Nannofossils and foraminifera from the Salamanca Formation (Paleocene) in Punta Peligro Norte (Chubut, Argentina)

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Abstract: An assemblage of nannofossils from the Salamanca Formation is reported for the first time from the Punta Peligro Norte locality in the San Jorge Gulf Basin, Argentina. Several recognized nannofossils have a stratigraphic distribution within the lower Danian. The assemblage of nannofossils and associated foraminifera is here discussed taking into account biostratigraphic and paleoecological aspects.

Key Words: Nannofossils; foraminifera; Paleocene; Salamanca Formation; San Jorge Gulf Basin.

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Résumé : ***Nannofossiles et foraminifères de la Formation Salamanca (Paléocène) à Punta Peligro Norte (Chubut, Argentine).-*** Une association de nannofossiles de la Formation Salamanca est signalée pour la première fois dans la localité de Punta Peligro Norte dans le Bassin du Golfo San Jorge en Argentine. Plusieurs nannofossiles identifiés ont une extension stratigraphique limitée au Danien inférieur. L'association, qui comporte des nannofossiles mais aussi des foraminifères, est discutée en prenant en considération les aspects biostratigraphiques et paléoécologiques.

Mots-clefs : Nannofossiles ; foraminifères ; Paléocène ; Formation de Salamanca ; Bassin du Golfo San Jorge.

Resumen: ***Nanofósiles y Foraminíferos de la Formación Salamanca (Paleoceno) en Punta Peligro Norte (Chubut, Argentina).-*** Se da a conocer por primera vez una asociación de nanofósiles procedente de la Formación Salamanca en la localidad de Punta Peligro Norte, Cuenca del Golfo San Jorge. Algunos de los nanofósiles reconocidos tienen una distribución estratigráfica dentro del Daniano inicial. La asociación de nanofósiles y los foraminíferos asociados se discuten tomando en cuenta aspectos bioestratigráficos y paleoecológicos.

Palabras-claves: Nanofósiles; foraminíferos; Paleoceno; Formación Salamanca; Cuenca del Golfo San Jorge.

Introduction

The present contribution deals with nannofossils and foraminifera from the Salamanca Formation, at the Punta Peligro Norte locality (45°30' S, 67°11' W), 45 kilometers north of Comodoro Rivadavia City, San Jorge Gulf Basin (Fig. 1). Previous micropaleontological studies from different outcrops of the Salamanca Formation including foraminifera, suggested a Paleocene age for the unit (see among others MENDEZ, 1966; MASIUK, 1967; BERTELS, 1975a, 1975b; CLYDE *et al*., 2014). However, a nannofossil assemblage with *Arkangelskiella cymbiformis* VEKSHINA, 1959, was reported from the subsoil in the centre of the basin, suggesting a Maastrichtian age for the lower levels of the studied unit (BARCAT *et al*., 1989). Recently, CLYDE *et al*. (2014) reported a multi-disciplinary geochronologic study of the Salamanca Formation in the western part of the basin with scarce nannofossils indicating an early Danian age.

The well preserved nannofossil assemblage presented here comes from the lower horizons of the Salamanca Formation at Punta Peligro Norte (Fig. 2.A). This assemblage includes some taxa restricted to the lower Danian biostratigraphic unit NNTp2 *Cyclagelosphaera alta* Zone (VAROL, 1999), partially correlated with the NP1-NP3 Zone (MARTINI, 1971) and the CP1A-CP2 Zone (OKADA & BUKRY, 1980).

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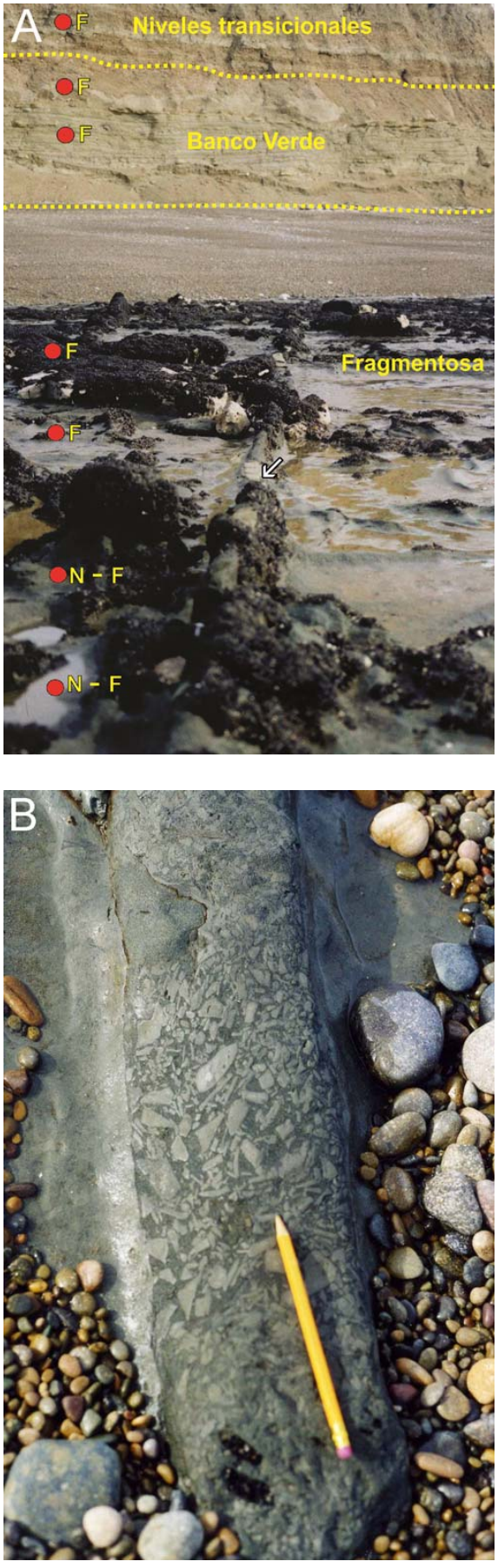
Figure 1: Satellite image showing the location of Punta Peligro Norte locality (Chubut Province, Argentina).

Geological setting and sampling

The Salamanca Formation (Lesta & Ferello, 1972) is the basal unit of the Cenozoic succession of the San Jorge Gulf Basin. It represents the first Atlantic marine transgression in the basin. The mentioned unit is overlain by continental levels of the Río Chico and the Sarmiento formations, the marine Chenque Formation and the continental Santa Cruz Formation. Finally, the section ends with the deposits of glacio-fluvial origin known as "Rodados Tehuelches".

The Salamanca Formation or "Salamanquense" was divided into four horizons by Feruglio (1949): Lignitífero, Glauconítico, Fragmentosa and Banco Verde, which divisions are still used by stratigraphers. At the Punta Peligro Norte locality, the Fragmentosa horizon partially crops out at low tide, and it is overlain by the Banco Verde bed, which in turn, grades transitionally (Niveles transicionales) upwards into the Banco Negro sediments (*transitional levels* of Raigemborn *et al.*, 2010): Fig. 2.A. Studies of the Banco Negro sediments at different localities have provided remains of turtles, crocodyliforms and a significant mammal fauna (see among others Pascual *et al.*, 1992; Bonaparte *et al.*, 1993, Bonaparte & Morales, 1997; Forasiepi & Martinelli, 2003; Forasiepi & Rougier, 2009).



▶ **Figure 2: A:** Panoramic view of the Salamanca Formation at Punta Peligro Norte, indicating the productive levels [N: nannofossils, F: foraminifera] and showing **B:** A detail of the clastic dike in the Fragmentosa horizon (arrow on A).

The Fragmentosa and the glauconitic facies (Glauconitico) represent a marine transgression event, referred to as an epicontinental flood by FOIX (2009). The approximate thickness of the outcrop at low tide is about 12 meters including fractured gray and dark gray-green calcareous shale. Upwards, the sandy levels include abundant bioturbation and well preserved shell fragments. Sporadic tabular clastic dikes a few centimeters thick are also observed (Fig. 2.B). These dikes were formed by the filling of fissures with dark olive gray sands from the overlying Banco Verde horizon (LEGARRETA & ULIANA, 1994). Numerous samples from the Fragmentosa horizon contain a well preserved and moderately diverse association of foraminifera, mostly benthonic, abundant ostracods and well preserved nannofossils, which are recovered exclusively from this horizon. The association of microfossils seems to correspond to a sublittoral platform in a normal marine environment.

The Banco Verde unit shows evidence of a marine regression, with 12 meters of sandstone and siltstone including a basal bioruditic breccia. The greenish-pale olive glauconitic sandstones contain abundant fragmented invertebrate remains and a fauna of calcareous microfossils. Many species of foraminifera and ostracods from this level were also recognized in the underlying Fragmentosa horizon. The greatest diversity of the microfossil assemblage is observed in the basal levels of the Banco Verde, decreasing upwards both in variety and number. The samples obtained from the upper levels, show a predominance of ostracods, buliminellas and buliminas. Forty two samples were recovered from the Fragmentosa and Banco Verde horizons, eighteen of them produced microfossils and only three samples included nannofossils.

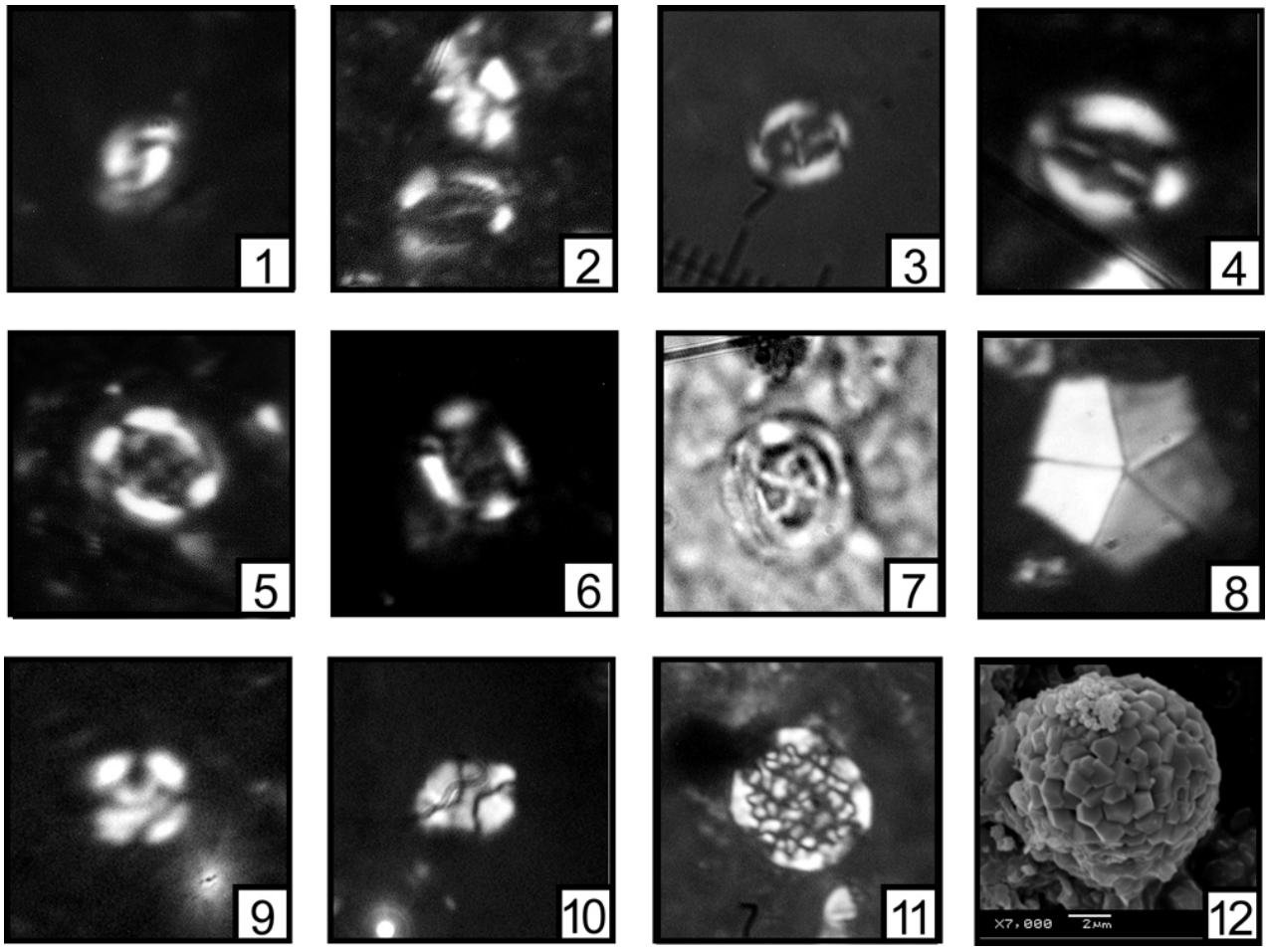


Figure 3: Nannofosils from the Fragmentosa horizon: 1. *Praeprinsius dimorphosus* (5.7µm); 2. *Hornibrookina teuriensis* (10µm); 3-4. C*ruciplacolithus primus* (7µm); 5. *Cruciplacolithus tenuis* (10 µm); 6-7. *Chiasmolitus* sp. (11µm); 8. *Braadurosphaera bigelowi* (12µm); 9. *Cyclogelosphaera alta* (5.7 µm); 10**.** *Neocrepidolithus fossus* (7 µm); 11. *Thoracosphaera operculata* (12.8µm); 12. *Thoracosphaera saxea.*

Taxonomic list of species of nannofossils and foraminifera recognized in the studied samples

Nannofossils

The present list of taxa follows the systematic scheme of YOUNG and BOWN (1997).

- *Praeprinsius dimorphosus* (PERCH-NIELSEN, 1969) VAROL & JAKUBOWSKI, 1989 (Fig. 3.1)
- *Hornibrookina teuriensis* EDWARDS, 1973 (Fig. 3.2)
- C*ruciplacolithus primus* PERCH-NIELSEN, 1977 (Fig. 3.3-4)
- *Cruciplacolithus tenuis* (STRADNER, 1961) HAY & MOHLER in HAY *et al*., 1967 (Fig. 3.5)
- *Chiasmolitus* sp. (Fig. 3.6-7)
- *Braadurosphaera bigelowi* (GRAND & BRAARUD, 1935) DEFLANDRE, 1947 (Fig. 3.8)
- *Cyclogelosphaera alta* PERCH-NIELSEN, 1979 (Fig. 3.9)
- *Neocrepidolithus fossus* (ROMEIN, 1977) ROMEIN, 1979 (Fig. 3.10)
- *Thoracosphaera operculata* BRAMLETTE & MARTINI, 1974 (Fig. 3.11)
- *Thoracosphaera saxea* STRADNER, 1961 (Fig. 3.12)

Foraminifera

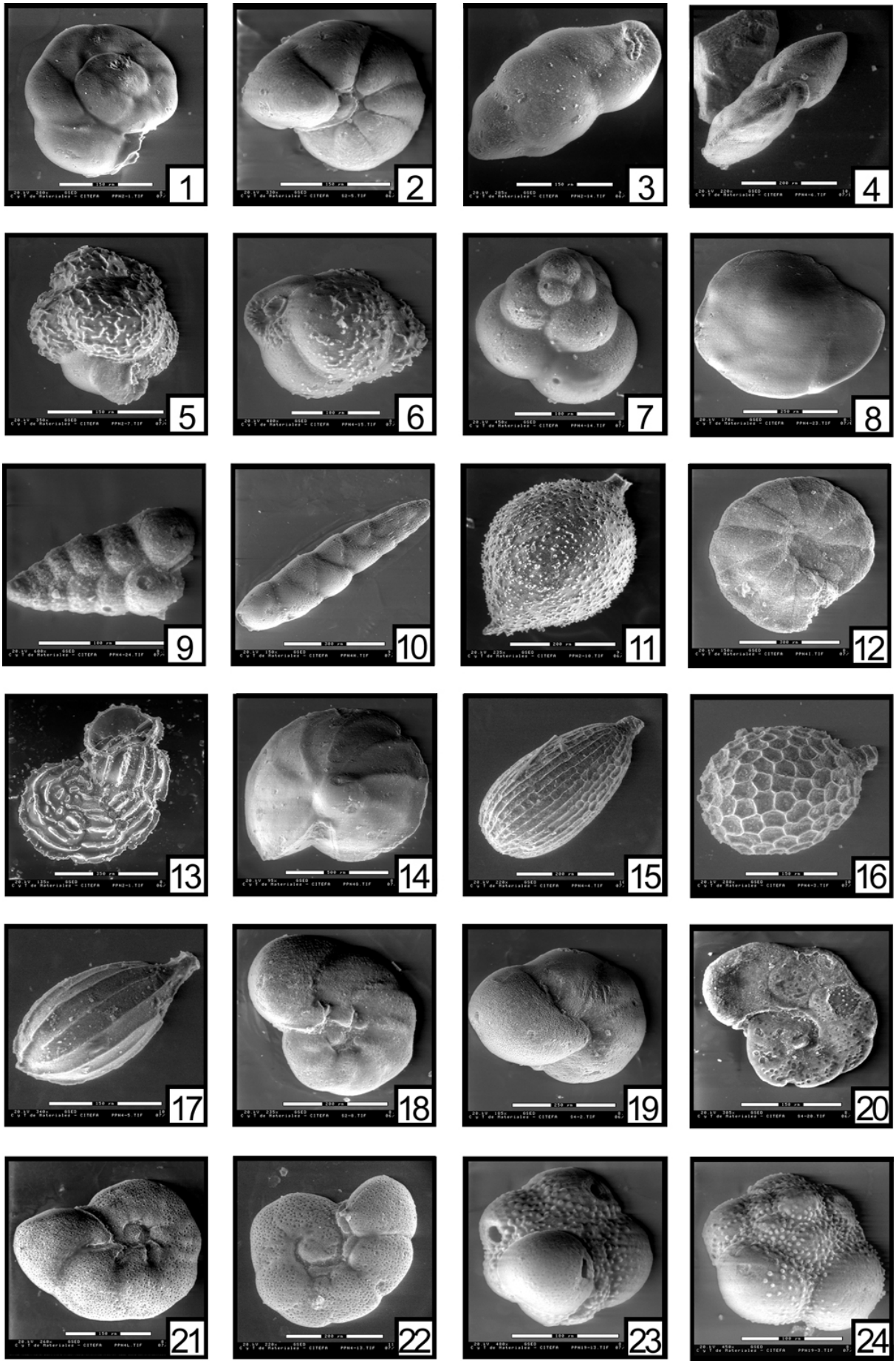
- *Gyroidinoides patagonicus* CAMACHO, 1954 (Fig. 4.1-2)
- *Buliminella isabeliana* CAMACHO, 1954 (Fig. 4.3)
- *Gavelinella midwayensis* PLUMMER, 1926 (Fig. 4.4)
- *Bulimina pascuali* BERTELS, 1975 (Fig. 4.5-6)
- *Guembelitria* sp. (Fig. 4.7)
- *Alabamina midwayensis* BROTZEN, 1948 (Fig. 4.8)
- *Chiloguembelina* sp. (Fig. 4.9)
- *Siphogeneroides elegantus* PLUMMER, 1926 (Fig. 4.10)
- *Pseudonodosaria neuquensis* BERTELS, 1975 (Fig. 4.11)
- *Cyclammina garcilassoi* FRIZZELL, 1943 (Fig. 4.12)
- *Lenticulina ulatisensis* BOYD, 1959 (Fig. 4.13)
- *Lenticulina rivadaviensis* CAMACHO, 1954 (Fig. 4.14)
- *Lagena archangelsky* BERTELS, 1975 (Fig. 4.15)
- *Lagena hexagona* WILLIAMSON, 1848 (Fig. 4.16)
- *Lagena* sp. (Fig. 4.17)
- *Discorbinella burlingtonensis* JENNINGS, 1936 (Fig. 4.18)
- *Cibicides* cf. *C. refulgens* MONTFORT, 1808 (Fig. 4.19)
- *Cibicides* sp. (Fig. 4.20)
- ?*Echigoina* cf. *E. hatai* MATSUNAGA, 1963 (Fig. 4.21-22)
- *Praepararotalia* cf. *P. cretacea* LIU, OLSEN & HUBERT, 1998 (Fig. 4.23-24)
- *Nodosaria latejugata* GÜMBEL, 1870
- *Buliminella* sp.
- *Gavelinella regina* MARTIN, 1943
- *Planularia* sp.
- *Cibicides* cf. *C. aknerianus* ORBIGNY, 1846
- *Cibicides* spp.
- *Spirillina* sp.
- *Spiroplectamina laevis* ROEMER, 1840

Discussion

The reported microfossil association was recovered from mudstones and sandstones from both the Fragmentosa and Banco Verde horizons. Nannofossils are exclusively from the basal levels of the Fragmentosa horizon. They are scarce but well preserved and the species listed below are restricted to the early Danian interval:

- *Cyclogelosphaera alta* FO: NP1 (MARTINI, 1971)
- *Hornibrookina teuriensis* FO: NP3 (MARTINI, 1971)
- C*ruciplacolithus primus* FO: NP1 (MARTINI, 1971)
- *Cruciplacolithus tenuis* FO: NP2 (MARTINI, 1971)
- *Praeprinsius dimorphosus* FO: NP2 (MARTINI, 1971)
- *Neocrepidolithus fossus* FO: NP1 (MARTINI, 1971)

▶ **Figure 4:** Foraminifera from the Fragmentosa and Banco Verde horizons: 1- 2. *Gyroidinoides patagonicus*; 3. *Buliminella isabeliana*; 4. *Gavelinella midwayensis*; 5-6**.** *Bulimina pascuali*; 7**.** *Guembelitria* sp.; 8**.** *Alabamina midwayensis*; 9. *Chiloguembelina* sp.; 10. *Siphogeneroides elegantus*; 11. *Pseudonodosaria neuquensis*; 12. *Cyclammina garcilassoi*; 13. *Lenticulina ulatisensis*; 14. *Lenticulina rivadaviensis*; 15. *Lagena archangelsky*; 16. *Lagena hexagona*; 17. *Lagena* sp.; 18. *Discorbinella burlingtonensis*; 19. *Cibicides* cf. *Cibicides refulgens*; 20. *Cibicides* sp.; 21-22. ?*Echigoina* cf. *E. hatai*; 23-24. *Praepararotalia* cf. *P. cretacea*.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The biostratigraphic importance of *Cyclogelosphaera alta* is here emphasized because its first occurrence (FO) indicates the base of the NNTp1 *Biantholithus hughesii* Zone (VAROL, 1999), which is correlated with the lower part of NP1 (MARTINI, 1971) and the CP1A Zone (OKADA & BUKRY, 1980). Its last occurrence (LO) indicates the top of the NNTp2 *Cyclagelosphaera alta* Zone (VAROL, 1999), which is correlated with the middle part of NP3 (MARTINI, 1971) and the CP2 Zone (OKADA & BUKRY, 1980).

Neocrepidolithus fossus is also a biostratigraphic marker whose last occurrence (LO) is used by VAROL (1989) to define the top of the Subzone NNTp4C, which is correlated with the middle part of NP4 (MARTINI, 1971) and the CP3 Zone (OKADA & BUKRY, 1980). The recognized associated foraminifera do not include species with biostratigraphic significance, but they are useful as paleoecological indicators.

The foraminiferal assemblage is more diverse and abundant in the Fragmentosa horizon. It indicates a shallow platform environment. Several species of *Cibicides* indicate well-oxygenated water, with a steady supply of food (KAIHO, 1994).

In turn, the Banco Verde horizon, interpreted as an estuarine environment (FOIX, 2009), shows a diverse association only in the basal levels, sharing many microfossil species with the Fragmentosa horizon. However, in the upper part, in the transitional levels to the Banco Negro horizon, the foraminifera are represented mostly by abundant and small specimens of *Buliminella* and *Bulimina*. This assemblage also includes ostracods and sponge spicules, and probably indicates specific paleoenvironmental conditions related to the transition into the continental levels of the Banco Negro.

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