

## SERIAL PLANKTONIC FORAMINIFERA FROM THE PALEOGENE OF THE TIERRA DEL FUEGO ISLAND, SOUTH AMERICA

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### ABSTRACT

In the lower Paleogene of the Austral (Magallanes) basin, planktonic foraminifera are small and very scarce. Those in the Fuegian Andes, the orogenic margin of the basin, are serial forms that are also relatively minute and generally scarce. These include species of *Chiloguembelina* coeval with chiloguembelinid abundance peaks in the Atlantic that have been associated with nutrient-enriched waters. The Punta Noguera Formation, which is rich in radiolarians and phosphatic nodules, yielded only two planktonic foraminiferal species, both of *Chiloguembelina*. One is *C. wilcoxensis* (Cushman and Ponton), a well-known index species that constrains the minimum age of the unit to the early Eocene. The other, *C. noguerensis* n. sp., is geographically restricted, and it is distinguished by its test surface that is covered with a conspicuous, irregular reticulation formed of coalescing pustules. In the Fuegian Andes, the triserial planktonic foraminifera *Jenkinsina triseriata* (Terquem) occurs in the upper lower Eocene section, but there is no record of serial planktonic foraminifera in the middle Eocene, partially due to an unconformity. Higher in the section, upper Eocene strata yield abundant *C. ototara* in association with *Praetenuitella insolita* (Jenkins), and Oligocene strata have scarce *C. cubensis* (Palmer).

### INTRODUCTION

The Austral, or Magallanes, basin in southernmost South America contains Cretaceous and Cenozoic foraminiferal assemblages characteristic of austral high latitudes and generally poor in planktonic forms. In the Fuegian Andes, the orogenic margin of the basin, a fairly complete marine Paleogene section is exposed. Dissolution in the flysch-like setting of the Paleocene–lower Eocene, however, has rendered that part of the section mostly devoid of planktonic foraminifera. In the middle-late Eocene rocks, planktonic foraminifera are very small and scarce because deposition was in shallow environments, and the marginal sea of the Austral basin was isolated from the open ocean (Malumián, 1993). The resulting rarity of planktonic foraminifera has precluded resolution of the complex stratigraphy and tectonic history of the Fuegian Andes (Olivero and Malumián, 2008). Thus, we were compelled to conduct a meticulous search for lower Eocene planktonic indices in the Punta Noguera Formation, which required study of the finer sediment fractions. The main objectives of this paper are to document the results of this investigation

and to analyze the findings relative to a recently proposed circumantarctic zonation (Huber and Quillévéré, 2006).

### GEOLOGIC AND BIOSTRATIGRAPHIC SETTING

The Fuegian marine Paleogene accumulated in four main depocenters that originated in a compressional tectonic regime. Along the Atlantic coast, it comprises three lithostratigraphic groups: (1) the upper Paleocene–lower Eocene Río Claro Group, (2) the upper middle–upper Eocene La Despedida Group, and (3) the uppermost Eocene–Miocene Cabo Domingo Group.

The Río Claro Group comprises a strongly dislocated turbidite system represented by three formations (Olivero and Malumián, 2008). The upper Paleocene, organic-rich La Barca Formation, 200 m thick, bears a poor agglutinated flysch-type assemblage, with only two very restricted horizons at which calcareous foraminifera are present. At lower horizon, buliminids dominate, forming the *Buliminella karpatica* Assemblage, a mostly Midway-type assemblage, with few endemic species such as *Antarcticella* sp. and *Buliminella isabelleana*, (Malumián and Caramés, 2002). The upper horizon records the last occurrence of *Stensioina beccariiiformis* (White) in the region (Torres Carbonell and others, 2009). Although preservation of calcareous foraminifera is very good, both horizons are devoid of planktonic forms.

The superjacent Punta Noguera Formation, 380 m thick and of early Eocene age, has scarce agglutinated foraminifera, including *Rzehakina minima* Cushman and Renz and *R. fissistomata* (Grzybowski). Despite intensive sampling and resampling of several outcrops, calcareous microfossils were recovered only from a single horizon at the stratotype locality (Fig. 1), which is usually accessible only by helicopter. The horizon bears a moderately preserved benthic foraminiferal assemblage and scarce chiloguembelinids. The benthic assemblage includes species known elsewhere to range into the Paleocene, such as *Alabamina creta* (Finlay) and *Charltonina acutimarginata* (Finlay). However, it also contains very abundant specimens of typical post-Paleocene shallow-water genera such as *Cribrorotalia* and *Elphidium*. These are the oldest global records of both genera, the former becoming the emblematic genus throughout the Patagonian Cenozoic. Unlike the cosmopolitan late Paleocene assemblage of the La Barca Formation, the post-Paleocene benthic assemblage also includes several species endemic to the Southern Hemisphere. This shift in the shallow-water fauna represents the most significant turnover of Cenozoic benthic foraminifera in the Austral basin and coincides with the widely recognized turnover in the deep ocean at the Paleocene/Eocene boundary.

Just above the Paleocene/Eocene boundary, benthic foraminifera in the Punta Noguera Formation indicate an early Eocene age that is consistent with stratigraphic position

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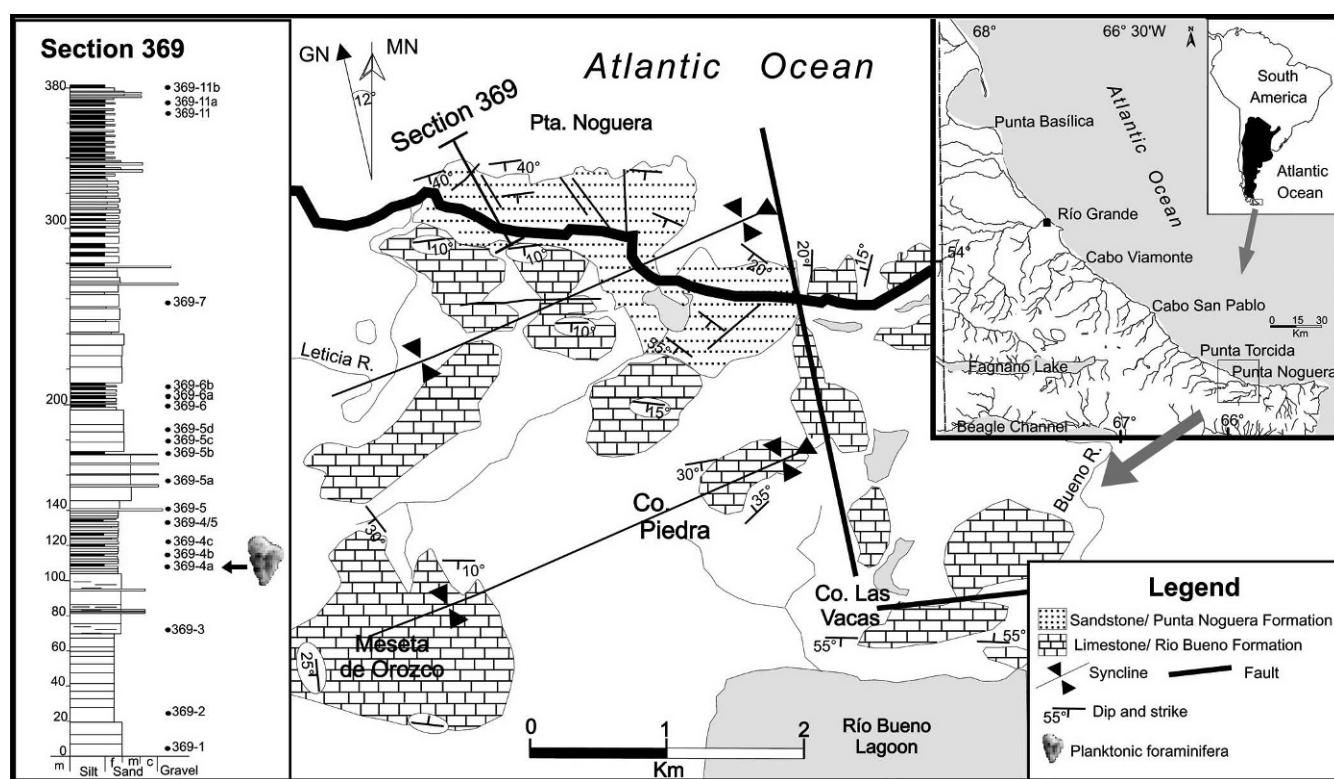


FIGURE 1. Stratigraphic section of the Punta Noguera Formation and location of the type sample of *Chiloguembelina noguerensis* n. sp. (modified after Olivero and others, 2002).

and palynology (Olivero and others, 2002). The associated *Nasselaria* radiolarians suggest a late Paleocene age equivalent to the upper RP5 zone of Hollis (1997) in New Zealand (Jannou, 2007), but they are considered reworked.

The youngest unit of the Río Claro Group, the Punta Torcida Formation, is late early Eocene in age and yields a diverse benthic assemblage with frequent endemic species such as *Antarcticella cecionii* (Cañón and Ernst), and a low diversity planktonic assemblage that includes some acariniids and *Globanomalina australiformis* (Jenkins), (Olivero and Malumián, 1999). In addition, we recently found abundant *Jenkinsina triseriata* (Terquem) in its uppermost member. The Río Claro Group is truncated by a regional unconformity that encompasses most of the lower middle Eocene.

Above the unconformity is the shallow-water La Despedida Group of late middle-late Eocene age. The only serial planktonic foraminifera recorded from this group is *Chiloguembelina ototara* (Finlay) from the late Eocene Cerro Colorado Formation, where it is scarce at the base and abundant at the upper part. Malumián and Olivero (2006) reported scarce *Chiloguembelina cubensis* (Palmer) in the lowest Oligocene of the successive Cabo Domingo Group.

#### SOUTHERNMOST SOUTH AMERICAN PALEOGENE SERIAL PLANKTONIC FORAMINIFERA

Considerable taxonomic confusion existed between *Chiloguembelina ototara* and *C. cubensis* until Hornibrook (1990), with convincing illustrations of topotypes, showed that both species are morphologically distinct and with different

stratigraphic ranges in New Zealand. In mainland New Zealand, *C. ototara* ranges upper middle Eocene–lower Oligocene, whereas *C. cubensis* ranges lower to upper Oligocene. Hornibrook also recorded the latter species in the basal Miocene of the Chatham Islands, but that does not support its widely accepted last appearance datum at the base of the Chattian Stage. Although both species occur in the Oligocene *Globigerina angiporoides* Zone, they were not found in the same assemblage nor do their ranges overlap.

Hornibrook (1990) interpreted *C. ototara* as having a rapidly expanding test with 11–12 chambers and a surface with randomly distributed minute tubercles and fine pores. In contrast, he distinguished *C. cubensis* by its slowly expanding test in lateral view with 14–16 and occasionally 22 chambers with minute tubercles aligned in longitudinal rows and tending to fuse as costae. Based on these criteria, most illustrated specimens of *C. cubensis* are from the Oligocene (e.g., Poore and Goswell, 1985; see synonymy in Huber and others, 2006). Instead, most illustrated specimens assigned to *C. cubensis* from the upper Eocene of the Southern Hemisphere belong to the Finlay's species, *C. ototara* (cf. Quilty, 1978, 2001; Hromic, 1990; Krashennnikov and Basov, 1983; Leckie and Webb, 1986; Fig. 2).

The oldest record of *C. cubensis* is near to the middle/upper Eocene boundary in the Agulhas Ridge (Galeotti and others, 2002). Huber and others (2006) considered that *C. cubensis* probably evolved from *C. ototara* during the late Eocene, although they mentioned an earlier record from the mid-middle Eocene of Tanzania. The Tanzanian specimen figured by Huber and others (2006) has costae that are less numerous,

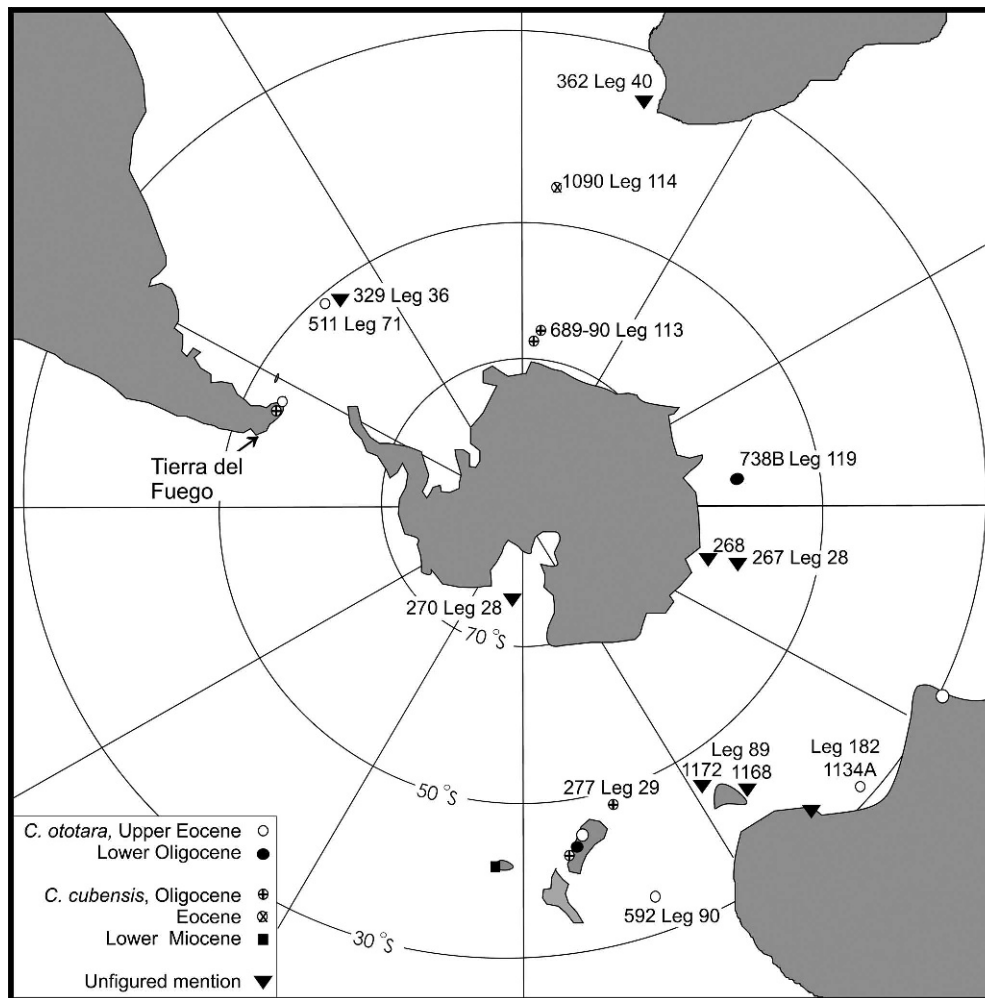


FIGURE 2. Southern high latitude main records of *Chiloguembelina cubensis* and *C. ototara* according to figured specimens from the DSDP and ODP sites and onshore sections.

more continuous, and more even than the *C. cubensis* topotypes that Hornibrook (1990) illustrated as having fine tubercles aligned and forming discontinuous costae.

In the Fuegian lower Paleogene, two biserial planktonic species are recorded from the Punta Noguera Formation, Río Claro Group. One is the widespread *Chiloguembelina wilcoxensis* (Cushman and Ponton), a species of relevant chronologic value at southern high latitudes because its regional austral extinction marks the top of Zone AE1 (53.39 Ma) of Huber and Quillevère (2005). The other is *Chiloguembelina noguerensis* n. sp., apparently restricted in geographic distribution, and morphologically distinguished by a test surface conspicuously ornamented with an irregular reticulation pattern formed by coalesced pustules.

In the Fuegian upper Eocene–lower Oligocene, two chiloguembelinid species are recorded. *Chiloguembelina ototara* occurs in the upper Eocene (Malumián and Nánuez, 1996; Olivero and Malumián, 1999) and is particularly abundant in uppermost Eocene shelfal deposits where it is associated with *Praetenuitella insolita* (Jenkins). *Chiloguembelina cubensis* is scarce and is characterized by an unusually small test showing 11 chambers. This species is

restricted to lowermost Oligocene rocks that originated in a deep-water setting. Its rarity could be explained by deposition of most Fuegian Oligocene sediments below the carbonate compensation depth, as the only other foraminifera preserved are agglutinants (Scarpa and Malumián, 2008). *Chiloguembelina ototara* and *C. cubensis* are stratigraphically separated in the Fuegian Andes.

In general, the occurrence of *Chiloguembelina* in the late Eocene and early Oligocene of the Austral basin are coeval with the abundance peaks of chiloguembelinids in Atlantic high latitudes (Boersma and Premoli Silva, 1988, 1989; Li and Radford, 1991) and in the late Eocene of the Southern Hemisphere (McGowran, 1987). The peak at mid-Eocene P11 Zone is not recognized in the Fuegian Andes because of the regional unconformity, but it was reported in the Chilean part of the Austral basin in the mid-middle Eocene, Moritzian local stage (Marchant, 1998). The record of two *Chiloguembelina* species in the Punta Noguera Formation is coeval with a secondary abundance peak indicated with question marks at the P7–P8 Zones by Li and Radford (1991). There is no record of Danian foraminifera in Tierra del Fuego, but the first of the three abundance peaks of

chiloguembelinids recognized by Boersma and Premoli Silva (1989) is reflected in the lowermost beds of the Danian of northern Patagonia, where there is a dominance of biserial and triserial planktonic foraminifera (Náñez, 2007).

In our search for minute planktonic forms in the Fuegian Paleogene, we also found the triserial *Jenkinsina triseriata* (Terquem) in the upper lower Eocene, upper Punta Torcida Formation. It is noteworthy that *Zeauvigerina*, a serial genus typical of the Eocene in Australasian mid-high latitudes, has never been recorded in Tierra del Fuego Island.

### Paleoecology

Chiloguembelinids have been related to upwelling areas and have been considered as an opportunistic species group that preferred waters characterized by low oxygen (Boersma and Premoli Silva, 1989) or fluctuations linked to available oxygen (McGowran, 1987). They dominate the southern high-latitude assemblages of ODP sites 738 and 744, from late Eocene to early Oligocene (Huber, 1991).

In Tierra del Fuego Island, *C. ototara* and *Praetenuitella insolita* occur in association with few or no specimens of *Globigerinatheka* and with abundant benthic foraminifera, particularly bolivinids and small uvigerinids. Their occurrence in shelfal deposits with phosphate nodules (Malumián and Olivero, 2006) reaffirm the preference of *Chiloguembelina* for environments where nutrient supply fluctuates, as was revealed in Australia by Li and others (1995).

An apparent ecological incompatibility between *C. ototara* and *C. cubensis* may be suggested by their non-association, at least in the Southern Hemisphere, despite their mid-Eocene to early Oligocene overlapping range. On the other hand, this could be an artifact of taxonomic confusion.

*Chiloguembelina noguerensis* n. sp. is recorded from rocks bearing abundant *Spumellaria* radiolarians and phosphate nodules, suggesting nutrient-rich waters. Its exclusive occurrence in shallow marine deposits that lack non-biserial planktonic foraminifera calls into question whether this form lived a planktonic mode of life. Smart and Thomas (2007) proposed a scenario in nutrient-rich waters where benthic biserial forms could become planktonic or might live tychoipelagically. We speculate that *C. noguerensis* might also have lived in a benthic habitat during part of its life cycle. The sharp increase in chamber size from the initial three pairs of chambers to the later pairs of chambers, as is seen in the holotype and some paratypes, suggests the living mode change.

## SYSTEMATIC PALEONTOLOGY

Family CHILOGUEMBELINIDAE Reiss, 1963

Genus *Chiloguembelina* Loeblich and Tappan, 1956

*Chiloguembelina noguerensis* Malumián, Jannou and Náñez n. sp.  
Pl. 1, figs. 1–6

**Diagnosis.** Biserial test with 4–6 pairs of inflated chambers, moderately increasing in size. Aperture eccentric on chamber face, bordered by distinct rim, inturned on

inner margin of aperture. Pustulose surface with coalescent pustules forming an irregular and incomplete reticulation.

**Etymology.** Named after Punta Noguera, the locality and formation from which the new species is described.

**Type material.** Seventeen specimens. Holotype: SEGEMAR 2823 (Pl. 1, Figs. 3a–d). Paratypes: SEGEMAR 2820 to 2822 and 2881 to 2883 (Pl. 1, Figs. 1–2, 4–6). Repository: Servicio Geológico Minero Argentino (SEGEMAR), Buenos Aires, Argentina.

**Type locality and horizon.** Punta Noguera Formation, Section 369, sample 369-4a (Fig. 1), Punta Noguera area, Tierra del Fuego Island, Argentina; 54°10'07"S, 65°14'03"W.

**Description.** Test small, elongate, tapering, periphery rounded; biserial throughout; 4–6 pairs of chambers inflated, globular, gradually increasing in size; sutures depressed, nearly perpendicular to growth axis. Aperture and foraminas nearly centered to off-center at base of chamber with residual and equidimensional lip surrounding foraminas and aperture. Wall microporolate and coarsely pustulose, pustules coalesce forming an irregular and incomplete reticulation that is slightly more developed in the initial part of the test.

**Dimensions of holotype.** Length 0.22 mm, breadth 0.09 mm.

**Remarks.** Poore and Goswell (1985) recognized two basic types of surface texture—with and without longitudinal ridges—in upper Eocene and Oligocene *Chiloguembelina*. The wall texture of *Chiloguembelina noguerensis* n. sp. is unique among chiloguembelinids (compare with D'Hondt and Huber, 1999; Huber and others, 2006). Some specimens exhibit a marked enlargement of the terminal chambers with respect to those of the juvenile stage (Pl. 1, figs. 1–3).

*Chiloguembelina wilcoxensis* (Cushman and Ponton, 1932)  
Pl. 1, figs. 8–11

*Guembelina wilcoxensis* Cushman and Ponton, 1932, p. 66, pl. 8, figs. 16, 17.

**Remarks.** Most of the specimens are typical with a comparative larger size than other Fuegian biserial species, and with rapid increase in chamber size in the early part of the test. This chamber enlargement has usually been considered the most distinguishing feature of the species, but it is not apparent in all specimens (e.g., Fig. 9) and is frequently displayed by *C. ototara*. A more consistent distinguishing feature of *C. wilcoxensis* is its distinctly dense papillate wall and its longitudinally elongate ultimate chamber pair.

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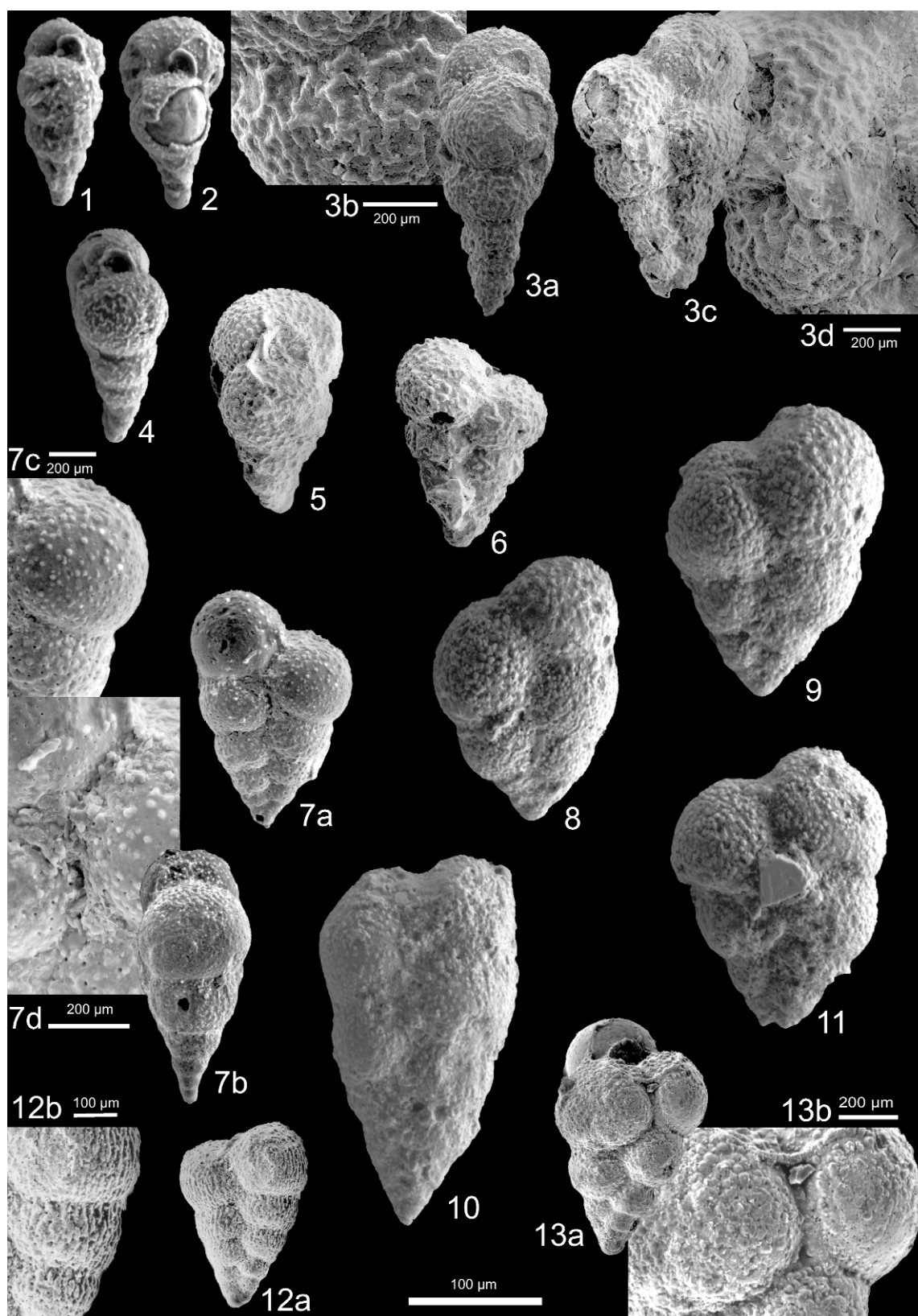


PLATE 1

1–6 *Chiloguembelina noguerensis* Malumián, Jannou and Nández n. sp., Punta Noguera Fm., lower Eocene; sample 369-4a: 1 Paratype, SEGEMAR 2883, peripheral view; 2 Paratype, SEGEMAR 2882, peripheral view; 3 Holotype, SEGEMAR 2823, a, peripheral view, b, detail, c, lateral view, d, detail; 4 Paratype, SEGEMAR 2881, peripheral view; 5 Paratype, SEGEMAR 2820, peripheral view; 6 Paratype, SEGEMAR 2821, lateral view. 7 *Chiloguembelina ototara* (Finlay), SEGEMAR 2891, upper Eocene, Cerro Colorado Fm., CCd member, a, lateral view, b, peripheral view, c–d, details

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showing dispersed and minute tubercles. **8–11** *Chiloguembelina wilcoxensis* (Cushman and Ponton), SEGEMAR 2885–2887 and 2889, Punta Noguera Fm., lower Eocene, sample 369–4a, lateral views. **12** *Chiloguembelina cubensis* (Palmer), SEGEMAR 2710, lower Oligocene, María Cristina beds: a, lateral view, b, enlargement of the surface. **13** *Jenkinsina triseriata* (Terquem), SEGEMAR 2892, upper lower Eocene, Punta Torcida Formation, upper member, a, lateral view, b, enlargement showing a dense cover of tubercles. Scale bar = 100 µm, except the details as indicated.