palabras clave: bioestratigrafía, nanofósiles calcáreos, formación Tepetate, Eoceno, Baja California Sur, México.

INTRODUCTION

While worldwide the calcareous nannoplakton is a valuable tool in biostratigraphy as well as in other Earth Sciences disciplines, in Mexico it is still poorly known, except for the research made in petroleum exploration, where results remain unpublished as private reports. Several undergraduate theses have been conducted in Mexico but unfortunately, all those remain unpublished.

In order to test the use of standard nannoplankton zonation in temperate areas in Mexico and its application to biostratigraphic studies, as well as to evaluate the resolution of this important group in comparison with other microfossils, the present paper evaluates the distribution of this flora throughout the upper part of the Tepetate formation and, on the basis of its assemblages, an age is proposed. The study forms part of a project consisting in the stratigraphic revision of the Cenozoic marine units that crop out in the Baja California Peninsula, which pretends to obtain enough data in order to best asses the geological evolution of the Baja California Peninsula.

PREVIOUS WORK

The Tepetate formation as an informal lithostratigraphic unit was named by Heim (1922) to include the marine rocks outcropping near rancho El Tepetate in Arroyo Colorado, Baja California Sur, Mexico. It is constituted by slightly folded, well-stratified sandstone and shale, 1,000 m thick, and was interpreted as an Eocene neritic deposit. Beal (1948) assigned a middle Eocene age to this unit concluding that it was deposited in a coastal marine environment. Mina-Uhink (1957), based on the presence of several species of foraminifers, strongly suggested an early Eocene age and considered that the deposits included a coastal to neritic paleoenvironment.

Within a biostratigraphic scope using microfossils, three important studies must be mentioned: the one by Knappe (1974, *in* Minch and Leslie, 1979), that of Fulwider (1976) using planktonic foraminifers, and Coleman's (1979) with calcareous nannoplankton. In spite of the important contribution of Fulwider's (1976) paper to the lithological and biostratigraphical characterization of the Tepetate formation, the lack of precise location of the composite measured sections, that otherwise are the same used by Coleman (1979) in her study, both master theses remain unpublished.

Ledesma-Vázquez *et al.* (1999) and Carreño *et al.* (2000), in a composite measured section at arroyo Colorado and complemented with a section measured at Las Pocitas, assigned a latest early Eocene-earliest middle Eocene age between 51.2 to 48.4 Ma on the basis of planktonic foraminifers. According to sedimentary structures, benthic foraminifers and ostracods association, these authors suggested a deposition from the inner to the outer marine shelf in depths shallower than 150 m. Recently, in the same core here studied, a planktonic foraminifer was recorded by Miranda-Martínez and Carreño (2008) and an early Eocene age between 50.4–49 Ma was assigned to the stratigraphic column. Based on benthic foraminiferal association, a middle upper bathyal deposit was suggested.

STUDY AREA

The sedimentary rocks of the Tepetate formation came from a core (Loc. IGM-2984; 24°24’00” N, 111°05’47” W, Las Pocitas Quadrangle, Baja California Sur, Mexico, 1:50,000, G12C79, INEGI, 1983; [Figure 1]), recovered in the surroundings of Las Pocitas town, located approximately 76 km south of Ciudad Constitución, La Paz County, Baja California Sur, east of the Transpeninsular Highway [MEX 1]. The drill hole of 80 m made by Secretarìa de Recursos Hidráulicos recovered 62 m of monotonous very light gray, fine-grained sandstone, capped by a limestone (Figure 2), from which 56 samples were obtained.

MATERIAL OF STUDY

For the calcareous nannofossil analyses, the samples were prepared according to the normal procedure (Perch-Nielsen, 1985) including selection, cleaning and pulverization, and subsequent smear-slide preparation. Two smear slides per sample were analyzed and for their observation and fossil identification a polarizing microscope (Olympus BH-2) with crossed nichols and 40X and 100X achromatic objectives DIN standard was used. In some cases, a ½ χ gypsum plate of 30 nm delay of wavelength was used to facilitate the observation of non birefringent nannoliths and discoasterids. The smear-slides were deposited in the Colección Nacional de Paleontología, Museo María del Carmen Perrilliat, Instituto de Geología, Universidad Nacional Autónoma de México with the numbers IGML-1-Mi to IGML-22-Mi, IGML-31-Mi to IGML-106-Mi and IGML-108-Mi to IGML-118-Mi. Thin-sections of samples from the limestone capping the Tepetate formation were prepared, but because no microfossils were found, the thin-sections are not deposited. Micrographs of specimen in polarizing microscope were taken and digital images were also left in the same repository with numbers IGMD-1-Mi to IGMD-60.

MICROPALEONTOLOGY

Taxonomic assignations of the calcareous nannoplankton recovered at the Las Pocitas core are based on Perch-Nielsen (1977, 1985), Bramlette and Sullivan (1961), Bramlette and Wilcoxon (1967), Bukry and Percival (1971), Gartner (1971), Sullivan (1965), and Wise *et al.* (2002).

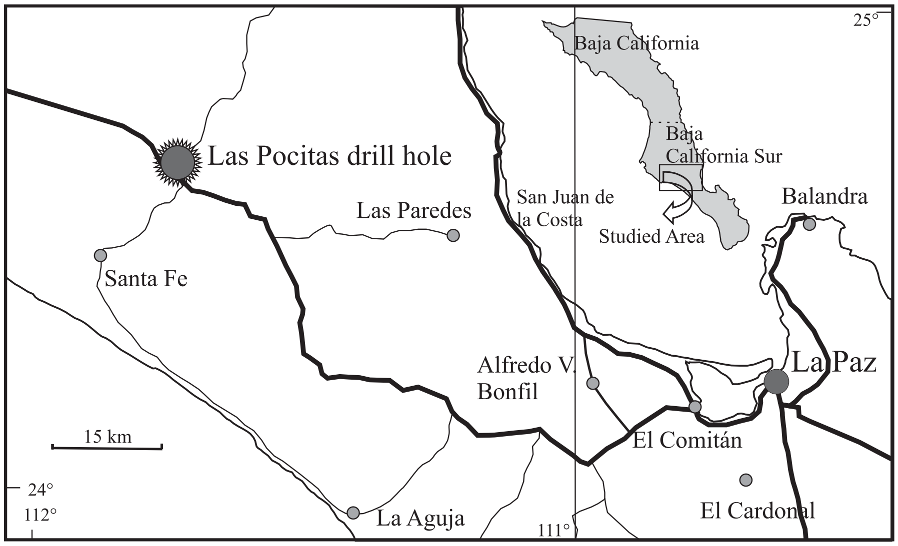


Figure 1. Location of the Las Pocitas drill hole, La Paz Municipality. Baja California Sur, México.

Sixty species belonging to 26 genera of calcareous nannofossils were identified**.** Calcareous nannoplankton was absent in the three upper samples of the recovered stratigraphic column, which otherwise might represent a younger unit instead of rocks belonging to the Tepetate formation.

In spite of the relative abundance recorded in several samples of the calcareous nannoplankton, most part of the assemblages correspond to Cretaceous and Paleogene reworked species. In general the nannofossils have moderate to good conservation and no sign of overgrowth is observed. Nevertheless, the absence of many forms, in particular diagnostic age species, suggests strong dissolution. The distribution along the core is not homogeneous for most part of the recorded species. According to ODP Leg 191 Shipboard Scientific Party (2001), the relative abundance is considered as common (one specimen in 2–10 fields of view at 100X immersion) for reworked Mesozoic species as *Watznaueria barnesae* and *W. fossacincta*, and Paleocene species as *Cruciplacolithus primus*, *Cr. tenuis*, *Cyclagelosphaera reinhardtii*, *Discoaster mohleri*, *Ericsonia subpertusa*, *Fasciculithus tympaniformis*, *Micrantholithus pinguis*, *Neochiatozygus digitosus* and *Toweius selandianus*.

The species with common frequency throughout the core length were *Markalius inversus*, *Fasciculithus involutus*, *Coccolithus pelagicus* and *Sphenolithus radians*, whereas species belonging to genera *Sphenolithus*, *S. anarrophus*, *S. obtusus*, *S. editus*, *Rhabdosphaera* Haeckel, (*R. crebra*, *R. pinguis*), *Helicosphaera* (*H. seminulum*, *H. lophota*) and *Pontosphaera* (*P. pectinata*, *P. ocellata*, *P. punctosa*), have only one isolated record per sample. From the total species identified, many of them were only recorded once throughout the core: *F. tympaniformis*, *Neochiastozygus digitosus*, *R. truncata*, *R. inflata*, *Transversopontis sigmoidalis*, *W. fossacincta*, *Scapholithus rhombiformis*, *D. mohleri*, *D. septemradiatus*, *Cruciplacolithus cruciformis*, *C. tenius*, *Pontosphaera versa*, *Chiasmolithus consuetus*, *C. bidens*, *C. solitus*, *E. subpertusa*, *Isthmolithus unipons* and *Micrantholithus pinguis.*

Biostratigraphy

Calcareous nannoplankton is scarce and sparse. Also, most of the diagnostic species that could allow the reconnaissance of standard low latitude biozones are diluted or dissolved. Therefore, the stratigraphic range of the species here recorded was examinated (Perch-Nielsen, 1985; Wise *et al.*, 2002) in order to estimate, as far as possible, the span of time covered by the studied sedimentary column.

With the exception of the species that has a restricted range to the Mesozoic and to the Paleocene, and besides the low-ranging Paleogene species, the association represented by *Fasciculithus involutus*, *Sphenolithus editus*, *Rhabdosphaera truncata*, *R. crebra*, *R. inflata*, *Chiasmolithus solitus*, *Girsia gammation*, *Isthmolithus unipons*, *Discoaster septemradiatus*, *Toweius callosus*, *Pontosphaera plana*, *Helicosphaera lophota*, *H. seminulum*, *Reticulofenestra dyctioda*, *R. pinguis*, *Micrantholithus flos*, *Pontosphaera pectinata*, and *Lanternithus minutus*, indicates that the whole sedimentary column belongs to the Eocene (Figure 3).

The erratic distribution of these species in the core (Table 1) does not allow recognition of FO's and LO's and even less of FAD's and LAD's; nevertheless, the co-occurrence of *R. dyctioda*, *R. crebra*, *R. pinguis*, *M. flos*, *P. pectinata* and *L. minutus* situates the studied stratigraphic column in the *Discoateroides kuepperi* CP12a Subzone of Okada and Bukry (1980), dated between 49.5 and 49 Ma around the boundary between the lower and

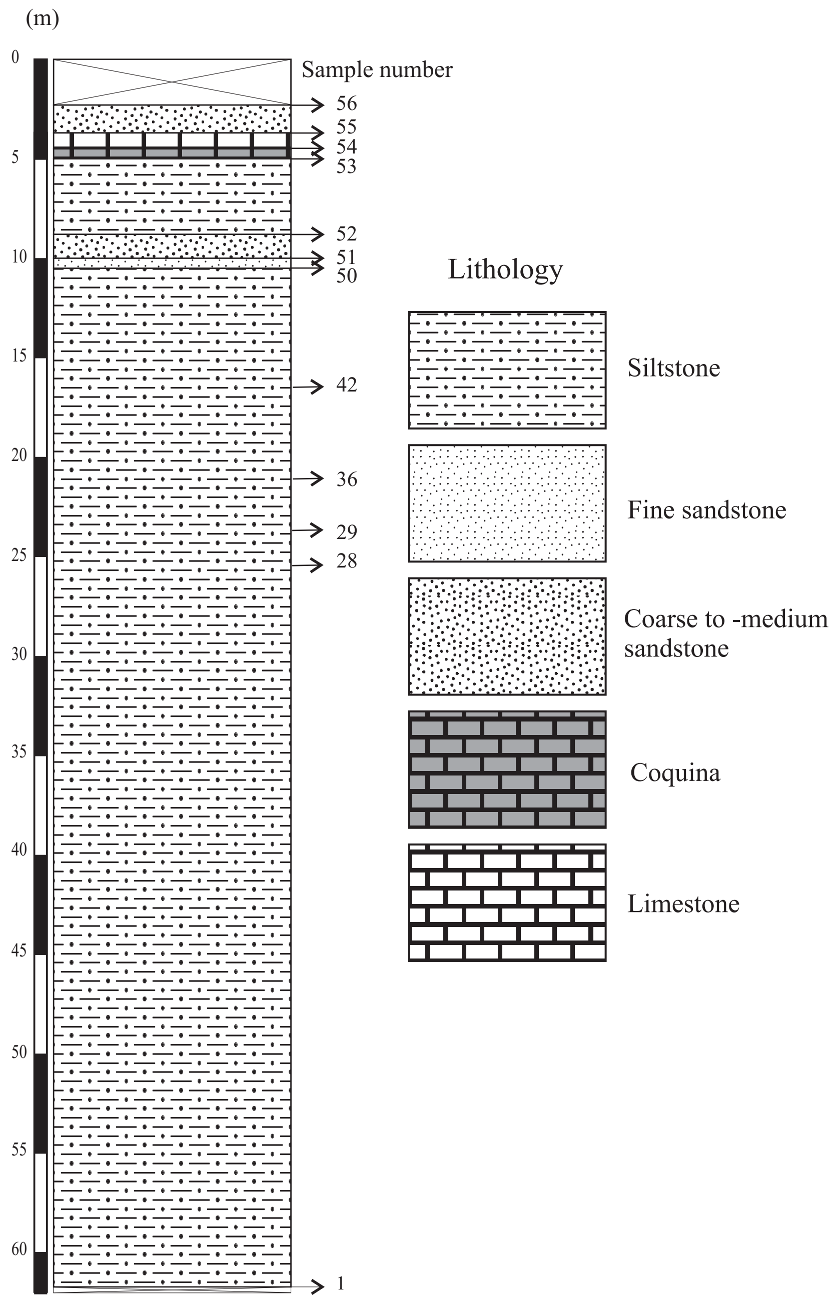


Figure 2. Stratigraphic column of the La Pocitas core, Tepetate formation, Baja California Sur, México.

middle Eocene (Figure 3).

Younger species such as *Micrantholithus* cf. *altus*, which has a restricted range in the CP14 *Reticulofenestra umbilica* Zone of Bukry (1973) and *Reticulofenestra scripsae* whose FAD occurs within this biozone, strongly suggest a younger age for the sedimentary column; nevertheless, the doubtful assignation of first species and the isolated record at sample 12 of the second species prevent assignment to this biozone.

This age assignment is in agreement with Carreño *et al*. (2000). Based on planktonic foraminifera, they established, at the Arroyo Colorado locality situated west of the Las Pocitas area, an age between 51.2 and 48.4 Ma, a span of time that includes the latest early Eocene to the early middle Eocene. Planktonic foraminifers recovered from Las Pocitas core at the same levels studied here (Miranda-Martínez and Carreño, 2008), allowed to recognize an assemblage equivalent of *Planorotalites palmerae-Acarinina pentacamerata* Zone (= P9 Zone of Premoli-Silva *et al*., 2003), which according to Berggren *et al*. (1995) situates this part of the unit in the early Eocene, between 50.4 and 49 Ma, age that matches well with that inferred from the calcareous nannoplankton. Diagnostic biostratigraphic species are illustrated in Figures 4 to 6.

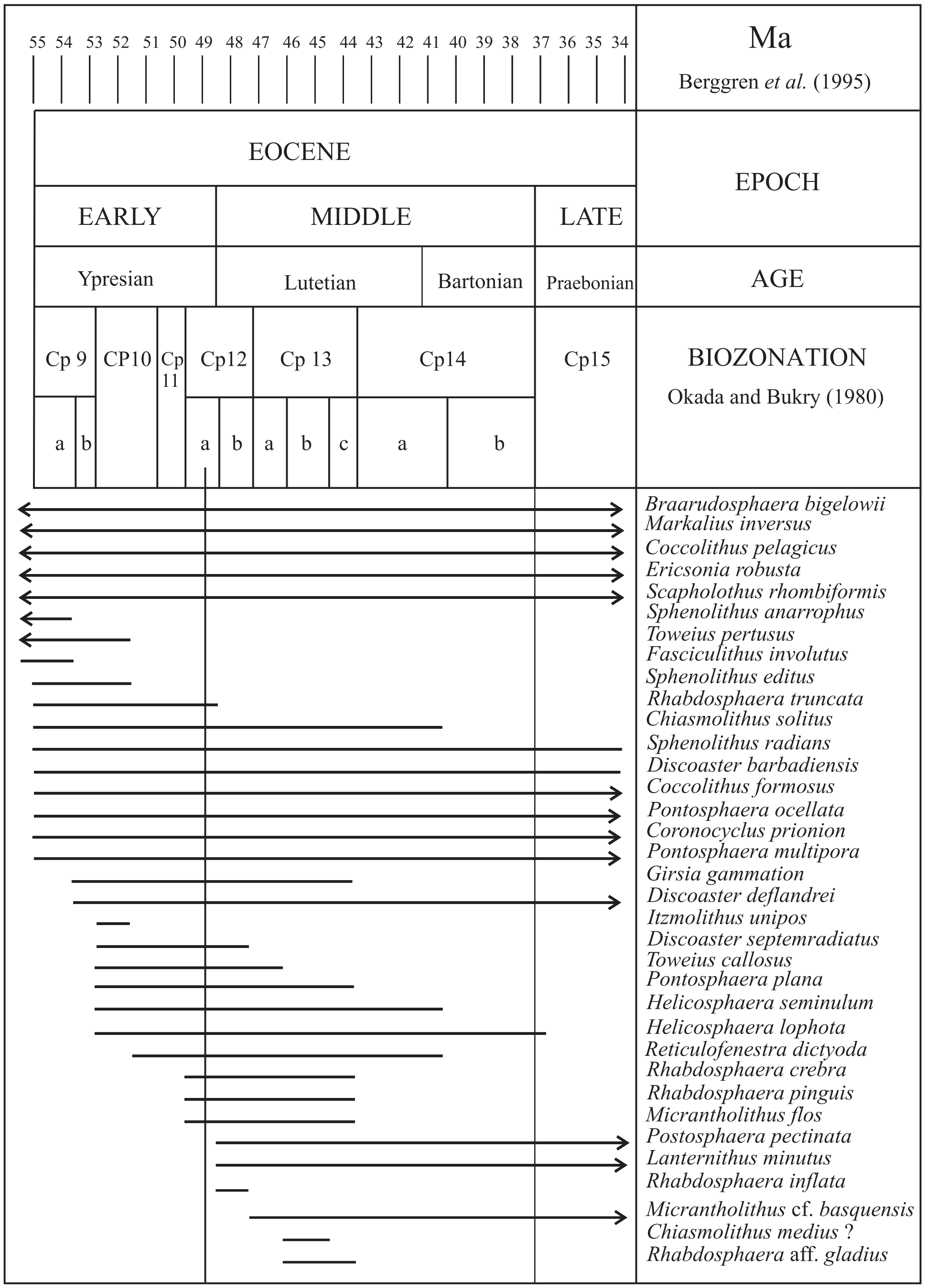


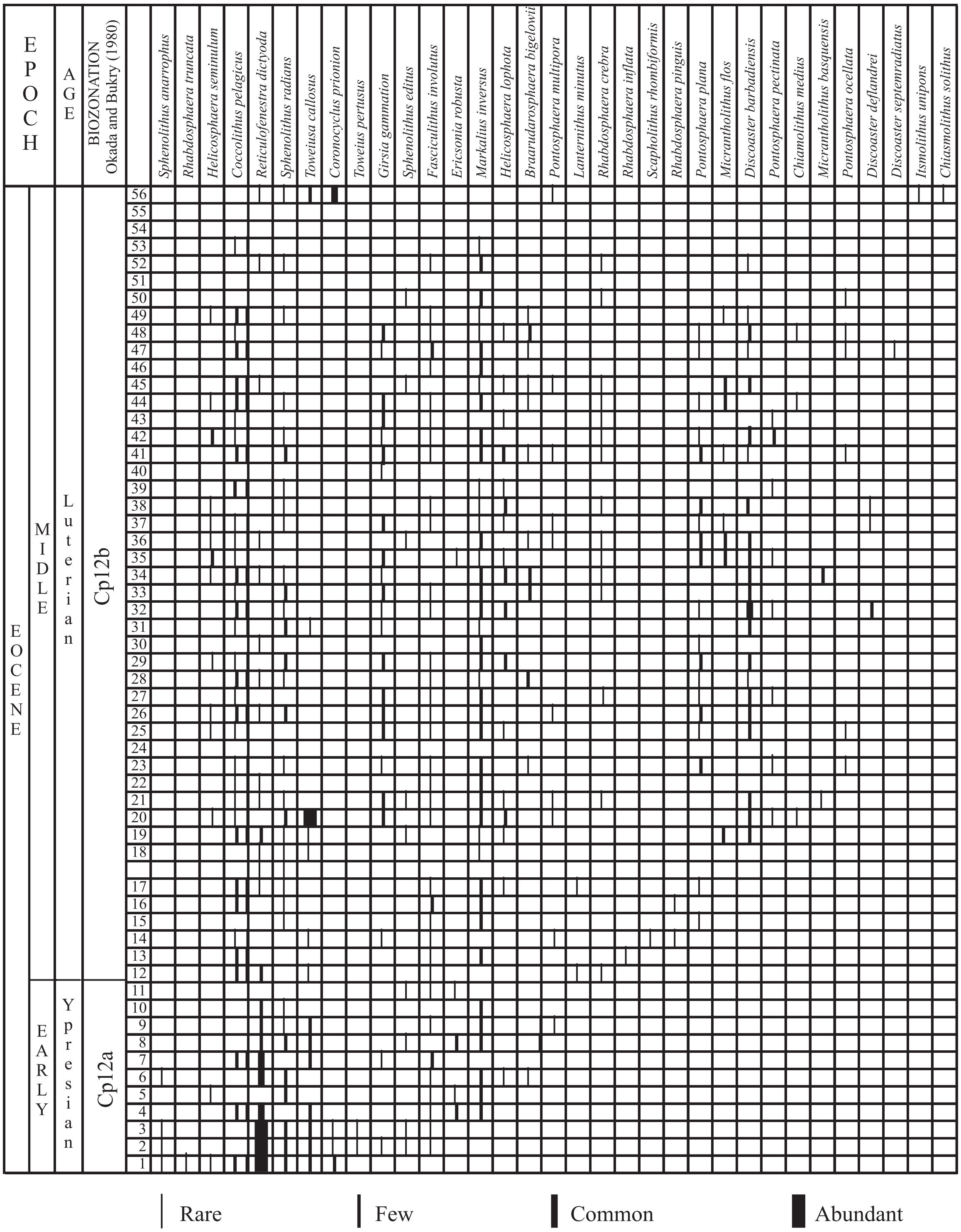
Figure 3. Stratigraphic range of selected species of calcareous nannoplankton distributed throughout the Tepetate formation in Las Pocitas core, Baja California Sur, México.

Paleoenvironment

The lithology present in the Las Pocitas core, which is formed by sandstone beds composed of fine-to-medium grained sand with siliceous cement, whose grains are composed of angular quartz, feldspars, and lithics, suggests that this part of the sedimentary column belongs to the upper part of the interbedded member of Fulwider (1976). These lithological characteristics, as well as the age assignment, suggest that this sedimentary package corresponds to the upper part of the Tepetate formation.

Following Perch-Nielsen (1985), *Sphenolithus* species are characteristic species of low latitude, open sea, and warm water, whereas *Pontosphaera* species are frequent in hemipelagic sediments. Both genera are well represented in the studied sedimentary column. Fulwider (1976) stated that some levels of the interbedded member were deposited under low oxygen conditions, probably in the upper submarine fan or possible canyon mouth deposit. However, throughout the stratigraphic section here studied, opportunistic species associated to stress conditions such as *Braarudosphaera bigelowii* are scarce; the absence of biogenic structures reinforces the interpretation that this part of the Tepetate formation was deposited in an oceanic paleoenvironment, near the upper slope under normal conditions in temperate water masses. The fact that many of the tropical index species are absent seems to strengthen a less warm or tropical climate.

Table 1. Distribution of diagnostic calcareous nannoplankton species throughout the Las Pocitas core, Tepetate formation, Baja California Sur, México.



According to Miranda-Martínez and Carreño (2008), the relative abundance of planktonic foraminifers over the benthonic ones in the Las Pocitas core is almost equal or slightly lower, whereas the high species diversity, as well as its frequency throughout the stratigraphic column suggest upper slope deposits, data that match well with the interpretation on the basis of calcareous nannoplankton. Diagnostic paleoenvironmental species are shown in Figures 4 to 6.

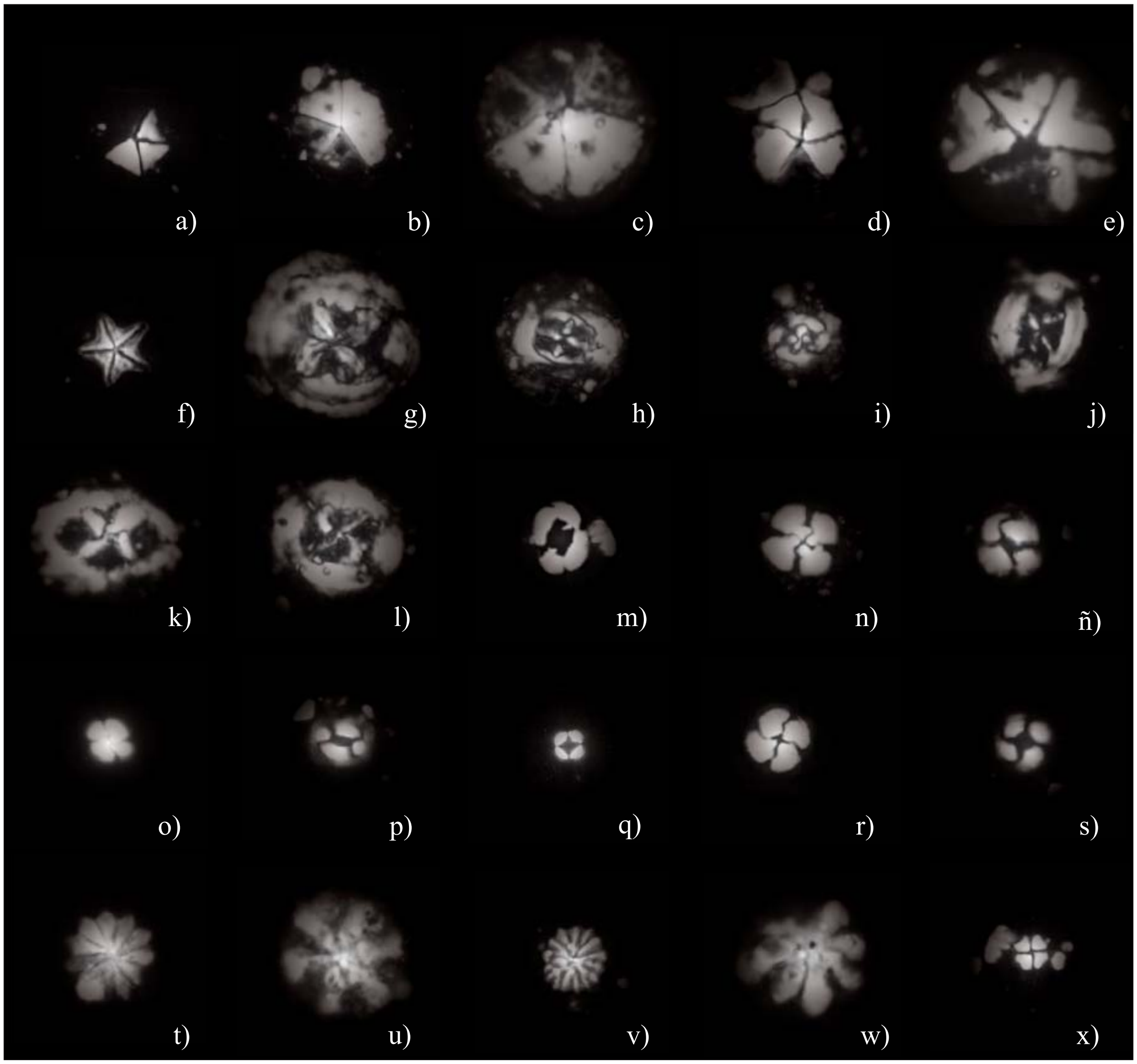


Figure 4. Specimens of calcareous nannoplankton from Las Pocitas core, Tepetate formation, Baja California Sur. All by 2 500 X. a: *Braarudosphaera bigelowii* (Gran and Braarud, 1935) Deflandre, 1947, IGMD-1-Mi, distal view 0°, sample 6-1; b: *Micrantholithus altus* Bybell and Gartner, 1972. IGMD-26-Mi, Distal view 0°, sample 18-1; c: *Pemma basquensis* (Martini, 1959) Báldi-Beke, 1971, IGMD-31-Mi, distal view 0°, sample 12-1; d: *Micrantholithus crenulatus* Bramlette and Sullivan, 1961, IGMD-27-Mi, dorsal view 0°, sample 28-2; e): *Micrantholithus flos* Deflandre, 1950, *in* Deflandre and Fert 1954, IGMD-28-Mi, proximal view 0°, sample 19-1; f: *Micrantholithus pinguis* Bramlette and Sullivan, 1961, IGMD-29-Mi, proximal view 0°, sample 29-2; g: *Cruciplacolithus cruciformis* (Hay and Towe, 1962) Roth, 1970, IGMD-10-Mi, distal view 0°, sample 20-2; h: *Cruciplacolithus primus* Perch-Nielsen, 1977, IGMD-11-Mi, distal view 0°, sample 22-2; i: *Cruciplacolithus tenuis* (Stradner, 1961) Hay and Mohler, 1967, IGMD-12-Mi, proximal view 0°, sample 28-2; j: *Chiasmolithus bidens* (Bramlette and Sullivan, 1961) Hay and Mohler, 1967, IGMD-2-Mi, distal view 0°, sample 44-1; k: *Chiasmolithus consuetus* (Bramlette and Sullivan, 1961) Hay and Mohler, 1967, IGMD-3-Mi, distal view 0°, sample 26-a; l: *Chiasmolithus eograndis* Perch-Nielsen, 1971b, IGMD-4-Mi, distal view 0°,sample 2-1; m: *Chiasmolithus solitus* (Bramlette and Sullivan, 1961) Locker, 1968, IGMD-5-Mi, distal view 0°, sample 56-2; n: *Cyclagelosphaera reinhardtii* (Perch-Nielsem 1968) Romein, 1977, IGMD-5-Mi, distal view 0°, sample 12-2; ñ: *Coccolithus formosus* (Kamptner, 1963) Wise, 1973, IGMD-Mi-6, distal view 0°, sample 7-1; o: *Coccolithus ovalis* (Black, 1964) Ladner and Wise, *in* Wise ***et al.***, 2002, IGMD-7-Mi, proximal view 0°, sample 2-1; p: *Coccolithus pelagicus* (Wallich, 1877) Schiller, 1930, IGMD-8-Mi, distal view 0°, sample 8-1; q: *Coronocyclus prionion* (Deflandre and Fert, 1954) Stradner *in* Stradner and Edwards, 1968, IGMD-9-Mi, distal view 0°, sample 56-2; r: *Ericsonia robusta* Bramlette and Sullivan, 1961) Wise ***et al.***, 2002, IGMD-18-Mi, distal view 0°, sample 4-2; s: *Markalius inversus* (Deflandre *in* Deflandre and Fert, 1954) Bramlette and Martini, 1964, IGMD-25-Mi, distal view 0°, sample 4-1; t: *Discoaster barbadiensis* Tan (1927), IGMD-14-Mi, distal view 0°, sample 21-1; u: *Discoaster deflandrei* Bramlette and Riedel, 1954, IGMD-15-Mi, proximal view 0°, sample 32-1; v: *Discoaster mohleri* Bukry and Percival, 1971, IGMD-16-Mi, distal view 0°, sample 18-1; w: *Discoaster septemradiatus* (Klumpp, 1953) Martini, 1958, IGMD-17-Mi, proximal view 0°, sample 47-2; x: Fasciculithus involutus Bramlette and Sullivan, 1961, IGMD-19-Mi, distal view 0°, sample 2-1.

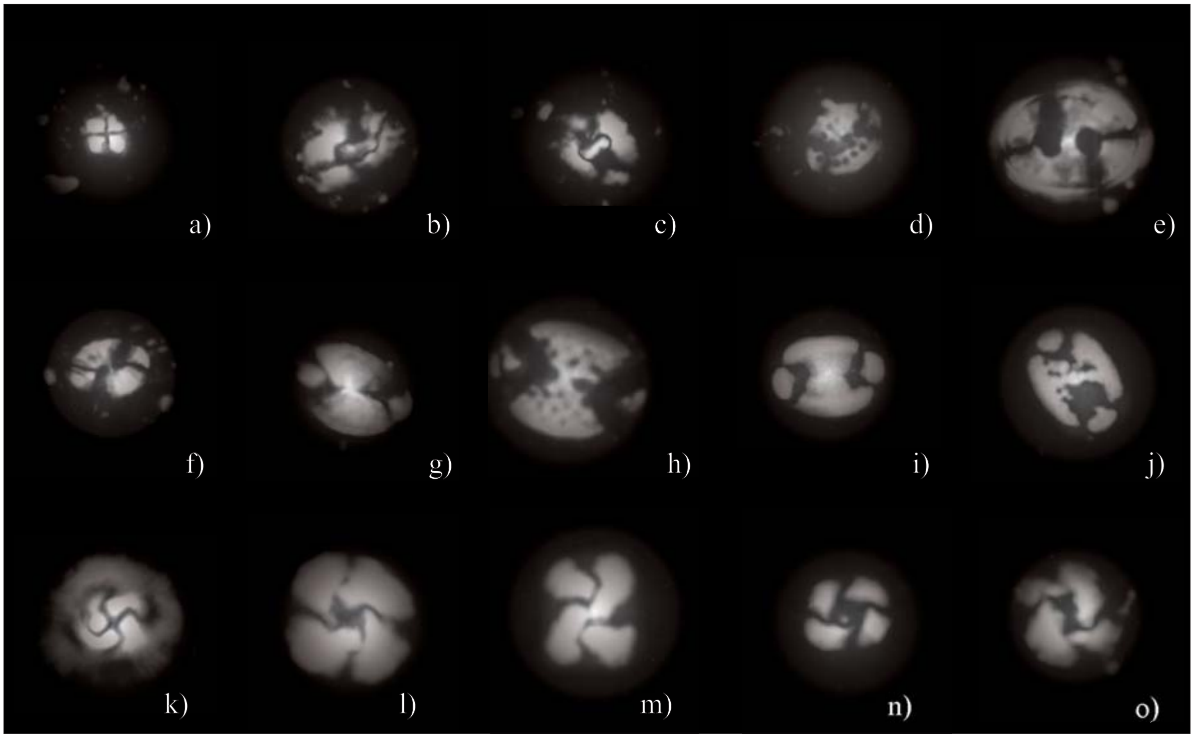


Figure 5. Specimens of calcareous nannoplankton from Las Pocitas core, Tepetate formation, Baja California Sur, Mexico. All by 2 500 X. a: *Fasciculithus tympaniformis* Hay and Mohler in Hay *et al.*, 1967, IGMD-20-Mi, distal view 0°, sample 1-1; b: *Helicosphaera lophata* Bramlette and Sullivan, 1961, IGMD-22-Mi, distal view 45°, sample 5-1; c: *Helicosphaera seminulum* Bramlette and Sullivan, 1961, IGMD-23-Mi, distal view 45°, sample 5-1; d: *Pontosphaera multipora* (Kamptner, 1948) Roth, 1970, emend. Burns, 1973, IGMD-32-Mi, distal view 0°, sample 56-2; e: *Pontosphaera ocellata* (Bramlette and Sullivan, 1961) Perch-Nielsen 1984, IGMD-33-Mi, distal view 0°, sample 35-2; f: *Pontosphaera pectinata* (Bramlette and Sullivan, 1961) Sherwood, 1974, IGMD-34-Mi, distal view 45°, sample 20-2; g: *Pontosphaera plana* (Bramlette and Sullivan, 1961) Haq, 1971, IGMD-35-Mi, distal view 0°, sample 15-2; h: *Pontosphaera punctosa* (Bramlette and Sullivan, 1961) Perch-Nielsen,1984, IGMD-36-Mi, distal view 0°, sample 25-1; i: *Pontosphaera versa* (Bramlette and Sullivann, 1961) Sherwood, 1974, IGMD-37-Mi, distal view 0°, sample 56-2; j: *Transversopontis sigmoidalis* Locker, 1967, IGMD-52-Mi, distal view 0°, sample 32-1; k: *Girsia gammation* Bramlette and Sullivan, 1961) Varol, 1989, IGMD-21-Mi, distal view 0°, sample 20-2; l: *Reticulofenestra dictyoda* (Deflandre *in* Deflandre and Fert, 1954) Stradner *in* Stradner and Edwards, 1968, IGMD-38-Mi, distal view 0°, sample 56-2; m: *Reticulofenestra scripsae* (Bukry and Percival, 1971) Roth, 1973, IGMD-39-Mi, distal view 0°, sample; n: *Toweius callosus* Perch-Nielsen, 1971b, IGMD-49-Mi, distal view 0°, sample 1-1; o: *Toweius pertusus* (Sullivan, 1965) Romein, 1979, IGMD-50-Mi, distal view 0°, sample 2-1.

DISCUSSION

The revision of the calcareous nannoplankton data given by Coleman (1979), who uses the biozonation of Bukry (1973) to assign age, suggests that the rocks of the Tepetate formation constitute a continuous deposit that covers a span of time from the Maastrichtian to the lower Eocene. This author mentions no species for the Late Cretaceous, and the age was established by the presence of long ranging calcareous nannoplankton species in rocks outcropping at arroyo Salada. However, for the lower Paleogene, the recognized biozones from the bottom to the top were the *Cruciplacolithus tenuis*, *Fasciculithus tympaniformis*, *Heliolithus kleinpellii*, *Discoaster mohlei*, *Heliolithus riedelii*, *Discoaster multiradiatus*, *Discoaster diastypus*, *Tribrachiatus orthostylus* and *Discoaster lodoensis.*

On the other hand, Fulwider (1976) recorded at the arroyo Salada outcrops the presence of *Tetralithus nitidus*, *Watznaueria barnesae*, *Watznauria biporta* and *Arkhangelskiella cymbiformis* and, on the basis of this assemblage, assigned a Maastrichtian age to the base of the Tepetate formation. Nevertheless, *A. cymbioformis*, which otherwise has several definitions attached, in the sense of Bukry (1973) is restricted to the Campanian *Eiffelithus augustus* Zone, while the other species has a more wide range.

Neither Coleman (1979) nor Fulwider (1976) mentioned the presence of reworked calcareous nannoplankton species throughout the studied lithostratigraphic columns. In the present study, the reworked Cretaceous species are continuously recorded throughout the Las Pocitas core, sometimes in such frequency that they constitute, as was stated earlier, the dominant assemblage in a sample.

Contrary to data presented by Coleman (1979), Fulwider (1976) recognized a hiatus at the base of the Paleogene, evidenced by the lack of at least two foraminiferal biozones, and being the *Morozovella trinidadensis* Zone the first recognized biozone. The encompassing examination of the species recorded by both authors as well as the updated biozonal schemes, situate the top of

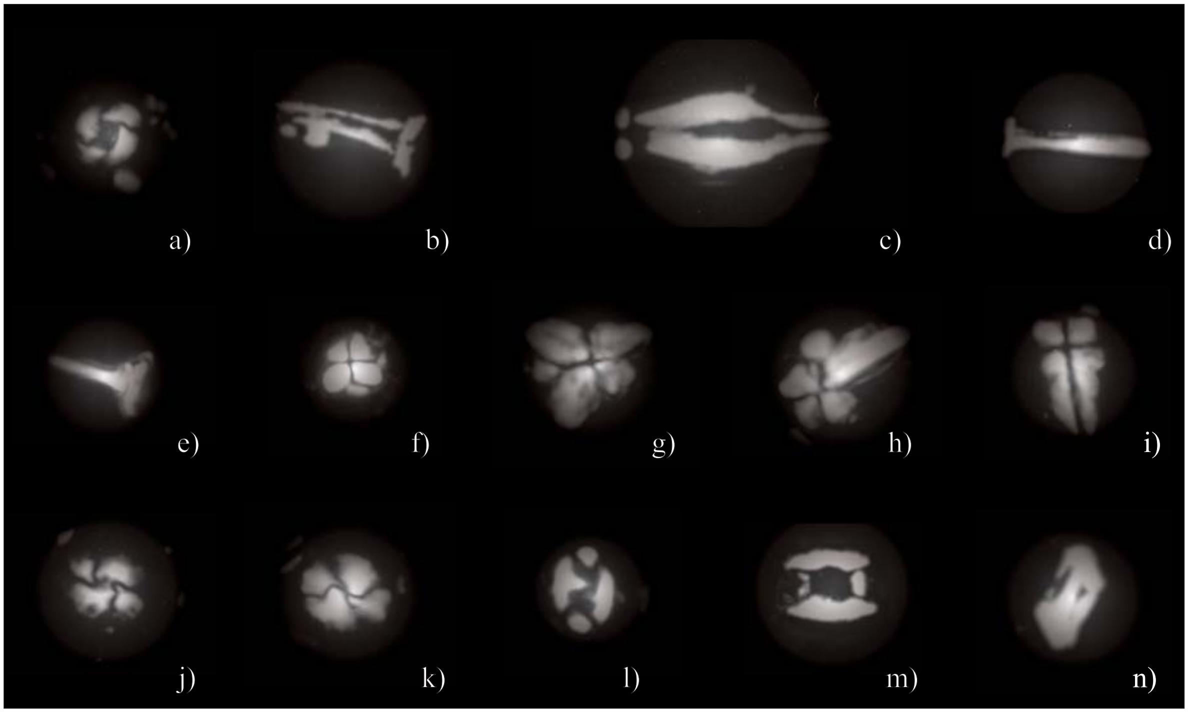


Figure 6. Specimens of calcareous nannoplankton from Las Pocitas core, Tepetate formation, Baja California Sur, Mexico. All by 2 500 X. a: *Toweius selandianus* Perch-Nielsen, 1979, IGMD-51-Mi , distal view 0°, sample1-1; b: Rhabdosphaera crebra (Deflandre *in* Deflandre and Fert, 1954) Bramlette and Sullivan, 1961, IGMD-40-Mi, sample 12-2; c: *Rhabdosphaera inflata* Bramlette and Sullivan, 1961, IGMD-41-Mi, sample 14-2; d: *Rhabdosphaera pinguis* Deflandre *in* Deflandre and Fert (1954), IGMD-42-Mi, 0°, sample 14-2; e: *Rhabdosphaera truncata* Bramlette and Sullilvan, 1961, IGMD-43-M, 0°, sample 1-1; f: *Sphenolithus anarrophus* Bukry and Bramlette, 1969, IGMD-45-Mi, 0°, sample 1-1; g: *Sphenolithus editus* Perch-Nielsen *in* Perch-Nielsen *et al*., 1978, IGMD-46-Mi, 0°, sample 8-1; h: *Sphenolithus obtusus* Bukry, 1971, IGMD-47-Mi, 45°, sample 6-1; i: *Sphenolithus radians* Deflandre *in* Grassé, 1952, IGMD-48-Mi, 0°, sample 1-2; j: *Watznaueria barnesae* (Black, *in* Black and Barnes, 1959) Perch-Nielsen, 1968, IGMD-53-Mi, distal view 0°, sample 13-1; k: *Watznaueria fossacincta* (Black, 1971) Brown *in* Brown and Cooper, 1989, IGMD-54-Mi , distal view 0°, sample 15-2; l: *Neochiatozygus digitosus* Perch-Nielsen, 1971a, IGMD-30-Mi, distal view 0°, sample 1-1; m: *Lanternithus minutus* Stradner, 1962, IGMD-24-Mi , 0°, sample 12-2; n: *Scapholithus rhombiformis* Hay and Mohler, 1967, IGMD-44-Mi, 0°, sample 14-2.

the Tepetate formation at around 48.60 ± 0.2 Ma in the late Ypresian (Gradstein *et al*., 2004), which is close to the age given for the base of the CP12a Zone of Bukry (1973) here assigned.

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