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Hugo Marengo

Neogene Micropaleontology and Stratigraphy of Argentina

The Chaco–Paranense Basin and the Península de Valdés

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…it was all a Sea from above Memphis to the Ethiopian Mountains, and likewise from the plains of Arabia. It was Sea also about Ilium, and all Teuthrania; and where the River Meander now runneth by Meadows. There be Lands also that are produced after another manner, and emerge on a sudden in some Sea: as if Nature struck a Balance with herself, by giving again in one place that which her gaping Gulfs had swallowed up in another.

Pliny, Natural History, II, 85–86 (trans. Philemon Holland. The Wernerian Club, 1847–48. London)

—The ground of the pampa, Bernini insisted, is a marine formation. The entire pampa is the vast floor of an ocean that at one time lapped up against the Andes until it withdrew…

Vacillating between indignation and respect, the High Priest Bernini asked how he had erred. By inventing a marine origin for the pampa's topsoil deposits, came the Glyptodon's response.

—And what proof is there to the contrary? challenged Bernini.

—The absence of horizontal strata left by any transgression or regression of the sea.

Leopoldo Marechal, Adán Buenosayres, III, 1 (trans. Norman Cheadle. McGill-Queen's University Press 2014. pp. 167–168. Montreal)

Preface

During the Miocene, two huge Atlantic transgressions flooded the Patagonian coast and much of the Argentine continental interior, covering more than 1 million km^2 and reaching poorly known areas of southern Paraguay and Bolivia and western Uruguay. The deposits of both transgressions are micropalaeontologically rich, which allowed the first reliable estimates of their ages and provided knowledge of the main environmental changes that occurred in the different regions involved. The knowledge of these transgressions coincided with the birth of geological science in Argentina, from the pioneering observations by Alcide d'Orbigny and Charles Darwin. However, few works have attempted a comprehensive study of these deposits from a modern perspective.

The first of these transgressions is known as the *Patagoniense* on the Patagonian coast, but it was virtually unknown in the Chacoparanense Basin, where it was erroneously assigned to the Maastrichtian; this is called the *Laguna Paiva Transgression* (TLP), which started during the Early Aquitanian (Early Miocene). The second transgression occurred between the Middle Miocene and the early Late Miocene; it is known by various names but is referred to in this work as the *Entrerriense-Paranense Transgression* (TEP). The dating of both events, as well as their correlation with global eustatic changes and with the moments of greater convergence between the South American and Nazca plates, is useful to consistently explain the origin of the two transgressions. They were mainly produced by the complex interaction of changes in sea level and the distal subsidence that occurred in the eastern margin of southern South America, related to Neogene Andean tectonics.

This book organizes and updates the most significant advances of the last two centuries and presents an unpublished micropaleontological study of more than 20 stratigraphic sections. This information is supplemented by numerous sedimentological observations and analyses, which allow the proposal of a new lithostratigraphic framework for the Neogene of the Chacoparanense Basin. This book is structured to facilitate fluent reading. A complete review of the knowledge of transgressions in Argentina and similar transgressions in other countries of South America is first discussed, along with the state of the art of different aspects relevant to these topics (age, paleoenvironment, micropaleontology, etc.). Then, the main findings for the TLP and TEP of the Chacoparanense Basin and the TEP of Península de Valdés are presented. Finally, the complete stratigraphic Profiles (Appendix A), Mineralogical Analysis (Appendix B), Distribution Charts (Appendix C), Systematics (Appendix D), and Plates (Appendix E) are presented.

Acknowledgments

I wish to acknowledge Roberto Scasso for encouraging me to overcome obstacles and promoting my curiosity. Gratitude is also extended to Adelma Bayarsky for hundreds of hours spent helping me make this work, Andrea Concheyro for the assistance in the study of calcareous nannoplankton, and Alicia Echeverría for the invaluable help in the study of ostracods. Special thanks to Jorge Rabassa for the thorough review and invaluable encouragement. This work was carried out in the laboratories of SEGEMAR (the Geological Survey of Argentina), using borehole samples from its repository; I am thoroughly grateful to this institution.

Contents

Abstract

Micropaleontological composition and some sedimentological features were studied in 18 boreholes in the Chacoparanense and Salado Basins; information from about 180 additional localities was also evaluated. Two marine levels were recognized, characterized by specific associations of foraminifers, ostracods, and calcareous nanoplankton. The lower marine level was erroneously assigned to the Maastrichtian-Danian; it is called the *Laguna Paiva Transgression* (TLP) and bears microfossils of Late Oligocene–Early Miocene age. The upper marine level corresponds to the Paraná Formation or the *Entrerriense-Paranense Transgression* (TEP), from the Middle-Late Miocene. Both transgressions flooded the entire Pampa and Chaco Plains and reached some sectors in the foothills of the Pampeanas Ranges, Cuyo, and northwestern Argentina; the TLP and TEP can be correlated respectively with the Patagonian *Leonense* and *Entrerriense* deposits.

In the Salado Basin, the TLP is characterized by microfaunas with low to moderate diversity, dominated by *Elphidium* spp., *Cribroelphidium* spp., big and ornamented miliolids, ostracods, and nanofossils belonging to the biozones NP25-NN1; in the Chacoparanense Basin, *Cribroelphidium*, *Nonion*, *Ammonia,* and *Peneroplis* are the most notable genera. The microfaunas of the TEP belong to the *Protelphidium tuberculatum* informal zone; nannofossils of the Salado Basin are typical of Biozone NN6. The microfossil assemblages suggest tropical to subtropical climates during the TLP. The water temperature may have been higher than today's adjacent seas during the TEP but lower than during the TLP. The first calcareous nanoplankton recovery was reported from both the TLP and the TEP. To the continental interior, the microfaunas become poorer, reaching the northwest and northeast of Argentina, with few species typical of brackish environments. The geographic distribution of the microfossils indicates that both transgressions flooded from the Salado Basin to the north. Ihering (1927) pointed out the similarities between the Caribbean and Argentinean marine faunas during the Miocene; he believed there was a migration of the faunas from north to south through a hypothetic intracontinental seaway, "The Arm of Tethys." The collected data demonstrate that this migration was not possible through the continental interior; it was probably done by the eastern continental platform of South America.

The Laguna Paiva Formation has been formalized and the Chaco Formation redefined; the latter was also divided into the Palermo, San Francisco, and Pozo del Tigre Members. The Chaco, Laguna Paiva, and Paraná Formations are clustered in the Litoral Group, representing the main filling of the basin during the Cenozoic. There is a good correlation between the TLP and TEP microfossil ages, the global eustatic changes, and the convergence rate and obliquity between Nazca and South America plates, suggesting that both transgressions were produced by the combination of tectonic and eustatic features.

The microfossiliferous and mineralogical composition in three sections cropping out in the Península de Valdés were studied. The sections belong to the Puerto Madryn Formation and are composed of deposits from the TEP. The foraminifers are typical of the *P. tuberculatum* informal zone and have few planktonic and agglutinated species. The variation in the rate of microfossils and glauconite was useful to identify the main eustatic changes during the TEP. The TEP began with a transgressive surface indicated by the abundance of *Buliminella elegantissima*, while the richest samples coincided with the maximum flooding surface (del Río et al. 2001). About at the upper half of the section, the microfaunas become gradually poorer, up to a complete continentalization. The mineralogical composition reveals a provenance associated with a transitional-dissected volcanic arc, with very limited contributions from basement rocks. This composition resembles that of the modern Patagonian coast, suggesting few differences between the climates of the Middle-Late Miocene times and the present.

Keywords Miocene transgressions · *Entrerriense-Paranense* · Laguna Paiva · Chacoparanense Basin · Salado Basin · Península de Valdés · Foraminifera · Ostracoda · Calcareous Nannoplancton · Litoral Group

Chapter 1
Introduction

1.1 Nature of the Work

This book is an update of the author's doctoral dissertation, which was submitted in 2006 and defended at the University of Buenos Aires in June 2007. Funding for the work was possible thanks to grants provided by CONICET between July 1996 and June 2000. Borelog samples are property of the Argentine Geological Survey (SEGEMAR).

This work reflects more than 10 years of research on a vast and insufficiently known theme: the Neogene of the Chacoparanense and Salado Basins and the Península de Valdés. These regions, taken in the broadest sense, cover more than 1 million km^2. This research began as an attempt to deepen the micropaleontological and sedimentological knowledge of the *Entrerriense* and *Paranense* marine deposits. The finding of unknown older Neogene marine microfossils radically altered the scope of the study. Therefore, very different results were achieved: On the one hand, there were detailed mineralogical and micropaleontological analyses of areas with good sampling, such as the basement of Buenos Aires City and the Diamante area, as well as the outcrops in the Península de Valdés. On the other hand, several sites with widely spaced sampling allowed an investigation of the characteristics of the sedimentary fill and microfaunas during the major transgressions in the Chacoparanense Basin. Finally, the analysis of approximately 200 sites allowed investigations of the boundaries, sediment thickness, facial and environmental variations of the deposits, and the relationship with related deposits in Argentina and South America.

1.2 Area and Material of Study

The Chacoparanense Basin was considered in a broad sense, including the area of the present basin, the northern half of the Buenos Aires province, and the western part of Corrientes and Entre Ríos provinces. Several profiles, cropping out in the

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southwest of Entre Ríos province and the southern coast of Península de Valdés, as well as various boreholes of Buenos Aires, Entre Ríos, Santa Fe, Córdoba, Santiago del Estero, and the Formosa provinces of Argentina were analyzed (Figs. 1.1 and 1.2). The *Entrerriense-Paranaense Transgression* (TEP) includes all of the marine sediments deposited by the transgressions of the Middle–Late Miocene, with megafossils related to those of the southwest Entre Ríos and the Península de Valdés. The *Laguna Paiva Transgression* (TLP) includes the marine subsurface sediments of the Chacoparanense Basin, previously known as the layers or strata of Paiva or the Mariano Boedo formation. The deposits of the TEP are present in large areas of Argentina and in small sectors of Uruguay, Paraguay, and Bolivia (Fig. 1.1). Existing information was available about the outcrops in the southwest of Entre Ríos and the northeast coast of Chubut, as well as several drillings in the Buenos Aires province, especially in the Colorado and Salado Basins. The outcrops in eastern Río Negro province and the subsoil of the Chacoparanense Basin have been poorly studied. Furthermore, both in outcrop and subsurface, have been assigned to the TEP deposits in the region of Cuyo, the northwest of Argentina (NOA), and the Golfo de San Jorge Basin.

The drilling materials correspond to cores, cuttings, and grab samples that belong to the SEGEMAR repository. The Península de Valdés samples were obtained in three sections during 1997 and 1998. Approximately 750 samples from 23 boreholes and outcrops were processed for micropaleontological studies. Approximately 170 samples were fertile. In total, more than 21,000 specimens of foraminifera and approximately 2,600 specimens of ostracods were found and classified. Fifteen samples from the Salado Basin were processed for calcareous nannofossil analysis. The samples of several boreholes did not yield positive results and therefore were not included in this work, but it is important to mention them for future research. In the boreholes Macachín 1 and Uriburu 1, the microfossils were rare and extreme recrystallized. Therefore, it is likely that the Macachín Basin has no promising prospects for further study. The samples from deep boreholes in General Madariaga, San Clemente del Tuyú, and General Belgrano from the center of the Salado Basin had abundant and well-preserved microfaunas, but they are apparently unrelated to the Miocene and belong to younger deposits. Finally, in several drillings from the Chacoparanense Basin, no microfossils were found: these included the TEP of Crespo and Santa Fe 4, as well as the TEP and TLP of Rufino 1, Gualeguay IV, and San Cristóbal 3.

1.3 Methodology

The megafauna were classified by comparison with specific literature and with the valuable aid of C.J. del Río. The usual techniques for the preparation of micro-paleontological samples were followed: disaggregation was performed with hydrogen peroxide for 48 h up to 60 °C; the material was sieved in mesh ASTM 230 (62.5 μm); then all microfossils were separated using a binocular microscope.

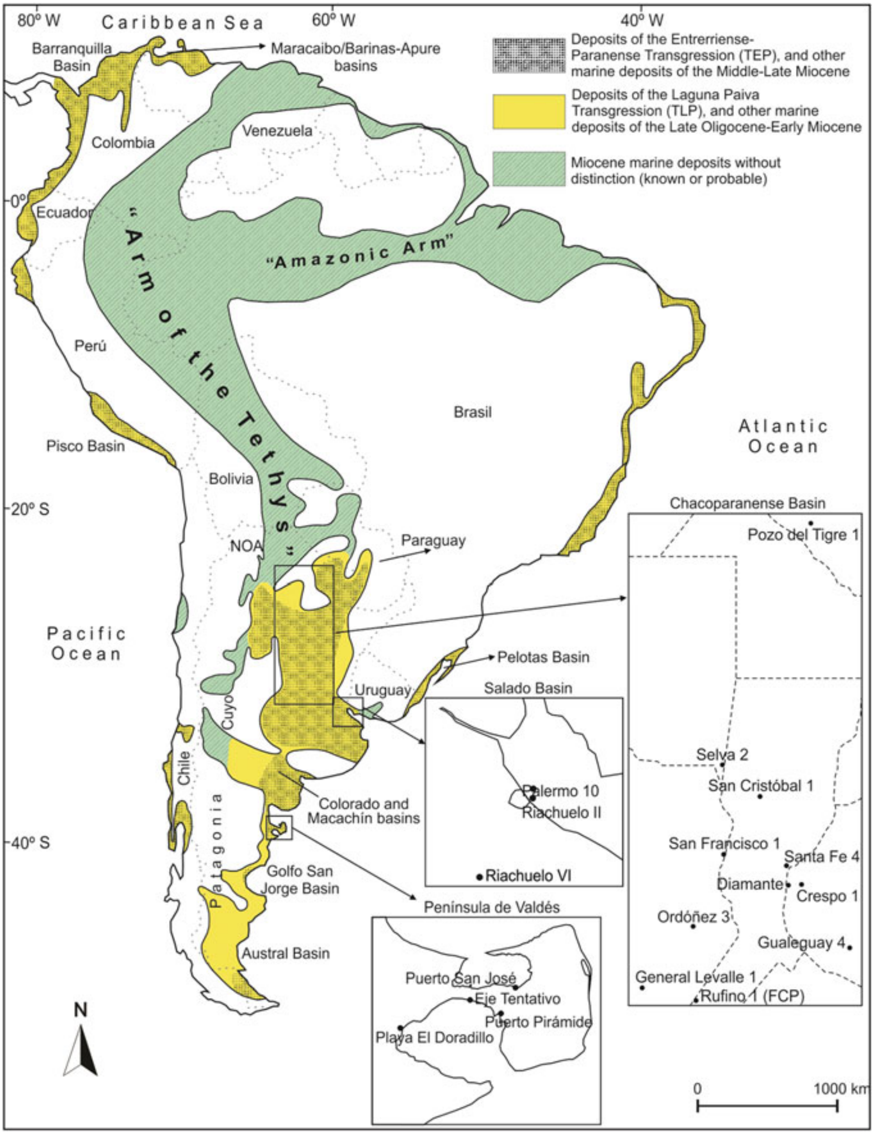

Fig. 1.1 South America's paleogeography during the Late Oligocene–Middle Miocene, according to Ramos (1982) and Bossi and Gavriloff (1998), including the geographic location of the studied sections and the main Miocene basins

Classification was made by comparison with the specific literature and the micropaleontological collections of SEGEMAR. The genera of foraminifera were updated according to Loeblich and Tappan (1988) and Luczkowska (1974). The final classification of ostracods was conducted entirely by A. Echevarría. The samples

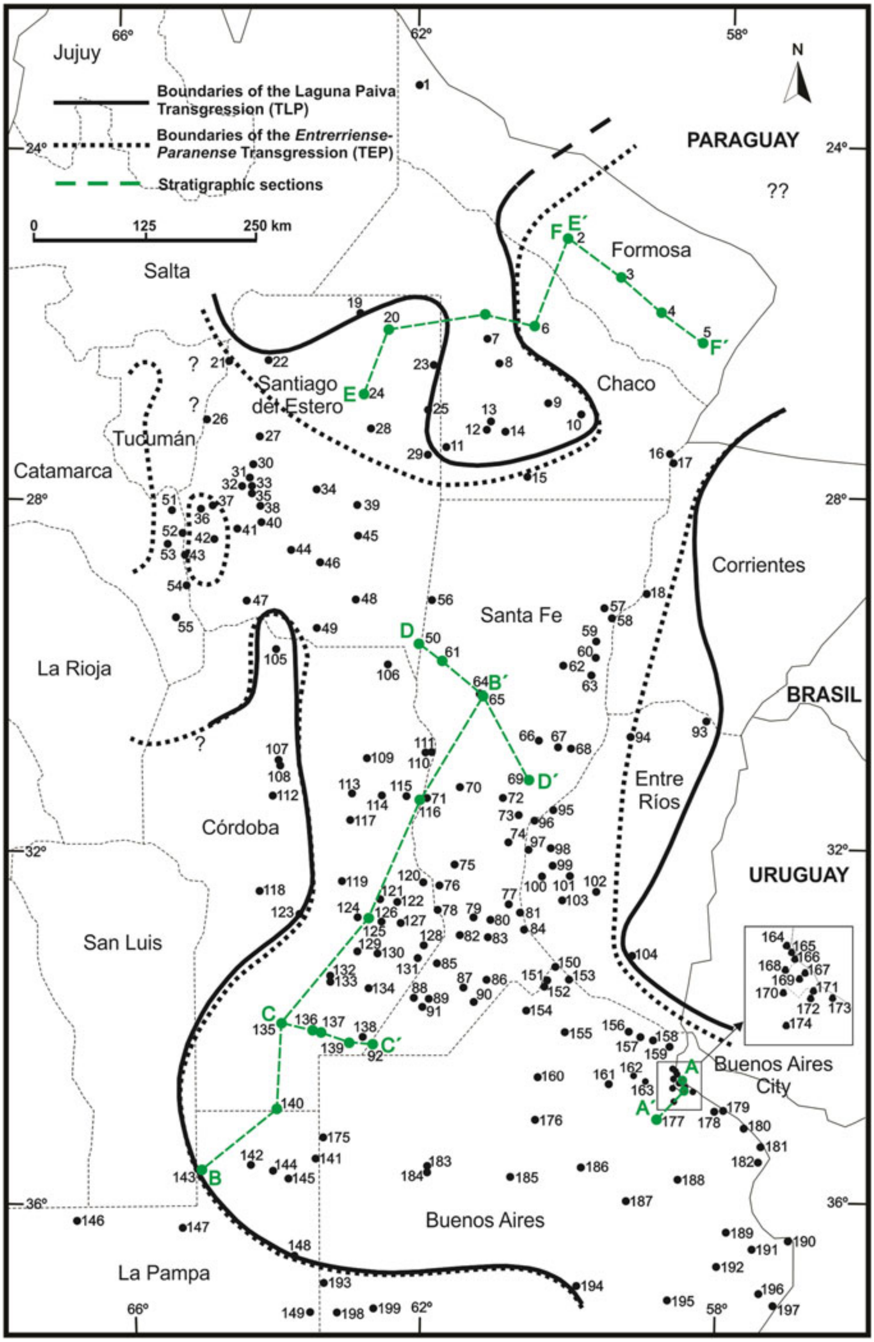

Fig. 1.2 Locations used to draw the structure and isopach maps

for nannofossil analysis were prepared using the smear slide technique (Edwards 1963) and were observed under a microscope with parallel and polarized light. The study was semiquantitative, counting the nannofossils in at least two successive traversals of the preparation. The taxonomic determination was performed by A. Concheyro. The material was photographed using scanning electron microscopes (SEM) from CITEFA, INTEMIN, and BGR (Hannover, Germany).

The mineralogy of sandy samples was performed on preparations of loose grains. All of the samples from the Península de Valdés were separated into light and heavy fractions using bromoform. At least 300 grains in each fraction were counted per sample, in the range of 250–62.5 μm. The mineralogy of the Litoral Group was plotted in a compositional triangle (basement minerals–volcanic minerals–glass shards), such as that applied by Marengo (2003) for the Quaternary of Santa Fe province; this approach better represents the characteristics of the Chacoparanense Neogene sediments than the traditional QFL (Dickinson et al. 1983).

The subsurface sections were described from top to bottom. The outcrops were described from bottom to top; the thickness corresponds to beds or bedsets, and the sample position refers to the distance from the bottom of the beds or bedsets. The samples or intervals with microfauna are shown in bold characters. The directions on the lithostratigraphic nomenclature by the Comité Argentino de Estratigrafía (1992) were respected. In the case of informal or not-current units, "formation" has been used instead of "Formation." The structural maps of the TEP and TLP refer to the mean sea level. The information was gathered from numerous sources, such as bibliographic records, borehole records of the SEGEMAR and Yacimientos Petrolíferos Fiscales (YPF, the Argentine national oil company), and our own data. The top and bottom values of the TEP are reliable because the information is abundant and the identification of those surfaces is simple. The top and bottom values of the TLP are less reliable due to the smaller amount of data and the difficulty of establishing the true boundaries in some boreholes, as the contacts are typically transitional. In the Chacoparanense and Salado Basins information was evaluated from 199 locations (Fig. 1.2).

1.4 Background

1.4.1 The Entrerriense-Paranense Transgression

Since 1827, when Alcide d'Orbigny made geological observations on the Cenozoic near the city of Paraná, much work on the Miocene marine transgressions has been published in Argentina. These studies expanded our knowledge of these deposits. However, because of the logical difference of criteria used during almost two centuries of research and the extensive areal distribution of the deposits, many contradictions and inaccuracies were generated concerning the stratigraphy of these units.

1.4.1.1 Overview

Alcide d'Orbigny toured the Paraná region between 1827 and 1828 conducting stratigraphic observations, a milestone that marks the beginning of geological research in Argentina (Aceñolaza 1976). These observations were published in his work of 1842, in which grouped the outcropping Cenozoic marine sediments from the Strait of Magellan to Entre Ríos under the name of *terrain tertiaire Patagonien* (Patagonian tertiary land). d'Orbigny assigned them a similar age as the Eocene deposits of the Paris Basin. Darwin (1846) grouped the same levels under the name "Patagonian tertiary formation," correlating the outcrops along the coast of Patagonia and Entre Ríos, based on megafaunal remains. Darwin tentatively correlated the Patagonian Formation with the Eocene of Europe. Ameghino (1889) noted that the terrains of Patagonia were older than those of Entre Ríos. Accordingly, he differentiated the *Formación Patagónica* and the *Formación Entrerriana*. In 1907, Ihering published a catalog of mollusks, establishing the criteria in the recognition of the megafauna; he analyzed the marine index fossils of the Cretaceous-Cenozoic of Argentina. Ihering (1927) explained the affinities between the *Entrerriense* and the Caribbean faunas through an intracontinental marine connection (the so-called Arm of Tethys). This connection would have connected the Río de la Plata region with the Caribbean Sea, which would have developed along the eastern portion of the Andes (Fig. 1.1).

1.4.1.2 Southwestern Entre Ríos Province

d'Orbigny (1842) described the outcrops on the left bank of the Paraná River near La Bajada (nowadays, the city of Paraná). He mentioned the levels *Grés tertiaire marin* D, *Grés Ostréen* H, and *Calcaire arenifére* I, which he considered to be products of a single transgression. de Moussy (1857) studied the same sections and assigned them to the Jurassic-Tertiary. Bravard (1858) identified about 32 m of outcropping marine sediments, which he called *formación marina del Paraná* (Paraná marine formation), establishing the priority for further lithostratigraphical nomenclature. Doering (1882) found a continental sedimentary intercalation between deposits of two different positions of sea level. Frenguelli (1920) defined three units of marine origin, the *Paranense cuspidal*, *Entrerriense*, and *Rionegrense marino*, interbedded with two continental units: the *Mesopotamiense* and *Rionegrense continental*. He assigned the *Paranense cuspidal* to the Late Miocene, and the *Entrerriense* and *Rionegrense marino* to the Pliocene. In 1947, Frenguelli considered that the *Paranense* was developed prior to the Second Stage of the Tertiary Andean Orogeny, and that it "was a great inland sea that completely occupied the vast area of the current Pampas, and whose perimeter was marked by the reliefs that nowadays circumscribe the vast region of the Pampa Plain," whereas the *Entrerriense* and *Rionegrense* seas occupied a "narrow marine bosom" from the Río de la Plata estuary and the Paraná valley, until shortly north of the city of Victoria.

Aceñolaza (1976) considered that the three marine levels that Frenguelli had described are concordant and actually belong to a single Miocene sedimentary sequence. He explained the continental interbedding by the confusing field relationships between the Paraná and the overlying Ituzaingó (continental, Pliocene) and Hernandarias (continental, Pleistocene) Formations. Aceñolaza and Aceñolaza (1996) presented a paleo-phytogeographical map in which the emerged areas were divided into the *Brasiliano* and *Pampásico-Ándico* territories. The paleofloras found in the southwestern Entre Ríos province would belong to the *Brasiliano* territory, with tropical to subtropical-temperate climate. The main micropaleontological studies were done by Rossi de García (1966, 1969a), Zabert and Herbst (1977), and Zabert and Barbano (1984). They described the main characteristics of the foraminifera and ostracoda present in these units and broadly proposed a Miocene age for the Paraná Formation. In 2000, a book with reviews on the TEP was published, including stratigraphical and paleogeographical aspects (Aceñolaza 2000), marine and freshwater vertebrates (Cione et al. 2000), malacofauna (del Río 2000), calcareous microfossils (Marengo 2000), and phytoliths (Zucol and Brea 2000). Finally, the first $^{87}Sr/^{86}Sr$ age of 9.47 Ma from the upper section of the Paraná Formation cropping out in Diamante (Pérez 2013) and a new revision of the megafauna (Pérez et al. 2013) were published.

1.4.1.3 The Chacoparanense and Salado Basins

Stappenbeck (1926) provided a detailed commentary on drill descriptions, explaining the changes in the level of the *Paranense* sea through successive periods of flooding and subsidence in a deltaic environment, as opposed to the ideas of Frenguelli (1920). Zabert (1978), Bertels and Zabert (1980), Zabert and Barbano (1984), and Herbst and Zabert (1987) studied the microfauna from some drill cores. They recognized foraminifera typical of the *Entrerriense*, with low to very low diversity. Marengo (2000) summarized the previous micropaleontological knowledge and updated the nomenclature. He described the findings of foraminifera and ostracoda on new boreholes and identified several new species for the region, considering that the temperature of the sea was very similar or slightly higher than the current Atlantic coast at the same latitude.

Wahnish (1939, 1942) described the megafauna of the boreholes Riachuelo V and Monte Veloz, very similar to that of southwestern Entre Ríos province and Península de Valdés. González Bonorino and Cetrángolo (1960) provided mineralogical and sedimentological data on the "green clays" in the subsurface of the city of Buenos Aires. Malumián (1970, 1972) studied the foraminifera in two boreholes, placing the *Entrerriense-Paranense* of the Salado Basin in the Late Miocene. Marengo and Concheyro (2001) identified new species of foraminifera in three boreholes located in the Buenos Aires urban area. On the basis of changes in the diversity and taxonomic composition, they identified atleast two eustatic rises in the lower half of the TEP deposits. Their finding of calcareous nannofossils with good stratigraphic resolution allowed them to assign the lower half of the TEP to the Biocronozone NN6 (Serravallian).

FORMOSA PROVINCE
1 Palmar Largo
2 **Pozo del Tigre**
3 *Comandante Fontana*
4 *Pirané*/5 *Mariano Boedo*

CHACO PROVINCE
6 Castelli/7 El Desierto
8 Las Breñas 2
9 Presidencia Roque Saenz Peña
10 *Machagay*/11 Gancedo
12 Charata/13 Las Breñas 1
14 Las Breñas Oriental
15 Villa Angela
16 Resistencia

CORRIENTES PROVINCE
17 *Corrientes*/18 *Santa Lucía*

SANTIAGO DEL
ESTERO PROVINCE
19 Monte Quemado
20 El Caburé/21 Rapelli
22 Los Horcones
23 Coronel Rico
24 Campo Gallo
25 Arbol Blanco
26 Tacanas/27 Huyamampa
28 Alhuampa/29 Roversi
30 *El Silencio*
31 *Santiago del Estero*
32 Mercedes/33 Rodeo
34 Suncho Corral
35 Santa María/36 Tres Flores
37 Santa Catalina
38 Simbol/39 Km. 511
40 Villa San Martín
41 Laprida/42 Choya
43 *Frías*/44 *Medellín*
45 Añatuya/46 *Salavina*
47 *El Bordito*/48 Las Abras
49 Sol de Julio/50 ***Selva***

CATAMARCA PROVINCE
51 *Bañado de Ovanta*
52 Tapso/53 *Dos Pocitos*
54 San Antonio/55 Esquiú

SANTA FE PROVINCE
56 Tostado/57 Avellaneda
58 San Jerónimo
59 *Romang*/60 *Colonia El Ceibo*
61 Ceres/62 Calchaquí
63 *Alejandra*
64 San Cristóbal 2
65 **San Cristóbal 1** and **3**
66 *San Justo*
67 *Paraje La Noria*
68 Saladero Cabal
69 Laguna Paiva
70 Rafaela/71 *Josefina*
72 Esperanza
73 **Santa Fe**
74 Coronda/75 El Trébol
76 Bouquet
77 Salto Grande
78 Tortugas
79 Cañada de Gómez
80 Carcarañá
81 San Lorenzo
82 San Ricardo
83 Casilda/84 Rosario
85 Berabevú/86 Alcorta
87 Melincué
88 Maggiolo/89 Venado Tuerto
90 Hughes/91 San Eduardo
92 **Rufino**

ENTRE RÍOS PROVINCE
93 El Yacaré/94 Estacas
95 *Villa Urquiza*/96 *Paraná*
97 ***Diamante***/98 **Crespo**
99 Villa General Ramírez
100 Molino Doll
101 Hernández
102 Nogoyá/103 *Victoria*
104 **Gualeguay**

CÓRDOBA PROVINCE
105 San Francisco del Chañar
106 Los Porongos
107 Jesús María/108 Colonia Caroya
109 *Marull*
110 Cotagaita/111 Seeber
112 Córdoba
113 Santiago Temple
114 *La Francia*/115 *Devoto*
116 **San Francisco**
117 Sacanta/118 Las Peñas
119 Villa María
120 Saira/121 Bell Ville
122 San Marcos
123 General Deheza
124 Idiazábal
125 **Ordóñez**
126 Justiniano Posse
127 Monte Buey
128 *Camilo Aldao*
129 Las Pascanas
130 Escalante
131 Corral de Bustos
132 Barreto/133 La Carlota
134 Canals/135 **General Levalle**
136 Guardia Vieja
137 Laboulaye
138 Laguna del Monte
139 Salas/140 Gallinao

LA PAMPA PROVINCE
141 Santa Aurelia
142 Arata
143 La Maruja
144 Trenel/145 Metileo
146 Santa Isabel
147 Telén/148 Uriburu
149 **Macachín**

BUENOS AIRES PROVINCE
and The CITY of BUENOS
AIRES
150 San Nicolás
151 Erézcano/152 Conesa
153 Ramallo/154 Pergamino
155 Arrecifes
156 Lima/157 Zárate
158 Campana
159 Paraná Miní
160 Chacabuco
161 Mercedes/162 Luján
163 General Rodríguez
164 San Fernando
165 San Isidro/166 Olivos
167 **Palermo**/168 San Martín
169 Flores/170 San Justo
171 Avellaneda
172 **Lanús** (Riachuelo II)
173 Quilmes/174 Ezeiza
175 Villa Sauze/176 Bragado
177 **Cañuelas** (Riachuelo VI)
178 La Plata/179 Río Santiago
180 Magdalena
181 Punta Indio
182 *Monte Veloz*
183 Larramendy/184 Pehuajó
185 Huetel/186 Saladillo
187 *Las Flores*
188 ***General Belgrano***
189 Dolores
190 **San Clemente del Tuyú**
191 Las Chilcas
192 General Guido
193 Maza/194 Azul
195 Ayacucho
196 General Madariaga
197 Sun-Fx-2
198 Rivera/199 Lago Epecuén

Localities corresponding to Fig. 1.2. Those sections studied with detail in this work are printed in bold type; localities with previous TEP microfossil knowledge are in italic type.

1.4.1.4 The Colorado Basin

Malumián (1970, 1972) studied the foraminifera, ostracoda, and calcareous nannoplankton, and described associations of Maastrichtian-Danian, Oligocene, Miocene, and Quaternary ages. He considered that the *Entrerriense* was deposited during the Middle Miocene, a bit older than in the Salado Basin. Becker and Bertels (1978) identified six micropaleontological associations in an offshore drilling east-southeast of the city of Bahía Blanca, where the Colorado Basin reaches its maximum depth. The assemblages were dated as Late Eocene–Early Oligocene, Oligocene, Early Miocene, Middle–Late Miocene, Late Miocene–Early Pliocene, and Pliocene. Boltovskoy (1980) described the foraminifera of the borehole Gil 1 and found Late Oligocene, Early Miocene, Miocene, and Quaternary microfaunas. He correlated the Miocene faunas with the *Entrerriense*, and pointed to a climatic deterioration from the Late Oligocene, with a gradual decrease in temperature and the foraminiferal associations related to the Brazilian marine current. Guerstein and Quattrocchio (1988), Quattrocchio et al. (1988), and Guerstein (1990) studied the paleoclimatic, paleoenvironmental, and eustatic variations through palynological analysis in boreholes from the Bahía Blanca area and offshore.

Echevarría (1988) found similarities between the ostracods of the *Rionegrense* of Playa Bonita with associations of the *Entrerriense* of southwestern Entre Ríos province and Península de Valdés. Malumián et al. (1998) found species of the *Protelphidium tuberculatum* informal zone (Middle–Late Miocene) in the type section of the Barranca Final Formation. Guler et al. (2002) studied the dinoflagellate cysts of the same site and estimated that their lower section was deposited during the Middle–Late Miocene, whereas the upper section would correspond to the Late Miocene. The dinoflagellate associations are characteristic of estuarine environments, with short periods of increased flood and warm-temperate to warm waters.

1.4.1.5 Northeastern Chubut Province

Darwin (1846) was the first one to study the outcrops in this region, which were included in his “Patagonian tertiary formation.” Rovereto (1921) found the *Aonikense*, an equivalent of the *Superpatagoniano*, between the *Patagoniano* and the *Entrerriense*. Frenguelli (1927) assigned a Miocene-Pliocene age to the *Entrerriense-Rionegrense* and considered that the first unit was developed in an open marine environment, whereas the latter recorded a gradual continentalization. Moreover, he described the *Rionegrense continental*, between the *Entrerriense* and the *Rionegrense marino*. Feruglio (1949) considered that the contact between the *Entrerriense* and the *Rionegrense* is transitional, and that the *Aonikense* is actually the bottom of the *Entrerriense*.

Haller (1978) named the *Patagoniano* as CF and the *A-E-R* as Puerto Madryn Formation. Scasso and del Río (1987) maintained this lithostratigraphical division and granted fundamental importance to the action of storms and tidal regimes in the accumulation of the *Entrerriense-Rionegrense* sequence. They considered that the contact between the *Patagoniano* and the *Entrerriense* was a probable surface of no deposition. Sato (1981) mentioned some foraminifera and ostracoda that were characterized by low diversity and poor preservation. del Río (1988, 1990, 1991) reviewed the systematics of the mollusks and proposed tropical to subtropical conditions for the Miocene sea, due to the high affinity with malacofauna of the Caribbean, Panamanian, Carolinian, and the Gulf of Mexico bio-provinces. Scasso et al. (2001) obtained $^{87}Sr/^{86}Sr$ ages between 9 and 11 Ma (Tortonian) for the upper section of the *Entrerriense*.

In 2005, several abstracts were presented at a special meeting on the geology of the Península de Valdés. Among them, several should be mentioned here: Scasso (2005) described sedimentary environment and depositional sequences of the Puerto Madryn Formation, and Palazzesi and Barreda (2005) presented advances on the first study in palynomorphs of the Puerto Madryn Fm. In addition, Casadío et al. (2005a, b), Cione (2005), Cozzuol (2005), del Río (2005), Echevarría and Marengo (2005), Gosztonyi and Riva Rossi (2005), and Tambussi and Acosta Hospitaleche (2005) presented updates or descriptions of various groups of marine fossils. Finally, Dozo et al. (2010) described the first finding of continental vertebrates (fishes, birds, and mammals) in the Puerto Madryn Formation, from the upper part (*Rionegrense* beds) of the Regressive Phase.

1.4.1.6 The Golfo San Jorge Basin

The Cenozoic stratigraphy of this basin is highly controversial. It is generally considered that all levels cropping out from the Atlantic coast to the Pampa del Castillo belong to the *Superpatagoniense-Patagoniense* cycle. There are few scientific quotes about the probable finding of the *Entrerriense*: Frenguelli (1929) mentioned a few meters with *Entrerriense* and *Rionegrense* faunulas in some sections around Comodoro Rivadavia. In turn, Tapia (1929) found near of Pampa del Castillo deposits of both levels characterized by *Ostrea alvarezi* and *O. madryna,* respectively. Legarreta and Uliana (1994) recognized unconformities between the *Juliense*, *Leonense*, *Superpatagoniense*, and *Entrerriense* and its continental counterparts. In contrast, Bellosi and Barreda (1993) refused to accept the existence of *Entrerriense* deposits in the region; in their opinion, subsidence did not take place during the Middle Miocene.

1.4.1.7 Northwestern Argentina and Cuyo Regions

Bertels and Zabert (1980) and Zabert (1984) described a few species of ostracods and benthic foraminifera related to the TEP, from the Valle de Santa María (Tucumán and Catamarca provinces). This microfauna suggests conditions of a very shallow marine environment with salinity over the usual. Bossi and Gavriloff (1998) and Gavriloff et al. (1998) synthesized the knowledge on the stratigraphy and paleontology of the Late Miocene deposits of the Valle de Santa María and nearby regions. They described more diverse associations of foraminifera and ostracods.

Russo and Serraiotto (1984) founded foraminifera and other marine fossils in the Anta Formation; however, they could not recognize the faunal composition and tentatively correlated it with the Paraná Formation. Cione et al. (1995) described a freshwater fish fauna from the base of the Anta Formation and assumed it was deposited during the end of the *Paranense*, during the Tortonian (10–11 Ma). Ramos and Alonso (1995) discussed a letter sent by F. Ameghino to H. von Ihering in 1909, in which they mentioned the discovery of Patagonian marine mollusks on the banks of the Río Grande de Jujuy. On the basis of this letter, Ramos and Alonso estimated the likelihood that the *Paranense* sea had flooded eastern Jujuy province. Alonso (2000) considered that the Quechua tectonic front during the Miocene was an effective barrier which isolated the Puna region during the marine ingression, and attributed the formation of the marine engulfments in the region to major tectonic subsidence as a result of the Quechua Phase. Pérez and Ramos (1996) reported microforaminifera from the Chinches Formation (Cordillera Frontal of San Juan province) at 3,100 m a.s.l. They correlated these deposits with the *Paranense* and assigned an age of 15 Ma (Middle Miocene) by the fission track dating of tuffs. They also correlated these deposits with various similar sites of the Andes in Mendoza, southern San Juan, and northern Neuquén provinces. No unambiguously marine facies or isotopic signatures were recently recognized in the Saguión (Salinas Grande, Córdoba), Anta, Del Buey and Del Abra (Famatina Ranges, La Rioja), and Chinches Formations (Ruskin et al. 2011).

1.4.2 The Laguna Paiva Transgression

The information herein presented is restricted to the marine ingression occurred during the Early Miocene in the Chacoparanense and Salado basins. This same transgression is known in Patagonia as the *Patagoniense*, among other informal names, and has been widely studied in the Colorado Basin and along the Patagonian coast. Several authors performed very complete reviews, among which Bellosi and Barreda (1993) and Legarreta and Uliana (1994) should be mentioned. The first mention of sea levels older than the TEP in the Chacoparanense and Salado basins was made by Stappenbeck (1926), who described one or more marine levels in boreholes from Santa Fe (Laguna Paiva), Córdoba (Seeber, Ordonez, Guardia Vieja, Justiniano Posse, and Cotagaita), Buenos Aires (Villa Sauze and Pehuajó), and La Pampa (Meridiano Quinto) provinces (Fig. 1.2). These deposits are located below the TEP by approximately 100–300 m from the "brown clay" (Olivos and Chaco formations). Stappenbeck defined the *capas de Paiva* as one or a series of green clay layers interbedded with brown clay and gypsum, and tentatively correlated with the *formación patagónica miocena*. He located the type section between 547.50 and 601.65 mb.g.s.in the Laguna Paiva borehole.

In the 1960s, research on the Chacoparanense Basin stratigraphy resumed as a result of the reactivation of the prospective activity by YPF. Padula and Mingramm (1963) mentioned, without a formal definition, the Mariano Boedo formation in the subsurface of the Formosa province, between 508 and 600 mb.g.s. of the YPF Mariano Boedo 1 borehole. This unit consists of a basal conglomerate with boulders of basalt, whitish pink calcarenites with interbedded shales in the lower and middle sections, and pink and red shales and marls in the upper part. Subsequently, Padula and Mingramm (1968) mentioned the Mariano Boedo formation in several boreholes in Santiago del Estero, Córdoba, Santa Fe, and Entre Ríos provinces, although with marked lithological variations with respect to the type section. They assigned this unit to the Late Cretaceous-Paleocene, based on regional stratigraphic relationships, and considered it to be discordant over the Early Cretaceous deposits (San Cristóbal Formation, Alhuampa Gr., Tacuarembó Formation or the basalts of Serra Geral). Finally, they correlated this unit with the Asencio and Mercedes Formations (Uruguay) and the Bauru Formation (Brazil). As a consequence, many authors published comments on the Mariano Boedo formation, although usually without new information. Yrigoyen (1969) considered that the Danian Sea was continuous with the Maastrichtian transgression, and "let shallow-water deposits, in partly of paralic and semiparalic environments, distributed from Tierra del Fuego up to engage with homologue deposits that enter again in Argentina from Peru through southern Bolivia."

Yrigoyen (1975) correlated the Mariano Boedo formation with the Las Chilcas Formation and *capas de Laguna Paiva*. Bracaccini (1972) correlated the *capas de Laguna Paiva* to "the Senonian of General Belgrano," the Mariano Boedo formation, and with some levels found in a borehole in Conesa (San Nicolás, Buenos Aires province) and considered that "it was in fact the lower part of the Tertiary." Zambrano (1974) considered that the deposits of the Salado, Rosario, Laboulaye, and Paraná basins began to coalesce to each other during the Late Cretaceous. When the subsidence was increased, sometime about the Maastrichtian-Paleocene boundary, it forced the development of very extensive continental and marine deposits (Mariano Boedo, Las Chilcas, and Paraná Formations), which overlapped extensively the earlier deposits. Russo et al. (1979) linked the Mariano Boedo formation with the *estratos de Laguna Paiva*, the top of the Salta Group, the Maastrichtian-Paleocene of the Salado Basin, the Abramo Formation of the Macachín Basin, the Roca Formation of eastern La Pampa province, the Caiuá and Baurú Formations of the Santa Catarina Basin (southeastern Brazil), and the Mercedes, Guichón, and Asencio Formations of Uruguay. They considered that the Mariano Boedo formation "is of Upper Cretaceous-Paleocene age, not because of the finding of defining paleontological evidence, but by the relationship it has with the Tacuarembó Formation The red sandstones, with quartz grains stained by iron oxide, indicate continental deposits in oxidizing environments. The sandy limestones and calcareous sandstones suggest nearshore marine deposits."

Uliana and Biddle (1988) reconstructed the paleogeography of southern South America during the Late Cretaceous (ca. 70 Ma). They postulated a marine ingression that linked the Salado Basin with northwestern Argentina (NOA) and southern Bolivia, through a thin marine branch that would have crossed the Chacoparanense Basin from south to north. Chebli et al. (1989) correlated the Mariano Boedo formation with some outcrops of eastern Entre Ríos and Corrientes provinces, and some places of Uruguay with Senonian vertebrate faunas. Moreover, Pezzi and Mozetic (1989) considered that the Mariano Boedo formation was deposited in paraconformity with the Early Cretaceous, and with much greater areal development. They proposed a continental origin and a marked lithological and tecto-sedimentary link to the Early Cretaceous, so it would be older than the Maastrichtian. Finally, Spaletti et al. (1999) proposed that the deposition of the Mariano Boedo formation would have started in the Campanian-Maastrichtian (ca. 75 Ma) and would be characterized by fluvial-lacustrine facies. The Late Cretaceous marine transgression would have been limited far to the South (the Salado and Punta del Este basins), and would have taken place during the Campanian-Maastrichtian, represented by the Las Chilcas Formation. Closer to Stappenbeck's opinions, Bracaccini (1980) proposed to give formational rank to the *capas de Paiva* (but unfortunately he did not), and hereinafter he eliminated the use of Mariano Boedo formation in the Chaco-pampean Plain. He considered that the Paiva formation was deposited mainly in marine environments and mentioned the first fossils (foraminifera) undoubtedly associated with marine sedimentation, but he did not specify the age or the taxonomic composition of the fauna.

1.4.3 Miocene Transgressions in South America

Sprechmann (1978) described marine fossils of the TEP in the Chuy 364 borehole, in the southern portion of the Pelotas Basin, northeastern Uruguay. He found very diverse foraminifera, ostracods, mollusks, bryozoans, and fishes, broadly assigned to the Miocene. These faunas have significant affinities with the TEP, except for the record of a high percentage of *Amphistegina gibbosa*, foraminifera of warmer waters currently unknown in the TEP of Argentina. Based on the finding of *A. gibbosa*, Sprechmann concluded that during the Miocene, the marine current of northern Brazil reached the shores of northeastern Uruguay.

Sempere et al. (1990) correlated the Petaca and Yecua Formations (southern Bolivia) with the *bancos de Salla*, dated as Late Oligocene-Early Miocene by magnetostratigraphy and radiometry. In turn, Marshall et al. (1993) found *Ammonia beccarii*, *Cyprideis* sp., *Bythociprys* sp., *Balanus* sp., mollusks, and decapods in the Yecua Formation. This association is typical from a very restricted marine to lacustrine environment; it was correlated with the *Paranense* and the Chasicoense mammal age (11–9 Ma) based on field relationships with continental deposits bearing vertebrate faunas. The Yecua Formation has a thickness of up to 300 m; it mainly consists of green to black marl and subordinate calcareous sandstones. Welsink et al. (1995), Sempere (1995), and Dunn et al. (1995) located the Yecua Formation in 20–21 Ma, and Baby et al. (1995) considered it was deposited between 11 and 7.5 Ma, although in neither case was new direct evidence on these ages provided. Wiens (1995) found thin levels of Middle Miocene marine sediments, interbedded within the Chaco Formation in the subsurface of center and western Paraguay. Räsänen et al. (1995) described sedimentary deposits with tidal structures in the Solimoes Formation, Amazonian foreland basin; they related these Late Miocene sediments with the "The Arm of the Tethys," and they considered the *Paranaense* or Pebasian as an inland sea surrounded by tidal flats that enabled the start of the initial phases of the Great American Biotic Interchange. Furthermore, Webb (1995) explained the huge diversity of native species in freshwater and terrestrial biota of the Amazon basin, from the evolution of marine species and the generation of continental environments separated by geographical barriers, after the flooding of the region by the sea during the Middle or Late Miocene.

In recent years, several groups have been working on the Miocene paleogeography of South America, mainly in relation to the *Paranense* and Pebasian transgressions. Although there is still far from agreement about the age of the marine deposits in the Chacoparanense and Amazon regions, it is possible that if there was ever a marine connection between both, it would be represented by the deposits of the Yecua Formation of central Bolivia. A significant faunal difference has been observed between the *Paranense* and Pebasian deposits. The available dating, yet unreliable, indicates that marine deposits within the Pebasian sequence are somewhat younger than the *Paranense*. The latest developments on the sedimentological and paleontological knowledge on the Yecua Formation and related units in central and southern Bolivia can be found in Hernández et al. (2005), Hulka et al. (2006), and Roddaz et al. (2006), among others, whereas Lovejoy et al. (2006), Muñoz-Torres et al. (2006), Rebata et al. (2006), Wesselingh and Macsotay (2006), and Westaway (2006) provided updated results on the study of ostracods, fishes, and sedimentary facies in the Amazon region.

DeVries (1998) described a depositional sequence of 15–11 Ma in the Pisco Formation of southcentral Peru, characterized by *Turritella infracarinata*. DeVries considered that the Cenozoic transgressions of the Peruvian coast were the result of global eustatic changes with local tectonic influences. According to N. Malumián (personal communication 2005), the Pisco Formation has the same age as the TEP, whereas the Cumana Formation is equivalent to the TLP, due to the finding of *Transversigerina transversa*. In the region of Barranquilla, in the Caribbean coast of Colombia, the Tubara strata have a rich fauna of mollusks and microfossils of open warm water and medium depth, similar to other Miocene faunas of the Caribbean Sea or the North Pacific Ocean. The foraminifera of the Tubara marine strata were divided into Zone I (Middle Miocene) and Zone II (Late Miocene; Redmond 1953). Macellari (1995) described several marine formations of the Late Oligocene–Early Miocene in the southwestern Caribbean basins of Colombia and

Venezuela. These marine units correspond to the C1 (Late Oligocene) and C2 (Early Miocene) subcycles, and they lie unconformably on Jurassic-Late Eocene rocks. In some basins, there is an unconformity between the sediments of the Late Oligocene and the Early Miocene. The C2 subcycle was characterized by the intercalation of continental and marine facies, whereas the C1 is predominantly of marine nature. The overlying B cycle was deposited on an unconformity usually restricted to the end of the Early Miocene, but in some places it reaches the median portion of the Middle Miocene. This cycle culminates at the end of the Miocene, and it is characterized by interbedded marine and continental sediments.

In the Lake Maracaibo and the Barinas-Apure basins in western Venezuela, two super sequences dominated by marine sedimentation were described: the Super Sequences E (Late Eocene–Early Miocene) and F (Middle Miocene-Pleistocene)—both of them deposited in a context of collision during the rising of the Mérida Ranges (Parnaud et al. 1995). The T5 sequence (Late Oligocene–Early Miocene) reached a large extension in the region, widely overlapping the deposits of the Late Eocene–Early Oligocene, due to a major marine transgression. During the deposition of the Super Sequence E, the marine environment retreated northward but remained more or less continuous in the region of Lake Maracaibo, where a new transgressive pulse took place during the Middle Miocene.

1.4.4 State of the Art

1.4.4.1 Paleoenvironments

There is little information about the sedimentary environments of the TEP. These studies were done on outcropping sections, and it is usually agreed that they were generated in very shallow marine environments, from estuaries and tidal flats with storm influence in Patagonia (Scasso and del Río 1987; del Río et al. 2001) or very marginal environments with marked continentalization in Mesopotamia, the Santa María Valley, and the Andes of San Juan and Mendoza (Aceñolaza 1976; Bossi and Gavriloff 1998; Pérez and Ramos 1996; Ruskin et al. 2011). Where the TEP is exclusively at the subsurface, the paleoenvironmental information is restricted to few groups of fossils. In the Salado and Colorado Basins (Malumián 1970; Boltovskoy 1980), the sections with greater diversity of microfossils suggest the development of inner shelf environments during the periods of maximum flooding, within an overall context of shallow to very shallow environments dominated by the informal zone of *P. tuberculatum*. In the Chacoparanense Basin, the microfaunal associations are typical of shallow to very shallow brackish environments (Herbst and Zabert 1987; Marengo 2000).

The information on deposits related to the TLP has been reduced to a discussion of whether they were mainly marine (Stappenbeck 1926; Yrigoyen 1969, 1975; Bracaccini 1980), mainly continental (Spalletti et al. 1999; Pezzi and Mozetic 1989), or mixed (Zambrano 1974; Russo et al. 1979).

1.4.4.2 Paleoclimates

For the TEP, the interpretations depend on which group of fossils are being considered; in some cases, the results were very different. The taxonomic composition of the faunas of mollusks and foraminifera are fairly uniform from southwestern Entre Ríos province to the center of coastal Chubut province. However, although the mollusks indicate mostly warm waters (del Río 1988, 1990, 1991; Martínez and del Río 2002), the foraminiferal associations suggest very similar temperatures to the current platform for Argentina (Malumián 1972; Zabert and Herbst 1977; Becker and Bertels 1978; Boltovskoy 1980; Marengo 2000), and only tropical to subtropical taxa were identified in high proportions in northeastern Uruguay (Sprechmann 1978). The distribution of *Cupuladria canariensis* (Busk) in the TEP is remarkable because it is a bryozoan currently restricted to warm waters. *C. canariensis* is common in the Salado Basin but has not been found in southern regions (Malumián 1999), although Casadío et al. (2005b) reported the warm-water bryozoans *Cupuladria* cf. *biporosa* Canu and Bassler and *Discoporella* n. sp. aff. *depressa* (Conrad) in outcrops near Puerto Pirámide. Studies on the palynomorphs of the TEP were made in the subsurface of the Colorado Basin and indicated a marked seasonality and much drier climates than in the Early Miocene (Quattrocchio et al. 1988). The continental vertebrates in Mesopotamia were typical of tropical to subtropical conditions (Gasparini 1968; Pascual and Odreman Rivas 1971; Gasparini and Báez 1975; Cione 1978), whereas in Patagonia these faunas dominated during the Early Miocene (Pascual and Odreman Rivas 1971; Tauber 1997). In the Middle Miocene a marked shrinkage was observed, with an increase in the proportion of more temperate faunas (Pascual and Odreman Rivas 1971).

No prior information on the paleoclimate of the TLP is available; however, many studies conducted in deposits of the same age in the Patagonia and the Colorado Basin indicated generally warm-temperate waters in the coastal marine environment and humid warm-temperate climates in the continent (Quattrocchio et al. 1988; Tauber 1997; Barreda and Palamarczuk 2000). However, the influence of Antarctic waters would have produced a pronounced decrease of the temperature in the outer shelf (Malumián 1999).

1.4.4.3 Calcareous Microfossils

The micropaleontological characteristics of the TEP are fairly homogeneous in almost all basins. Generally, the foraminifera belong to the informal zone of *P. tuberculatum* (Malumián 1970), which is characterized by hyaline shallow water benthic foraminifera, with few miliolids and agglutinated taxa. The informal zone of *P. tuberculatum* was founded in the Camacho Formation (western Uruguay), the Paraná Formation (Chacoparanense Basin), the Puerto Madryn Formation (northern coast of Chubut), the Barranca Final and Gran Bajo del Gualicho Formations (northeastern Río Negro province), and the TEP of the Colorado and Salado Basins. In some sites, some variations were recognized with respect to the typical composition of the informal zone of *P. tuberculatum*. In some levels of the Salado and Colorado Basins, the microfaunas have greater diversity and comprise some planktonic species; therefore, they are characteristic of deeper water, possibly related to periods of maximum flooding. In the Chuy 364 borehole (Pelotas Basin), the abundance of *Amphistegina gibbosa*, a warm-water benthic foraminifera, is remarkable; it was previously unrecognized in another region of the TEP. In southern Bolivia, the NOA, and many levels of the Chacoparanense Basin, there is a marked impoverishment of the microfaunas due to the progressive continentalization and the consequent increase of brackish environments, with a sharp dominance of *Ammonia parkinsoniana*.

The sea was usually very shallow, except during maximum flood in areas closest to the Atlantic coast; consequently, the planktonic foraminifera are very rare. The planktonic foraminifera are only suitable as markers in the Colorado Basin (Malumián 1970, 1972), which indicated a Middle Miocene age. Other estimations on the age of the TEP based on foraminifera are not very reliable. The ostracods have yet not been thoroughly studied, except perhaps in southwestern Entre Ríos province (Rossi de García 1966, 1969a; Zabert and Herbst 1977), and to a lesser extent in the Colorado and Salado Basins (Malumián 1970) and the Chacoparanense Basin (Zabert 1978; Bertels and Zabert 1980; Zabert and Barbano 1984). Even though all available data have not been compared, these ostracod faunas would be very homogeneous and indicate the same environmental conditions as the foraminifera. To date, calcareous nannofossils were not recognized at any level associated with the TEP, except for those described by Marengo and Concheyro (2001). With regard to the TLP, there is no prior information on microfossils and megafossils.

1.4.4.4 Lithology

The characteristic lithology of the TEP is olive-green massive mudstones, with or without megafauna. Light-gray and light-yellow to pale-olive sandstones and clayey sandstones with or without megafauna are also common, mainly in northeastern Chubut and southwestern Entre Ríos provinces. In some localities, fossiliferous limestones and conglomerates were found. The TLP is characterized by alternating beds of olive-green shales, with very few fragments of oysters, and very friable light to dark reddish-brown mudstones and pelitic sandstones, with abundant crystals and aggregates of gypsum and few calcareous concretions. In some places, calcarenites and oolitic sandstones were found.

1.4.4.5 Stratigraphy and Age

The deposits related to the TEP received various names, depending on the region: *Entrerriense* or Puerto Madryn Formation in northeastern Chubut; the Gran Bajo del Gualicho Formation in northeastern Río Negro province; *Entrerriense* or Barranca Final Formation in the Colorado Basin; Macachín Formation (Salso 1966) in the

Macachín Basin; Saguión Formation (Bertolino et al. 2002) in northern Pampeanas Ranges; *Entrerriense*, *Paranense,* or Paraná Formation in the Salado Basin, southwestern Entre Ríos province, the Chacoparanense Basin, some outcrops of the NOA, Andes of Mendoza and San Juan provinces, and southern Bolivia; and *Entrerriense* or Camacho Formation in western Uruguay. The age ranges primarily from the Miocene in general to the Early Pleistocene, with greater agreement in the Middle–Late Miocene. The deposits of the TEP rely apparently conformably over the continental deposits of the Chaco, Fray Bentos and Olivos Formations in the Chacoparanense and Salado basins, over the Elvira (Oligocene–Early Miocene, marine) and Ombucta (continental) Formations in the Colorado Basin, and discordantly over the Catalina or Gaiman Formations or the *Patagoniense* in northeastern Chubut. They are covered by continental sediments of the Puelches Formation and equivalent units in the Chaco-pampean Plains, and by the *Rionegrense continental* in the Patagonian coast.

The deposits of the TLP are known by the names of *estratos de Paiva*, *capas de Paiva*, formación Paiva, Mariano Boedo formation, or have been included within the Chaco Formation. The relationship of the TLP with Las Chilcas Formation (Salado Basin) is unknown, as well also with some sections outcropping in the NOA included in the Anta Formation. The age of the TLP has been determined on the basis of regional stratigraphic relationships, in any case by paleontological studies, and has been assigned by various authors to the Miocene, Oligocene, Maastrichtian-Paleocene, Late Cretaceous, and even the Early Cretaceous. The basal contacts of the TLP are not well known, although it is supposed that they are usually unconformably lying over rocks of the Early Cretaceous (San Cristóbal and Tacuarembó Formations and Serra Geral basalts). The top is concordant with the Fray Bentos, Chaco, and Olivos Formations. Finally, the continental deposits associated with both the TEP and TLP have received little attention and in general were mainly dated through dubious correlations. Due to their wide geographical and stratigraphical distribution, they received several names and were generally poorly described. As a result, only the Fray Bentos Formation has been acceptably defined in Uruguay, although it is not part of the Chacoparanense Basin *s.s.* The rest of the units remain informal, as the Chaco and Olivos formations, the continental deposits of the Mariano Boedo formation, or those sedimentary levels known simply as *arcillas pardas*, *formación Terciaria arcilla parda*, or *Mioceno rojo*.

1.4.4.6 The Arm of Tethys

In 1927, Hermann von Ihering postulated the hypothesis on the migration of marine mollusks from the Caribbean to the Río de la Plata region, through an intracontinental seaway called "The Arm of Tethys," which would have developed in the Andean foreland basins in times of the TEP. Since then, many authors have adhered to this idea and correlated outcrops of possible marine sediments with the TEP in the continental interior of South America. It should be noted that most of these "correlations" were based on the apparently marine character of possibly Neogene sediments or on the discovery of few fossils with doubtful stratigraphical value.

The latter is the case for *Ammonia parkinsoniana*, a benthic foraminifer that is tolerant to broad environmental changes and is very common worldwide throughout the Neogene. Thus, each finding of this species was useful to assign the bearing sediments to the TEP, reinforcing the hypothesis of "The Arm of Tethys." On the other hand, in the continental interior, the abundant and diverse fauna of mollusks mentioned by von Ihering was never found, beyond southern Entre Ríos and Santa Fe provinces. The associations found in the NOA and Bolivia are restricted to generally extremely poor faunas, indicating very shallow and very hyposaline waters. The quotes that related the outcrops of the NOA, Cuyo, Bolivia, and the southern Amazon Basin with the TEP were summarized in Sects. 1.4.1.7 and 1.4.3. A few articles presented alternative correlations, among which Sempere et al. (1990), Sempere (1995), and Dunn et al. (1995) should be mentioned; they assigned the Yecua Formation to the Late Oligocene–Early Miocene, based on correlations with nearby profiles dated by radiometric methods.

Chapter 2
Results and Discussion

2.1 The Chacoparanense and Salado Basins

2.1.1 The Laguna Paiva Transgression

2.1.1.1 Distribution

The TLP (Figs. 2.1, 2.2, and 2.3) has a geographical distribution that is similar to but slightly larger than the TEP (Figs. 2.4, 2.5, and 2.6). As shown in the stratigraphic sections (Figs. 1.2 and 2.7, 2.8 and 2.9), the TLP was deposited over rocks of very different ages. They are lying directly over the Precambrian basement rocks (La Maruja), Las Breñas Formation (Silurian, YPF Pirané $x-1$), the Sachayoj Formation (Carboniferous-Permian, Caburé 1), the Early Cretaceous basalts of the Serra Geral Formation (Laguna Paiva 1), or the Palermo Member of the Chaco Formation (Sect. 2.1.4.2). This suggests that almost the entire region of the Chacoparanense Basin was a highland from the Early Cretaceous to the Oligocene, at the end of which would have started a period of subsidence, the beginning of large-scale continental deposition, and the ingression of the TLP (Figs. 2.1, 2.10, and 2.11).

2.1.1.2 Microfossils and Paleoenvironments

Foraminifera, ostracods, and calcareous nannoplankton were found in the deposits known as *capas de Paiva* (Stappenbeck 1926) or Mariano Boedo formation (Padula and Mingramm 1963) in several locations in the provinces of Formosa, Santa Fe, Santiago del Estero, Córdoba, and Buenos Aires. These findings confirm the mainly marine nature of these sediments. This is the first finding of foraminifera and ostracods of the TLP in the Chacoparanense Basin and of foraminifera, ostracods and calcareous nannoplankton of the TLP in the Salado Basin. The foraminifera of

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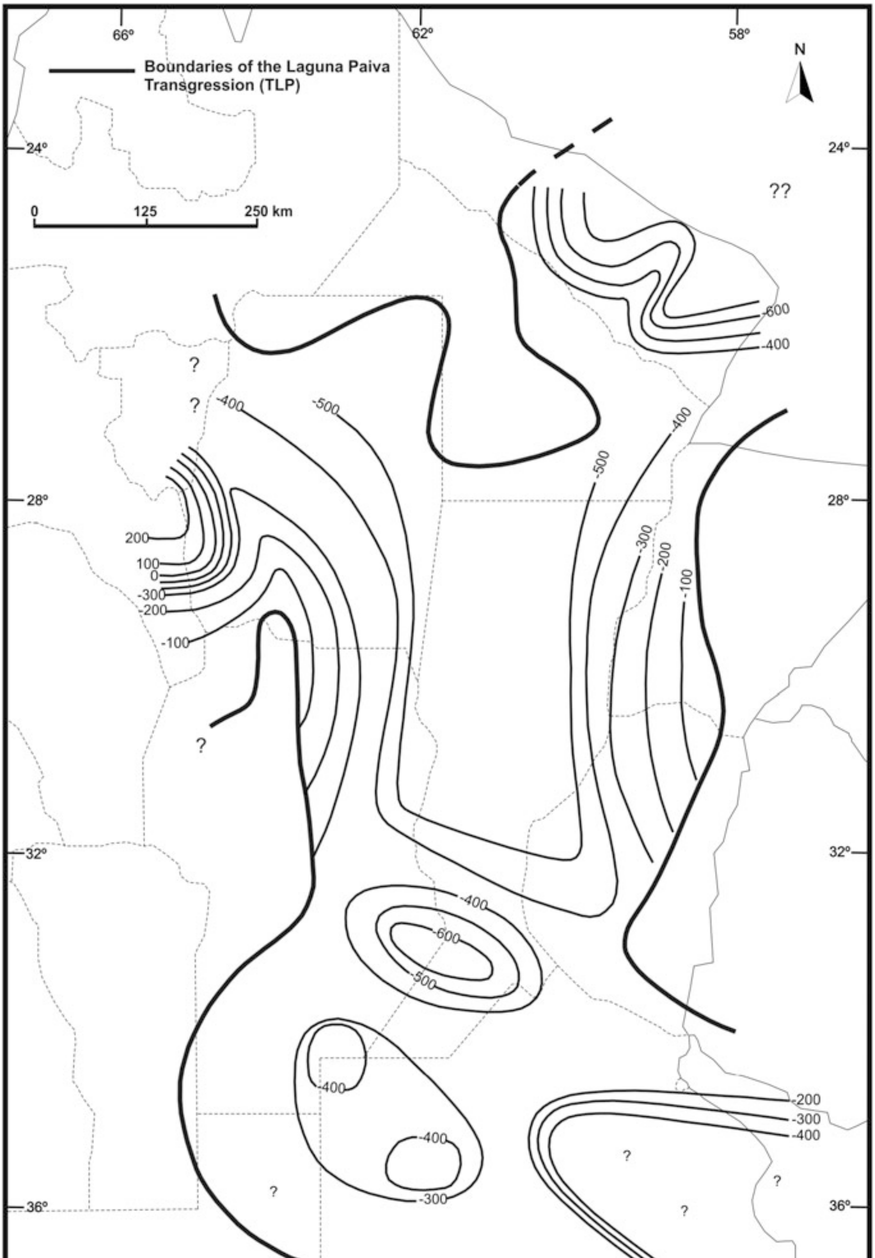

Fig. 2.1 TLP structural base in the Chacoparanense and Salado Basins

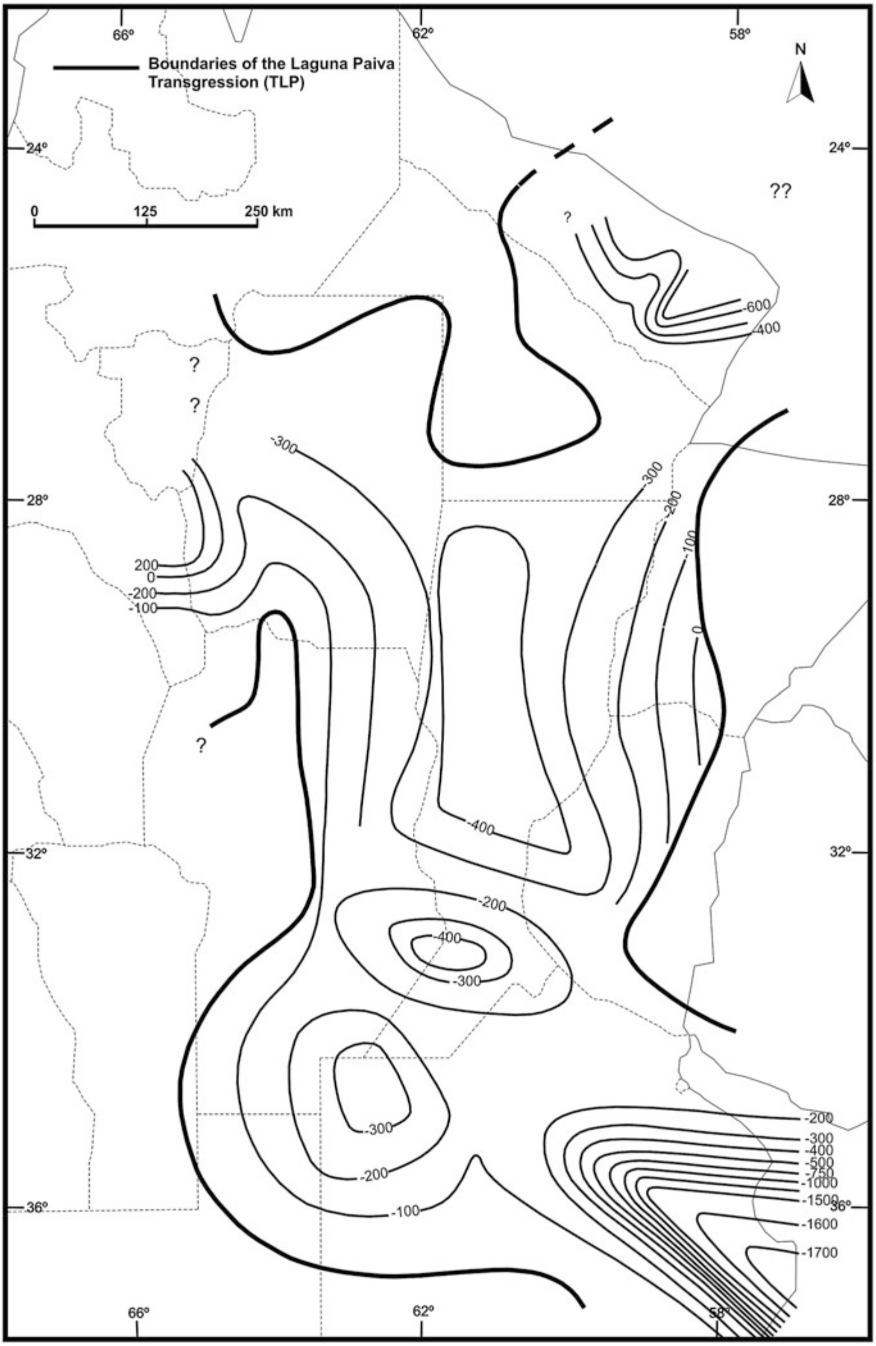

Fig. 2.2 TLP structural top in the Chacoparanense and Salado Basins

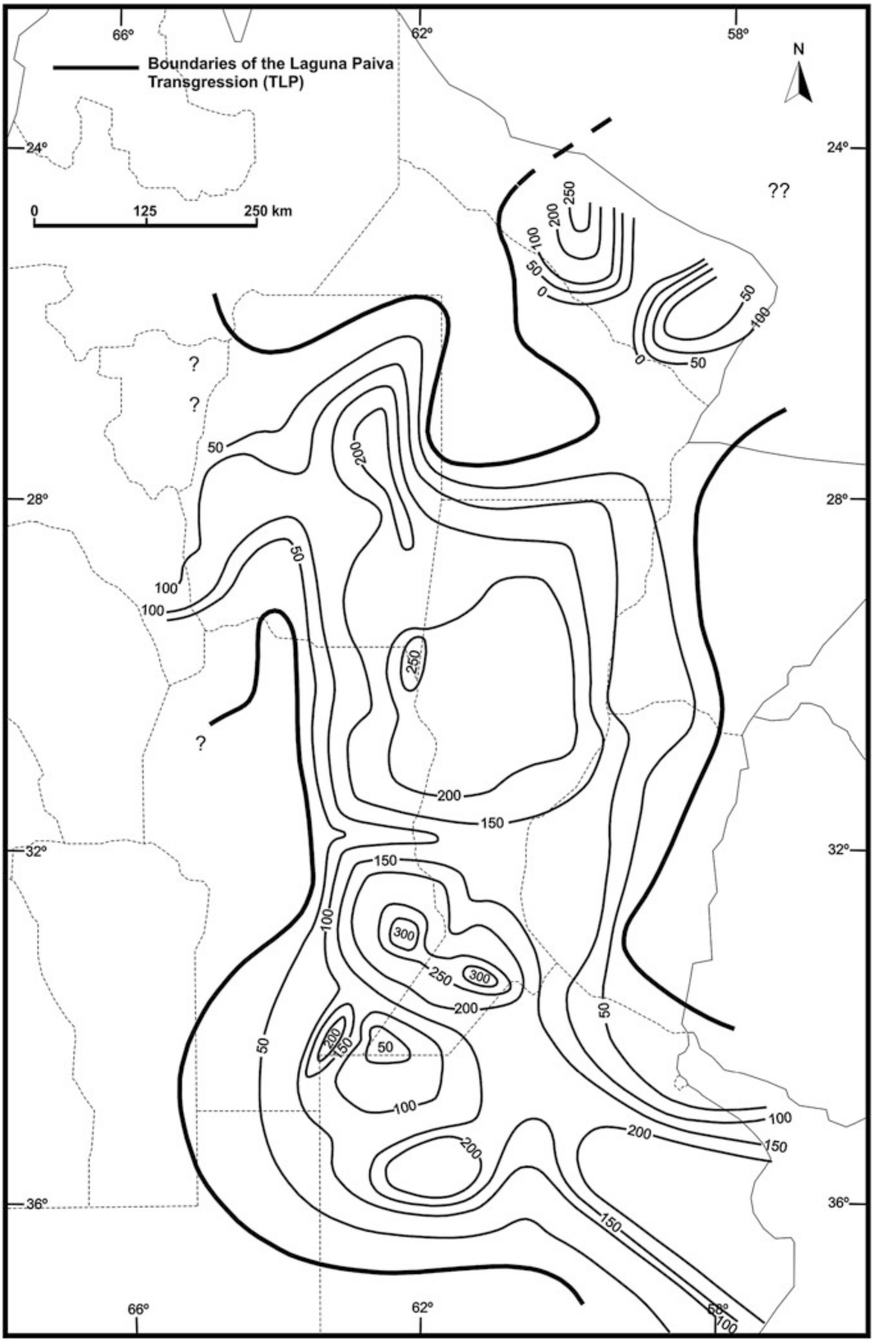

Fig. 2.3 Isopach map of the Laguna Paiva Formation in the Chacoparanense and Salado basins

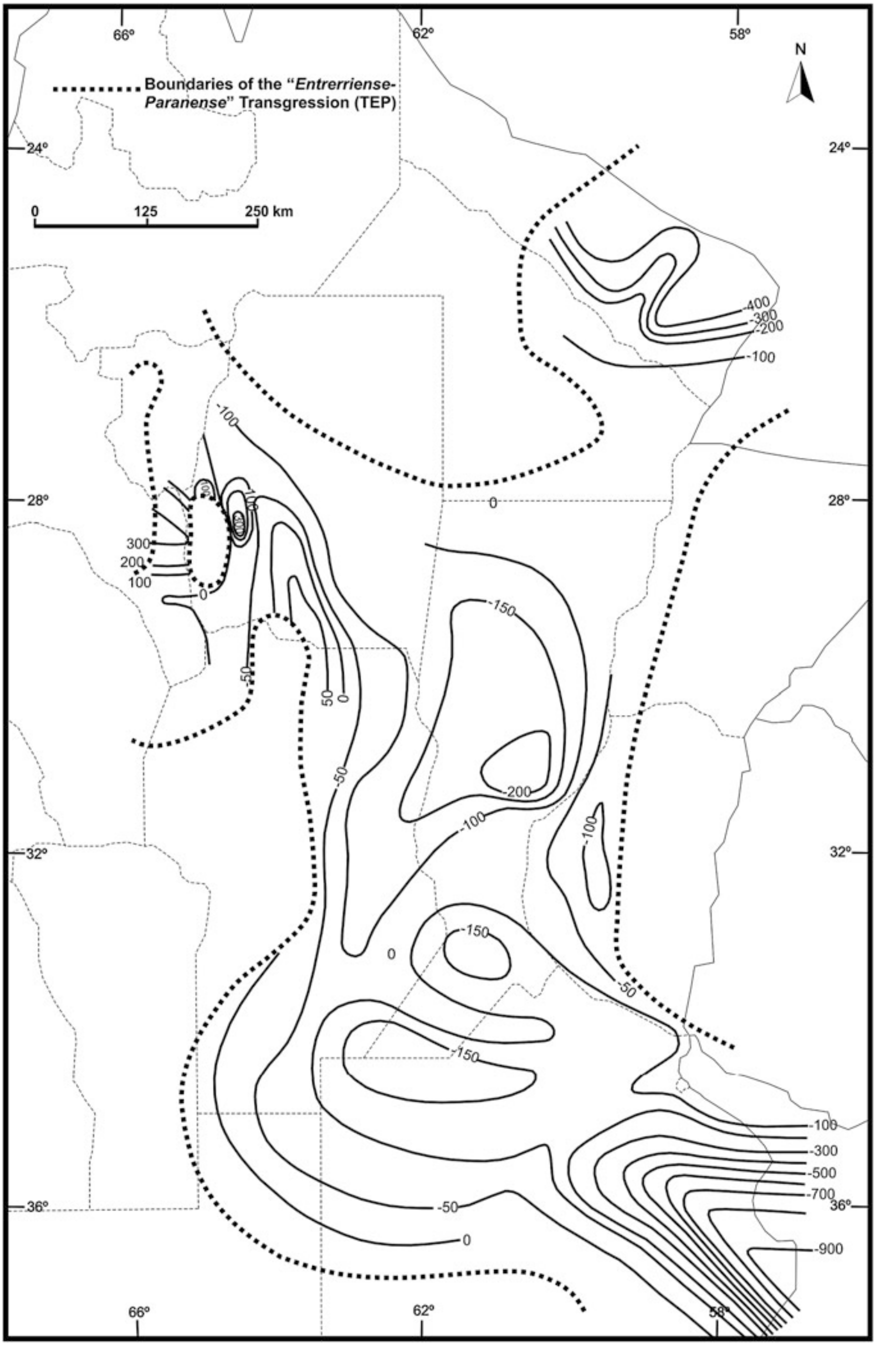

Fig. 2.4 TEP structural base in the Chacoparanense and Salado basins

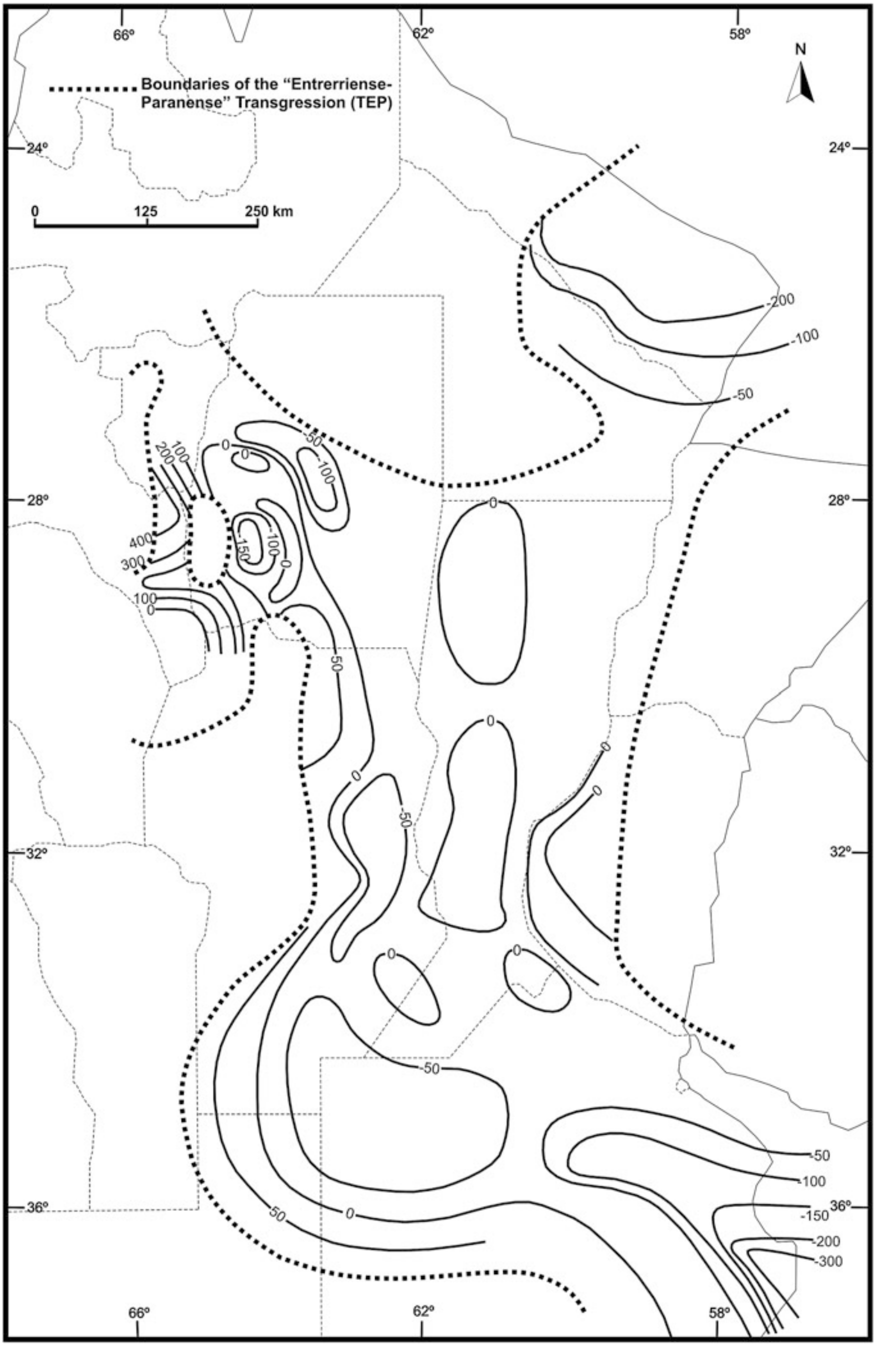

Fig. 2.5 TEP structural top in the Chacoparanense and Salado basins

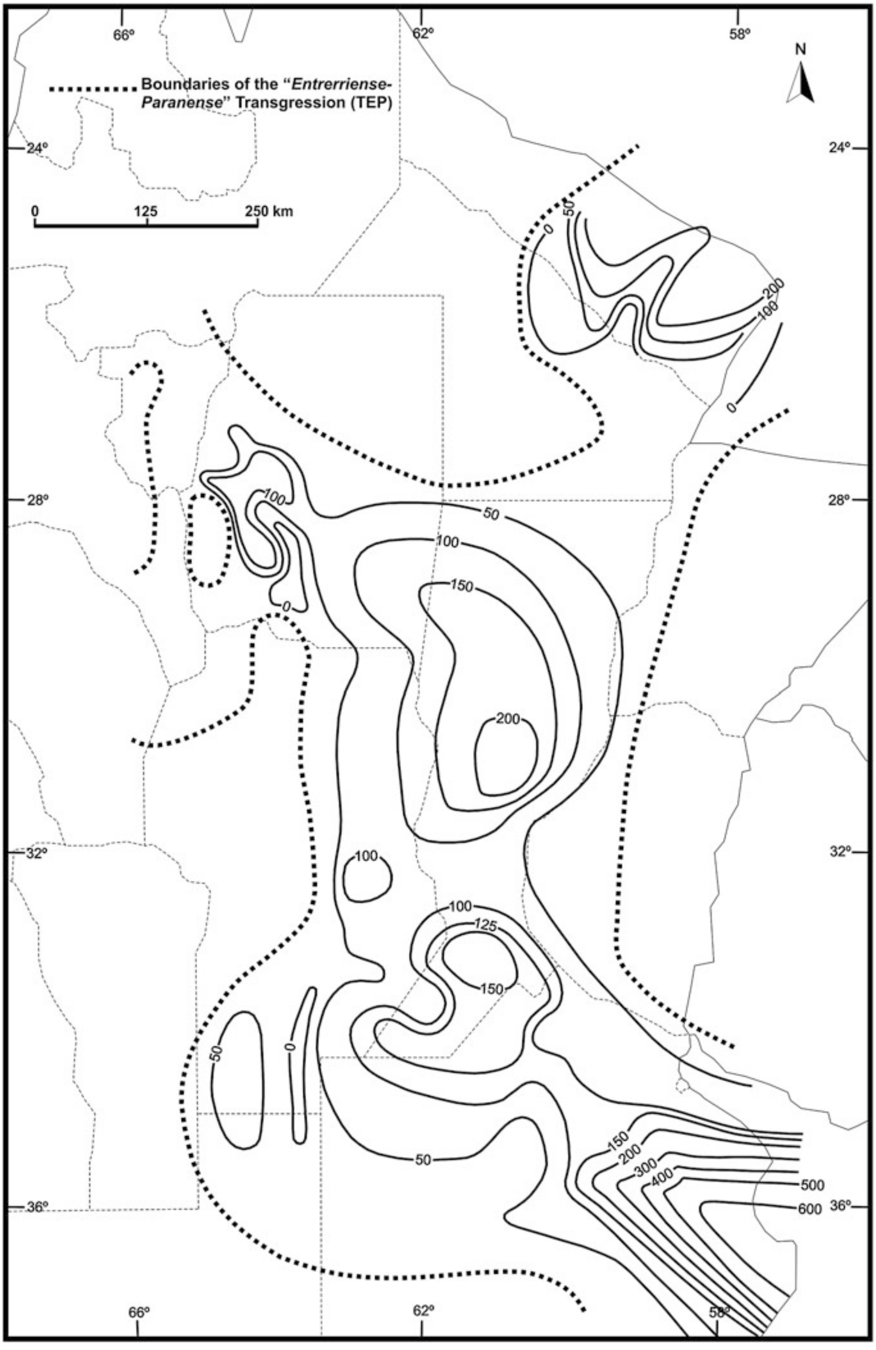

Fig. 2.6 Isopach map of the Paraná Formation in the Chacoparanense and Salado basins

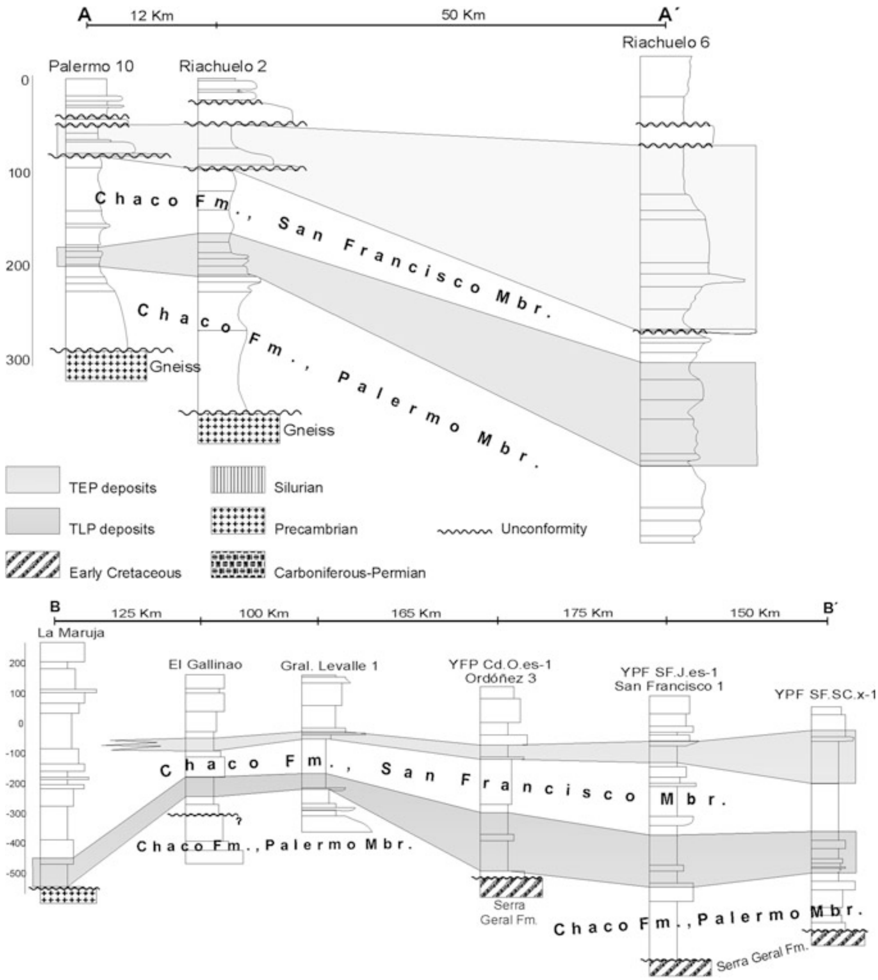

Fig. 2.7 AA′ and BB′ stratigraphic sections according to Fig. 1.2

the Chacoparanense Basin form very poor associations, usually dominated by *A. parkinsoniana*, two or three possibly new taxa of benthic foraminifera related to *Nonion* or *Haynesina*, few specimens of *Cribroelphidium*, nodosariaceans, *Quinqueloculina,* and *Peneroplis*. The preservation is moderate to poor, with frequent recrystallization and dissolution of the shells of foraminifera and ostracods. In Pozo del Tigre 1, there is strong oolitization and pyritization of the ostracods. In the boreholes around the city of Buenos Aires, the microfaunas are characterized by the abundance of large and strongly ornamented miliolids, *Cribroelphidium* spp., *Elphidium* sp. cf. *E. lens*, *B. peruviana campsi*, and large ostracods, which are all moderately preserved with frequent abrasion and recrystallization.

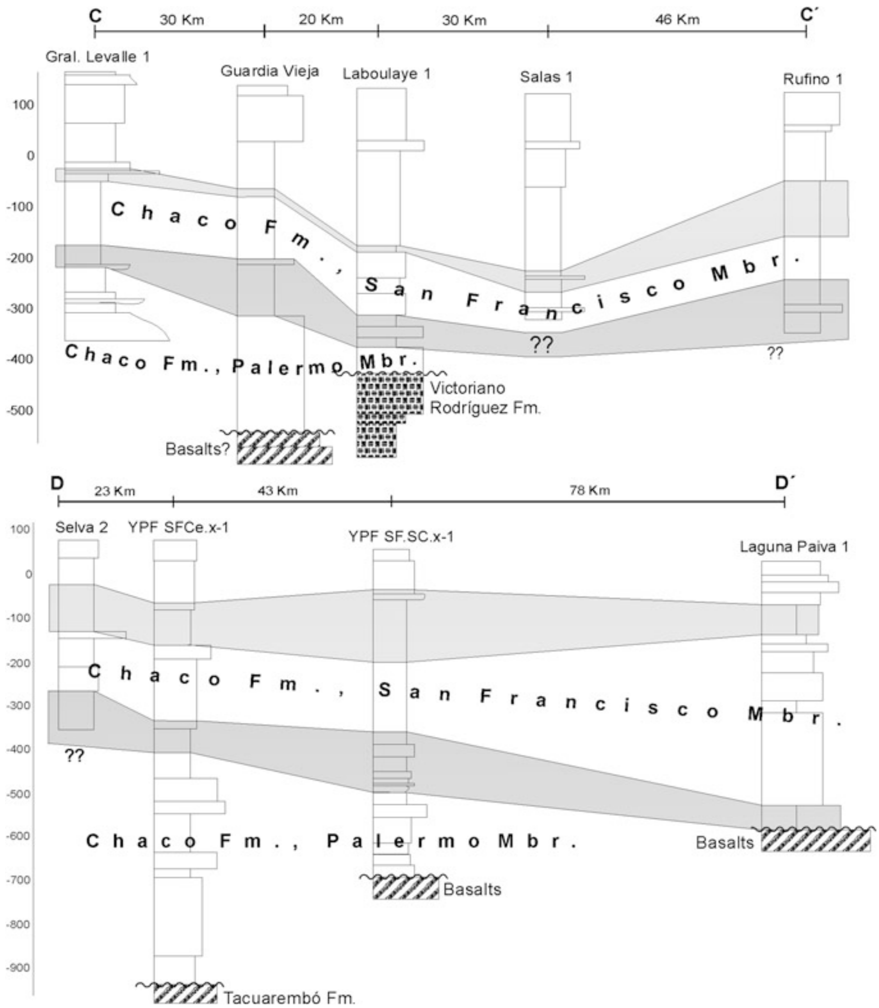

Fig. 2.8 CC′ and DD′ stratigraphic sections according to Fig. 1.2

Despite the poverty of the microfaunas, some useful elements were found to define the paleoclimatic conditions of the TLP. For instance, the Genus *Peneroplis* (San Francisco 3, Ordóñez 1) restricts the water temperature to tropical climates (Murray 1991), which is consistent with the abundance of oolites in some horizons of the boreholes in Pozo del Tigre and San Francisco localities. The remaining paleoenvironmental and paleogeographical conditions of the TLP are very similar to those previously known for the TEP, such as the dominance of *Ammonia* and *Nonion* or *Haynesina*, which have similar environmental requirements to *Protelphidium*, and the conspicuous lack of miliolids, which are appropriate indicators of very shallow water and low salinity. The abundance of pyrite in some horizons

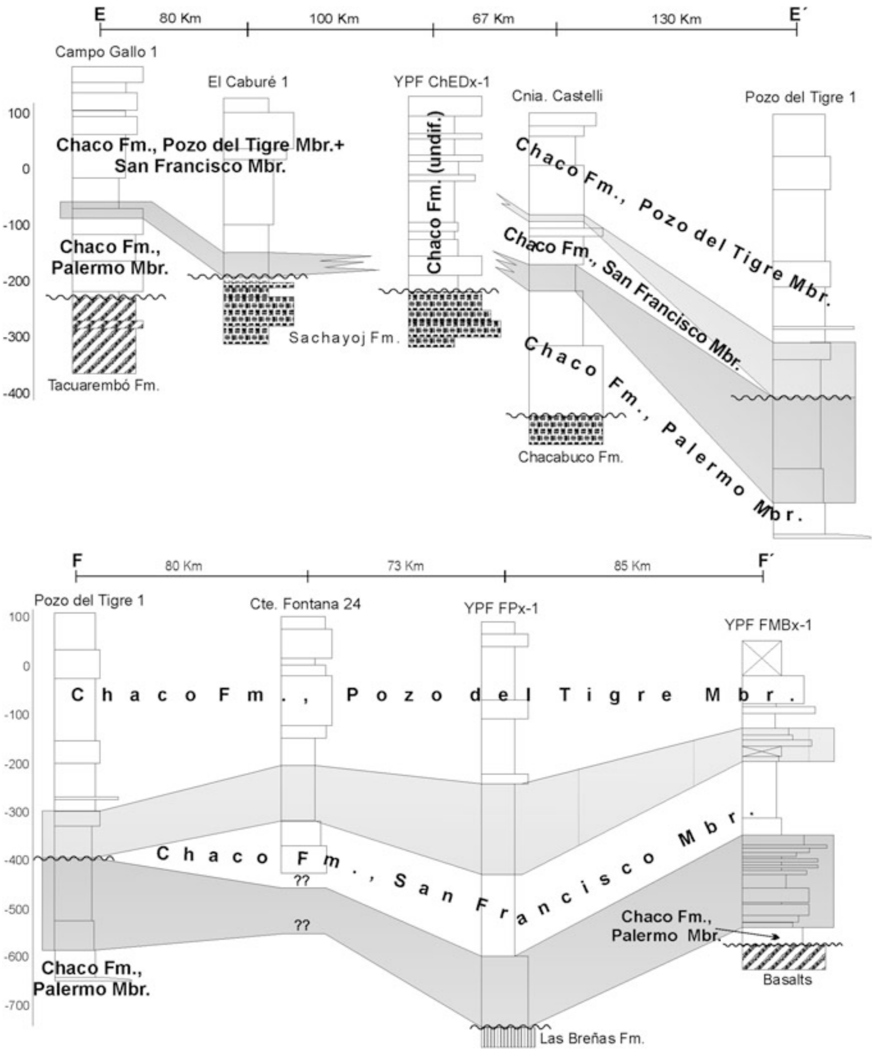

Fig. 2.9 EE′ and FF′ stratigraphic sections according to Fig. 1.2

would indicate the action of reducing bacteria that is typical in substrates with low oxygen content. The ostracods suggest shallow environments with variations of salinity, and the continental provenance is presumed by the presence of charophytes and *Candona* sp. in San Francisco 1 (Echevarría and Marengo 2006). On the northern margin of the Salado Basin, the formation of possibly warm-water hypersaline lagoons is suggested by the abundance of large and very ornate miliolids. In other sites, the salinity would have been lower, as indicated by the dominance of *Cribroelphidium discoidale* f. *pausicamerata*, which sometimes

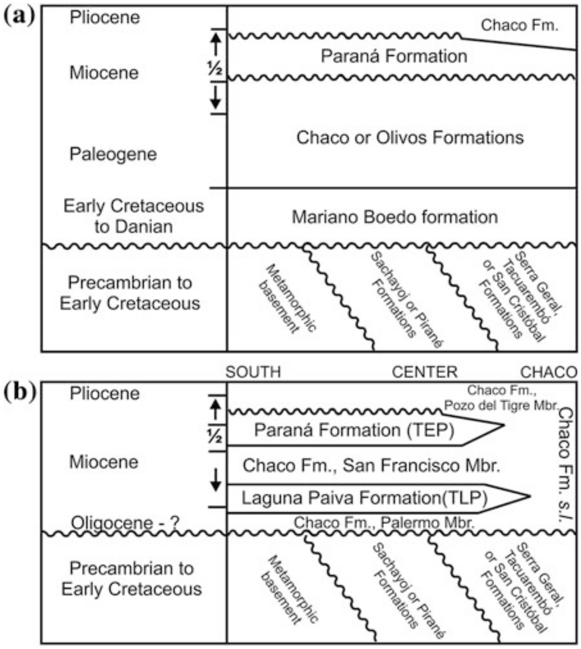

Fig. 2.10 Proposed stratigraphic outlines for the Chacoparanense Basin. **a** Modified from Padula and Mingramm (1968), Pezzi and Mozetic (1989) and Chebli et al. (1999). **b** This paper

formed monospecific associations. The abundance of young specimens of ostracods generally suggest shallow-water environments with a moderate level of energy (Echevarría and Marengo 2006).

The TLP formed a very shallow sea with successive advances and retreats of the shoreline, as implied by the interbedding of green shale with reddish mudstone and clayey sandstone rich in gypsum and gyrogonites. This feature is better developed in the northern Chacoparanense Basin, because the marine sedimentation was more continuous in the Salado Basin. Evidence to attribute these variations to eustatic, tectonic, or sedimentological causes is still not sufficient. In any case, the great sedimentary thickness recorded during the Early–Middle Miocene suggests that the sedimentation rates were very high, so some changes in the relative sea level would have been produced by the progradation of continental environments. Moreover, the number of continental interbedding within the TLP varies widely, suggesting that the advances and retreat of the sea were regulated by local differences in sediment supply.

2.1.1.3 Age

There are several reasons to assign the beginning of the TLP to the base of the Miocene or the latest Oligocene, but there is no certainty about its completion, which could have occurred in the Late Aquitanian. The finding of calcareous

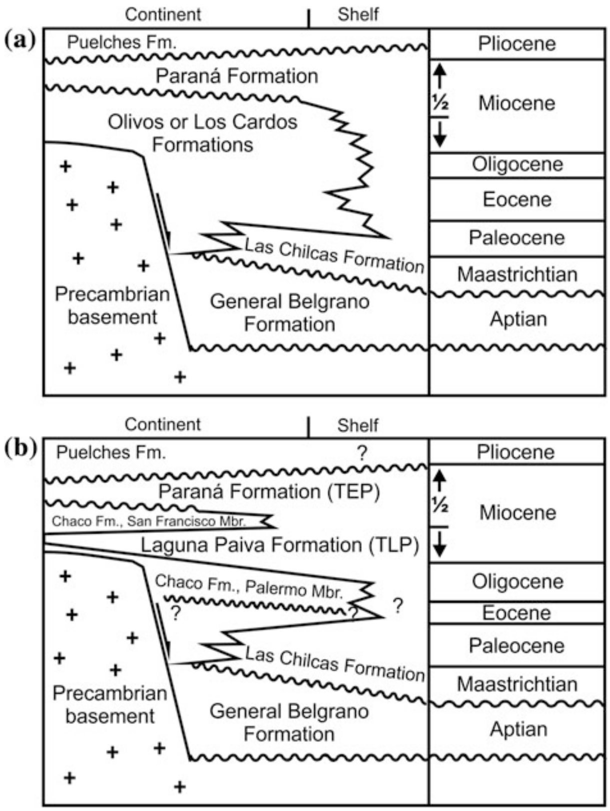

Fig. 2.11 Proposed stratigraphic outlines for the Salado Basin. **a** Modified from Yrigoyen (1999). **b** This paper

nannoplankton in the Riachuelo II borehole (194.7–197.0 mb.g.s.), near the base of the TLP, is the most accurate element of dating and the unique finding of this group of fossils in the TLP. *Triquetrorhabdulus carinatus* is an index fossil that defines the top of the Oligocene and the bottom of the Miocene, with a biochron restricted to the Zones NP25-NN2, whereas *Cyclicargolithus abisectus* appeared during the Oligocene and became extinct during the Early Miocene, with biochron in Zones NP25-NN1 (Martini 1971, Young 1998). On the basis of these two species, the base of the TLP can be assigned to the Late Oligocene–Early Miocene, Zones NP25-NN1 (Marengo and Concheyro 2001).

The *Ammonia* and *Peneroplis* genera appeared globally at the base of the Miocene (Loeblich and Tappan 1988) and were recorded near the base of the TLP in San Francisco 1, Ordóñez 3, and Pozo del Tigre 1 boreholes; consequently, the beginning of the TLP could be located with few doubts at the base of the Miocene. The rest of the foraminifera are endemic and are unknown in other deposits of the country or have a very broad biochron; therefore, they are not useful for biostratigraphical purposes. However, some of these endemic taxa could serve as index fossils for the TLP given its abundance, such as the case of *Quinqueloculina boueana* d'Orbigny 1846, *Massilina secans* (d'Orbigny 1826) f 1 and 2, *Cycloforina brongniartiana* (d'Orbigny 1839a), *Cribroelphidium paivensis* sp. nov., *Cribroelphidium discoidale pausicamerata,* and *Nonion depressulus* (Walker and Jacob 1798) in the northern margin of the Salado Basin, and *Peneroplis* sp., *Nonion* sp. 1 and *N. depressulus* in the Chacoparanense Basin.

The ostracods gave similar, although less accurate, results (Fig. 2.12). The ages were assigned by comparison with Patagonian faunas with little bounded ages. *Soudanella cleopatrae* and *Patagonacythere* sp. 1 have affinities with species whose biochron extends until the Late Aquitanian. According to Marengo et al. (2005), *Ambostracon paranensis*, *Argenticytheretta miocenica*, *Callistocythere marginalis*, *Cytheretta punctata*, *Garciaella leoniana*, *Henryhowella* aff. *Evax,* and *Quadracythere neali*, from the Salado Basin, are the only species previously known in the region. They were found in sediments of the Miocene–Holocene in the Pelotas Basin (southern Brazil), the Late Miocene–Early Pliocene and Quaternary in the Salado and Colorado Basins, the Late Miocene–Early Pliocene in the Valdés Basin, the Eocene–Miocene of the Austral Basin, and the Holocene of the Río de La Plata estuary and the Argentine continental shelf. They also noted affinities with species of the Holocene in the Pelotas Basin and the continental shelves of Brazil and Uruguay. Finally, Echevarría and Marengo (2006) studied the specimens of Pozo del Tigre 1, San Francisco 1, and San Cristobal l boreholes, finding only one species previously recognized in the country, *S. cleopatrae*, from the Oligocene of the south-central and southeastern Santa Cruz province. Two species have morphological similarities to other previously known from Holocene deposits of the Argentinian, Brazilian, and Uruguayan continental shelves.

There are indirect elements, although very consistent with the fossil record, such as the global eustatic sea level curve (Haq et al. 1987) and the rate and obliquity of the convergence between the Nazca and South America plates (Somoza 1998), as summarized in Fig. 2.13. A good correlation is observed between the ages of the microfossils and nannofossils, the tectonic events in the Pacific margin, and the global sea level changes. Likely, there is not a direct relationship between the tectonic and eustatic factors, whereas it is clear that the occurrence of a period of very strong deformation at the western margin of the continent would have been enough to cause the subsidence in the Chacoparanense Basin, allowing the income of the sea during the eustatic rise at the end of the Oligocene. In the same figure, the combination of these factors is useful for explaining the ingression of the TEP during the Serravallian, although it is less obvious because the variation of the convergence does not appear to have been so sharp. Accordingly, the onset of TLP occurred between the end of the Oligocene and the beginning of the Miocene, which otherwise is the age when many transgressive events occurred in the Pacific and Atlantic coasts of all of South America (Sect. 1.4.3 and Fig. 1.1). The eustatic

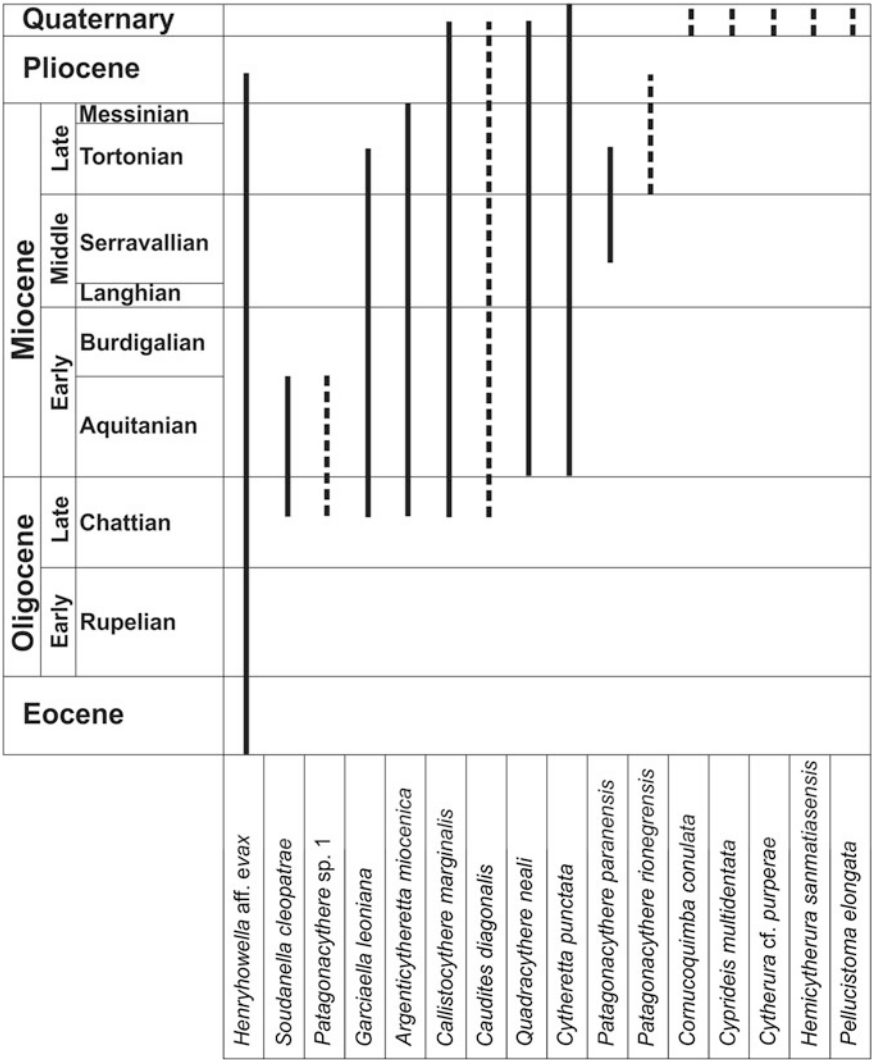

Fig. 2.12 Some TLP ostracod ages according to previous works in Argentina, Uruguay, and Brazil. *Dotted lines* indicates the ages of species with affinities to those found in this investigation

fall and the decline of the convergence and obliquity rates towards the end of the Aquitanian possibly indicate the maximum age for the regression of the sea. The thick continental sedimentary mantle, up to 200 m thick, deposited above the TLP is an additional tool to estimate the age of the top. These continental sediments would have been deposited in a period of approximately 5–6 million years, which means a sedimentation rate of approximately 3–4 cm/ky—a consistent value for loessoid and fluvial deposits.

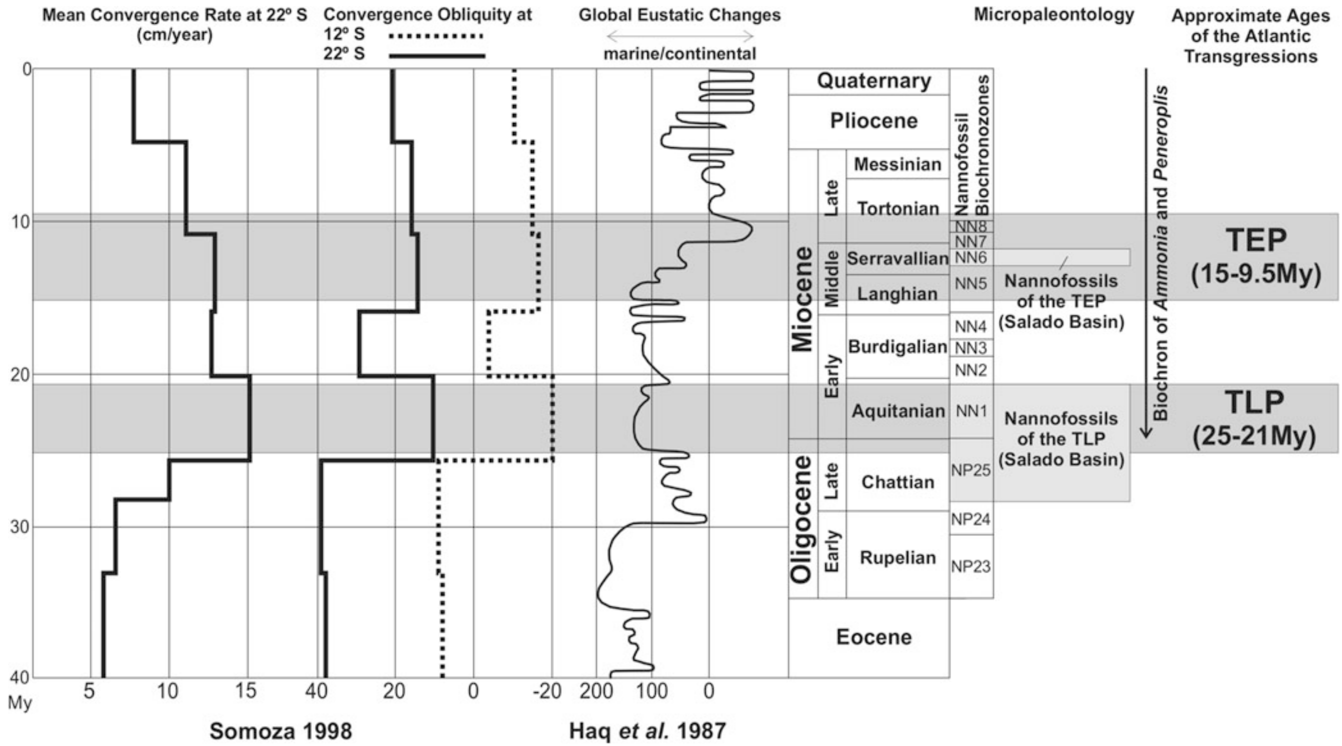

Fig. 2.13 Correlation between the microfossil ages of the TLP and TEP, the eustatic curve after Haq et al. (1987), and the convergence rate and obliquity between Nazca and South America (Somoza 1998)

2.1.1.4 Older Marine Deposits

As seen in Sect. 1.4.2, some authors have pointed out a Cretaceous–Paleocene age for the Mariano Boedo formation, and consequently for the deposits equivalent to the TLP. It should be noted that no Cenozoic marine sediments prior to the TLP were found in any borehole. Most of the continental deposits located below the TLP (Palermo Member) apparently belong to the same Neogene depositional cycle, as they have very similar mineralogical and diagenetical characteristics to the San Francisco Member (Sect. 2.1.4.2). Consequently, there are no reasons to consider that the Maastrichtian–Danian transgression had flooded beyond the center of the Salado basin. Therefore, the paleogeographical reconstructions where this older transgression is spread throughout the Chacoparanense Basin to the NOA (Uliana and Biddle 1988; Spaletti et al. 1999) need to be revised. In some areas where the Palermo Member is thicker than usual, there are continental deposits that could be Paleogene or older, such as those studied in the YPF Cd-Saira-Ex.1 borehole (province of Córdoba; Musacchio 2000; Musacchio et al. 2002), between 630 and 732 mb.g.s., where the gyrogonites *Nitellopsis supraplana* (*s.l.*), *Porochara gildemeisteri* and *Gobichara* (*Pseudoharrisichara*) sp. were found, which are characteristic of the latest Cretaceous.

2.1.2 The Entrerriense-Paranense Transgression

2.1.2.1 Distribution and Lithology

The TEP formed a shallow sea that entered through the Salado Basin, flooded the Chacoparanense Basin, and possibly reached southern Bolivia, crossing the NOA region. It is also likely that some sea branches have advanced westward, bordering the northern Pampeanas Ranges, and reached some regions currently occupied by the Andes Mountains. There are some doubts about their actual geographical distribution arising from the discovery of the TLP, to which some of the records assigned prior to the TEP in the Andean region, the NOA, and southern Bolivia probably correspond. This uncertainty may only be clarified by reviewing the microfaunas of the San José, Anta, and Yecua Formations, among other profiles.

The distribution of the TEP in the Chacoparanense Basin (Fig. 1.2) is very similar to the TLP although somewhat smaller, possibly by partial filling of the basin at the Middle Miocene. There was also a slight tectonic uplift in the Subandinas Ranges (Fig. 2.14), which prevented the flooding in northern Santiago del Estero and western Chaco and Formosa provinces. In Mesopotamia, the large region located in between the Paraná and Uruguay rivers, the transgression was restricted to a fringe near the area of the current Paraná River, probably due to a slight rise of this region. Its thickness is smaller and more constant than in the TLP (Figs. 2.3 and 2.6), in general between 50 and 100 m, with a maximum of 200 m in eastern Formosa and central Santa Fe provinces. In the center of the Salado Basin,

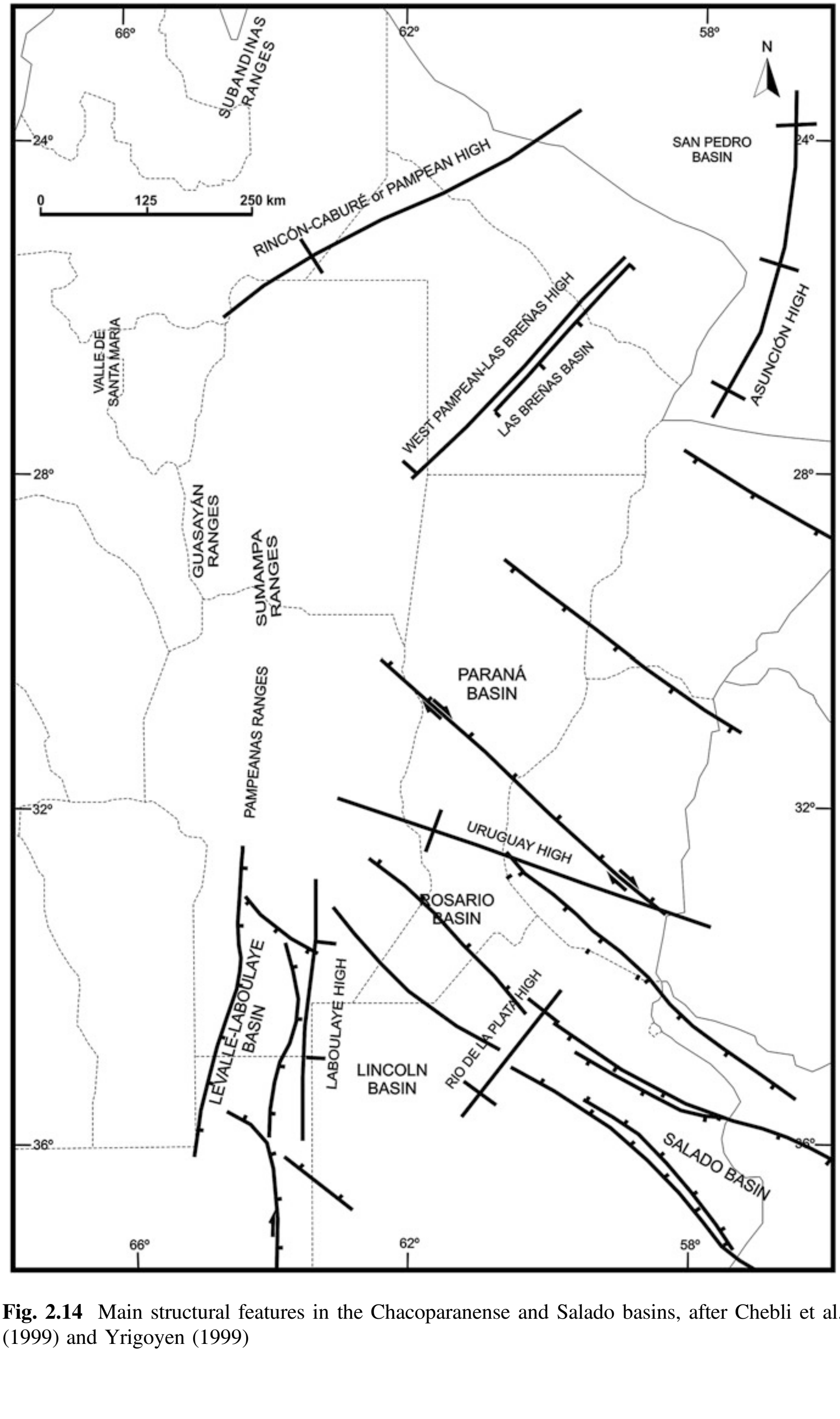

Fig. 2.14 Main structural features in the Chacoparanense and Salado basins, after Chebli et al. (1999) and Yrigoyen (1999)

the thickness is much larger because marine sedimentation was continuous along most of the Neogene and Quaternary.

The sediments are mainly light-olive mudstones, with a few rather sandy intercalations. In the three boreholes obtained in the city of Buenos Aires, the base consists of yellowish-brown conglomeratic sands with marine megafauna. The megafauna from boreholes is scarce and badly preserved. Except for the relative abundance of eroded oyster fragments, the remaining shells fragments are unidentifiable. Some specimens of the bryozoan *Cupuladria canariensis* Busk were found in the northern margin of the Salado Basin.

2.1.2.2 Microfossils and Paleoenvironments

The foraminifera in the Chacoparanense Basin were found in nine sites, but ostracods were only found in three sites; neither planktonic foraminifera nor calcareous nannoplankton were found. In the Salado Basin foraminifera, ostracods and calcareous nannoplankton were found in three boreholes. The distribution charts, the systematic list, and pertinent illustrations can be found in Appendices C, D, and E.

The Chacoparanense Basin (Figs. C.1–C.3 and C.9)

The main characteristics of the microfaunas were referred to by several authors and synthesized within a regional scheme by Herbst and Zabert (1987). The information obtained in this work significantly increases the amount of information on the microfossils of this region. The foraminifera are typical of very shallow, usually hyposaline seas, suggesting a temperature similar to the current Argentine continental shelf. The only exception is *Disconorbis bulbosa*, a benthic foraminifer now restricted to the northern Brazil shelf; therefore, the water temperature of the TEP could have been slightly higher than the current for the same latitude. The dominant foraminifera in all the sites are *P. tuberculatum* and *A. parkinsoniana*; both species are highly tolerant to lower salinities (Malumián 1978; Murray 1991). In the upper section of the Paraná Formation at Diamante, Entre Ríos province, the diversity of ostracods and foraminifera is higher and there is a considerable increase in the abundance and diversity of miliolids; thus, they represent a moment where the salinity would have been closer to normal, and the TEP would have reached the maximum depth and the peak of flooding.

The most diverse microfaunas were recognized in southwestern Entre Ríos and eastern Santa Fe provinces; to the north and northwest of the country, they became dramatically impoverished due to a decrease in depth and mixture with freshwater. The highest diversity was recorded in the Diamante area, where some new species of foraminifera for the basin were found, such as *Miliammina* sp., *Textularia candeiana*, *Pyrgoella* sp., *D. bulbosa*, *Fissurina quadricostulata*, *Guttulina problema*, *Lagena* sp., and *Neoeponides* sp. Outside the area of Diamante, the ostracods were only found in Pozo del Tigre 1, San Francisco 1, and Selva 2 boreholes. Nine podocopids genera, four genera with doubts and two indeterminate ones, and 11 species were found. These microfaunas indicate that the sediments were deposited in a shallow marine environment with changes in salinity. *Cytheridella ilosvayi* suggests oligohaline conditions in the sample Pozo del Tigre 1–89 (491.05–501.05 mb.g.s.).

Northern Margin of the Salado Basin (Figs. C.4–C.7 and C.9)

Near the top of the TEP, at the sample YPF Palermo 10 (51–65 mb.g.s.), calcareous microfossils are very scarce, being also altered by dissolution and pyritization. The pyritization is revealed by the abundance of framboidal pyrite and pyrite casts of microgastropods and foraminifera, whereas solution is suggested by the scarcity or total absence of calcareous material. From 65 mb.g.s. to the bottom, the dissolution and pyritization were less intense, and the foraminifera and ostracod microfaunas have greater diversity and abundance. In the samples located at 65–66 and 69–70 mb.g.s., two peaks of diversity were recorded with a similar abundance of microfossils, although the latter has a much higher proportion of planktonic foraminifera and the only finding of calcareous nannoplankton in this well. The microfossils in Riachuelo II borehole have the same preservation characteristics than in YPF Palermo 10, although the alteration is somewhat less intense. From 60 mb.g.s. to the bottom, associations with greater abundance and diversity of foraminifera and ostracods were recovered; between 65 and 70 mb.g.s., about the middle portion of the TEP, there is a peak of maximum diversity and abundance of planktonic and benthic foraminifera and ostracods, as well as the only record of calcareous nannoplankton. The samples were taken at very irregular intervals in the Riachuelo VI borehole, with large sections without samples. Both sectors with the greatest diversity and abundance of microfauna were found in samples 147.0–150.0 and 280.0–291.35 mb.g.s. The latter is near the base of the TEP and has the greatest diversity and abundance of benthic and planktonic foraminifera and ostracods, and the only record of calcareous nannoplankton.

In summary, the TEP would have started with very high-energy environments that eroded the previous continental sediments (San Francisco Member), depositing conglomeratic sands with or without pelecypod fragments. Towards the center of the sections, the TEP would have reached the maximum extension as indicated by the composition of microfossils and nannofossils. To the top, the microfaunas are quickly depleted, indicating a gradual decline of the marine environment. The microfaunas located above the maximum flood peak have very low diversity and are characteristic of nearshore environments. Particularly, the ostracods indicate shallow environments, such as the genus *Perissocytheridea* found at the top of the Riachuelo VI borehole, which is typical of water bodies with sharp salinity shifts (Marengo et al. 2005). The nannofossils are rare and restricted to the levels with greater diversity. They indicate somewhat different environmental characteristics from those inferred by foraminifera and ostracods. *Discoaster broweri* is a Cenozoic discoasterid characteristic of temperate-warm waters, whereas *Braarudosphaera bigelowi*, *Thoracosphaera heimii*, *Rhabdosphaera clavigera*, *Pontosphaera multipora,* and several species of *Helicosphaera* are indicative of shallow marine nearshore environments, with normal salinity to slightly hyposaline water (Perch-Nielsen 1985).

2.1.2.3 Age

The nannofossils are characteristic of the Biozone or Interval D (Young 1998), between the last occurrence of *Sphenolithus heteromorphus* and the first appearance of *Catinaster coalitus*, and are characterized by *Reticulofenestra pseudoumbilicus*, *Coccolithus pelagius*, *Calcidiscus leptoporus*, *Discoaster exilis*, *Helicosphaera carteri*, *Umbilicosphaera jafari* and *U. rotula*. Other common species in the association include *Discoaster kugleri* and *Helicosphaera orientalis*. *Calcidiscus premacyntyrei*, *H. orientalis*, *H. walbersdorfensis,* and *R. pseudoumbilicus* are also relevant, which restrict the association to the Zone NN6 (Martini 1971 and Young 1998), corresponding to the middle of the Serravallian (Middle Miocene). The benthic foraminifera do not allow for further clarification of the age than that indicated by Malumián (1970, 1972) for the informal zone of *P. tuberculatum* (Middle–Late Miocene in the Colorado and Salado Basins). The planktonic foraminifera found in the northern Salado Basin are very small, belonging to juvenile specimens or being broken.

Some specimens of *Globorotalia prescitula* Blow 1959 and *Neogloboquadrina continuosa* (Blow 1959) transitional to *Paragloborotalia mayeri* (Cushman and Ellisor 1939) could be determined, which possess broader biocrone culminating between biozones N12 and N14 (Fig. 2.15), very similar to the age indicated by the nannofossils. The ostracoda are not good age indicators; the age of nearby sites where common species with the TEP were found is detailed (Fig. 2.16): *Ambostracon paranensis*, *Aurila* sp. 3 *Valicenti*, *Callistocythere marginalis*, *Coquimba* sp. *Echevarria*, *Henryhowella* aff. *evax*, *Perissocytheridea victoriensis*, *Wichmannella deliae,* and *Wichmannella juliana* were previously recognized in the Miocene sediments of the Chacoparanense Basin, in the Miocene-Quaternary of the Pelotas Basin, in the Late Miocene–Early Pliocene basins of the Colorado and Valdés Basins, and in the Eocene–Early Miocene of the Austral Basin; *Argenticytheretta miocenica* was previously found in sediments from the Oligocene of south-central Santa Cruz province, the Miocene subsurface of the city of Buenos Aires, the Late Miocene of Entre Ríos and Santa Fe provinces, the Early Miocene of the island of Tierra del Fuego, and the Late Miocene–Early Pliocene of Puerto Pirámide, Chubut province, and *Cytheridella ilosvayi* was recognized in Holocene deposits in southern Buenos Aires province. Also, some species have morphological similarities to species from the Eocene of southern Santa Cruz, the Late Pliocene of southwestern Atlantic Ocean, the Holocene of southeastern Buenos Aires province, and the Holocene of the coast of Chubut and Santa Cruz provinces, eastern Tierra del Fuego, southern Brazil, and the western portion of the Strait of Magellan (Marengo et al. 2005).

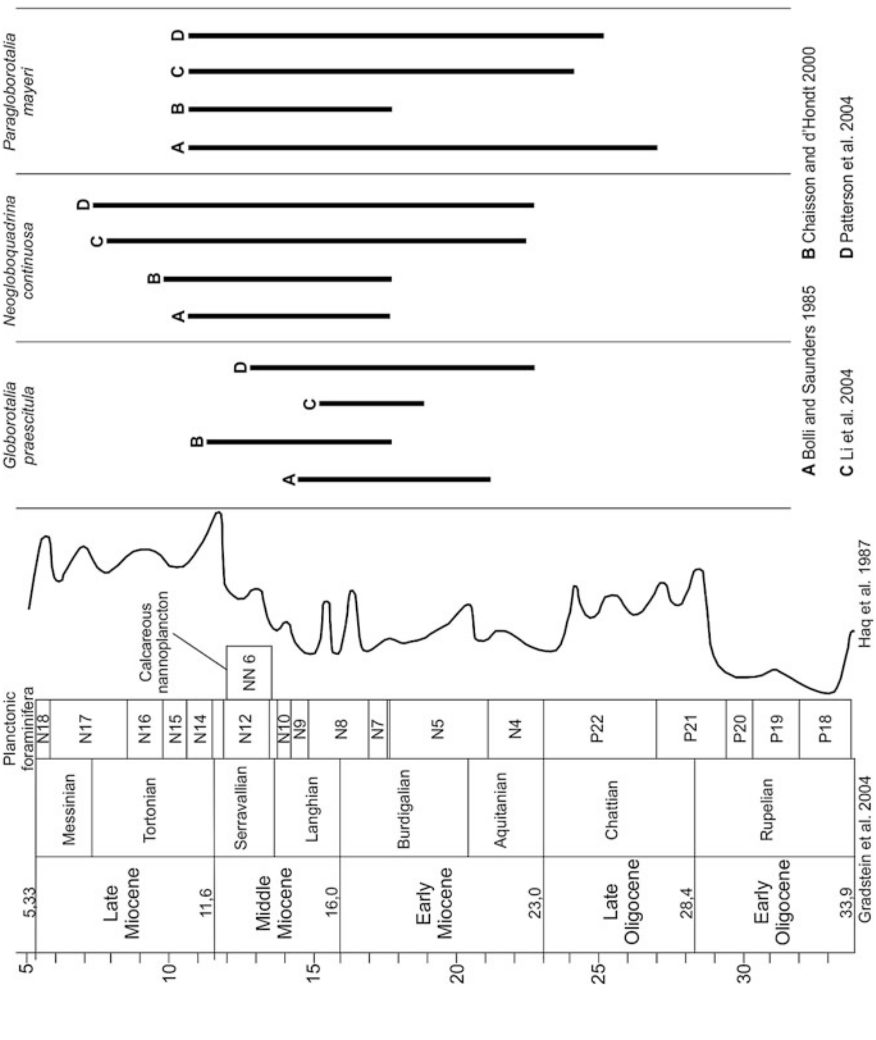

Fig. 2.15 Age of planktonic foraminifera and calcareous nannoplankton in the TEP of the Salado Basin

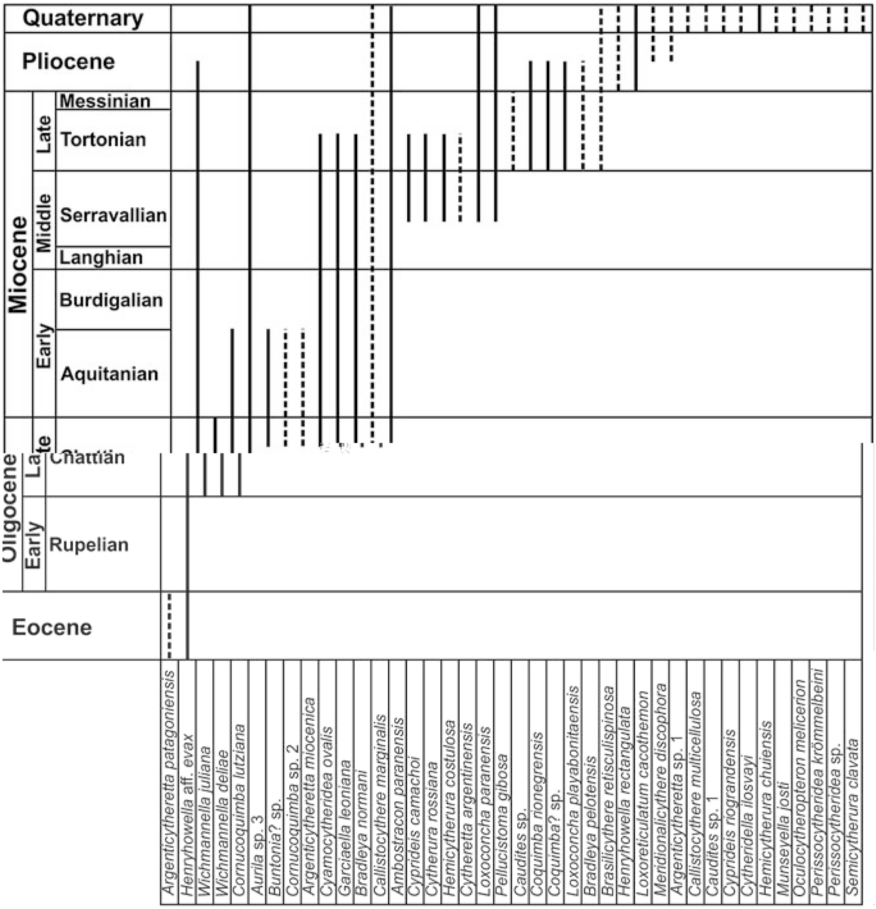

Fig. 2.16 Some TEP ostracod ages according to previous works in Argentina, Uruguay, and Brazil. *Dotted lines* indicates the ages of species with affinities to those found in this research

From the study of these fossil groups, it can be concluded that age is better determined by the nannofossils, which indicate that the middle sector of the TEP in the Riachuelo II and Palermo 10 boreholes, as well as the lower to middle sector in Riachuelo VI borehole, were deposited in Zone NN6 (Martini 1971; Young 1998), Serravallian, Middle Miocene. The recent dating of the upper section at Diamante (9.47 Ma, Pérez 2013) is helpful to estimate the end of the TEP, but there are no clues to determine the beginning of it, although the correlation with the global eustatic cycles and convergence rates in the western margin of southern South America (Fig. 2.13) suggest that it may have occurred about at the end of the Langhian. Taking all of these factors into account, it can be estimated that the TEP was developed between 15 and 9.5 Ma.

2.1.2.4 The TEP in Diamante, Entre Ríos Province

The most relevant lithology and micropaleontological content were studied in four wells in the town of Diamante, Entre Ríos Province. In Fig. A.3, an ideal section of the area is shown. The following distribution of microfossils for the Diamante region was determined:

- 47–53 mb.g.s.: moderate diversity dominated by *P. tuberculatum*, *A. parkinsoniana*, *H. boueana*, miliolids, *Paracypris* sp. *Cyprideis camachoi*, *Cyamocytheridea ovalis,* and *Patagonacythere* spp. Towards the roof, diversity decreased and there was a significant increase in the proportion of *H. boueana* and the disappearance of the miliolids and ostracods.
- 55–60 mb.g.s.: lower diversity and abundance dominated by *P. tuberculatum* and *A. parkinsoniana*, and fewer specimens of *H. boueana*, *B. campsi peruviana*, *C. discoidale*, and ostracods.
- 85 mb.g.s.: very few specimens of *P. tuberculatum* and *A. parkinsoniana*.

The deposits of the TEP start with a sharp contact on the loess-like deposits of the Chaco Formation. This contact would not have been erosional because it lacks the coarse fraction typical of a lag deposit. The first 40 m of the Paraná Formation are composed of marine olive mudstones with fewer microfossils and fragments of oysters, interbedded with thick deposits of continental sands that would indicate a long period during which the progradation of coastal sediments competed with rising sea level. Frenguelli (1920) explained the interbedded sandy layers in the Paraná Formation as a result of several transgressive–regressive cycles associated with orogenic movements. Stappenbeck (1926) interpreted that those were produced by the progradation of a deltaic system on the coastal environment; in turn, Aceñolaza and Aceñolaza (2000) considered that these sandy layers were deposited in an environment of coastal dunes. The finding of very fresh fragments of wood and thin insertions of dark shales in the Diamante boreholes would support the interpretation offered by Stappenbeck.

Then, one or two sandy levels with abundant marine microfauna and megafauna were deposited. These sandy levels have a faunal assemblage equivalent to that found in outcrops along the river coast at Diamante, which may be correlated throughout southwestern Entre Ríos province. At the top of the sequence, the peak of maximum flooding would have been reached, as deduced from the composition and diversity of the microfauna. The marine or transitional sedimentation ends with the deposition of a thick bed of occasionally laminated green shale with calcareous concretions and very well-developed gypsum crystals, and a bed of fining upward sandstone strongly cemented; this bed suggests the final regression of the sea. Finally, a new level of massive red mudstone with calcareous concretions of undoubtedly continental origin was deposited.

In summary, the Paraná Formation at Diamante seems to be the result of a single very shallow marine ingression, regulated by the progradation of coastal environments. Towards the top, the sea reached its maximum elevation and areal expansion, after which the regression took place and distinctly continental sedimentation was restored. If the Paraná Formation is considered as the greenish–yellowish marine and transitional deposits clearly distinguished from the reddish continental sediments, this unit is about 60 m thick, of which only the upper 20–25 m crop out.

2.1.2.5 The TEP in the Chacoparanense Basin and the Arm of Tethys

The TEP deposits from the northern Salado Basin to its northernmost probable records in southern Bolivia have fairly uniform lithology. They consist of massive green mudstones and shales and green to yellow sandstones, with a variable content of marine fossils and frequent levels rich in gypsum. The marine microfossils are usually found in green or yellow sandstones with megafauna, and they are rare and poorly preserved in the green mudstones. The microfaunas are typical of very shallow, usually hyposaline marine environments. Foraminifera have moderate to low diversity, with a sharp depletion of the diversity and an increase in the proportion of *A. parkinsoniana* towards the continental hinterland. The sea entered from northern Buenos Aires province and spread towards the center and northern portions of Argentina, probably reaching southern Bolivia and Paraguay (Fig. 1.1), with an inland marked impoverishment of the microfaunas and the disappearance of the species of normal salinity beyond Santa Fe province.

Based on the remarkable similarity between the Caribbean and TEP malacofaunas, Ihering (1927) postulated the migration of some genus of tropical mollusks from the Caribbean Sea to the coast of Argentina, through a seaway that would have crossed inner South America along the western part of the continent, which he named as "The Arm of Tethys" (Fig. 1.1). Many authors who studied the TEP agreed with this hypothesis (Boltovskoy 1958, 1979; Boltovskoy and Lena 1974; Closs 1962; del Río 1990; Pérez and Ramos 1996). The microfossil distribution of the TEP (Fig. 2.17) clearly indicates that the migration of the faunas may have not taken place through this hypothetical inland sea because the number of genera decreased rapidly towards the interior of the continent. In Bolivia, only one genus of foraminifera and two genera of freshwater ostracods were recognized. Moreover, the malacofaunas related to the Caribbean Sea and southwestern Entre Rios province were not found beyond the center of Santa Fe province. It is much more likely that the migrations had occurred through the eastern continental shelf of South America, as was already suggested by Malumián (1970) and Sprechmann (1978).

	Genera of Foraminifera	Genera of Ostracoda
Salado Basin	42	24
SW Entre Ríos	25	39
Santa Fe	17	24
Córdoba and Santiago del Estero	17	12
Corrientes, Chaco and Formosa	5	5
Tucumán and Catamarca	6	3
Bolivia	1	2

Fig. 2.17 Microfossil genera of the TEP according to this study and the work of previous authors

2.1.3 Main Features of the Basins

The reactivation of the Chacoparanense depocenters would have occurred since 26 Ma ago, during the Late Oligocene (Ramos 1999b); thereafter, a process of subsidence with two peaks of maximum rate began, broadly coincident with the age of the TLP and the TEP (Fig. 2.13). The sedimentary infill may widely be considered as distal deposits of the Andean foreland (Ramos 1999a), dominated by alluvial and eolian sedimentation (the Chaco Formation and Quaternary deposits), interrupted by two periods of marine sedimentation.

The geographical distribution of both transgressions was very similar but slightly larger for the TLP, indicating the coalescence of ancient depocenters active in the region during the Paleozoic–Early Cretaceous: Lincoln, Laboulaye-Levalle, Rosario, Paraná, and Las Breñas. The structural map of the floor of the TLP (Fig. 2.1) indicates that the depocenters of the Chacoparanense Basin during the Neogene were developed partly equivalent to the older basin areas. On the other hand, the structural map of the top of the TEP (Fig. 2.5) shows the almost complete silting of these depocenters and therefore a marked decrease of the subsidence, except in the northwestern part. In all sections, the TLP and TEP are separated by the continental San Francisco Member (Chaco Formation), and there are no signs of unconformities or nondepositional hiatuses. The unique exception was found in the Pozo del Tigre 1 borehole, where the deposits of both transgressions are in erosional contact. Although it is not possible to unequivocally identify discordant surfaces in borehole samples, the preservation of the microfauna at the roof of the TLP suggests a period of subaerial exposure; foraminifera are partially dissolved, with a different type of solution compared to the rest of the samples, and are covered by a thin patina of iron oxide. Consequently, it would have been assumed that there was a slight tectonic rise between the end of the TLP and the beginning of the TEP, possibly correlated with the Quecha I Tectonic Phase (Salfity and Marquillas 1999), which separates the Metán and Jujuy Subgroups in the NOA.

2.1.4 Proposed Litostratigraphic Units

The existing stratigraphic divisions are incomplete and mostly do not meet the standards of the *Comité Argentino de Estratigrafía* (1992). Due to the huge distribution of the deposits, their relative simplicity and lithological homogeneity, and the presence of marine deposits with known ages, it is possible to make a useful lithostratigraphic division for the entire region, defined at a time by their lithological characteristics and relationships between the different units, while also incorporating information about its genesis and age. Of all the units in use, only the Paraná Formation (Bravard 1858) meets the requirements of the Argentine Stratigraphic Code. All other units are not precisely defined or were not defined ever as the Chaco or Olivos formations. The Fray Bentos Formation is correctly defined in

Uruguay but belongs to a different basin. According to the present knowledge, it is not possible to correlate it within the Chacoparanense Basin because its type profile has very little vertical development, and the relationship with the Paraná Formation in the Argentine outcrops is not exactly known. A new lithostratigraphic division for the entire region is proposed. This division is valid for the sediments deposited after the outflowing of the basalts of the Serra Geral Formation or older units, until completion of the TEP or until the deposition of Quaternary units in the northern Chaco Plain. This division tries to keep the existing terms as much as possible, avoiding the generation of too much instability in the nomenclature, although some units should be disposed because they are synonyms. Consequently, the Litoral Group has been created, covering all considered deposits. The Chaco Formation has been formalized and divided into three members. Finally, the Laguna Paiva Formation has been formalized too, and one Hypostratotype is proposed for the Paraná Formation.

2.1.4.1 The Litoral Group

Definition

The Litoral Group comprises continental and marine sediments distributed in the Chacoparanense Basin and northern margin of the Salado Basin, including the Chaco, Laguna Paiva and Paraná Formations. It consists mainly of olive-green, reddish-brown or brown shales and sandy claystones, with some levels of yellowish or reddish sand or sandstone; some sectors are very rich in calcareous concretions and gypsum.

The Holostratotype is located in the sections 50.0–287.0 mb.g.s. of the YPF Palermo 10 borehole, located in the Palermo neighborhood of the city of Buenos Aires (Fig. A.10). As Parastratotypes, the profiles of the boreholes Laguna Paiva 1 at 122.5–610.8 mb.g.s., San Francisco 1 at 140.0–680.0 mb.g.s., and Pozo del Tigre 1 at 3.65–760.75 mb.g.s. are proposed.

Geographic Distribution

The Litoral Group occupies at least 700,000 km^2 in Argentina and an undetermined, large area in portions of western Paraguay and eastern Bolivia. Its complete distribution has not been established, but it is broader than the TLP (Fig. 2.1), mainly in the center and western parts of the Chaco province, where there is no record of marine sedimentation. Towards the west, it is limited by the Pampeanas Ranges and then underground through southern Córdoba and northern La Pampa provinces. To the north of the Guasayán and Sumampa Ranges (Fig. 2.14), it continues westward, mingling with the Neogene synorogenic deposits of the central segment of the Andes; to the northwest, it occupies almost the entire Santiago del Estero province and extends to the Catamarca, Tucumán, and Salta provinces, where some outcrops of the marine and continental units are likely to exist, and it would be partially equivalent to the Metán Subgroup. Towards the east, it is approximately limited to the western half of the Entre Rios and Corrientes provinces, whereas in Buenos Aires province it is restricted north of the Salado River; it has not been studied yet further south.

The thickness is highly variable, with minor development in areas close to the Pampeanas Ranges. In the vicinity of the city of Buenos Aires, it ranges between 250 and 300 m, becoming much stronger towards the center of the Salado Basin. In the Chacoparanense Basin, it is thicker than 800 m at the YPF Ceres x-1 borehole, and it is about 700 m thick in the Pozo del Tigre 1, YPF San Cristóbal 1 and YPF Josefina es-1 boreholes. In many sites, the complete Litoral Group was not completely drilled; thus, its thickness could be even larger.

2.1.4.2 The Chaco Formation

The Chaco Formation was defined by Russo et al. (1979) as "the reddish and purple sandstones and mudstones, between the Mariano Boedo and Paraná formations, and when the latter is absent between the Mariano Boedo and Pampa formations." These authors did not designate either a type location or a type section. According to Fernández Garrasino and Vrba (2000), this unit is not equivalent to the Chaco Group of the Cordillera Oriental (Fossa Mancini 1938), or the *Estratos del Chaco* of the Subandinas Ranges of Salta province. The original definition (Russo et al. 1979) is quite brief and it does not sufficiently reflect the lithological variability; additionally, it is limited by its relationship with the Mariano Boedo formation, which is invalidated in this work. Consequently, to avoid instability in the nomenclature the name of the Chaco Formation remains, its definition is extended, and one Lectostratotype is designated.

Definition

The Chaco Formation comprises essentially Neogene sediments of continental origin, distributed in the subsurface of the Chacoparanense and northern margin of the Salado basins. It is composed mainly of reddish-brown to brown shales, friable sandstones and sandy mudstones with little carbonate cement, some levels of yellowish or reddish sand and conglomeratic sand, and a few greenish mudstone intercalations; some parts of it are very rich in gypsum and calcareous concretions. It was deposited unconformably on basalts of the Serra Geral Formation or older units depending on their location, and it is limited at its top by the Paraná Formation or Quaternary continental sediments. The Lectostratotype is chosen in the section between 80 and 670 mb.g.s. of the YPF Las Breñas 2 (YPF Ch. LB x−2) borehole because this section is the best described and has no marine intercalations. A summary of its original description is outlined in Appendix A.

Overview

The Chaco Formation has the same geographical distribution of the Litoral Group and constitutes most of its thickness. The interbedding of the marine levels of the Laguna Paiva (TLP) and Paraná (TEP) formations allows the separation of this unit into three members, except in the central and western part of the Chaco province and western Formosa provinces, where the continental sedimentation was continuous. Although it has a marked lithological homogeneity, small macroscopic and mineralogical differences between the three members were observed.

Correlations

This unit is considered equivalent to the Olivos formation (Groeber 1961). The latter was mentioned by several authors mainly in northern Buenos Aires Province, but it was never defined by P. Groeber. In fact, he only mentioned the "layers of Olivos" twice, without further explanation. The Olivos formation is equivalent to the San Francisco and Palermo Members. The Fray Bentos Formation is correctly set but belongs to another basin, and it is very difficult to establish a precise correlation with the Chaco Formation. The Fray Bentos Formation is a very thin outcropping unit, and the relationship with the marine units of the Chacoparanense Basin is still unclear. Furthermore, the Chaco Formation is equivalent to some sectors previously described in the Mariano Boedo formation, particularly some undoubtedly continental deposits usually located at the lower section.

The Palermo Member

The Palermo Member is the oldest member of the Chaco Formation and underlies the Laguna Paiva Formation in apparent conformity. Its base has been reached in few holes, in which it was observed that it was deposited unconformably on the basalts of the Serra Geral Formation or older units. Its composition, diagenesis, preservation, and the gradual contact with the marine deposits of the TLP suggest that it belongs to the same sedimentary cycle that deposited the Litoral Group; therefore, the age is estimated between the Late Oligocene and Early Miocene. However, as discussed in Sect. 2.1.1, an association of Maastrichtian gyrogonites was found at the bottom of this member in Saira locality, and the same would be expected in other areas of thicker development. In Fig. 2.13, it is possible to estimate that the period of deformation which started in the Late Chattian has been responsible for the reactivation of subsidence in the Chacoparanense Basin, generating the space and availability of large amounts of sediments deposited in the Litoral Group.

The Palermo Member is composed of brown, reddish brown, to whitish clayey silty sandstones, siltstones, and conglomeratic sandstones, with abundant calcareous concretions and sometimes very well developed gypsum crystals. The Holostratotype is designated in the sections 198.0–287.0 mb.g.s. of the YPF Palermo 10 borehole, from the Palermo neighborhood of the city of Buenos Aires. Although is quite similar to the other members of the Chaco Formation, it is the only one with gravel size clasts, and the gypsum crystals are more abundant. In some sites, deposits of green mudstones with neogene gyrogonites were found, probably of marshy origin (Musacchio, personal communication). Near the base of the Pozo del Tigre 1 borehole, there are abundant basalt fragments, which could indicate the proximity of outcrops of the Serra Geral Formation during the deposition of the Palermo Member.

The mineralogical study of 61 samples from 5 boreholes (Figs. 2.18 and B.1) was performed. In the lower half of the Palermo Member in the type section, the volcanic shards are very abundant; these concentrations were not found in other holes, but certainly tephra falls must have been an important phenomenon of wide distribution. In Riachuelo VI and Frías 1 boreholes, there is a higher percentage of minerals from the metamorphic-plutonic basement, corresponding to the Río de la Plata Craton and the Pampeanas Ranges, respectively. In the San Cristóbal 1 borehole, the mineralogy is dominated by volcaniclastic material and the basement provenance is minimal, according to their distance to the cratonic outcrops.

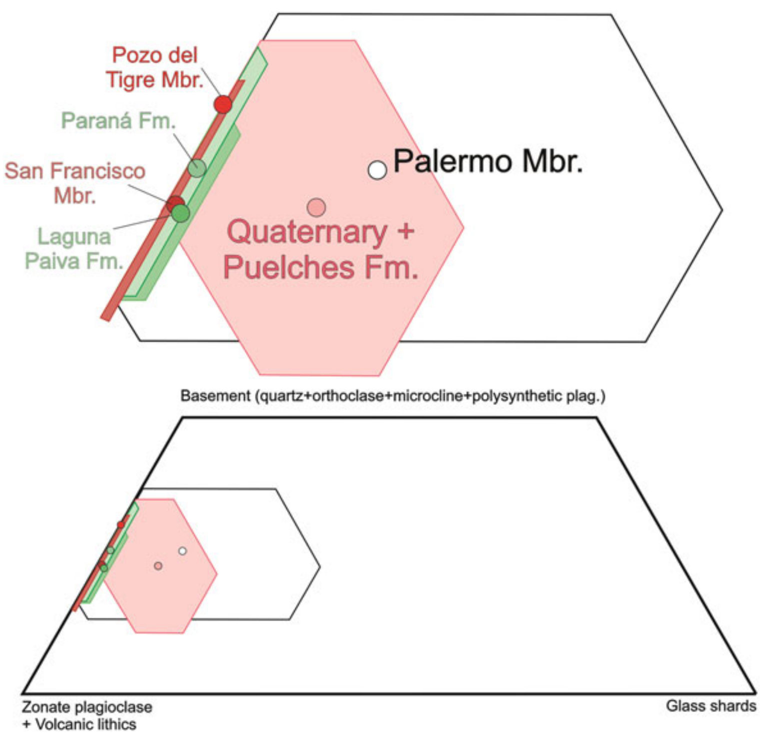

Fig. 2.18 Compositional triangle of light minerals of the Litoral Group

Apparently, the volcaniclastic contribution was characteristic of the central and southern Chacoparanense Basin during the Neogene, as can be seen in the composition of all the units in San Cristóbal 1 and Ordóñez 3 boreholes. Finally, the sand percentage is the largest of all units—a feature that may be useful for differentiation from other members—and could indicate a greater availability of nearby rocky outcrops and higher energy conditions as a result of fast subsidence. The rest of the units of the Litoral Group have similar values, as shown in Fig. 2.18, which may reflect greater mineralogical maturity or more homogeneous provenance than the Palermo Member.

The San Francisco Member

The San Francisco member is interposed between the Laguna Paiva and Paraná formations; consequently, it was deposited between the Late Aquitanian and Late Langhian. It is apparently conformant with the TLP and TEP marine deposits, except north of the Salado Basin, where the base of the Paraná Formation was erosive. In some sites, there is common interbedding of greenish clayey beds without microfossils; therefore, it is difficult to assign a marine or continental origin to all the sections. This member was found in all the places where both marine transgressions are present, except in the Pozo del Tigre 1 borehole, where the Paraná Formation was deposited unconformably over the Laguna Paiva Formation. This unconformity may be possibly correlated with the Quechua I Tectonic Phase, which produced an unconformity of similar age in the Subandinas Ranges (Salfity and Marquillas 1999). The Holostratotype corresponds to sections 260.0–440.0 mb.g.s. of the San Francisco 1 borehole.

The lithology is similar to that of the Palermo Member, although it is more homogeneous and has a much higher content of fine sediments, prevailing reddish brown clays and sandy mudstones, and a high proportion of gypsum and calcareous concretions. The sandy levels are sporadic and underdeveloped. Figure B.1 shows the mineralogical analysis of 13 samples with a similar average composition as the Palermo Member, although the contribution of basement minerals is slightly lower. The sand content is about one-third of the Palermo Member, indicating lower energy environments or scarce availability of sand.

The Pozo Del Tigre Member

This unit was found in some sites of the Chaco and Formosa provinces, and it was only described in the Pozo del Tigre 1 borehole. The Holostratotype is defined in the latter between 3.65 and 409.45 mb.g.s. The contact with the Paraná Formation is apparently transitional; the upper limit is very difficult to establish and is tentatively placed below the layer with abundant organic matter of the Holocene. The age is broadly estimated as Late Miocene-Quaternary.

It consists of alternating reddish brown mudstones and clayey sand, with abundant crystals of gypsum and calcareous concretions. The sharp increase in the percentage of monocrystalline quartz (Fig. B.1) with respect to the other members of this unit indicate a greater fluvial rework, as suggested also by the marked increase in the rate of sand. These sediments were poorly studied, but presumably at any sector of this member, they have started the settling of the huge alluvial fans that characterize the Chaco Plain during the Quaternary.

2.1.4.3 The Laguna Paiva Formation

The Laguna Paiva Formation is widely developed in the subsurface of the Chaco-Pampa Plain. It occupies an even larger area than the Paraná Formation and is an excellent guide level. The principle of priority is respected; therefore, it is herein formalized using the name given by Stappenbeck (1926) in the Laguna Paiva borehole. It represents the record of the first great Cenozoic transgression in central and northern Argentina.

Definition

Massive mudstones are usually olive-green, but with some sectors of dark gray to brown colors, and some reddish-brown interbedded layers and subordinate sandstones or loose sands. It has abundant gypsum and few calcareous microfossils and mollusk fragments. It was deposited unconformably over the Serra Geral Formation or older units, or it is transitional with the Palermo Member. The top is transitional with the San Francisco Member, except in the Pozo del Tigre 1 borehole, where the contact with the base of the Paraná Formation is erosive. Stappenbeck (1926) did not formally define the stratotype of the "*capas de Paiva*" but provided data of its distribution in several boreholes. Consequently, his criterion is respected, and thus the Lectostratotype is located between 324.10 and 601.56 mb.g.s. of the Laguna Paiva drilling. Stappenbeck confused the true location of the Paraná Formation in this borehole, assigning it to the green clays that appear at 324.10 mb.g.s., while it actually corresponds to the green clays located at 122.50 mb.g.s. The samples of the Laguna Paiva borehole are lost, but there is a good description of the original ones, and samples of other sites were also studied in detail. The Hypostratotypes were designated in the sections 175.7–200.0 mb.g.s. of the Riachuelo II and 506.05–697.30 mb.g.s. of the Pozo del Tigre 1 boreholes.

Overview

The Laguna Paiva Formation records the sedimentation of a very shallow sea over an extended period of time, with successive stages of flooding over the continental environment. The marine deposits of the TLP typically have a thickness of 100–

250 m and must have been deposited with significantly high sedimentation and subsidence rates. The stratigraphic sections (Figs. 2.7, 2.8 and 2.9) and the structural maps (Figs. 2.1, 2.2, 2.4, and 2.5) give an idea of the subsidence over some sectors of the Chacoparanense Basin between the beginning of the deposition of the TLP and the completion of the TEP, when the basin clogs. Some sectors had more subsidence than others and were maintained, although at a much lower rate after the completion of the TEP, as the depocenters of Lincoln, Rosario, Paraná, and the Salado Basin. The estimated thickness in the center of the Salado Basin is uncertain, and it possibly may be exaggerated due to the lack of adequate biostratigraphic control. The shallow nature of the TLP is exposed by frequent interbedding of continental sediments; by the association of foraminifera and ostracods; and by the abundance of gypsum, gyrogonites, and oolites in some drillings. Except for the Salado Basin, where some specimens of calcareous nannoplankton were found, the microfaunas are generally typical of very shallow environments and are tolerant to low salinity.

The mineralogy of 70 samples from six boreholes (Figs. 2.18 and B.2) is very similar to those of the Palermo and San Francisco Members and the Paraná Formation. This indicates a regular supply during the deposition of the Litoral Group, with a marked predominance of mesosilicic volcanic minerals, except in the Frías 1 borehole located near Pampeanas Ranges, wherein there is a slight increase in the provenance from the igneous-metamorphic basement. These features suggest very little reworking of the original materials.

Correlations

This unit is equivalent to the marine layers of the Mariano Boedo formation and probably to some subsurface levels of the Anta Formation, after the age assigned to the latter by Salfity and Marquillas (1999). It also corresponds to the top of the Las Chilcas Formation, but it is still impossible to determine the boundary, with older deposits at the center of the Salado Basin. Further south, it correlates with the Patagonian, especially with the *Leonense*—for example, the lower section of the Barranca Final Formation in the Colorado Basin, the Catalina and Gaiman Formations in northeastern Chubut, the Chenque Formation in the Golfo de San Jorge Basin, and the Monte León Formation in the Santa Cruz coast.

2.1.4.4 The Paraná Formation

This unit was originally defined by Bravard (1858), who referred to it as "marine terrains of Paraná or marine Paraná formation." He described two profiles near the city of Paraná and settled there its type area. Aceñolaza (2000) provided a complete summary of the distribution in the type area, the fossiliferous content, the lithology, and the synonymy. The integrated section of the Diamante area (Fig. A.3) is designated as Hypostratotype, complementing the knowledge of the Paraná Formation in an area with particular characteristics (Sect. 2.1.2.4).

Overview

The Paraná Formation has fairly uniform characteristics in all the areas of distribution. It is mainly composed of massive olive-green mudstones and clayey sandstone, with high content of mollusks and calcareous microfossils. In the Salado Basin, the base is erosive over the San Francisco Member, composed of coarse fossiliferous sand with abundant gravel size bioclasts, whereas the middle and upper sections are argillaceous. In southwestern Entre Ríos province, the Paraná Formation is much more complex because there are frequent sandy intercalations interpreted as the progradation of a deltaic system (Sect. 2.1.2.4).

It has a distribution similar to the Laguna Paiva Formation, although slightly reduced in area and thickness (Fig. 1.2), as it was deposited when the basin was partially in-filled. The retreat of the TEP marks the ending of the great Atlantic transgressions in southern South America; thereafter, only 50–150 m of continental sediments were deposited, with the exception of the center of the Salado Basin and the northern Chaco Plain, forming the current topography of the Chaco-Pampa Plain. The thickness is quite regular, between 50 and 100 m, with a maximum of about 200 m in northern Formosa and the center of the Paraná sub-basin; in the center of the Salado Basin, it is much thicker due to the persistence of the marine environment during most of the Neogene. Forty-nine samples of the light sand fraction were herein analyzed (Fig. B.2), which has very similar mineralogical characteristics to the Laguna Paiva Formation, with only a small increase of glauconite pellets and greater percentage of the sand fraction.

Correlations

Full synonymy is extensive for this unit; the different names received in the Chacoparanense Basin are available in Aceñolaza (2000). In other regions, it can be correlated with the upper section of the Barranca Final and Macachín Formations in the Colorado and Macachín basins, the Puerto Madryn Formation in northeastern Chubut, and the *Entrerriense* levels quoted in the Golfo de San Jorge. Historically, it has been correlated with the San José and Anta Formations of the NOA, although due to the dating of the Laguna Paiva Formation, more detailed studies are needed to determine if they correspond to the TLP or the TEP, as the described microfaunas are not diagnostic.

2.1.5 Regional Context of the TLP and TEP

The dating and knowledge of TLP distribution suggest profound changes in our understanding of the Chacoparanense Basin. It was thought that these deposits originated by a transgression of the Late Cretaceous or Early Paleogene. Consequently, it was considered that the continental deposits located under the TEP had an indefinite age, such as Paleocene–Middle Miocene. However, during most of this time, it seems that the Chacoparanense Basin was an upland composed of ancient rocks from the Precambrian Basement to the Early Cretaceous basalts (Figs. 2.7, 2.8 and 2.9), possibly a similar landscape to that of the present eastern Paraguay. The beginning of the subsidence during the Late Oligocene (Ramos 1999b) coincides with a sharp increase of the convergence in the active margin of the continent, which led to the beginning of the structuring of the Andes Ranges. However, the tectonic mechanisms that produced the subsidence in the Chacoparanense Basin, located 800 km from the active margin, are still unclear. Lima (2000) proposed the buckling of the lithosphere by lateral compression to explain the subsidence of the Pantanal Basin, a northern analogue of the Chacoparanense Basin. Dávila and Lithgow-Bertelloni (2013) considered that the Neogene actual subsidence of the Chacoparanense Basin was greater than that predicted by the flexural model, and the difference can be attributed to dynamic subsidence; the latter would be produced by mantle drag forces in the basement of the Pampas.

The ages of both transgressions reasonably correlate with two peaks of deformation in the Andes: the Pehuenche and Quechua I phases. These tectonic phases broadly correspond with an increase of convergence between the Nazca and South America Plates (Somoza 1998). As a result of orogenic activity, huge amounts of synorogenic deposits were produced (Fig. 2.19); the eastern expression of these deposits is recorded in the marine and continental deposits of the Litoral Group. Moreover, the volcanic activity increased significantly in the Andes around the Late Oligocene (from north to south: Pirurayo Volcanic Complex, Moreta Formation, Cerro Rajado Formation, Las Trancas Formation, Doña Ana Group, Hornillas Andesitic Breccia, Contreras Formation, Los Cerrillos Formation, and Molle Formation, among others), as recorded in the tuffaceous deposits at the base of the Palermo Member. The volcanism continued to be very active during the deposition of the entire Litoral Group (Fig. 2.18).

Both margins of the basin were subjected during the Neogene-Quaternary to west-east compressive lateral stresses; this situation is very clear along the western margin. It is generally considered that the eastern Pampeanas Ranges began to be structured during the Miocene (Ramos 1999b). However, the high proportion of basement debris in the Palermo Member in the Frías 1 borehole (Fig. B.1) indicates exposition of crystalline rocks by the Late Oligocene. The finding of possible Eocene continental deposits also suggests an early rise of the Sierra Chica de Córdoba (Astini et al. 2014). The distribution of the TLP and TEP suggests that the eastern margin of the basin was structurally controlled. The evolution of the filling of the Litoral Group (Figs. 2.1, 2.2, 2.4, 2.5, 2.13, and 2.14) indicates a west migration of the coastline during the Miocene. This migration could be attributed to the rise of the megablock of the Mesopotamia (Corrientes and Entre Rios provinces), limited by a north-south fault located approximately in the current course of the Paraná River, still active during the Quaternary (Marengo 2008). An analogous situation can be founded further north, where the eastern margin of the Pantanal Basin is being uplifted (Lima 2000).

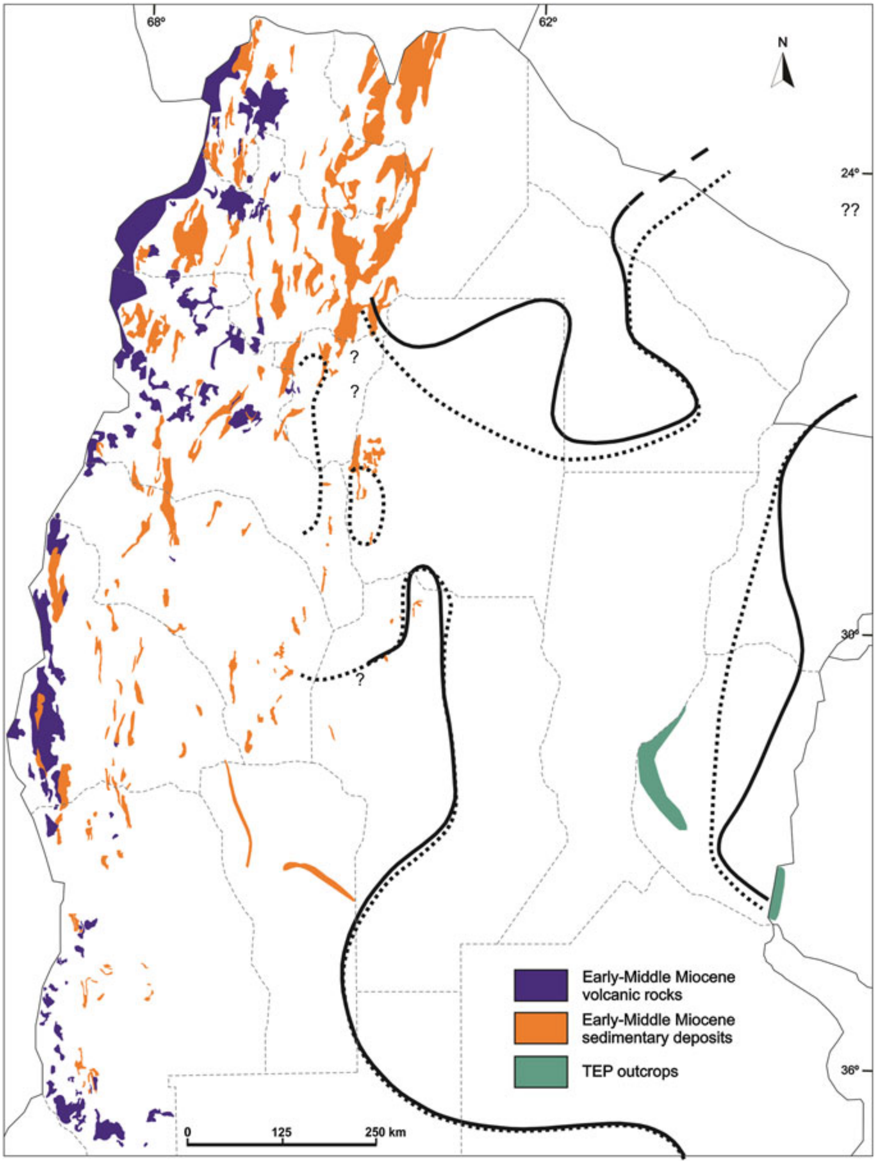

Fig. 2.19 Early–Middle Miocene outcrops in central-northern Argentina

2.2 Península de Valdés

2.2.1 Main Features of the Sections

Three sections in the area of the Península de Valdés were analyzed. They correspond to those studied by Scasso and del Río (1987), del Río et al. (2001), and Scasso et al. (2001), in Puerto Pirámide, Playa El Doradillo, and Eje Tentativo sites (Figs. 1.1 and A.13–A.15). These authors described in detail the profiles and the megafauna found in them, and they interpreted the lithofacies according to the relative height of sea level. Toward the west of Península de Valdés emerges the contact between the TEP or *Entrerriense* (Puerto Madryn Formation) and the underlying TLP or *Patagoniense* (Gaiman Formation). To the east of it, this contact is located under sea level and at the Lobería (i.e., a sea lion colony) of Puerto Pirámide, only the *Entrerriense* crops out. del Río et al. (2001) proposed a correlation of several of these profiles; they determined the most relevant paleobathymetric characteristics of each of the lithofacies from the study of the malacofauna assemblages and the physical continuity of some strata. These interpretations were corroborated in general by the micropaleontological analysis presented here, but due to the lack of appropriate microfaunas in many levels (by dissolution or incorrect exposure), a poorer definition was obtained.

In the Playa El Doradillo and Eje Tentativo sites (Figs. A.13 and A.15), the TEP is erosionally deposited over the *Patagoniense* beds. The lowest part of the TEP corresponds to the Transgressive Phase of del Río et al. (2001), at the end of which the maximum abundance of foraminifera and ostracods was recorded; this sector culminates in the Maximum Flooding Surface. The section continues in the Maximum Highstand Phase, with some secondary peaks in diversity and abundance of microfauna. Finally, the Regressive Phase of the section is recorded, including the upper portion of the *Entrerriense* and the *Rionegrense* units. The Maximum Highstand and Regressive Phases could not be identified unequivocally by the micropaleontological study, due to scarcity or poor preservation of the microfossils. In Playa El Doradillo, the Puerto Madryn Formation is much thinner than in the other two profiles, probably because it corresponds to environments closer to the coast subjected to reworking by waves. The contact between the *Entrerriense* and the *Patagoniense* beds is sharp. The abundance of boulders, intraclasts of the *Patagoniense*, and worn fragments of fossils at the base of the Puerto Madryn Formation clearly indicate the erosive surface. The contact between the *Entrerriense* and the *Rionegrense* is transitional. On the section at Puerto Pirámide (Fig. A.14), only the Puerto Madryn Formation outcrops, both its lower section and the top of the *Patagoniense* beds, are under sea level. The contact between the *Entrerriense* and the *Rionegrense* is transitional, lacking micropaleontological, sedimentological or any major mineralogical differences. According to Scasso and del Rio (1987), both informal units were deposited over the same sedimentary cycle in a regressive context.

The correlation of the microfossil and glauconite pellets abundance was attempted to identify significant eustatic variations. In Puerto Pirámide, there are three sectors with acceptable coincidence of both components (samples PP-1 to 4, PP-9 to 12, and PP-16 to 25), but they could be more due to covered sectors without samples. In the Eje Tentativo locality, the correlation is much better, with a peak of glauconite at the beginning of the transgression (ET-3), but with scarce microfossils probably due to strong dissolution; then, there is a sector with abundant microfossils and glauconite at the end of the Transgressive Phase and during the Maximum Highstand Phase (ET-15 to 20), and a third sector during the Maximum Highstand Phase and the onset of the Regressive Phase (ET-28 to 31). In the Playa El Doradillo site, the correlation was not good, probably because the high energy of the environment has inhibited the generation of glauconite pellets or has led to strong reworking.

2.2.2 Microfossils

In Eje Tentativo, the microfossils are generally well preserved but are frequently recrystallized; in some sections, they were subjected to a severe partial solution (samples ET-6 to ET-12), where the megafauna is scarce and only rusty molds were found. In the Puerto Pirámide and Playa El Doradillo localities, the preservation is even worse, so there is a higher degree of crystallization and partial dissolution. The distribution charts are shown in Figs. C.10–C.14.

2.2.2.1 Foraminifera

The foraminifera of the three profiles are characteristic of the *P. tuberculatum* informal zone (Malumián 1970), characterized by hyaline benthic foraminifera from shallow water, few miliolids and agglutinated, and very few planktonic species. Some taxa were found hitherto unrecorded in the TEP, such as *Uvigerina bifurcata*, *Pyrgo elongata*, *Marginulinopsis* sp., and *Asterigerinata* sp. In the locality of Puerto San José, two samples were taken within infaunal mollusks in life position, with the aim of knowing the occurrence of unmixed associations. Low-diversity microfaunas typical of the TEP were found, but with excellent preservation and a higher proportion of miliolids. According to del Río et al. (2001) the profile of Puerto San José locality is part of the Regressive Phase of the TEP.

The composition of the foraminiferal microfauna in the three profiles is generally not useful to paleobathymetric purposes, possibly due to the mixing of the assemblages by reworking of the sediment. However, the abundance of *Buliminella elegantissima*, from the base of the Puerto Madryn Formation in Playa El Doradillo (samples ED-3 and 4), is a good indicator of the transgressive conditions during the beginning of the TEP. *B. elegantissima* is an infaunal foraminifer found in very few TEP locations as an accessory component; in present and fossil examples, it usually has an opportunistic behavior with excellent development in environments subject to strong stress, sucg as as those generated during a fast marine transgression (Malumián and Caramés 1995). The taphonomic and sedimentological features of this part of the section are consistent with this interpretation (Scasso and del Río 1987, del Río et al. 2001).

In the tempestite levels of the samples ET-25 and ET-27 (del Río et al. 2001), four specimens of *Pachymagas pyramidesia* were collected. This is a terebratulid brachyopod generally found with closed valves, even in places where other marine megafossils have been transported by high-energy currents. These samples are named ET-S/N, ET-BC, ET-BM, and ET-BG; with the exception of the second one, they have provided microfaunas with higher diversity and abundance of foraminifera and ostracods. The ET-S/N sample has an association dominated by about 90 % of *Cibicides aknerianus*, a benthic foraminifer that lives attached to vegetation, typical of seagrass environments (Brasier 1975, Murray 1991). ET-BG has abundant microfauna with the greatest diversity of foraminifera and ostracoda found to date in the TEP in any location of Argentina, including several specimens of very recrystallized planktonic foraminifera. The ET-BM sample has a much less diverse and abundant assemblage than ET-S/N and ET-BG. It is striking that in the matrix of the tempestites, the microfossils are very scarce; the microfaunas inside the brachyopods, on the other hand, are very abundant, different from each other, and typical of very different environments. To date, a satisfactory explanation has not yet been found because the number of samples is small. A preliminary hypothesis suggests that the dead brachyopod specimens came originally from different areas of the platform, keeping inside the sediments (and consequently the microfossil assemblages) characteristics of each position in depth. Later, during stormy events, the concentration of the brachiopod shells may have taken place. These kinds of brachyopods have valves that can stick together during transport, and the globose form could favor their transport through the substrate during stormy events; also, the foramen located in the pedicle valve is wide enough to allow the entry of the sediment inside the shell.

2.2.2.2 Ostracoda

The ostracods were only classified in samples with more abundant and better preserved specimens. The systematic determinations and main stratigraphic and environmental conclusions follow those of Echevarría (2004) and Echevarría and Marengo (2005), and they were not included in Marengo (2006). The ostracods of the Puerto Madryn Formation have been poorly studied to date, despite being very abundant and highly diverse microfaunas. Rossi de García (1970) described some species of the site of Puerto Pirámides, whereas Bertels (1976) studied specimens of *Henhyhowella* aff. *evax* from the same site. The results from 29 fertile samples from the sections Eje Tentativo, Playa El Doradillo, Puerto San José, and Puerto Pirámides are shown in Figs. C.13–C.14. A total of 906 fairly to poorly preserved specimens were studied, which were classified into the orders Podocopida (46 genera, 100 species) and Platycopida (2 genera, 4 species).

In all sections, the sedimentation rate was moderate to high (but occasionally slightly low) due to the predominance of shells over valves. The scarcity of juvenile specimens suggests higher energy conditions. A shallow environment with variations of salinity is pointed out in *Perissocytheridea*, among other taxa. In Eje Tentativo, Playa El Doradillo, and Puerto Pirámides sites, the environmental features were similar, but *Callistocythere*, *Caudites* and *Munseyella* also suggest warmer waters. Among the species that could be accurately determined, 18 of them are known, in order of importance, from the Middle–Late Miocene of Entre Ríos and Santa Fe provinces and southern Brazil, the Holocene of Argentine and Brazil continental shelf, and the Late Oligocene–Early Miocene of Buenos Aires province and south-western Santa Cruz. They are also known from the Oligocene of south-central and eastern Santa Cruz province, the Late Miocene–Early Pliocene of eastern Río Negro and Chubut provinces, the Eocene and Miocene of eastern Tierra del Fuego, the Late Eocene–Early Oligocene of eastern Santa Cruz province, and the Holocene of southeastern Buenos Aires province.

2.2.3 Mineralogy and Paleoclimate

The detrital modes of the three sections reveal that most of the material came from areas associated with a transitional arc environment (Fig. 2.20). The abundance and good preservation of the volcanic lithic fragments, zoned plagioclase, and volcanic

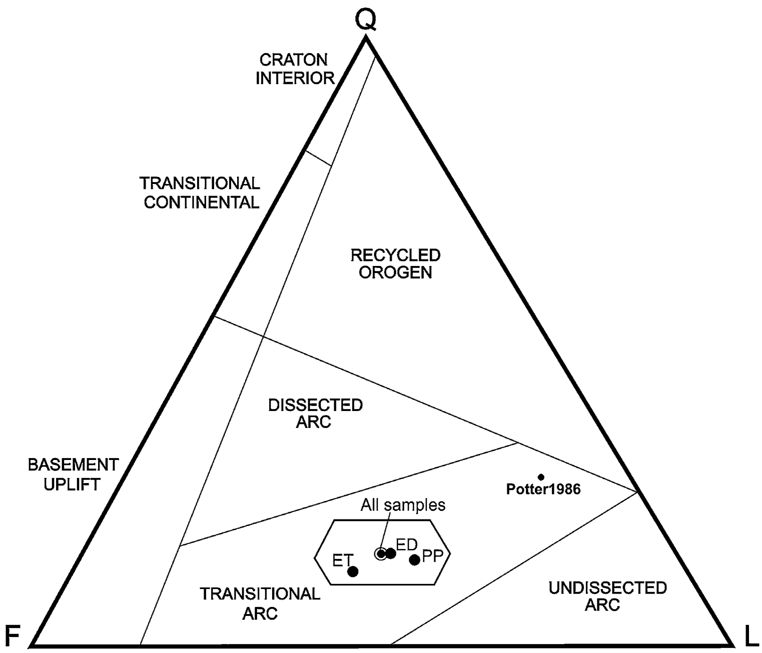

Fig. 2.20 ET, PP, and ED modal QFL analysis. Provenance tectonic features are according to Dickinson et al. (1983). The mean of each outcrop as well as the mean and the standard deviation of all the samples are shown. The mean value published by Potter (1986) is also shown

glass shards, mixed with poorly preserved minerals, would indicate that the clastic material was supplied by contemporary volcanic activity mixed with recycled or long transported volcaniclastics. The contribution of the basement rocks is quite low, with an apparent dominance of metamorphic over plutonic supply, as revealed by the composition of the heavy minerals. The abundance and excellent preservation of the hornblende and pyroxenes, particularly the hypersthene, are quite remarkable. The high roundness of the monocrystalline quartz contrasts sharply with the rest of the major components, suggesting that it was reworked; the marked variation in the abundance would indicate variation in the rate of sediment supply to the basin. In the QFL compositional triangle (Fig. 2.20), most of the samples, the mean of the profiles, and the standard deviation of all the samples are restricted to the field of transitional arc, whereas few samples plotted in the fields of undissected arc and dissected arc. Potter (1986) and Etchichury and Tófalo (1996) obtained similar compositions in their studies of Holocene sands in the Patagonian coast. They attributed this anomalous composition to the arid climate and the relative short distance to the Andean orogenic front. Teruggi and Andreis (1971) studied the stability of the minerals in recent sands of the Patagonian coast, attributing the higher concentration of amphibole and pyroxene to the lower chemical weathering as a result of the very arid climate. The similarity between the composition of the *Entrerriense* beds and current light and heavy minerals suggests that the dominant climatic conditions in the continent during the deposition of the TEP in northeastern Chubut were very similar to those in the Holocene.

Regarding the climatic characteristics inferred from mineral stability, it is interesting to briefly summarize the paleoclimatic background of the *Entrerriense* beds and related continental units. It is widely accepted that during the deposition of the *Entrerriense* units the climate was much warmer and wetter than today. In Mesopotamia (northeastern Argentina), this was amply corroborated by vertebrate faunas typical of the hot and humid climate (Gasparini 1968; Pascual and Odreman Rivas 1971; Gasparini and Báez 1975; Cione 1978) and by mollusks (del Río 1990). In Patagonia, although marine faunas of warm waters have been found (Cione 1978; del Río 1990), the finding of tropical to subtropical continental vertebrates is restricted almost exclusively to the lower section of the *Santacrucense* beds (Lower–Middle Miocene; Pascual and Odreman Rivas 1971; Tauber 1997). At the top of the *Santacrucense* and in the *Friasense* (Middle Miocene) beds, the vertebrates and palynomorphs (Volkheimer 1970; Pascual and Odreman Rivas 1971; Quattrocchio et al. 1988) indicate much drier conditions and markedly seasonal climate, and the sharp withdrawal of subtropical vertebrates. Palazzesi and Barreda (2005) and Palazzesi (2008) found pollen associations indicative of xerophytic and halophytic shrubs and herbs in the Puerto Madryn Formation. This is in contrast to the pollen found in the Gaiman Formation (Lower Miocene), which indicated the existence of nearshore forests. Consequently, the good correspondence between the mineralogical and paleontological information suggests that during the TEP, the climate in northern Patagonia was similar but probably slightly warmer than the present one.

A good correlation is observed in Figs. 2.21, 2.22 and 2.23 between the distribution of some minerals, such as the inverse ratio between green–brown

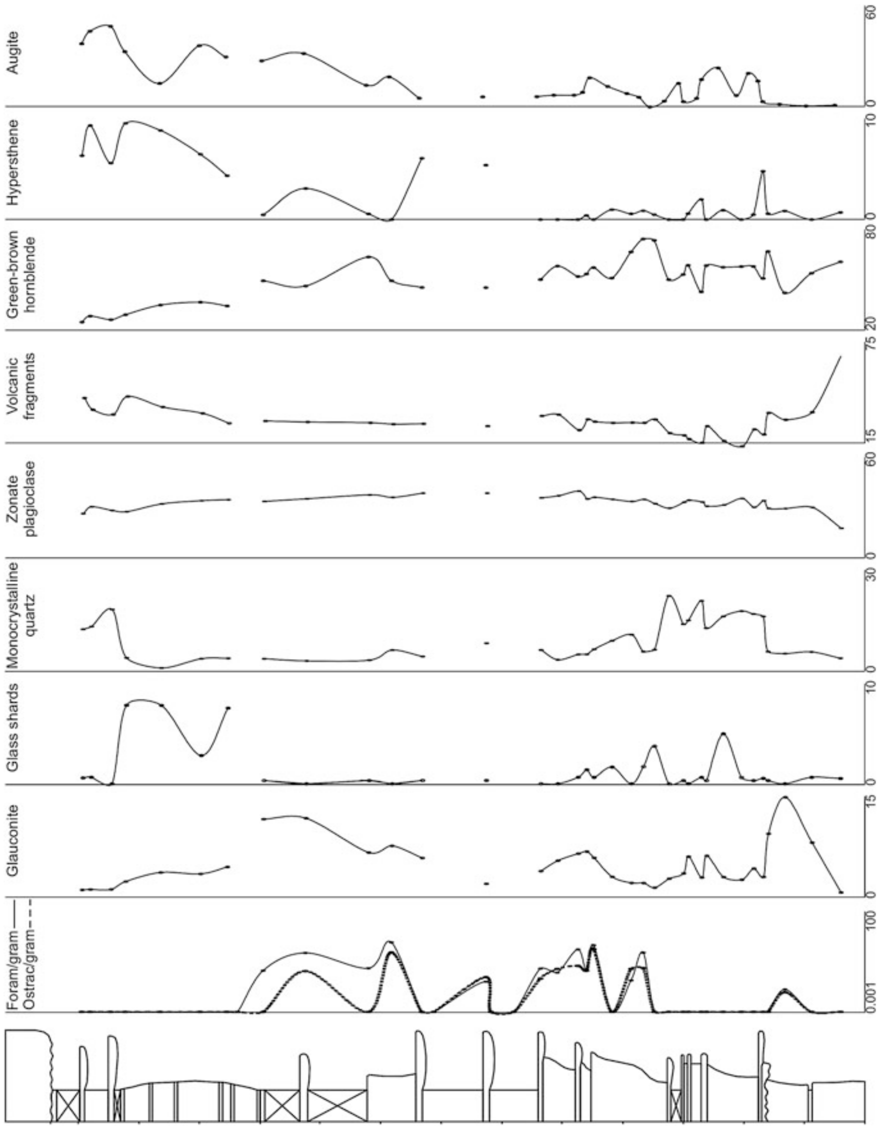

Fig. 2.21 Some minerals (in %) in the Eje Tentativo locality

hornblende and hypersthene or augite (the latter to a lesser degree); the inverse ratio between volcanic lithic fragments and zonal plagioclase; or the less obvious direct ratio between the zoned plagioclase and green brown hornblende. These variations have been interpreted as compositional changes of the contemporary volcanism (Marengo 1999). Comparison of the relative percentages of the components suggests that background volcaniclastic sedimentation was provided by older deposits or

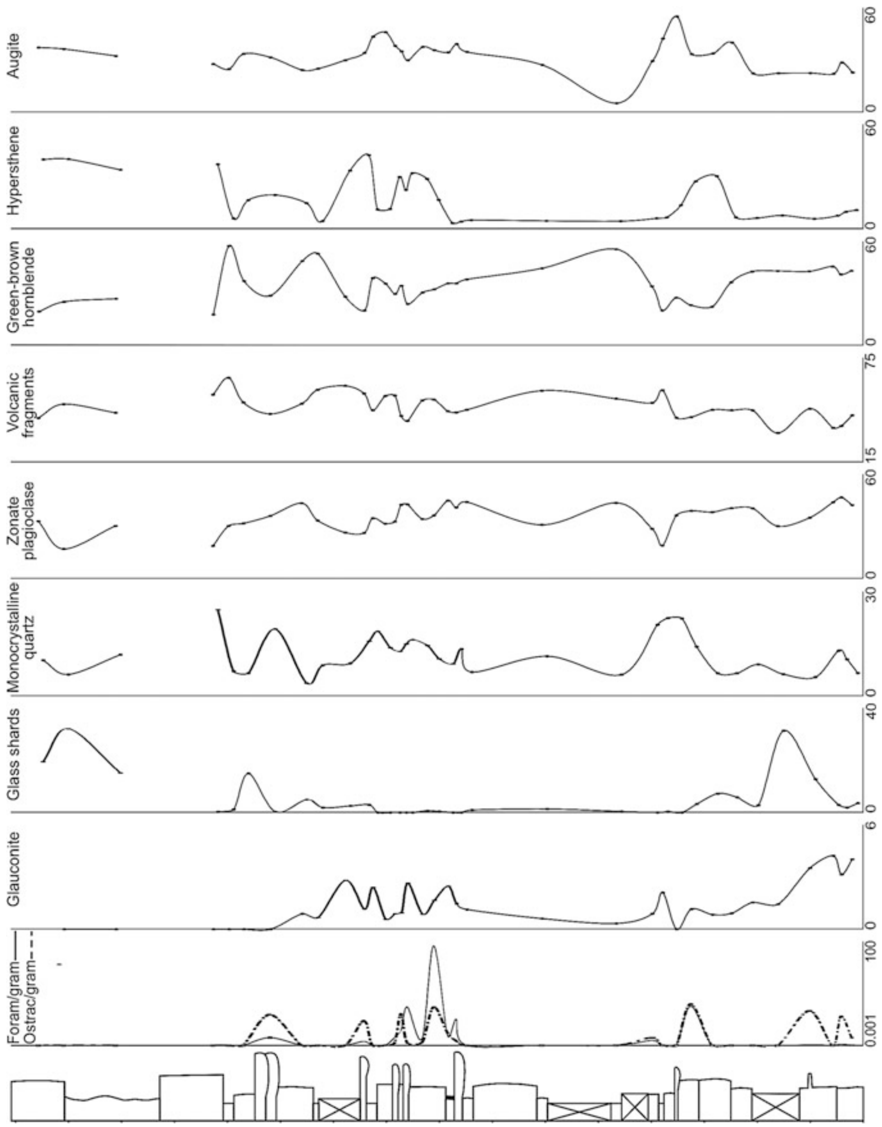

Fig. 2.22 Some minerals (in %) in the Puerto Pirámide locality

weathered volcanites located in the source areas, rich in zonal plagioclase, volcanic lithic fragments, green–brown hornblende, and augite. Contemporary volcanicastic rocks with compositions ranging between typical andesites to hypersthene-andesites or even basalts could have been added to the background composition. A pattern for the variation of glass shards was not found at the scale of sampling. The abundance of volcanic glass could be regulated by the high energy of the environment, because

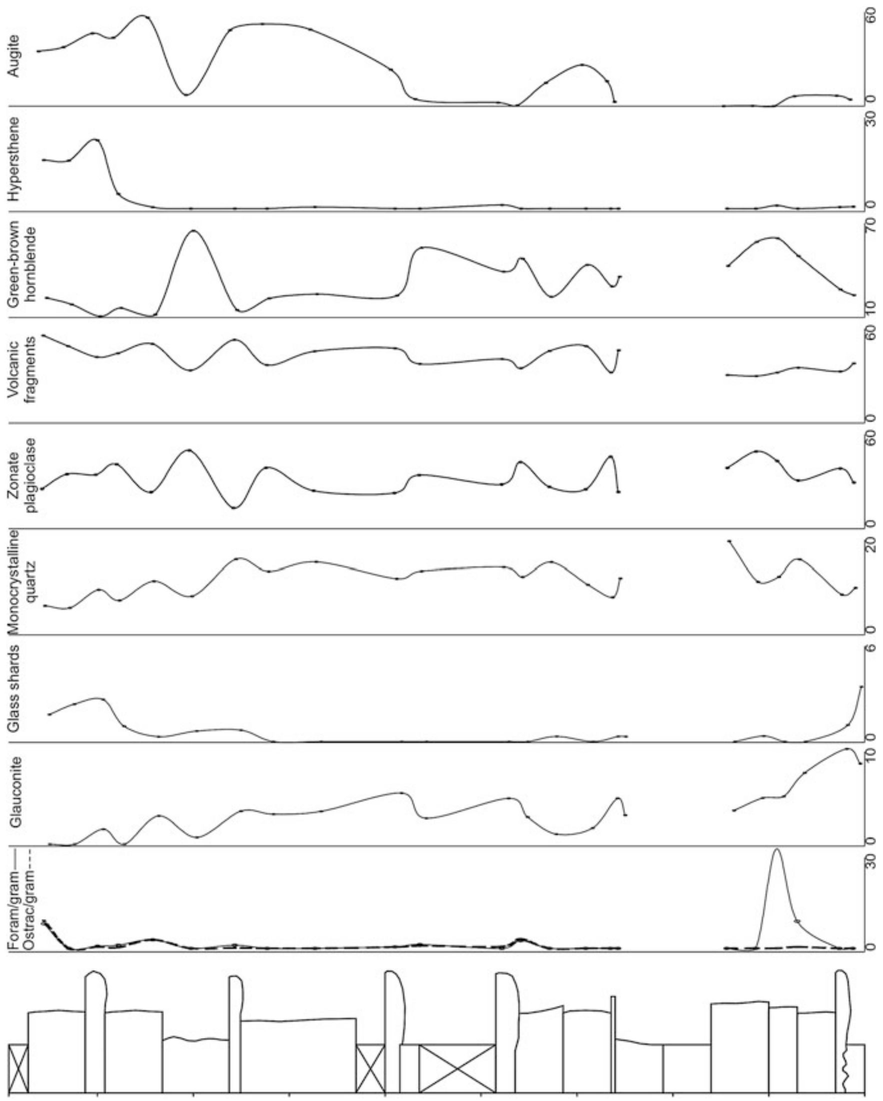

Fig. 2.23 Some minerals (in %) in the Playa El Doradillo locality

the lower density of the fragments allows the suspension and subsequent deposition in lower-energy places. In this sense, the increase of the percentage from Playa El Doradillo to Puerto Pirámide localities is noteworthy, and a decrease in the average marine energy between these locations can be assumed due to the paleogeographical location. Diagenetic causes to these variations were discarded because of the excellent preservation of the glass shards in nearly all samples.

Chapter 3
Conclusions

1. The micropaleontology and sedimentology of the Chacoparanense and Salado basins allowed us to distinguish two Miocene marine levels: the Transgression of Laguna Paiva (TLP) and the Transgression of the *Entrerriense-Paranense* (TEP). The first one was virtually unknown and erroneously correlated with the Maastrichtian-Danian marine ingression. No older marine deposits were found between the TLP and the basalts of the Serra Geral Formation.

2. The TLP was a shallow and warm-temperate sea that flooded the entire Chacoparanense Basin and western Corrientes and Entre Rios provinces, and which possibly extended up to Northwestern Argentina (NOA) and Cuyo regions. The microfaunas have low diversity and are of Neogene age, as indicated by *Ammonia*, *Peneroplis,* and some ostracods. The finding of calcareous nannoplankton allows the limitation of the TLP to the NP25–NN1 zones (Martini 1971), Chattian–Aquitanian (Late Oligocene–Early Miocene). The TLP can be bounded to about 25–21 Ma (Late Chattian–Aquitanian), taking into account the age of the fossils, the global eustatic variations, the deformation events on the western margin of the continent, and the age of the overlying deposits. The sedimentary record of the TLP has been formalized as the Laguna Paiva Formation (Stappenbeck 1926) and includes interbedded continental sediments. The TLP can be correlated with the *Patagoniense* transgression that flooded vast areas of Patagonia.

3. The TEP was a shallow hyposaline sea, colder than the TLP. In some sectors of the Salado Basin, there were moments of open water with abundant planktonic foraminifera and calcareous nannoplankton. The benthic foraminifera belong to the *P. tuberculatum* informal zone, of Middle–Late Miocene age. Some specimens of planktonic foraminifera allow us to broadly bound the age of the TEP to the Middle Miocene. The first finding of calcareous nannoplankton for the TEP allowed the restriction of the middle section of the TEP in the Salado Basin to the NN6 zone (Martini 1971; Young 1998), Middle Miocene. The complete age can be estimated with acceptable accuracy between 15 and 9.5 Ma, with the aid of indirect correlation tools, such as the global eustatic curve and the South America/Nazca convergence curves. The maximum depths and/or the normal salinities would have

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been reached for short periods in the Salado Basin, central and southern Santa Fe, and southwestern Entre Ríos provinces. The geographical distribution of the microfossils and mollusks indicates undoubtedly that the faunas entered from the Atlantic Ocean and were sharply impoverished towards the continental hinterland, probably due to a decrease in depth and salinity. Therefore, the migration from the Caribbean Sea would have been impossible through the hypothetical intracontinental seaway known as The Arm of Tethys, and it is much more likely that the migration took place through the Atlantic Ocean continental shelf.

4. The discovery of fossils, the dating of the TLP, and the precise dating of the TEP posed profound changes in the understanding of the sedimentary in-filling of the Chacoparanense Basin. With the exception of some places with possible Cretaceous or Paleogene continental deposits, the region was an upland with outcrops of rocks with different ages, from the Precambrian basement to Early Cretaceous basaltic flows. By 26 Ma (Late Oligocene), the dynamic subsidence related to the Andean tectonism started, which reactivated the depocenters of the Paleozoic and Mesozoic basins. This new topography enables the income of the sea during the immediate eustatic rise during the Late Chattian, registered in the deposits of the TLP. Thereafter, a decline in the rate of subsidence by 20 Ma would have prevented the flooding of the basin during the Burdigalian eustatic high. Around 15 Ma, there was an increase in the deformation rate and a new eustatic rise, allowing the flood of the basin during the Late Langhian and the entire Serravallian, while the sediments of the TEP or Paraná Formation were being deposited. During the Tortonian, the basin was almost filled up and most of the subsidence ceased, preventing the access of the sea during the highstand periods of the Late Cenozoic beyond areas closer to the coast.

5. The Chaco Formation is composed of continental sediments deposited below the TLP (the Palermo Member), between the TLP and TEP (the San Francisco Member), and above the TLP in the Chaco Plain (the Pozo del Tigre Member). In the center of the Chaco Plain, the continental sedimentation was continuous, without marine intercalations or internal discontinuities, and therefore the Chaco Formation integrated a single lithostratigraphic unit. The Chaco, Laguna Paiva, and Paraná formations have been included in the Litoral Group.

6. The foraminifera of the TEP in the Península de Valdés area are characteristic of the *P. tuberculatum* informal zone, dominated by *C. discoidale*, *P. tuberculatum*, *B. peruviana*, *A. parkinsoniana*, *C. aknerianus*, *G. ovula,* and *Quinqueloculina* spp, with very few agglutinated and planktonic specimens. Previously unknown species were found in the TEP, such as *U. bifurcata*, *P. elongata*, *Marginulinopsis* sp., and *Asterigerinata* sp. The variation in the abundance of microfossils and glauconite pellets roughly indicates major eustatic variations of the TEP in this region, which are consistent with those obtained from marine megafauna assemblages. The TEP began with a transgressive surface clearly indicated by the abundance of *B. elegantissima* in the Playa El Doradillo site. Subsequently, the samples with greater diversity and abundance of microfossils in the Eje Tentativo and Playa El Doradillo localities coincide with the Maximum Flooding Surface (del Río et al. 2001). Later, the microfaunas became gradually impoverished, in conjunction with other regressive

evidence, until the complete continentalization of the region took place during the end of the *Rionegrense* stage.

7. The mineralogy of the TEP in the Península de Valdés area reveals a provenance mainly related to transitional to dissected arcs, with very little contribution from basement areas. The mineralogical composition of the TEP is very similar to the present sand on the Patagonian coasts; combined with the excellent preservation of very labile minerals such as hypersthene, this suggests little difference between the paleoclimate of northern Patagonia during the TEP and the current climate. These data are consistent with paleontological evidence from Middle Miocene continental deposits, indicating a marked aridity of the region from the end of the deposition of the Patagonian beds during the Early Miocene.

Appendix A
Profiles

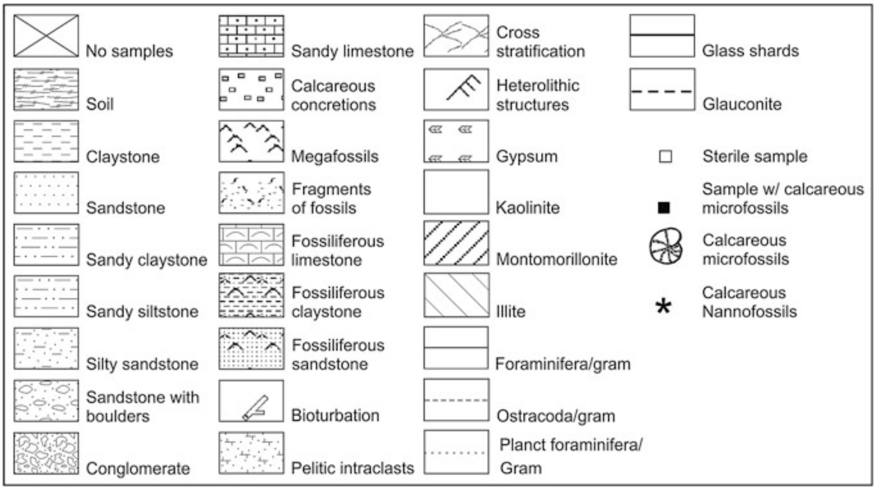

Fig. A.1 Symbols used in Figs. A.2, A.3, A.4, A.5, A.6, A.7, A.8, A.9, A.10, A.11, A.12, A.13, A.14 and A.15

Entre Ríos Province

Borehole:	**Puerto Diamante 3 (PPD3)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	1930s
LOCATION:	Regimiento 3 de Artillería, Diamante
SAMPLING METHOD:	Grab samples
ELEVATION (m over the Riachuelo):	56.44
MAXIMUM DEPTH (mb.g.s.):	74.80
ORIGINAL DESCRIPTION:	E Wahnish
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

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Summary of levels from the original description, Obra Nº 848 (SEGEMAR), complemented by own lithological and paleontological observations. Samples with microfossils are in bold characters.

0.0–7.8 Dark soil, sandy, calcareous nodules
7.8–25.2 Brownish to reddish mudstone with calcareous nodules. Yellowish brown to greenish sand, some clay
25.2–29.5 Whitish, very hard calcareous level
29.5–45.7 Light-green calcareous mudstone with abundant calcareous nodules. Light-green sandy mudstone
45.7–52.65 Grayish green sandy mudstone, undeterminable mollusk fragments
52.65–60.3 Brownish to yellowish medium sandstone, green clay. **PPD3 15** moderately preserved benthic foraminifera. **PPD3 16-20** benthic foraminifera and ostracods with moderate to bad preservation. Diatoms, bryozoans, *Ostrea* sp., *Balanus* sp., undeterminable mollusk fragments
66.3–67.8 Greenish-brown silty sandstone
67.8–74.8 Yellowish to pinkish medium sandstone, with scarce calcareous nodules

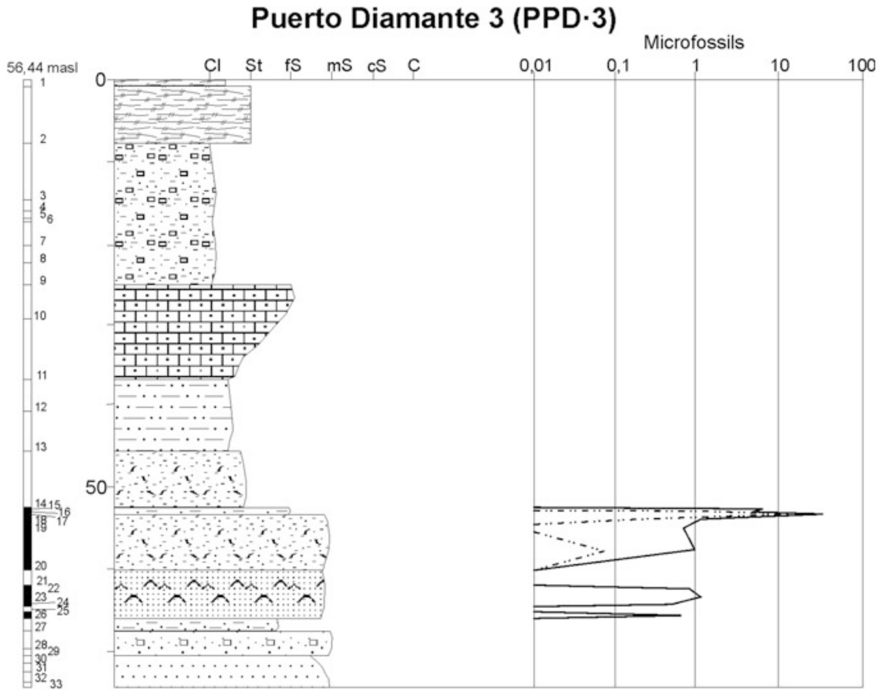

Fig. A.2 Log of PPD3 borehole. Microfossil distribution in number of specimens/gram of sample

Integrated Profile of Diamante

Because the intervals between samples are irregular, to obtain an average-cross section of the area, the well samples of Puerto Diamante 1, 2, and 3 and Diamante 1 boreholes were studied. All samples belong to SEGEMAR.

The exact geographical location is unknown; for the Puerto Diamante 1, 2, and 3 boreholes, the elevation over the level of the Riachuelo (m.a.0m) is known. It is assumed that all the sites are enough closely together, so it is assumed that they lack significant stratigraphic differences. The information obtained from the original descriptions is supplemented with outcropping data by Pisetta (1968) and Zabert and Herbst (1977). The top is located at 56.44 m.a.0m, and it is estimated that the medium level of the Paraná River is approximately at 60 mb.g.s.

RECENT

0.0–0.7 Dark soil

HERNANDARIAS FORMATION

0.7–25.0 Light reddish-brown masive silt and claystone with small calcareous nodules

ITUZAINGÓ FORMATION

25.0–37.0 Yellowish-grey medium sandstone with calcareous cement

PARANÁ FORMATION

37.0–47.0 Light olive-green mudstone, occasionally laminated, with calcareous concretions and gypsum crystals

47.0–52.0 Yellowish-gray, very fine, poorly selected, and very friable sandstone. Numerous fragments of pelecypods and some small oysters up to 3 cm. Bryozoans, abundant foraminifera and ostracods, generally well preserved, except in the case of miliolids, which are partially dissolved

52.0–61.0 Well-selected and friable, medium-grained yellow sandstone. Some fragments of oysters and other indeterminable mollusks. Few foraminifera and ostracods, generally recrystallized

61.0–85.0 Yellowish-green to yellow friable sandstone, with thin interbedded dark shale. Fragments of very recrystallized oysters. Very few highly recrystallized foraminifera and ostracods. In some samples, very little mineralized wood fragments up to 2 cm

85.0–97.5 Greenish-gray silty sandstone, interbedded with olive-green sandy mudstone

CHACO FORMATION, SAN FRANCISCO MEMBER

97.5–101.0 Dark greenish-brown mudstone with calcareous concretions

101.0–143.0 Dark reddish-brown mudstone with calcareous concretions and gypsum crystal at the bottom

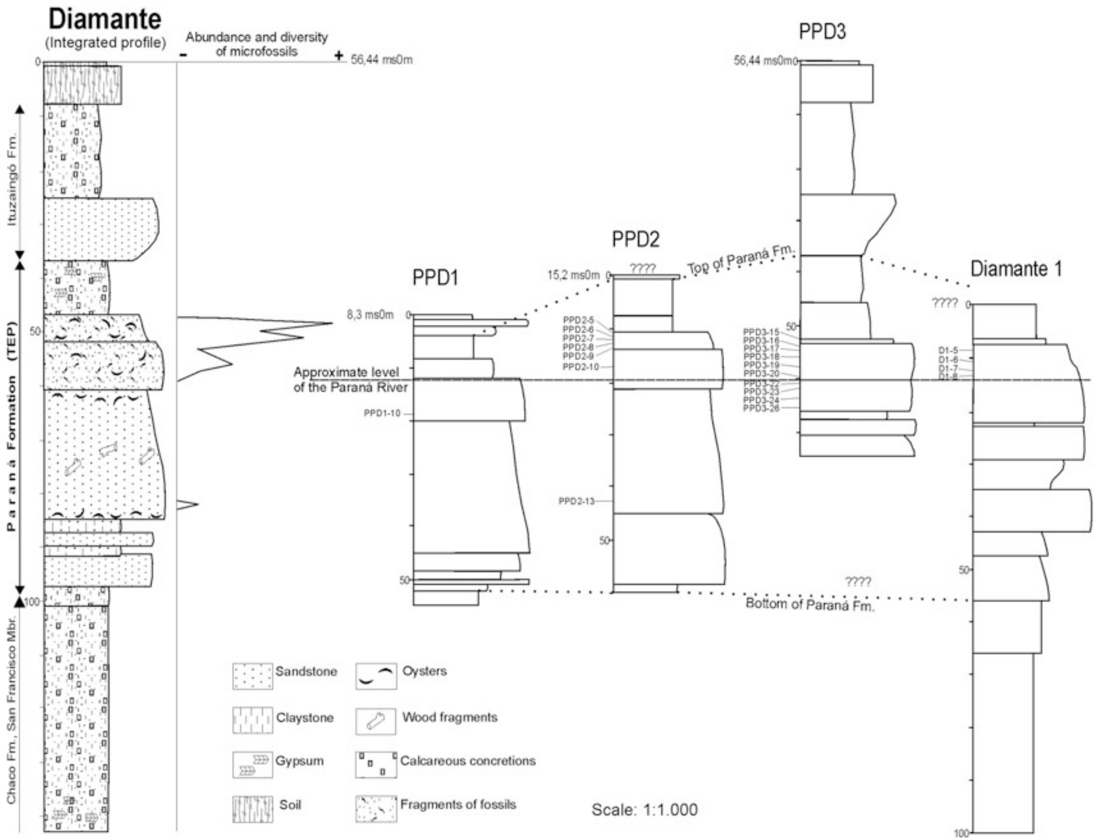

Fig. A.3 Integrated section from the Diamante area. Correlation between PPD-1, 2, and 3, and Diamante 1 boreholes

Córdoba Province

Borehole:	**Ordóñez 3 (O3)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	before 1926
LOCATION:	Ordóñez, Córdoba
SAMPLING METHOD:	grab, cutting, cores
ELEVATION (ma.s.l.):	132
MAX DEPTH (mb.g.s.):	616.9
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

PAMPEAN SEDIMENTS-ITUZAINGÓ FORMATION

0–40.0 Dark loessoid soil with small calcareous nodules
40.0–119.0 Light-brown sandy loess
119.0–160.0 Reddish-brown massive shale with small calcareous nodules
160.0–193.0 Reddish-brown, medium to fine grained, quartz sand

PARANÁ FORMATION

193.0–237.0 Olive-green massive shale toward the bottom interbedded with reddish brown shale. Abundant glauconite pellets and microcrystalline aggregates of pyrite. Few fragments of shells
237.0–241.5 Reddish-brown, very friable silty sandstone, interbedded with olive-green silty sand. Few glauconite pellets and microcrystalline aggregates of pyrite. Few fragments of shells and very few poorly preserved foraminifera at **237.5–238.5** mb.g.s. (sample **16**)

CHACO FORMATION, SAN FRANCISCO MEMBER

241.5–265.0 Reddish-brown massive shale
265.0–340.0 Reddish-brown massive shale with abundant gypsum crystals
340.0–409.0 Reddish-brown massive sandy shale; abundant gypsum crystals and few calcareous concretions

LAGUNA PAIVA FORMATION

409.0–490.0 Alternating reddish-brown and olive-green massive shale. Very few foraminifera, pyritized and with partial dissolution, at **409.0–414.2** and **480.0–490.0** mb.g.s. (samples **30** and **38**)
490.0–510.0 Alternating reddish-brown and olive-green massive shale, with abundant gypsum crystals
510.0–616.9 Alternating reddish-brown and olive-green massive shale. Very scarce foraminifera, ostracods and microgastropoda, pyritized and with moderate dissolution, at **520.0–530.0** and **540.0–550.0** mb.g.s. (samples **42** and **44**)

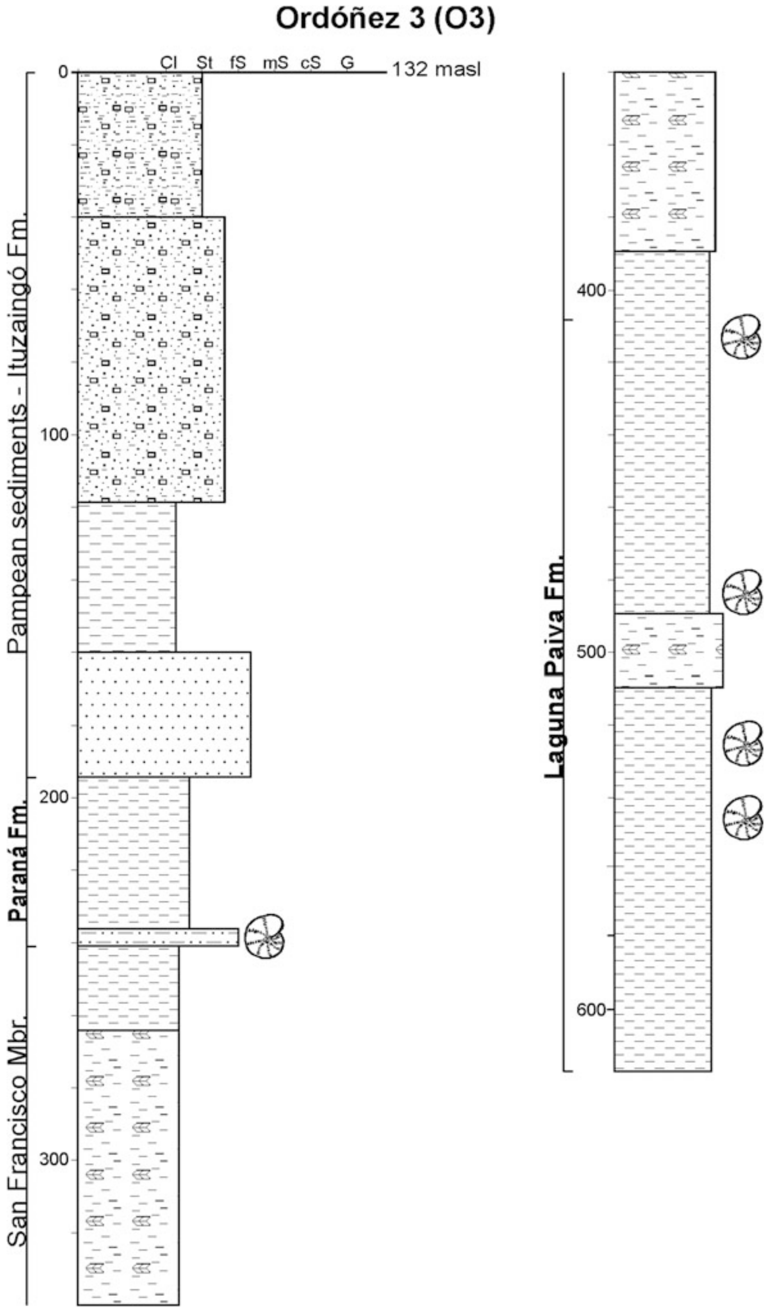

Fig. A.4 Log of Ordóñez 3 borehole

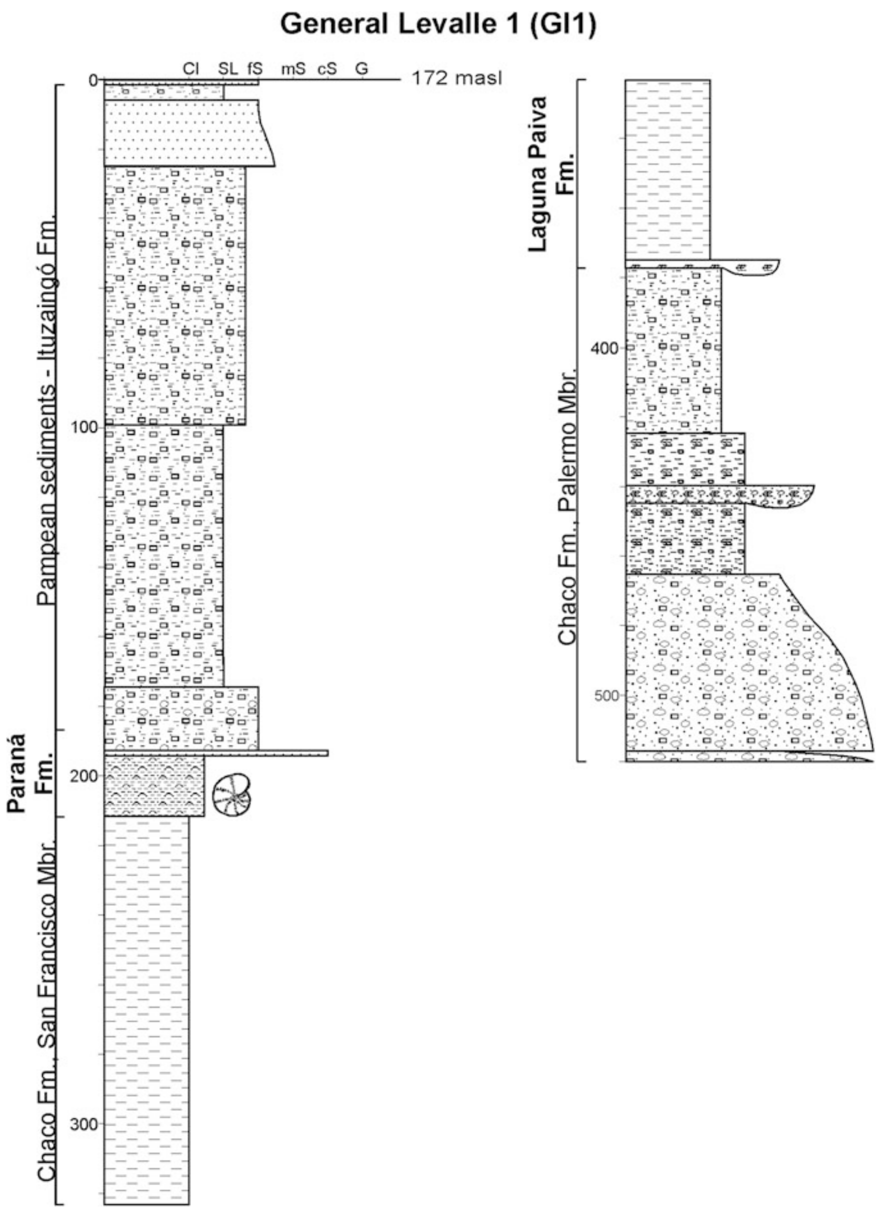

Fig. A.5 Log of General Levalle 1 borehole

Borehole:	**General Levalle 1 (GL1)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	unknown
LOCATION:	General Levalle, Córdoba
SAMPLING METHOD:	grab samples, cutting, and cores
ELEVATION (ma.s.l.):	172
MAX. DEPTH (mb.g.s.):	520.7
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

PAMPEAN SEDIMENTS-ITUZAINGÓ FORMATION

0–1.5 Brown, fine-grained sand
1.5–3.3 Yellowish-brown argillaceous calcrete
3.3–25.0 Yellowish-brown sandy loess, with boulders in the bottom
25.0–178.6 Friable sandy loess with calcareous concretions
178.6–187.4 Dark-brown sandy shale with concretions and small boulders

PARANÁ FORMATION

187.4–193.4 Olive-green massive sandy shale with concretions and small boulders
193.4–203.6 Olive-green coarse sand and massive sandy shale with small boulders
203.6–212.4 Olive-green massive shale. Abundant fragments of bioeroded shells. Few pyritized foraminifera (sample **19**)

CHACO FORMATION, SAN FRANCISCO MEMBER

212.4–324.2 Reddish-brown massive sandy shale

LAGUNA PAIVA FORMATION

324.2–376.2 Reddish-brown and olive-green sandy shale, with gypsum crystals

CHACO FORMATION, PALERMO MEMBER

376.2–377.5 Very big and clear crystals of gypsum
377.5–441.3 Brown sandy marl with gypsum crystals
441.3–446.4 Brown, very coarse sand with gypsum crystals
446.4–520.7 Reddish-brown friable argillaceous sandstone; small boulders, calcareous concretions, and gypsum crystals

Borehole:	**San Francisco 1 (SF1)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	unknown
LOCATION:	San Francisco, Córdoba
SAMPLING METHOD:	grab samples and cutting
ELEVATION (ma.s.l.):	103

MAX DEPTH (mb.g.s.): 680.0
ORIGINAL DESCRIPTION: R Stappenbeck
REPOSITORY: SEGEMAR
QUALITY OF THE SAMPLES: good

RECENT-PAMPEAN SEDIMENTS

0–100.0 Reddish to yellowish, coarse to fine-grained sand, with calcareous nodules

ITUZAINGÓ FORMATION

100.0–120.0 Light yellowish-brown friable sandstone
120.0–130.0 Yellowish-grey massive shale
130.0–140.0 Light yellowish-brown, fine-grained sand, with calcareous nodules

PARANÁ FORMATION

140.0–150.0 White medium-grained sand and olive-green shale
150.0–167.0 Olive-green clayey sand. Abundant shell fragments. Abundant foraminifera moderately preserved (samples **13** and **14**)
167.0–235.0 Olive-green massive shale. Abundant shell fragments. Abundant foraminifera and few ostracods moderately preserved and usually recrystallized at **167–180**, **180–190**, **190–200**, **200–220**, and **220–235** mb.g.s. (**15**–**19**)
235.0–260.0 Olive-green massive sandy shale. Abundant shell fragments. Abundant foraminifera and few ostracods well preserved, at **235–250** mb.g.s. (**20**)

CHACO FORMATION, SAN FRANCISCO MEMBER

260.0–270.0 Reddish-grey clayey sand
270.0–290.0 Reddish-brown massive shale, with gypsum crystals and calcareous concretions
290.0–300.0 Reddish-brown sand
300.0–398.0 Reddish-brown massive shale, with gypsum crystals and calcareous concretions
398.0–400.0 Yellowish limonitic fine-grained sand
400.0–430.0 Reddish-brown clayey sand, with calcareous concretions
430.0–440.0 Reddish-brown massive shale

LAGUNA PAIVA FORMATION

440.0–560.0 Olive-green and reddish-brown massive shale with calcareous concretions. Few moderately preserved foraminifera and ostracods at **440–480** and **490–560** mb.g.s. (samples **41–44**, **46–52**). Abundant well-preserved oogonia of charophytes at 440–450, 450–460, 490–500, and 500–510 mb.g.s. (41, 42, 46, and 47)
560.0–580.0 Reddish-brown massive sandy shale. Very few moderately preserved foraminifera and ostracods at **570–580** mb.g.s. (**54**)

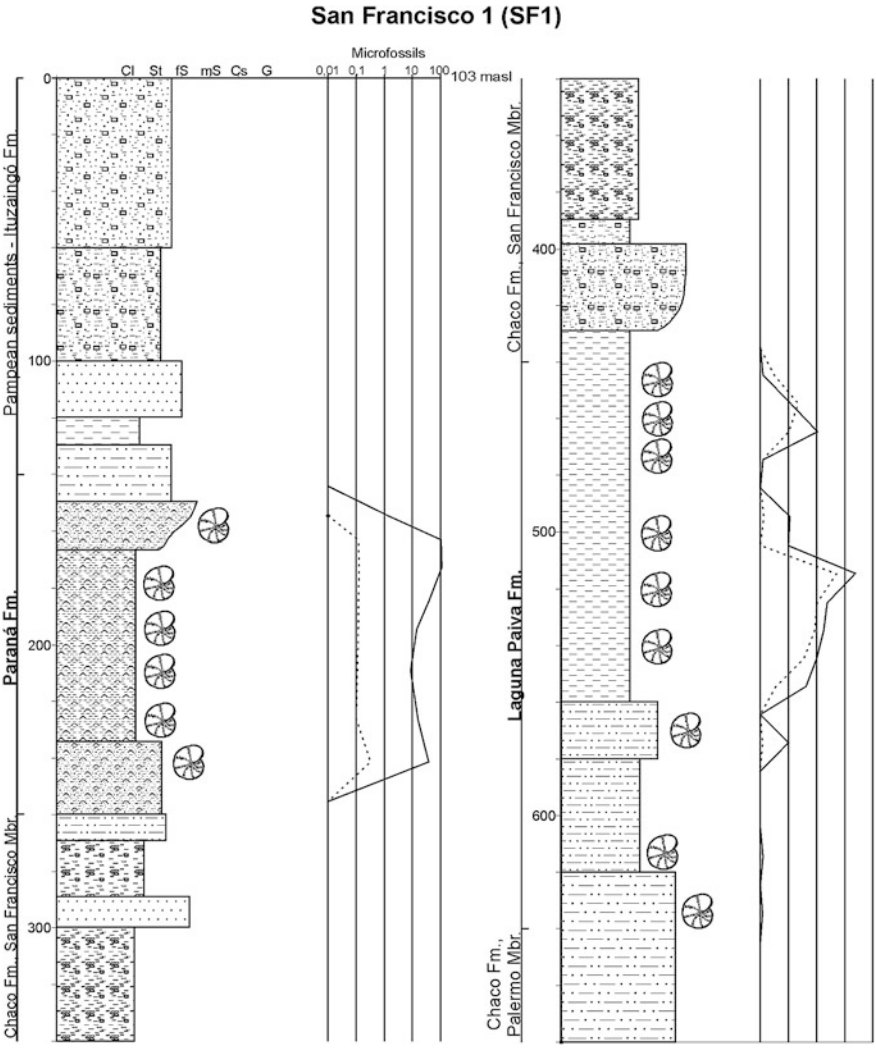

Fig. A.6 Log of San Francisco 1 borehole. Microfossil distribution in specimen number/gram of sample

580.0–620.0 Olive-green and reddish-brown massive shale with calcareous concretions. Few moderately preserved foraminifera and very abundant oolites, at **610–620** mb.g.s. (**58**)
620.0–640.0 Olive-green massive sandy shale. Very few moderately preserved foraminifera and ostracods, and abundant oolites, at **630–640** mb.g.s. (**60**)

CHACO FORMATION, PALERMO MEMBER

640.0–680.0 Yellowish-brown clayey sand with calcareous concretions

Santiago del Estero Province

Borehole:	**Selva 2 (S2)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	before 1926
LOCATION:	Selva, Santiago del Estero
SAMPLING METHOD:	grab samples
ELEVATION (ma.s.l.):	84
MAX DEPTH (mb.g.s.):	630.0
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

PAMPEAN SEDIMENTS—ITUZAINGÓ FORMATION

0–0.4 Black soil with abundant organic matter
0.4–37.5 Dark brown loess with calcareous concretions
37.5–38.5 Grey argillaceous calcrete
38.5–55.5 Grey massive clay
55.5–57.0 Yellowish-grey massive clay with calcareous concretions
57.0–64.8 Yellowish-brown quartz sand with gypsum crystals
64.8–93.0 Reddish-brown massive mudstone
93.0–101.0 Grey mudstone with gypsum crystals

PARANÁ FORMATION

101.0–163.0 Olive-green massive shale. Shell fragments. Abundant well-preserved foraminifera at **125.7–143.7** mb.g.s. (sample **24**)
163.0–164.7 No sample
164.7–204.75 Olive-green massive shale. Shell fragments. Abundant well to moderate preserved foraminifera and ostracods at **164.7–199.25**, and **201.45–204.75** mb.g.s. (samples **30**, **31**, and **33**)
204.75–207.7 Dark grey shale

CHACO FORMATION, SAN FRANCISCO MEMBER

207.7–219.5 Massive yellowish-brown fine sand with gypsum crystals
219.5–278.5 Grey massive shale with gypsum crystals and calcareous concretions
278.5–283.0 Bluish-grey massive shale with gypsum crystals
283.0–301.2 Grey to reddish-brown massive shale. Gypsum crystals, calcareous concretions and few boulders
301.2–308.5 Bluish-grey massive calcareous shale
308.5–337.2 Grey to reddish-brown massive shale with gypsum crystals and calcareous concretions

LAGUNA PAIVA FORMATION

337.2–357.2 Olive-green to reddish-brown massive shale with gypsum crystals and calcareous concretions
357.2–366.0 Olive-green to reddish-brown massive shale
366.0–407.0 Reddish-brown massive shale, some sectors with sand
407.0–425.1 Olive-green to reddish-brown massive shale

Santa Fe Province

Borehole:	**YPF San Cristóbal 1 (SC1)**
OPERATOR:	YPF
DATE:	unknown
LOCATION:	San Cristóbal, Santa Fe
SAMPLING METHOD:	cutting and cores
ELEVATION (ma.s.l.):	70
MAX DEPTH (mb.g.s.):	785.0
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

PAMPEAN SEDIMENTS

0–1.5 Black soil with organic matter
1.5–26.0 Reddish-brown massive shale
26.0–28.0 Olive-green to reddish-brown massive shale, with calcareous nodules
28.0–52.0 Olive-green to greyish-brown massive shale

PARANÁ FORMATION

52.0–88.0 Olive-green massive shale
88.0–100.0 Dark olive-green massive shale. Few poorly preserved foraminifera (sample **6**)
100.0–114.0 Greenish-brown silty sand
150.0–155.0 Dark olive-green massive shale
200.0–205.0 Light olive-green massive shale

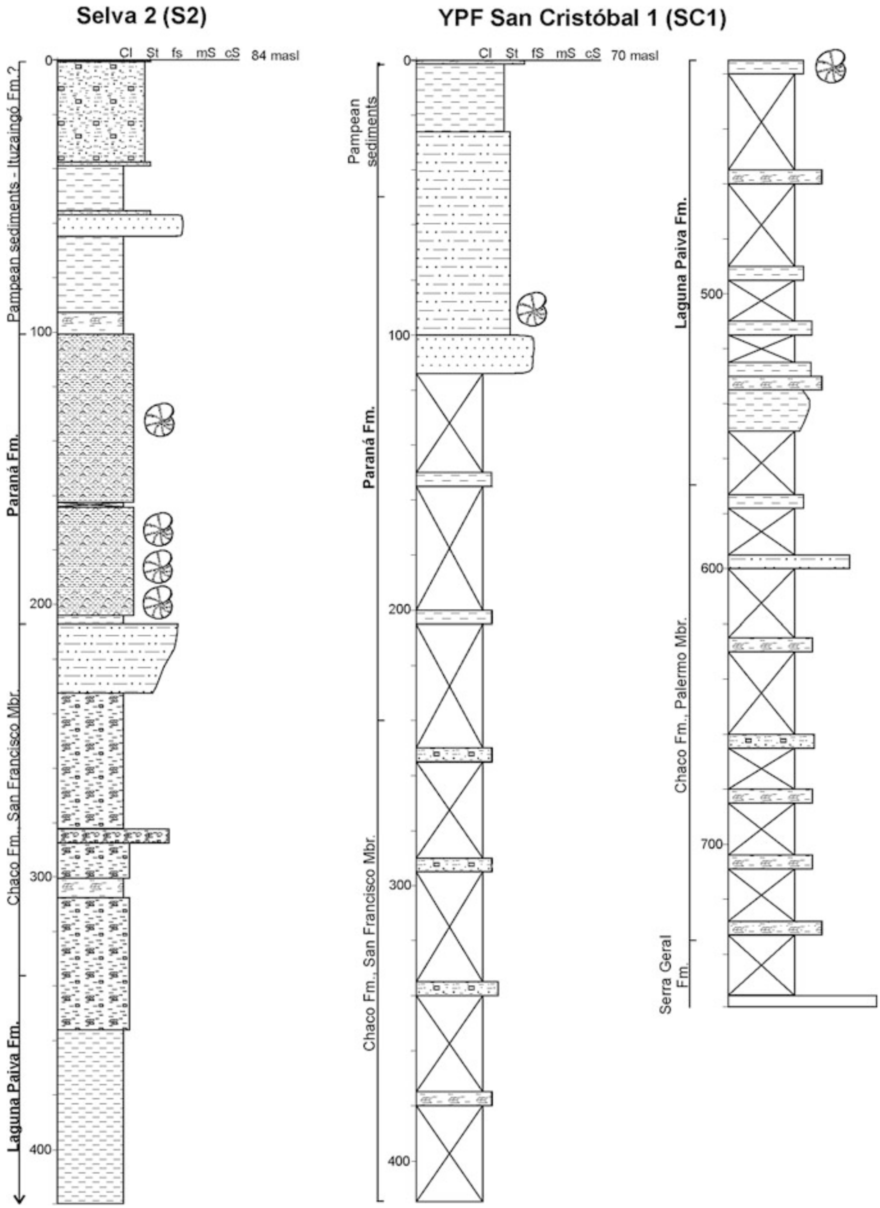

Fig. A.7 Log of Selva 2 and YPF San Cristóbal 1 boreholes

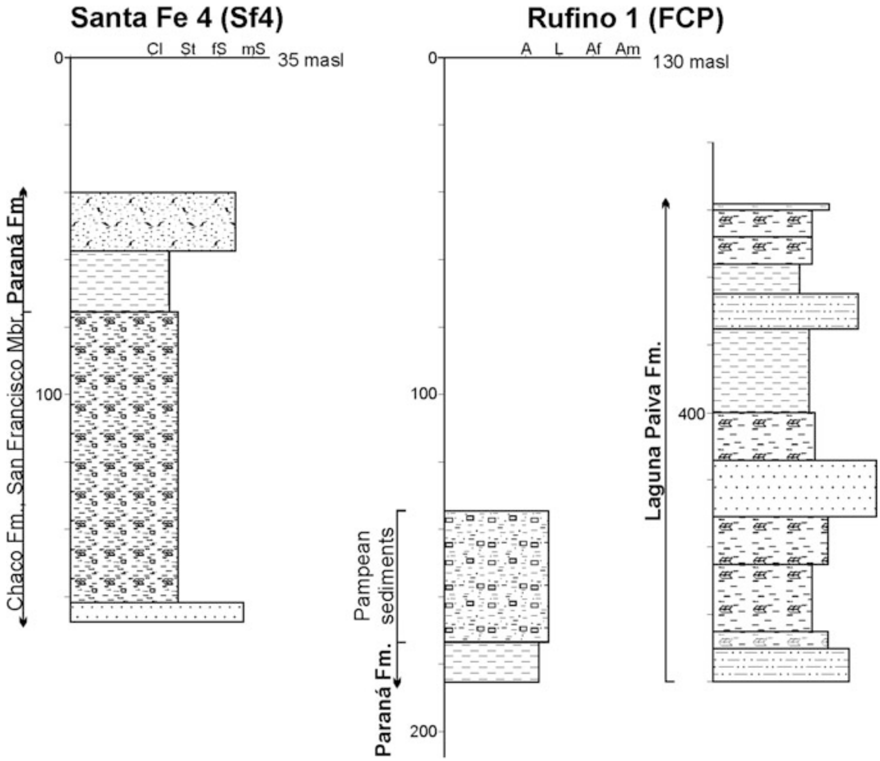

Fig. A.8 Log of Santa Fe 4 and Rufino 1 (FCP) boreholes

CHACO FORMATION, SAN FRANCISCO MEMBER

250.0–255.0 Olive-green to reddish-brown massive shale, with calcareous nodules
290.0–340.0 Light reddish-brown massive shale, with calcareous nodules
375.0–380.0 Light reddish-brown to grey massive shale, with abundant gypsum crystals

LAGUNA PAIVA FORMATION

415.0–420.0 Greyish-green to reddish-brown massive shale. Very abundant moderately preserved foraminifera and few ostracods (sample **15**)
455.0–495.0 Greyish-green to reddish-brown massive shale with abundant gypsum crystals
510.0–530.0 Olive-green to reddish-brown massive shale
530.0–535.0 Greyish-green to reddish-brown massive shale with abundant gypsum crystals
535.0–545.0 Reddish-brown massive sandy shale
545.0–550.0 Light-grey massive shale

CHACO FORMATION, PALERMO MEMBER

573.0–578.0 Reddish-brown massive shale
595.0–600.0 Reddish-brown massive sandy shale
625.0–630.0 Reddish-brown to olive-green massive sandy shale. Big clear gypsum crystals at 629.0–629.2
660.0–733.0 Reddish-brown massive shale; abundant calcareous concretions and gypsum crystals

SERRA GERAL FORMATION

755.0–759.0 Very dark-grey amigdaloid basalt
780.0–785.0 Reddish-grey basalt

Borehole:	**Santa Fe 4 (SF4)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	unknown
LOCATION:	City of Santa Fe, Santa Fe
SAMPLING METHOD:	grab samples
ELEVATION (ma.s.l.):	35
MAX DEPTH (mb.g.s.):	162.2
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good (there are samples from 40.05 mb.g.s.)

PARANÁ FORMATION

40.05–57.5 Greenish-gray silty sand with few calcareous concretions and abundant shell fragments
57.5–75.8 Laminated to massive olive-green shale with brown patches, and few calcareous concretions

CHACO FORMATION, SAN FRANCISCO MEMBER

75.8–162.2 Reddish-brown massive shale with calcareous concretions and gypsum crystals
162.2–? Reddish-brown, medium-grained sand

Borehole Rufino 1 (FCP)

OPERATOR:	unknown
DATE:	unknown
LOCATION:	Rufino, Santa Fe
SAMPLING METHOD:	grab samples and cutting
ELEVATION (ma.s.l.):	130
MAX DEPTH (mb.g.s.):	470
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good (there are samples only at 135.0–185.0 and 340.0–470.0 mb.g.s.)

PAMPEAN SEDIMENTS

135.0–174.0 Dark to light reddish-brown massive mudstone with calcareous concretions

PARANÁ FORMATION

174.0–185.0 Dark olive-green massive shale with gypsum crystals

LAGUNA PAIVA FORMATION

340.0–348.0 Olive-green massive shale
348.0–356.0 Reddish-brown massive shale with gypsum crystals
356.0–365.0 Olive-green massive shale
365.0–375.0 Greenish-grey silty sand
375.0–414.0 Reddish-brown massive shale with gypsum crystals
414.0–431.0 Reddish-brown silty sand
431.0–465.0 Reddish-brown massive shale with gypsum crystals, calcareous concretions, and small boulders
465.0–470.0 Olive-green massive shale with gypsum crystals. Few oogonia of charophytes
470.0–? Dark-brown silty sand

Chaco Province

Borehole:	**YPF Las Breñas 2 (YPF Ch. LB x-2)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	1967
LOCATION:	Las Breñas, 9 de Julio, Chaco
SAMPLING METHOD:	cutting
ELEVATION (ma.s.l.):	105
MAX DEPTH (mb.g.s.):	1812
ORIGINAL DESCRIPTION:	unknown
REPOSITORY:	YPF

Brief description from the original record. The original lithostratigraphic nomenclature is included in brackets. The Chaco Formation/Quaternary boundary is tentative.

QUATERNARY (PAMPA FORMATION)

0–8 Light-brown sandy loam, well-rounded clasts and some sheets of biotite and muscovite, patina of Fe and Mn
8–52 Equal but more clayey, with fibrous and crystalline gypsum
52–68 Pinkish loam with abundant gypsum
68–76 Equal to section 8–52
76–80 Yellowish to pinkish-white shale with crystals of gypsum

CHACO FORMATION

80–90 Pinkish mudstone
90–138 Pinkish mica bearing clayey silt, with small dark spots (MnO) and scarce gypsum
138–192 Pinkish slightly calcareous loamy sandstone
192–254 Pinkish calcareous silty mudstone and silty sandstone
254–260 Light-pink sandy mudstone and reddish sandstone
260–230 Very light calcareous sandstone with very rounded quartz grains
300–310 Reddish-brown quartzite
310–326 Pinkish calcareous clayey silt with dark spots
326–360 Pinkish calcareous clayey sandstone with very rounded quartz grains
360–364 Light-red sandstone
364–404 Equal but slightly clayey
404–410 Equal to section 310–326
410–416 Equal to section 326–360 but less calcareous
416–422 Equal to section 264–300
422–440 Pinkish partially calcareous clayey sand
440–456 Pinkish calcareous friable clayey sandstone
456–500 Equal to section 364–404
500–548 Pinkish and whitish medium-grained sand
548–552 Pinkish calcareous sandstone
552–582 Pinkish-brown, fine- to medium-grained sandstone

(MARIANO BOEDO FORMATION, LATE CRETACEOUS)

582–588 Reddish friable calcareous sandstone
588–640 Pinkish calcareous clayey sand
640–670 Equal but slightly fine grained

(TACUAREMBÓ FORMATION, EARLY CRETACEOUS)

Formosa Province

Borehole:	**Pozo del Tigre 1 (PT1)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	unknown
LOCATION:	Pozo del Tigre, Formosa
SAMPLING METHOD:	grab samples, cutting, and cores
ELEVATION (ma.s.l.):	107
MAX DEPTH (mb.g.s.):	760.75
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

RECENT

0–3.65 Dark reddish-brown sandy silt

CHACO FORMATION, POZO DEL TIGRE MEMBER

3.65–264.3 Reddish-brown to pink massive sandy mudstone, with crystals of gypsum and calcareous concretions. Carbonized wood fragments at 32.5 and 60.9 mb.g.s.
264.3–310.3 Reddish-brown to pink massive argillaceous sand, with crystals of gypsum
310.3–368.1 Reddish-brown to pink massive sandy mudstone, with crystals of gypsum
368.1–382.25 Reddish-brown massive mudstone
382.25–384.05 Big crystals of gypsum, reddish brown mudstone and light-grey hard sandstone
384.05–409.45 Dark reddish-brown massive mudstone, with several crystals of gypsum

PARANÁ FORMATION

409.45–430.2 Dark reddish-brown and light olive-green massive mudstone
430.2–432.25 Reddish-brown massive mudstone
432.25–440.2 Dark reddish-brown and light olive-green massive mudstone
440.2–506.05 Massive dark olive-green shale with few crystals of gypsum. Bivalve fragments, very few oogonia of charophytes. Few moderately preserved ostracods and abundant, recrystallized to well-preserved foraminifera (samples **86–89**)

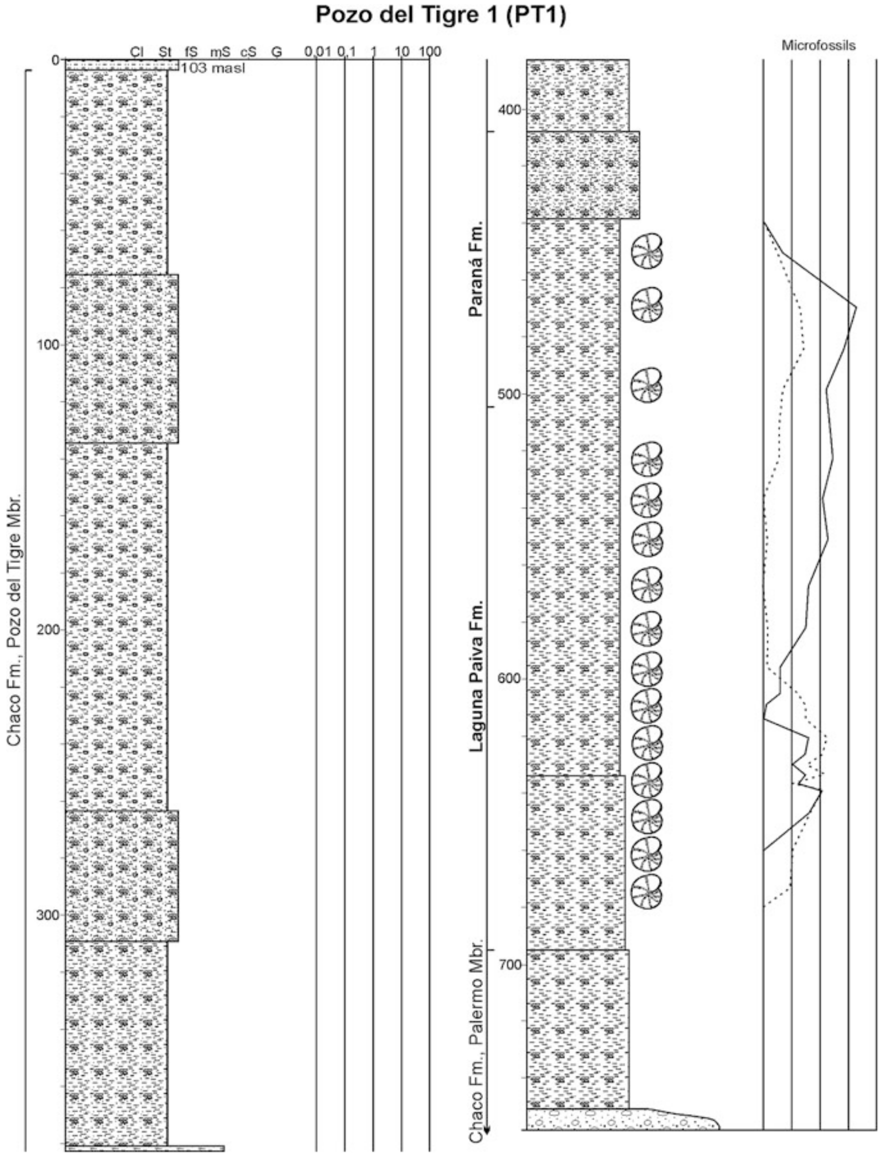

Fig. A.9 Log of Pozo del Tigre 1 borehole. Microfossil distribution expressed in specimen number/gram of sample

LAGUNA PAIVA FORMATION

506.05–603.05 Massive dark olive-green shale, with abundant gypsum crystals. Abundant microcrystalline to framboidal aggregates of pyrite. Very rare oolites. Very few, poorly preserved ostracods, usually pyritized. Abundant to very few, moderately to poorly preserved foraminifera (samples **90–96**)
603.05–636.05 Massive light olive-green shale, with few gypsum crystals. Abundant microcrystalline to framboidal aggregates of pyrite. Very abundant oolites. Abundant to very few, poorly preserved ostracods, usually pyritized. Scarce moderately to poorly preserved foraminifera (samples **97–103**)
636.05–697.3 Light reddish-brown and olive-green massive shale. Few microcrystalline pyrite aggregates. Very scarce oogonia. Moderate to poorly preserved ostracods. Scarce, poorly preserved foraminifera (samples **104–108**)

CHACO FORMATION, PALERMO MEMBER

697.3–753.3 Reddish-brown to pink massive sandy shale, with abundant gypsum crystals
753.3–760.75 Light pink, argillaceous to conglomerate sand with crystals of gypsum

City of Buenos Aires

Borehole:	**YPF Palermo 10 (P10)**
OPERATOR:	YPF
DATE:	before 1926
LOCATION:	Sociedad Rural Argentina, Palermo
SAMPLING METHOD:	cores
ELEVATION (ma.s.l.):	5.5
MAX DEPTH (mb.g.s.):	289
ORIGINAL DESCRIPTION:	R Stappenbeck
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	good

In the log of the well, the percentages of volcanic glass and clay minerals, and total number of foraminifera, planktonic foraminifera, and ostracods/gram, have been plotted.

PAMPEAN SEDIMENTS

2.0–3.0 Brownish-grey loess with calcareous nodules
8.0–16.0 Light-grey argillaceous loess
22.0–23.0 Light greenish-grey loess
29.0–30.0 Laminated mica bearing silty sand
32.0–33.0 Brownish-grey loess

PUELCHES FORMATION

39.0–44.0 Friable greenish-grey loessoid sandy siltstone

PARANÁ FORMATION

50.0–52.0 Grayish-green compact silty claystone. Spherical radiolarians, fish teeth, diatoms. Irregular microgranular pyrite. Few pyritized molds of benthic foraminifera at 51–52 mb.g.s.
52.5–54.0 Grayish-green silty claystone. Fish teeth
54.0–55.0 Grayish-green compact silty claystone. Spherical radiolarians, fish teeth and diatoms. Irregular microgranular pyrite. Few pyritized molds of benthic foraminifera
56.5–60.0 Grayish-green compact silty claystone. Spherical radiolarians, fish teeth and diatoms
60.0–63.0 Grayish-green claystone. Spherical radiolarians, fish teeth, and diatoms. Pyritized molds of benthic foraminifera and microgastropoda
63.0–64.0 Grayish-green compact claystone. Spherical radiolarians and fish teeth
64.0–65.0 Grayish-green compact claystone. Spherical radiolarians, fish teeth, and diatoms. Abundant pyritized molds of benthic foraminifera
65.0–66.0 Grayish-green clayey sandstone. Fragments of bivalves. Spherical radiolarians, fish teeth, diatoms, and spines of echinoderms. Abundant well-preserved foraminifera and ostracods
66.0–67.0 Green claystone. Spherical radiolarians
67.0–68.0 Grayish-green clayey sandstone. Bivalve fragments. Spherical radiolarians, fish teeth, and diatoms; *Cupuladria canariensis* (Busk). Abundant, well-preserved foraminifera and ostracods
68.0–69.0 Grayish-green clayey sandstone. Spherical radiolarians and diatoms
69.0–70.0 Grayish-green clayey sandstone. Bivalve fragments. Spherical radiolarians, spines of echinoderms and diatoms; *C. canariensis* and other briozoans. Abundant, well-preserved foraminifera and ostracods
81.0–82.0 Grayish-green clayey sandstone with boulders

CHACO FORMATION, SAN FRANCISCO MEMBER

85.0–86.0 Pinkish-brown silty claystone with calcareous nodules
94.0–95.0 Light reddish-brown clayey siltstone with calcareous nodules
110.0–111.0 Brown clayey siltstone
126.0–136.0 Light reddish-brown clayey siltstone
142.0–143.0 Brownish-grey clayey siltstone with gypsum
150.0–160.0 Greyish-brown sandy siltstone with calcareous nodules
163.0–164.0 Brownish-grey clayey siltstone
173.0–174.0 Greyish-brown sandy siltstone
175.0–176.0 Brownish-grey clayey siltstone

LAGUNA PAIVA FORMATION

179.0–180.0 Laminated yellowish-grey clayey siltstone
181.0–185.0 Greenish-grey silty claystone with gypsum
188.0–195.0 Brownish-grey siltstone with gypsum
196.0–197.0 Very dark brownish-grey claystone

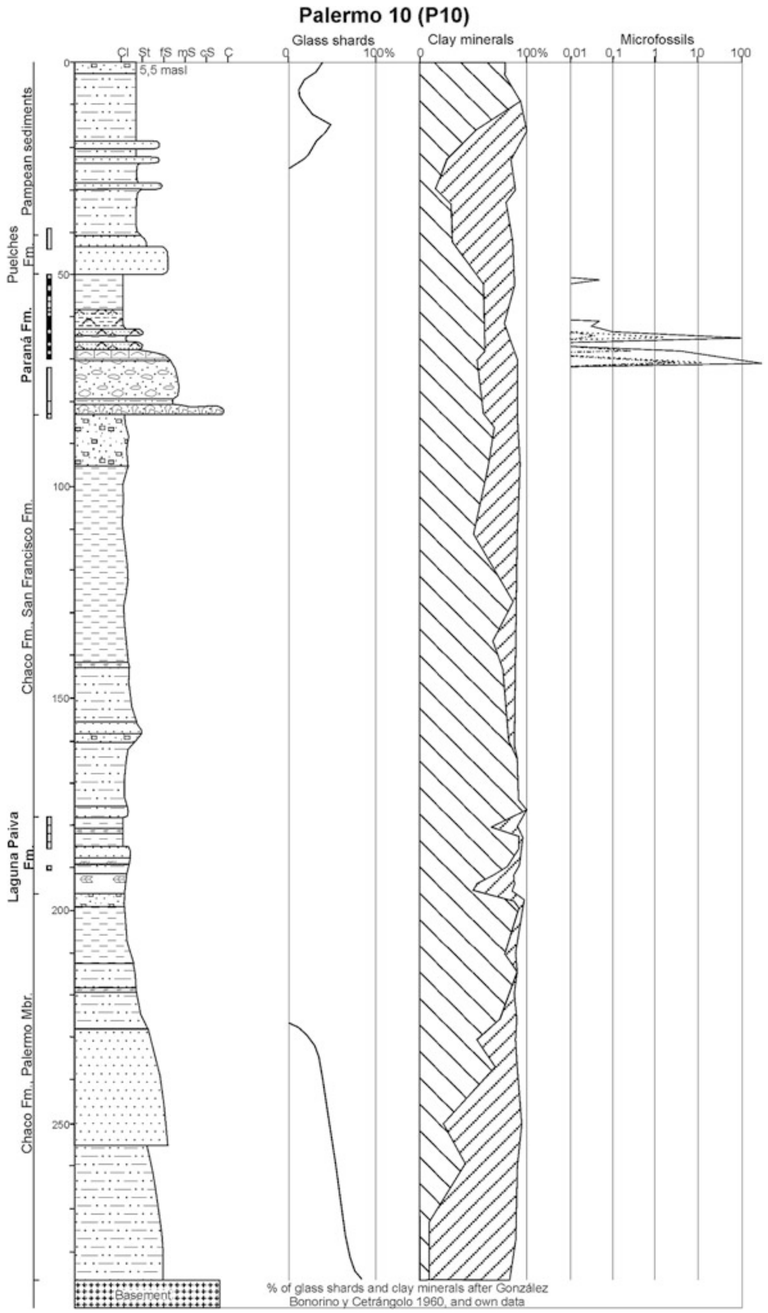

Fig. A.10 Log of the YPF Palermo 10 borehole

CHACO FORMATION, PALERMO MEMBER

198.0–199.0 Brownish-grey clayey siltstone with calcareous nodules
209.0–210.0 Light greyish-brown, friable sandy siltstone
213.0–215.0 Brownish-grey clayey siltstone
218.0–219.0 Light greyish-brown, friable sandy siltstone with gypsum
224.0–225.0 Brownish-grey clayey siltstone
229.0–230.0 Light greyish-brown, friable sandy siltstone, with 20 % of glass shards
235.0–250.0 Light greyish-brown, friable sandy siltstone, 40 % of glass shards
259.0–260.0 Light greyish-brown, friable sandy siltstone, 50 % of glass shards
276.0–277.0 Light grey, fine-grained tuff
286.0–287.0 Light grey, fine-grained tuff

CRYSTALLINE BASEMENT

287.0 Gneiss

Buenos Aires Province

Borehole:	**Riachuelo II (RII)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	decade of 1930
LOCATION:	Estación PuenteAlsina, Lanús County
SAMPLING METHOD:	grab samples
ELEVATION (ma.s.l.):	5.9
MAX DEPTH (mb.g.s.):	357.50
ORIGINAL DESCRIPTION:	R Rigal
REPOSITORY:	SEGEMAR
QUALITY OF THE SAMPLES:	moderate

QUERANDÍ FORMATION

0.00–1.50 Greyish-brown clayey sand
1.50–3.00 Green and brown sandy claystone
3.00–6.30 Greenish-brown clayey sand
6.30–13.00 Greenish-grey, fine-grained sand with mollusk fragments
13.00–15.00 Dark-green clay with mollusk fragments and *Tagelus gibbus*
15.00–20.30 Greenish-grey, fine-grained sand with mollusk fragments. *Corbula* and *Littoridina*
20.30–23.00 Yellow clayey sand with mollusk fragments

PUELCHES FORMATION

23.00–26.60 Yellow to pink sandy clay
26.60–49.00 Light-yellow coarse sand with some boulders

PARANÁ FORMATION

49.00–58.00 Dark-green sandy claystone (no samples)
58.00–62.20 Idem, with mollusk fragments. **RII-47** (**60–61**) with some boulders, fish teeth, spherical radiolarians and benthic foraminifera. RII-48 (61–62.2) with fish teeth
62.20–74.60 Very dark-green marly claystone. *Amussium* sp. RII-49 (62.2–65) with fish teeth and few pyritized molds of foraminifera. **RII-50** (**65–70**) and **RII-51** (**70–74.6**) with fish teeth, abundant planktonic and benthic foraminifera, and abundant ostracods with fair to good conservation
74.60–91.00 Greyish-green clayey sandstone, with mollusk fragments. **RII-53** (**79–82.55**) few benthic foraminifera
91.00–97.00 Fine- to coarse-grained sand
97.00–98.00 Light greenish-grey claystone

CHACO FORMATION, SAN FRANCISCO MEMBER

98.00–141.50 Reddish-brown sandy claystone
141.50–175.70 Light-red sandy claystone with clacareous nodules and gypsum crystals

LAGUNA PAIVA FORMATION

175.70–187.70 Interbedded green and reddish claystone with calcareous nodules and gypsum crystals
187.70–191.00 Green marl, red claystone, and light-yellow sandstone, with eroded fragments of shells and gypsum crystals. RII-89 (188–189.3) with fish teeth, bryozoans, and abundant ostracods and benthic foraminifera. RII-90 (**189.3–191**) with fragments of oysters, fish teeth, spherical radiolarians, bryozoans, and abundant ostracods and benthic foraminifera
191.00–200.00 Idem, with more gypsum. **RII-91** (**191–193.55**) very abundant monoespecific microfauna of recrystallized *C. poeyanum*. **RII-94** (**194.7–197**) with ostracods and benthic foraminifera, and shell fragments

CHACO FORMATION, PALERMO MEMBER

200.00–211.00 Idem, without shell fragments
211.00–227.40 Red sandstone and marly claystone; abundant gypsum crystals and very few fragments of oysters
227.40–347.00 Light-red marly sandy claystone with gypsum
347.00–354.50 Red fine-grained sandstone with mica and boulders of quartz and gneiss

CRYSTALLINE BASEMENT

354.50–357.50 Gneiss

Borehole:	**Riachuelo VI (RVI)**
OPERATOR:	Dirección Nacional de Minas y Geología
DATE:	1936 to 1938
LOCATION:	Plaza San Martín, Cañuelas
SAMPLING METHOD:	grab samples

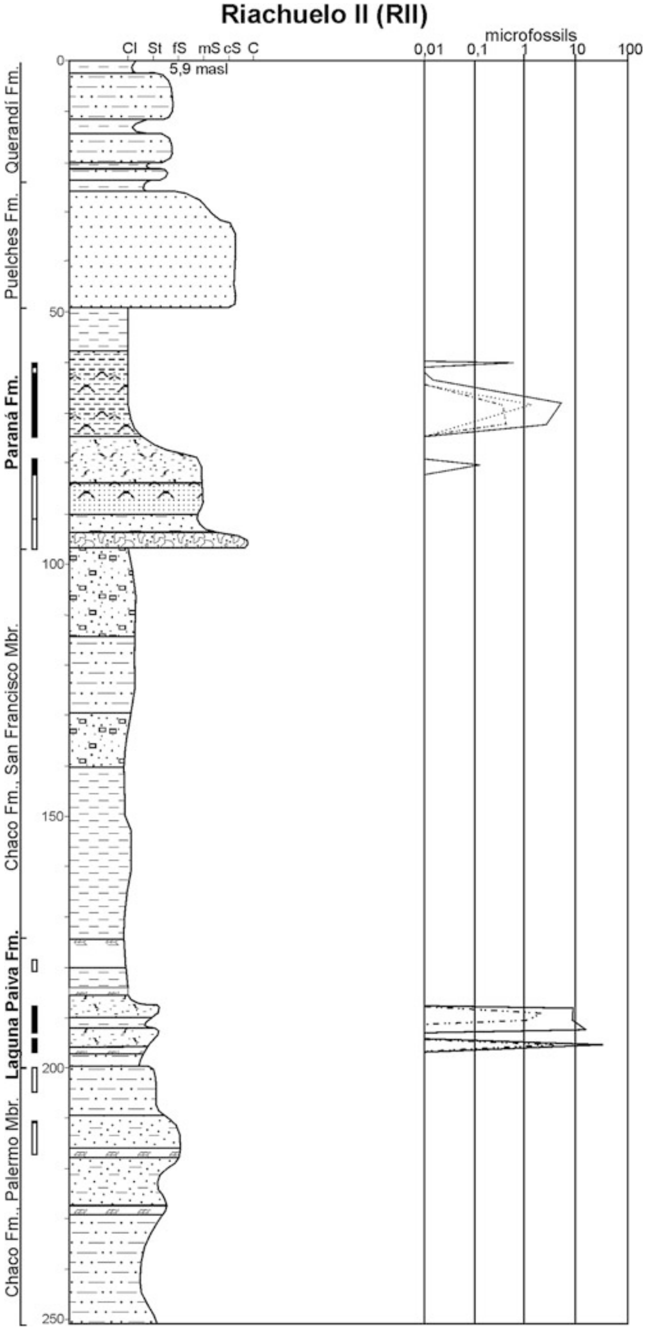

Fig. A.11 Log of Riachuelo II borehole

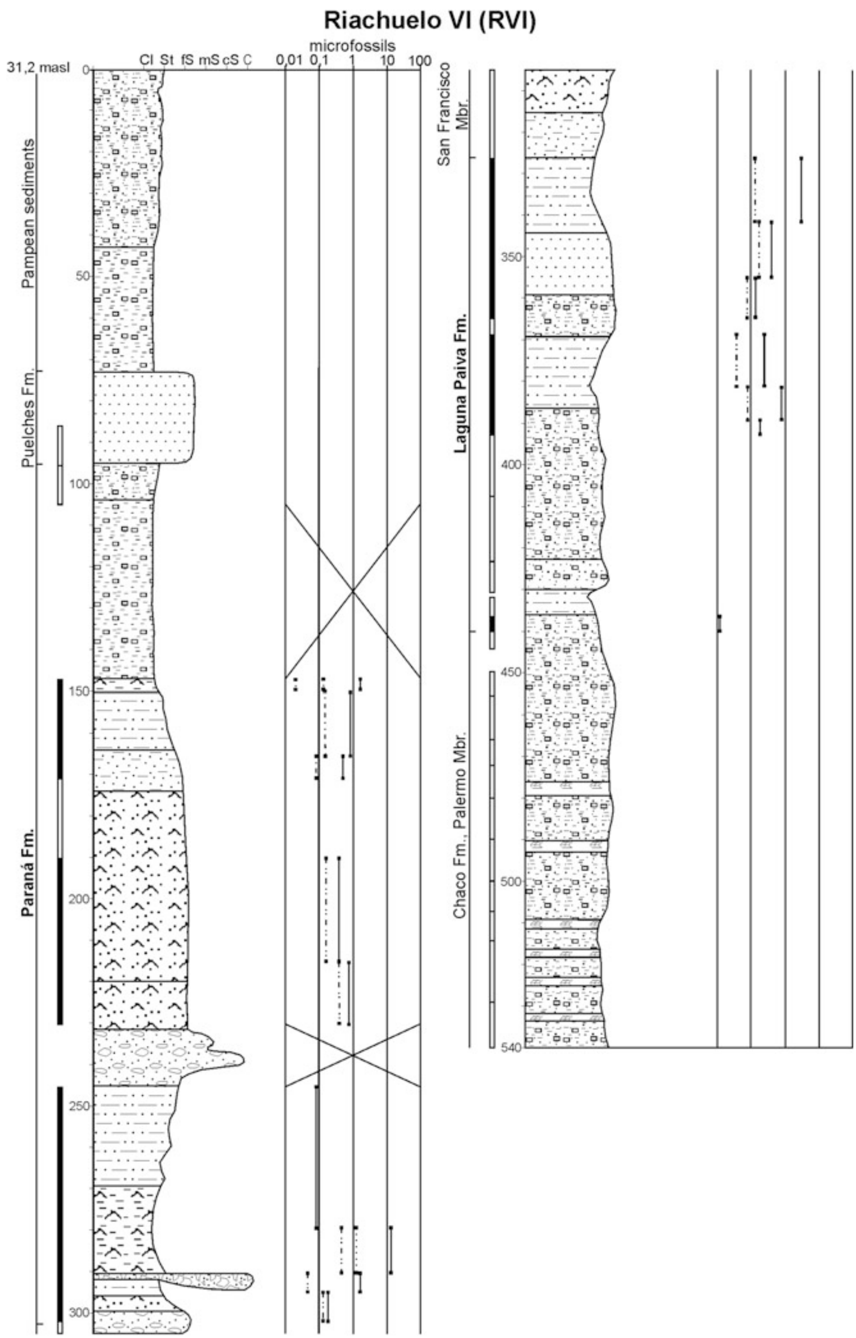

Fig. A.12 Log of Riachuelo VI borehole

ELEVATION (ma.s.l.): 31.20
MAX DEPTH (mb.g.s.): 716.90
ORIGINAL DESCRIPTION: unknown
REPOSITORY: SEGEMAR
QUALITY OF THE SAMPLES: moderate

RECENT

0–0.70 Dark sandy soil

PAMPEAN SEDIMENTS

0.70–8.30 Light-brown clayey sand, calcrete
8.30–46.10 Reddish-brown clayey marly sand
46.10–72.86 Light-brown sandy clay with calcareous nodules

PUELCHES FORMATION

72.86–95.65 Light yellowish-brown micaceous sand with fine boulders

PARANÁ FORMATION

95.65–150.00 Yellowish-green claystone with coating of limonite. Bluish-green claystone with *Amussiumdarwinianum* d'Orb. and *Chione muensteri* d'Orb. **RVI-17** (**147–150**) *Turritella* sp., *Ch. muensteri* d'Orb., *Glycimeris* sp., *Dosinia* sp., spines of echinoderms, *Natica* sp., spherical radiolarians, fish teeth, abundant well-preserved ostracods and benthic foraminifera, and few well-preserved planktonic foraminifera
150.00–165.69 Greenish-grey sand and bluish-green marly shale with shells. **RVI-18** (**150–165.69**) spines of echinoderms, few well-preserved benthic foraminifera and ostracods
165.69–280.00 Light-brown fine sand with shells and green shale. **RVI-19** (**165.69–171**) with spherical radiolarians, *C. canariensis*, very few ostracods and benthic foraminifera. **RVI-21** (**190.1–215.2**) very few poorly preserved benthic foraminifera and ostracods; **RVI-22** (**215.2–229.4**) spherical radiolarians, poorly preserved ostracods and benthic foraminifera. **RVI-24** (**245–280**) fish teeth and very few benthic foraminifera
280.00–291.35 Greenish-grey shale. **RVI-25** (**280–291.35**) *Variocorbula* sp., *Cardium* sp., fragments of gastropods, diatoms, spherical rariolarians, *C. canariensis*, ostracods and abundant benthic and planktonic foraminifera
291.35–291.86 Pink conglomerate with quartz, opal, sandstone, and shell fragments
291.86–302.58 Green shale and light sandstone. **RVI-27** (**291.86–295**) radiolarians, *C. canariensis*, few benthic and planktonic foraminifera, **RVI-28** (**295–302.58**) fish teeth, bryozoans, mollusk fragments, and very few ostracods and benthic foraminifera

CHACO FORMATION, SAN FRANCISCO MEMBER

302.58–327.00 Red sandy claystone with calcareous concretions and oyster fragments

LAGUNA PAIVA FORMATION

327.00–342.20 Green sandy shale. **RVI-30** (**327–342.2**) few ostracods and benthic foraminifera
342.20–355.25 Light-brown sand. **RVI-31** (**342.2–355.25**) few ostracods and benthic foraminifera
355.25–368.00 Greyish-brown sandstone with calcareous nodules and small boulders. **RVI-32** (**355.25–364.9**) *C. canariensis*, few ostracods and benthic foraminifera
368.00–440.80 Reddish-brown sandy loamy claystone, with shell fragments and gypsum. **RVI-34** (**368–381.5**) and **RVI-35** (**381.5–389.2**) very few ostracods and benthic foraminifera; **RVI-36** (**389.2–393**) few benthic foraminifera; **RVI-41** (**436.7–440.8**) microgastropods and very few benthic foraminifera

CHACO FORMATION, PALERMO MEMBER

440.80–450.80 Reddish-brown loamy claystone and scarce green friable sandstone
450.80–507.10 Yellowish-brown sandstone with calcareous nodules and gypsum
507.10–515.40 Reddish-brown sandy claystone with calcareous nodules and gypsum
515.40–657.30 Light-brown clayey sandstone with gypsum, *Balanus* sp. and crab claws
657.30–670.70 Yellowish-grey sandstone and dark claystone with gypsum
670.70–716.90 Dark-brown claystone and light brown sandstone with small boulders, gypsum, and anhydrite

Península de Valdés

Eje Tentativo (ET)

Located at the cliffs south of the Florentino Ameghino Isthmus, near to the place called Eje Tentativo, a projected site for a tidal power plant. Its thickness is about 67 m.

GAIMAN FORMATION ("PATAGONIAN")

4.5 m Whitish-green tuffaceous very fine grained massive sandstone, jointed and weathered. Abundant horizontal to subvertical tubular bioturbations, more frequent toward the top
5–10 cm Green claystone, laterally very continuous
3.5 m Whitish-green tuffaceous, very fine-grained massive sandstone, coarser and more bioturbated near the top than previously in the section, and with some strongly weathered shells

PUERTO MADRYN FORMATION ("*ENTRERRIENSE*")

40 cm Light-green sandstone, with scattered molds of *Turritella*, bryozoans and indeterminable mollusks. Numerous intraclasts of the Patagonian, up to 4 cm long
10–20 cm Coquina formed by fragments of pectinids, oysters, *Turritella*, and *Glycimeris* molds. Abundant bioturbation as horizontal tubes
6.4 m Green, massive, fine-grained sandstone, with many bioturbations similar to *Thalassinoides*. Towards the center, the bioturbation increases. The last 2–2.5 m are

somewhat coarser, with three intercalations of harder beds of 20 cm thick, very weathered fossils and molds of *Turritella*, worms, glycimerids, and oysters. These beds have irregular lower contacts, seemingly erosive, and lack good lateral continuity
1.2 m Recent cover
10–20 cm Very weathered fossiliferous sandstone with scattered molds of *Turritella*, *Aequipecten* sp., and other indeterminable bivalves
6.2 m Light-gray friable sandstone, very thin at the bottom, coarsening upward. The first meters with interbedded clay; very strong bioturbation giving the rock a mottled appearance, and very weathered scattered fossils. The following 2 m are similar, with better preservation of the fossils. Fragments and shells of *Ostrea patagonica* d'Orbigny, bryozoans, *Aequipecten paranensis* (d'Orbigny), *Turritella* sp., *Chlamysactinodes* (Sowerby), and *Trophon* sp. The last meters contains small clusters (about ten specimens) of *Ostrea alvarezi* d'Orbigny in life position. The bed ends with a higher concentration of fossils and shell fragments
1.0 m Yellowish coarsening upward clayey sandstone. Fossils dispersed and distributed without any apparent order, more concentrated towards the top. *O. patagonica*, *Turritella* sp., *A. paranensis,C. actinodes*, and *Trophon* sp.
30 cm Hard coquina with dissolved and eroded fossil fragments
2.80 m Yellowish clayey sandstone. Fossils are dispersed and distributed without any apparent order, more concentrated towards the top. *O. patagonica*, *Turritella* sp., *A. paranensis*, *C. actinodes*, and *Trophon* sp.
30 cm Hard coquina with dissolved and eroded fossil fragments
4.0 m Dark greenish-brown massive claystone
60 cm Hard coquina with dissolved and eroded fossil fragments, abundant complete shells of *Amusiumdarwinianum* d'Orbigny and terebratulid brachiopods with closed valves
5.0 m Partially covered, dark greenish-brown, massive claystone
50 cm Hard coquina with dissolved and eroded fossil fragments, abundant shells of *Amusiumdarwinianum* d'Orbigny and terebratulid brachiopods with closed valves.
4.0 m Yellow friable sandstone with disperse oysters and pectinids
5.0 m Recent cover
60 cm Hard sandy coquina with abundant molds
3.0 m Recent cover
12.0 m Very friable gray clayey sandstone. Common horizontal and subhorizontal fibrous gypsum veins up to 0.5 cm thick. The bed ends with one gypsum layer about 3–4 cm. Flaser and wavy heterolithic structures are frequent about 2 m from the bottom, and in some sectors are possible ripple cross lamination and chevron structures. *Thalassinoides* bioturbations are frequent at 5 m from the base
50 cm Recent cover
50 cm Coquina composed of very big oysters. There are also pectinids, briozoans, *Glycimeris*, and other mollusks
2.0 m Brown massive claystone
30 cm Thin-grained coquina composed of shell fragments, briozoans, and *Balanus* sp.
2.0 m Recent cover
30 cm Pinkish-grey, flower-like gypsum

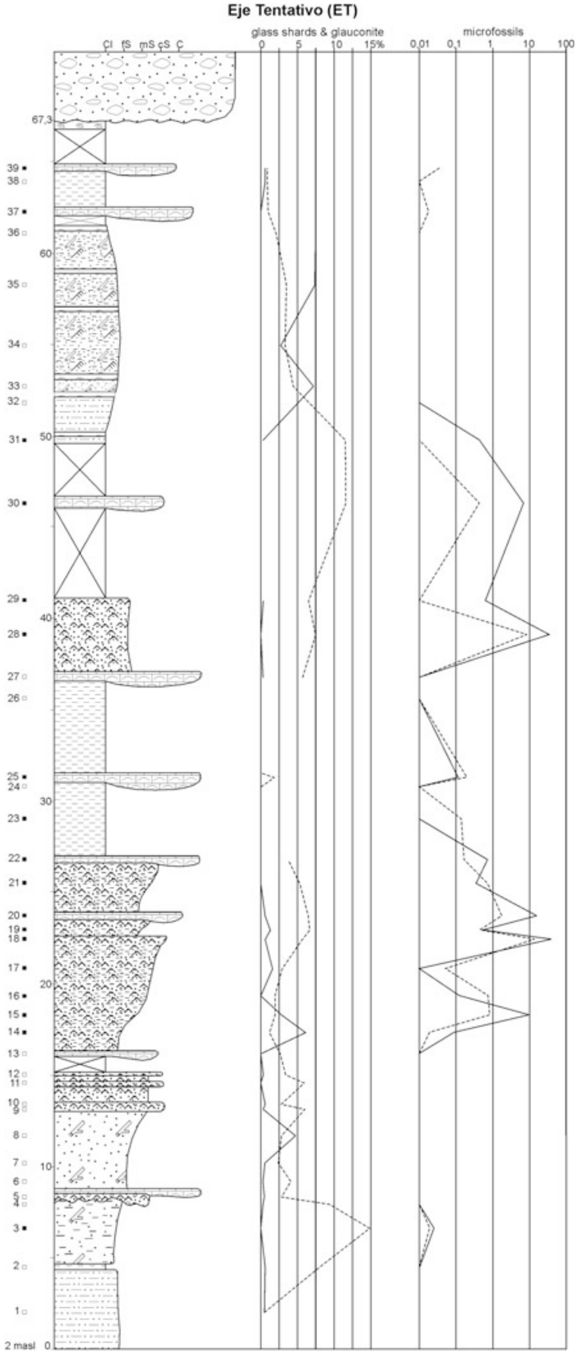

Fig. A.13 Log of Eje Tentativo (ET). Microfossil distribution in specimen number/gram of sample

Puerto Pirámide (PP)

Located at the cliffs between the post of the warden of sea lions and the village of Puerto Pirámide. The thickness is about 80 m.

PUERTO MADRYN FORMATION ("*ENTRERRIENSE*")

2.5 m Dark greenish-brown (5Y 5/2) to light brown (5Y 6/1), fine-grained, very fossiliferous sandstone. Oysters, pectinids, *Turritella*, and bryozoans

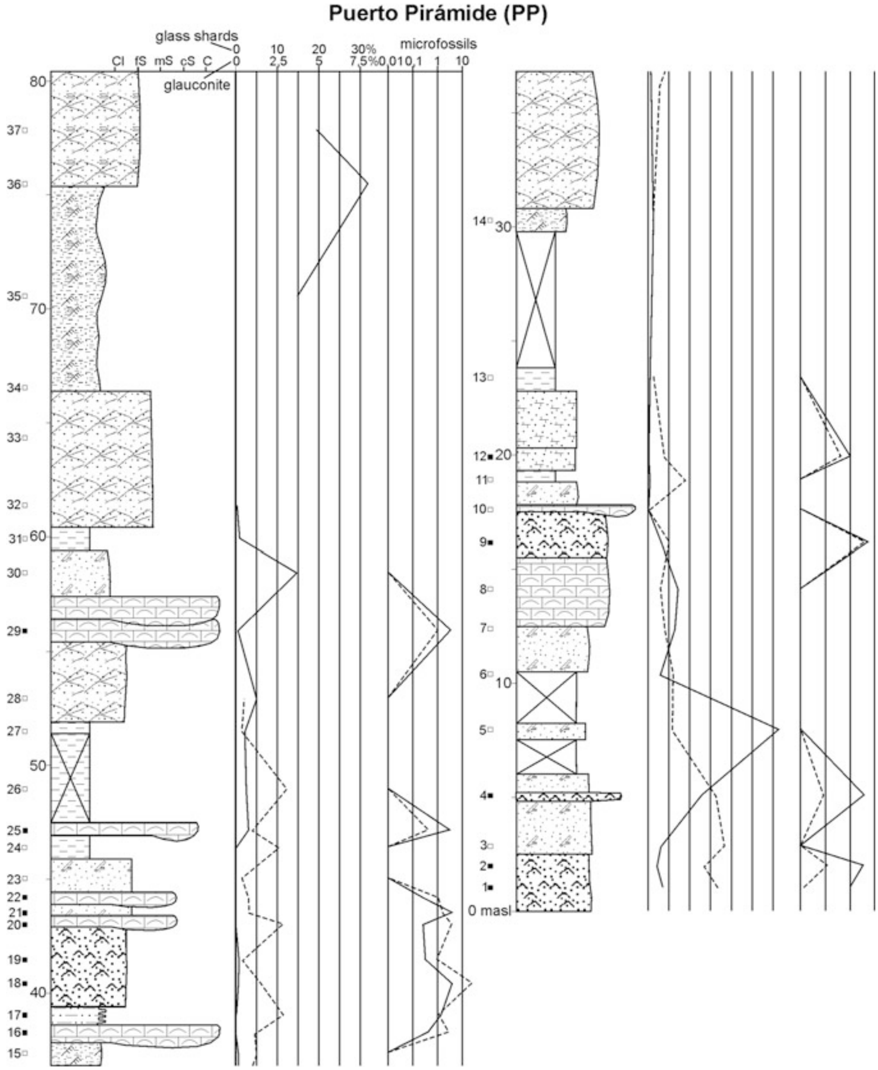

Fig. A.14 Log of Puerto Pirámide (PP). Microfossil distribution in specimen number/gram of sample

3.5 m Light olive-green (5Y 6/1 to 5Y 8/1) silty sandstone with vertical veins of gypsum and few fossils. The megafossils are generally rusty or found only on molds or fragments. Strong bioturbation. At 2.5 m from the bottom, there is a thin bed of oysters and pectinids with closed valves
5.0 m Partially covered, fine-grained sandstone
2.0 m Light olive-green silty sandstone with iron oxide coatings
3.0 m Light olive-green (5Y 8/1) sandstone
2.0 m Light-gray friable sandstone, with fragments of shells and scattered oysters and *Monophoraster* sp.
30 cm Very hard coquina with large specimens of oysters, *Monophoraster* sp., and other mollusks. This bed is continuous along several kilometers
1.0 m Massive, very bioturbated sandstone
50 cm Brown (10YR 6/2) massive, partially sandy claystone
1.0 m Light-brown hard sandstone with clayey intraclasts and fragments of pectinids and bryozoans
2.5 m Partially covered, fine-grained sandstone
1.0 m Dark-brown claystone
6.0 m Recent cover
1.0 m Massive dark-brown claystone with lenticular type stratification
6.0 m Very friable, dark-gray sand with cross stratification. It would be a continental recent deposit
1.0 m Massive dark-brown claystone with lenticular type stratification
80 cm Sandy coquina with big oysters, *Monophoraster* sp., and shell fragments
80 cm Brown claystone with thin sandy interbedded layers
3.5 m Gray (5Y 7/2) sandstone with clayey intraclasts. Abundant poorly preserved mollusks and *Monophoraster*
50 cm Very hard coquina with abundant oysters, pectinids, *Monophoraster* sp., and other mollusks
50 cm Very friable sandstone
50 cm Very hard coquina with abundant oysters, pectinids, *Monophoraster* sp., and other mollusks
1.5 m Very friable yellowish sandstone
1.0 m Light brownish, olive-green claystone, strongly bioturbated
50 cm Very hard and fossiliferous sandstone. Fossils are strongly dissolved
4.0 m Partially covered claystone
50 cm Massive sandy claystone
3.0 m Very friable dark-gray sand with cross stratification. This would be a continental recent deposit
1.0 m Very hard and fossiliferous sandstone. Fossils are strongly dissolved
1.0 m Very hard and fossiliferous sandstone. Fossils are strongly dissolved
2.0 m Lamination silty sandstone with flaser stratification
1.0 m Very continuous bed of light olive-green shale
6.0 m Very friable dark-gray sand with cross stratification. It is composed of coarse to medium-sized fragments of shells. It would be a continental recent deposit
9.0 m Light-brown mudstone and clayey sandstone. Some places with lenticular and flaser stratification and shale intraclasts

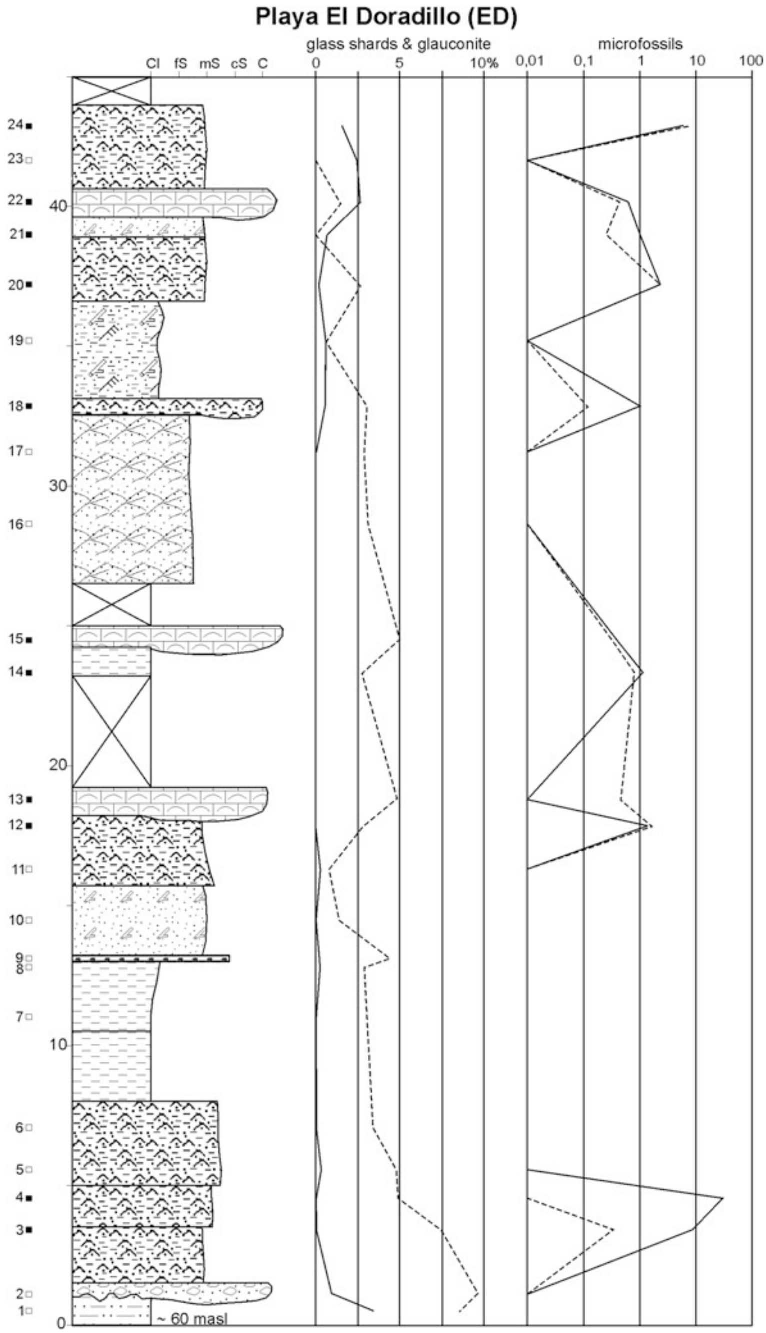

Fig. A.15 Log of Playa El Doradillo (ED). Microfossil distribution in specimen number/gram of sample

5.0 m Very friable dark-gray sand with cross stratification. Composed of coarse- to medium-sized shell fragments. It would be a continental recent deposit

Playa El Doradillo (ED)

About 2 km west of Playa El Doradillo. The profile begins at 60 ma.s.l.

GAIMAN FORMATION ("PATAGONIAN")

1.0 m Light olive-green (5Y 8/1) massive claystone

PUERTO MADRYN FORMATION ("*ENTRERRIENSE*")

50 cm Friable conglomeratic sandstone with weathered bioclasts and intraclasts of the Gaiman Formation
2.0 m Fine sandstone similar to the above with lower content of boulders and mollusk fragments
1.5 m Fine sandstone similar to the above, but without boulders
3.0 m Massive medium sandstone (10YR 7/4) with abundant, strongly dissolved pectinids and oysters
5.0 m Pale olive (5Y 8/1), massive to slightly laminated shale, somewhat sandy at the roof
10 cm Gray sandstone strongly cemented with gypsum, with abundant trace fossils at the bottom
2.5 m Friable massive yellowish (10YR 8/2) sandstone with clay lenses
2.5 m Very weathered fossiliferous sandstone, with marked variations in cementation
1.0 m Weathered coquina with partial dissolution of the megafauna remains
3.0 m Partially covered claystone
1.0 m Dark greenish-brown massive shale
80 cm Weathered coquina with partial dissolution of the megafauna
1.5 m Recent cover
6.0 m Friable sand with cross stratification
60 cm Dark-grey friable sand composed of shell fragments
3.0 m Very friable, fine sandstone interbedded with clay, with heterolithic stratification
2.0 m Fossiliferous sandstone composed of finely fragmented megafauna, *Turritella*, oysters, barnacles, and unidentifiable molds arranged in very irregular manner, occasionally grouped in lenses
50 cm Very similar to the above, but much more fossiliferous and with large *Ophiomorpha* toward the top
1.0 m Whitish coquina. Weathered whole oysters, pectinids, and *Turritella.*
2.5 m Fossiliferous sandstone composed of finely fragmented megafauna, *Turritella*, oysters, pectinids, and unidentifiable molds arranged in very irregular form, occasionally grouped in lenses
1.0 m Recent cover

Appendix B
Mineralogical Analysis

Chacoparanense and Salado Basins

The light minerals of 258 samples from two boreholes in the Salado Basin (YPF Palermo 10 and Riachuelo VI), and four boreholes in the Chacoparanense Basin (Ordóñez 3, San Cristóbal 1, Frías 1 and Pozo del Tigre 1) were analyzed. At least 300 grains were counted per sample, in the fine and very-fine sand fractions. The heavy mineral content is generally very low; thus, they were not studied. Pliocene and Quaternary deposits have been considered together, as they are beyond the

Pozo del Tigre Mbr.		San Francisco Mbr.					Palermo Mbr.				
	Pozo del Tigre 1	Palermo 10	Riachuelo VI	Ordóñez 3	San Cristóbal 1	Frías 1	Palermo 10	Riachuelo VI	San Cristóbal 1	Frías 1	Pozo del Tigre 1
No. of samples	30	2	1	6	2	2	6	25	7	18	5
% sand	23	?	?	24	4.9	9.7	?	48	?	26	22
Monocrystalline quartz	26	17	18	14	11	29	?	26	7.5	35	19
Policrystalline quartz	.0	.2	.0	.0	.2	.0	?	.0	.1	.0	.3
Orthoclase	.3	.5	.0	2.0	.0	1.7	?	.3	1.0	1.2	.9
Polysynthetic plagioclase	0,0	1.0	.0	.5	.0	.0	?	.0	.1	.1	.0
Zonate plagioclase	60	70	72	69	68	62	?	65	58	58	52
Glass shards	.0	.2	.0	.3	.0	.5	50	2.8	0,4	.1	.0
Glauconite	.0	.0	.3	.0	.0	.0	?	.0	.0	.0	.0
Pelitic fragments	.0	.0	.0	.0	2,8	.0	?	.0	.3	.0	.0
Acid volcanic fragments	0,4	.0	.0	.2	1.2	.0	?	.1	.7	.0	.7
Basic/inter. volcanic frag.	13	9.4	7.6	14	16	4.7	?	5.0	31	3.7	26
Microcline	.7	1.7	2.0	.8	.5	1.0	?	1.2	1.2	.7	.3
Mica	.0	.0	.0	.0	.0	1.0	?	.0	.0	1.2	.0

Fig. B.1 Light minerals from the Chaco Formation

scope of this work (Figs. B.1 and B.2).

H. Marengo, *Neogene Micropaleontology and Stratigraphy of Argentina*,
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	Quat./Puelches Fm.						Paraná Fm.						Laguna Paiva Fm.					
	Palermo 10	Riachuelo VI	Ordóñez 3	San Cristóbal 1	Frías 1	Pozo del Tigre 1	Palermo 10	Riachuelo VI	Ordóñez 3	San Cristóbal 1	Frías 1	Pozo del Tigre 1	Palermo 10	Riachuelo VI	Ordóñez 3	San Cristóbal 1	Frías 1	Pozo del Tigre 1
No. of samples	6	5	9	4	9	2	19	11	6	2	3	8	4	11	22	11	2	20
% sand	?	3.5	?	6.3	56	20	?	?	32	4.2	5.5	11	?	?	5.1	12	7.0	7.6
Monocrystalline quartz	13	23	8.6	12	31	18	16	21	16	15	32	16	19	21	21	5,7	22	17
Policrystalline quartz	.1	.0	.0	.2	.0	.0	.1	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Orthoclase	.2	.0	.8	.0	1.8	.8	.5	.8	1.2	.0	1.7	.6	.8	.6	.7	.0	1.1	1.4
Polysynthetic plagioclase	.1	1.0	.0	.0	.1	.0	.6	.3	1.0	.0	.1	.0	.3	.3	.1	.7	.0	.2
Zonate plagioclase	62	69	43	58	56	59	67	66	64	53	58	66	71	70	62	50	71	67
Glass shards	16	.8	22	7.8	1.2	.0	.7	.2	.1	.0	.0	.1	.3	.5	2.0	.8	.0	.0
Glauconite	.0	.0	.0	.0	.0	.0	2.4	1.8	2.2	.0	.0	.0	.2	.2	.0	.0	.0	.0
Pelitic fragments	.0	.0	.0	2.8	.0	.0	.0	.0	.0	2.5	.0	.0	.0	.0	.0	.7	.0	.0
Acid volcanic fragments	.0	.0	.1	1.1	.1	.5	.0	0.4	.8	3.0	.0	.8	.0	.2	.6	.7	.0	.7
Basic-inter. volcanic frag.	8.2	5.2	25	17	2.8	22	11	8.2	14	26	4.5	16	7.4	6.0	12	40	4.0	13
Microcline	.6	.7	.5	1.3	.8	.2	1.3	1.5	1.3	.7	1.6	.8	1.2	1.7	1.6	1.2	.6	.4
Mica	.3	.0	.0	.0	6.5	.0	.1	.0	.0	.0	1.6	.1	.0	.0	.0	.0	1.2	.0

Fig. B.2 Light minerals from the Quaternary/Puelches formation and Paraná and Laguna Paiva Formations

Península de Valdés

All samples with more than 5 % of sand were analyzed. One hundred samples were studied in both light and heavy components (Figs. B.3, B.4 and B.5). Quantification aimed to determine the tectonic framework of the source area (Dickinson et al. 1983). The choice of the different species and subspecies reflect the mineralogical diversity and its importance as provenance indicators. For example, quartz was differentiated up to second-order components (mono- and polycrystalline), whereas feldspar (orthoclase, zonate plagioclase, and polysynthetic twinning plagioclase) and lithic fragments were differentiated up to thrird-order components. The components are described in order of abundance.

Light minerals

Zonate plagioclase: The dominant component in most samples, in some cases exceeding 50 % of the total. Very angular euhedral to subhedral tablets, or fragments of larger crystals. Good to regular preservation, commonly coated with iron oxide patinas or weathered clays. Sometimes there are crystals with embayed edges or with negative glass filling.

Basic to intermediate volcanic fragments: Major component in all the samples. Subrounded to subangular fragments. Moderate to poor preservation, commonly weathered to clays and incipient glauconitization; sometimes mafic minerals are very weathered. Intersertal, pilotaxitic, and hyalopilitic textures.

Acid volcanic fragments: Secondary component in most samples. Subrounded to subangular fragments. Moderate to poor preservation, strong to mild alteration to clays and incipient glauconitization. Microgranitic and felsitic textures.

Monocrystalline quartz: Highly variable abundance, with a maximum of 23.1 % and a minimum of 0.6 %. Subrounded to well-rounded clasts, occasionally subangular. Very good preservation, with common inclusions of different types. Straight extinction dominates over undulose extinction. Rounding is the most striking feature, as it contrasts sharply with the rest of the primary and secondary components.

Glauconite: Highly variable frequency may be absent or be a secondary or accessory component. Aggregates are well-rounded, ovoid to spherical, with numerous surface cracks. There are very immature aggregates formed from the alteration of intermediate to basic volcanic fragments. Brown (less commonly greenish-brown) to dark green in color. Sato (1981) and Scasso and del Río (1987) classified these pellets as glauconite. However, there are some doubts about their true composition; in most cases, they do not have the color or the most characteristic internal structure. This could correspond to very early steps in the glauconitization process.

Glass shards: Very variable frequency may be absent or be a secondary component. Colorless, very angular, and very little weathered. Occasionally devitrified, light-brown cuspate fragments.

Orthoclase: Minor component in all of the samples. Subhedral to euhedral tablets. Conservation is poor to very poor, very weathered to clay, and coated with iron oxide patina. In some cases, Carlsbad twin and micropertitic texture are recognized.

Polysynthetic twinning plagioclase: Minor component in all of the samples. Subhedral to euhedral tablets. Moderate to poor preservation, commonly clayey and sericitic alteration. The main composition is oligoclase to andesine, occasionally labradorite.

Polycrystalline quartz: Secondary to accessory component. In all cases, mosaics are formed by more than five crystals.

Clayey fragments: Secondary to accessory component. Yellowish-brown to reddish-brown, irregular, subangular fragments.

Microcline: Accessory component in some samples. Subhedral to anhedral, subangular to subrounded clasts. Fair to good preservation with little clayey alteration.

Opal: Accessory component in some samples. Angular to very angular clasts. Very weathered and coated with iron oxide patina.

Siliceous spicules: Accessory component in some samples. Colorless tubular and acicular isotropic particles. Very good preservation.

Heavy minerals

Green-brown hornblende: Main component in most samples. Tablets or prisms elongated along the axis c, with subrounded to sparsely serrated edges. Light- to dark-brown or green to brown, characteristic pleochroism.

Augite: Highly variable frequency, with a marked increase in abundance towards the top of the sections. Short prismatic crystals, some well-rounded with serrated

	Monocrystalline quartz	Polycrystalline quartz	Acid volcanic fragments	Basic/inter. volcanic frag.	Pelitic fragments	Orthoclase	Microcline	Polysynthetic plagioclase	Zonate plagioclase	Glass shards	Glauconite	Opal+Siliceous spicules	Opaque minerals	Green-brown hornblende	Basaltic hornblende	Blue-green hornblende	Augite	Titaniferous augite	Diopside	Hypersthene	Biotite + Muscovite	Epidote+Clinozoisite	Zircon	Garnet	Monazite + Rutile
ET-1	3.7	.5	38	36		.5		1.4	17	.5	.5	.5	.4	.8	.05	.1	.05			tr	.05	tr	tr	.05	
ET-2	5.7	1.5	2.8	19	2.4	1.2		1.2	38	.6	7.9		.5	.9	.05	tr	.05	tr			tr	.2			tr
ET-3	5.2	1.9	20	16	.8	1.2	.4	2.3	37		15		.5	.5	.05	tr	.05	tr		tr	tr	.1	tr	tr	
ET-4	5.8	.3	22	18	3.4	1.8		1.2	37	.3	9.2		.3	1.2	tr	tr	.1	tr		tr		.2	tr		
ET-5	16	1.4	16	9.9	1.6	1.9		1.9	43	.5	2.7		.6	2.0	.1	.2	.8		.1	.2	.2	.2	.05	.05	
ET-6	18	.9	16	13	1.2	3.3		3.3	37	.3	4.0		.2	1.2	.05	.05	.5	.1		tr		.1	tr		tr
ET-7	19	1.5	9.2	1.4	2.4	4.1	.3	2.4	47	.6	2.4		.2	.6	tr	tr	.1	.05	tr		tr	.05	tr	tr	tr
ET-8	17	1.6	9.6	13	3.1	3.4	.3	2.8	4.3	4.7	2.8		.1	.6	tr	.05	.3	tr		tr	.05	tr	tr	tr	tr
ET-9	13	1.5	11	2.4	2.2	2.5		1.9	39	.3	5.9	.3	.2	1.2	tr	tr	.4	.1			.1	.1		tr	tr
ET-10	22	1.2	8.7	13	1.8	3.0	.3	2.1	43	.6	2.7		.5	1.0	.1	.1	.2		.05	.05	.05	.35	.2	.05	.05
ET-11	16	1.4	1.8	13	.8	3.3		1.9	45		5.8	.8	.3	1.0	tr	.05	.1	.05	tr	tr	.1	.2	tr	tr	
ET-12	14	3.0	9.2	17	1.6	3.3		3.3	43	.3	3.3		.4	1.2	tr	.05	.4	.1			.1	.1	.05	tr	tr
ET-13	23	1.4	12	15	1.4	3.4		1.7	36		2.5		1.0	1.6	tr	.05	.2	.1	.05		.05	.3	tr	.05	tr
ET-14	6.4	2.6	14	21	2.0	2.0		3.5	42	3.5	1.2		.4	1.5	tr	.1	.05			tr	.05	.1			tr
ET-15	5.8	2.6	12	22	1.3	3.2		2.6	45	1.6	1.9		.1	.8	tr	.1	.1			tr		.1		tr	
ET-16	11	1.6	13	21	1.2	3.1		1.9	43		1.9		.2	1.2	.05	.05	.2	tr		tr	.1	.1			tr
ET-17	9.0	.6	14	19	1.5	1.2		1.2	44	1.5	2.7	.6	.9	2.5	.05	.2	.8		.1	.05	.3	.05	.5		.05
ET-18	6.5	.3	13	21	.3	1.2	.3	1.2	47	.6	5.6		.3	1.3	.1	.1	.5	.1				.1	tr	tr	
ET-19	4.9	.3	14	21	.6	1.6		1.0	46	1.3	6.5		.5	1.3	.2	.1	.3	.05		tr	.1	.1		tr	.05
ET-20	4.8		14	15	1.3	1.6		.3	53	.6	6.1		1.1	2.1	.1	.05	.4		.05			.35	.05	.05	.05
ET-21	3.2		17	22	.6	1.0		.3	49		5.2		.3	1.2	tr	tr	.2	tr			.3	.1	tr		
ET-22	6.2	.3	18	20	.3	1.6		1.0	46		3.6		1.1	1.6	.1	.1	.3	.1	tr			.2	tr	tr	
ET-25	8.1	.6	14	16	.6	1.7		1.1	50	.3	1.7		1.7	2.5	.05	.1	.5		.3	.3	.2	.1	.05	.1	.1
ET-27	4.1	.3	16	16	.6	.9		1.2	50	.3	5.4		1.7	2.3	.2	tr	.4	.1		.3		.3	tr		
ET-28	6.1	.8	14	18	.6	1.7		.8	46		7.2		.9	2.0	tr	.1	.9	.1	.05		.1	.2	.05	tr	tr
ET-29	3.1	.3	15	18	1.2	.9		1.8	5.1	.3	6.4	.3	.2	1.2	tr	tr	.3	tr		tr	.2	tr			
ET-30	2.8	.6	17	17	.6	.9		1.3	45		11		.4	1.5	.05	.05	1.2		.05	.1	.1	.05			
ET-31	3.5	.6	17	17	1.2	1.2		1.7	43	.3	11		.3	1.1	tr	tr	0.7	.05		tr	.1	.05		tr	
ET-33	3.7	1.5	16	17	1.2	.3		1.5	46	7.1	4.3		.1	.4	tr	.	.4	.05	tr	.05	.2	tr		tr	
ET-34	3.5	1.2	17	22	.9	.6		2.3	44	2.6	3.2		.3	1.1	.05	.05	1.3	.1		.2	.1	.1	tr	tr	tr
ET-35	.6	.3	18	26	1.0	.6		.6	42	7.4	3.5		.1	.2			.1	tr		.05	.1	.05			
ET-36	3.8	.6	19	31	.6	.3		.6	33	7.3	2.1		.3	.6	.05	tr	.8	.05	tr	.2	.2	tr	tr	tr	
ET-37	18	.6	15	22	.9	1.7		1.5	32		.9		1.1	1.8		.05	3.9	.3		.4		.1	.05		
ET-38	13	.9	17	24	.6	.6		.9	37	.6	.9		.5	1.2	.05	tr	2.2	.2		.4		tr		.05	
ET-39	12	1.9	18	27	.3	.8		.5	29	.5	.8		2.7	2.1	.3	.2	4.1			.6				.1	.1

Fig. B.3 Eje Tentativo detritic minerals

edges due to intrastratal solution. Sometimes in aggregates of several crystals. Pale yellowish-green to pale green.

Opaque minerals: Primary to secondary component. Subhedral equant crystals or irregular aggregates.

Epidote: Secondary component, occasionally principal. Short prismatic crystals, and irregular to fibrous aggregates. Moderate to poor conservation. Green to yellowish-green.

	Monocrystalline quartz	Polycrystalline quartz	Acid volcanic fragments	Basic/inter. volcanic frag.	Pelitic fragments	Orthoclase	Microcline	Polysynthetic plagioclase	Zonate plagioclase	Glass shards	Glauconite	Cristobalite	Green-brown hornblende	Basaltic hornblende	Blue-green hornblende	Augite	Titaniferous augite	Diopside	Hypersthene	Biotite+Muscovite	Garnet	Epidote+Clinozoisite	Zircon	Monazite+Rutile	Opaque minerals
PP-1	4.0	.6	.9	36		1.2		1.9	42	3.4	4.3	.3	1.9	tr	tr	1.2	.1	.1	.4	.4		.3		tr	.6
PP-2	7.7		2.2	29	.6	.6		2.8	46	1.9	3.4		1.8	tr	tr	1.5	.1	.1	.3	.2		.2	tr	tr	.6
PP-3	10	.9	1.3	30	.3	1.3		1.3	45	2.8	4.7		1.0	tr	tr	.6	.1	.1	.1	.1		.2		tr	.3
PP-4	3.0		2.4	40		.3		.3	36	13	4.0		.4	tr		.3	tr	tr	tr	.1	tr	tr	tr		.2
PP-5	3.9	.6	2.6	26		1.3		.6	31	31	1.6		.6	tr		.3	.1	tr	.1	.1		.1		tr	.2
PP-6	6.5	1.0	2.4	39	.3	.7		2.1	41	2.7	1.7	.3	.8	tr	tr	.5	tr	tr	.1	.2		.1	tr	tr	.4
PP-7	4.1		1.7	40	.7	1.0		2.7	41	5.8	1.0		.7	tr	tr	.9	tr	tr	.1	.1		.1		tr	.3
PP-8	3.9	1.5	1.8	38	.9	.6		2.1	37	6.8	.9		1.1	.1	tr	2.4	.2	.1	2.0	.3		.2			.7
PP-9	11	.9	.9	35		1.8	.3	1.5	38	3.0	1.2		1.1	tr		2.4	.2	.1	1.7			.2	tr		1.1
PP-10	18	.7	1.6	34		2.3	.3	1.0	35				1.4	tr	tr	3.8	.1		.7			.1	tr	tr	.5
PP-11	19	1.9	2.2	48	.3	1.3		.6	18	.3	2.2		.8	tr	tr	2.7	.2		.2		.1	.2		.1	1.9
PP-12	17	1.3	2.9	42	.3	1.3		1.6	28		1.0	.3	1.0	tr		1.1	.1	tr	.1			.2	tr	tr	1.0
PP-13	3.8	.4	2.6	46				.8	45	.4	.4		.4	tr		.1			tr		tr	tr	tr	tr	.2
PP-14	8.7	.7	2.7	49		.7		1.3	31	1.3	.7	.7	1.4	tr		1.0	.1		.1			.3		tr	.8
PP-15	4.4	1.6	2.8	38		1.6		1.6	44	.9	1.2		1.2	.1	tr	1.3	.1	tr	.1	tr		.2			.8
PP-16	11	1.3	2.9	36		1.3		1.0	41		1.6		1.3	.1		1.8	.1	tr	tr			.1		tr	.9
PP-17	6.4		1.8	37		.6		1.2	44		2.6		1.8	tr	tr	2.2	.1	tr			.1	.3	tr		1.5
PP-18	7.8	2.1	2.5	43		.4		.7	35	.4	1.8		1.6	.1	.1	2.2	.1		.9		.1	.3	.1		.7
PP-19	12	1.3	2.8	43		.9		.6	34	.6	.9		.8	tr		1.3	.1		.9		tr	.1			.2
PP-20	12	.9	2.4	30		.3		1.2	40		2.7		1.6	.1		2.8	.3		2.8		tr	.2			1.5
PP-21	12	1.4	2.0	35		1.4		.3	42		1.0		1.5	.1	.1	2.0	.2		1.1	tr	tr	.1			.4
PP-22	10	1.6	1.9	47		1.0		1.0	32		1.0	.3	1.0	.1		1.6	.1		1.2		tr	.1			.2
PP-23	11	.6	2.5	46		1.6		2.2	31		.6	.3	1.2	tr		2.0	.1		.4			.2		tr	.3
PP-24	15	1.0	1.6	39		.7	.3	1.0	34		2.6		1.5	tr	tr	2.0	.1		.4			.2		tr	.3
PP-25	12	1.2	2.1	45	.3	1.2		.6	24	2.7	1.2		1.3			3.4	.2		4.0		tr	.2			.7
PP-26	6.5	1.2	3.2	49	.3	1.2		.9	25	2.4	2.9		1.7	.1	tr	2.4	.1		2.4	tr	tr	.2	tr	.1	.7
PP-27	6.3		1.9	51		.4		1.5	34	1.9	.7	.4	.9	tr	tr	.5	tr		tr	tr		tr			.3
PP-28	1.3		1.7	44		.7		.7	45	5.0	1.0		.5	tr		0.3	.1	tr	.1	tr		tr			.1
PP-29	15	1.2	2.7	33		.9		2.7	33	.3			2.6			3.8	.2	.1	2.0		.1	.2	.1		2.7
PP-30	4.1	.3	3.1	42		.3		.6	32	15			.7	tr	tr	.8	.1		.3		tr	tr			.3
PP-31	4.7	.4	1.6	59				1.6	31	1.2			.7	tr		.3	.1		tr		tr	tr			.1
PP-32	20	2.1	1.2	45		1.5	.6	2.4	17	.3			.9			2.5	.4		3.1		.1	.1	.1		1.5
PP-35	9.0	.9	1.2	38		.9		1.2	30	15			.9	tr		1.6	.1		1.5		tr	tr			.5
PP-36	3.8		1.6	43		.6		.3	17	32			.4	tr		.8	tr		.8			tr			.1
PP-37	7.7		1.3	35		.6			33	19			.3	tr		1.0	.1		1.0			tr			.1

Fig. B.4 Puerto Pirámide detritical minerals

Biotite: Isotropic foils with subhedral to rounded contours. Dark-brown to green.

Basaltic hornblende (lamprobolite): Euhedral to subhedral tablets. Typical reddish pleochroism.

Blue-green hornblende: Subhedral elongated tablets. Green to blue-green pleochroism.

Hypersthene: Elongated prismatic habits, generally rounded. Strong green light to red-brown pleochroism.

Titaniferous augite: In some samples, may be a minor component. Short prismatic crystals, some well-rounded with serrated edges due to intrastratal solution. Purplish brown.

Zircon: Small euhedral prismatic crystals with high relief and birefringence. Colorless to pale yellow.

Diopside: Short prismatic crystals; some well-rounded with serrated edges due to intrastratal solution. Colorless to pale yellowish-green.

Garnet: Equant subangular isotropic crystals, corroded. Light-pink to reddish-brown, sometimes colorless.

Rutile: Crystals with prismatic habit and very high relief. Bright colors, from reddish-brown to red.

Clinozoisite: Short prismatic crystals and irregular to fibrous aggregates. Conservation moderate to poor, very weathered. Colorless, with characteristic anomalous birefringence color (Berlin blue).

Monazite: Subhedral prismatic crystals with high relief and birefringence. Yellow.

Muscovite: Subhedral to rounded isotropic foils. Colorless.

	Monocrystalline quartz	Polycrystalline quartz	Acid volcanic fragments	Basic/inter. volcanic frag.	Pelitic fragments	Orthoclase	Microcline	Polysynthetic plagioclase	Zonate plagioclase	Glass shards	Glauconite	Opal+Siliceous spicules	Green-brown hornblende	Basaltic hornblende	Blue-green hornblende	Augite	Titaniferous augite	Diopside	Hypersthene	Biotite	Garnet	Epidote+Clinozoisite	Zircon	Monazite+Rutile	Opaque minerals
ED-1	9.1	.7	11	28	.7	.4	.4	.4	36	3.6	8.4	1.5	.1	tr		tr				.1		tr		tr	.1
ED-2	7.4		15	17	.7	2.1	.4	1.1	41	1.1	9.5	.4	1.3		tr	.3	.1		.1		tr	.1		.1	2.6
ED-3	15		19	16		1.8		1.1	37		7.3	1.8	1.1	.1	tr	.1			tr	tr	tr	.1	tr	tr	.5
ED-4	11		11	21		1.4		2.1	47		4.9	.4	1.3	tr	tr	tr	tr		tr	tr	tr	.1	tr	tr	.4
ED-5	10	.7	6.6	23		.4		1.1	52	.4	4.8		1.0	tr	tr	tr				tr	tr	.2	tr	tr	.4
ED-6	18	1.4	5.9	24		1.4		.7	43		3,5		1.0	.1	tr	tr	tr			tr	tr	.4	tr	.1	0,6
ED-8	11	1.6	9.6	36	.3	1.6		2.6	30	.3	2.9	.3	1.7	.1	tr	.2				.1		.5	.1		2.0
ED-9	6.6	1.6	9.7	20	.6	1.3	.3	1.6	46	.3	4.4		2.5	.1		1.4	.1	.1	.1		tr	1.3		tr	2.6
ED-10	9.4	1.3	13	35	.6	2.3		1.0	31		1.6		1.8	tr	tr	1.1	.1	tr	tr	.1	tr	.5			.2
ED-11	13	.6	9.7	34		1.3		1.0	31	.3	1.0		1.8	.1		1.2	.1	tr	.2	tr		.8			3.6
ED-12	11	.9	6.8	28	.3	1.2		.9	46		2.8	.3	1.0	.1	tr	tr	tr	tr	tr	tr	tr	.2	tr		.6
ED-13	13	1.0	6.0	34		2.7	.3	1.0	34		4.7		.9	.1	tr	.1	tr		tr		tr	.5	tr	tr	.6
ED-14	12	2.3	6.3	31	.3	1.7		2.0	39		2.7		1.3	tr	tr	.1	tr				tr	.3			.4
ED-15	10	1.2	5.0	40		.9		1.6	29		5.0		1.7	.1	tr	1.7	.1	tr	.1		.1	.4	.1	tr	2.6
ED-16	14	1.3	3.0	42		1.0		.7	31		3.3	.3	1.0	.1	tr	2.1	.1	tr	.1			.3			.3
ED-17	12	1.0	3.6	31		1.0		1.0	41		2.9		1.5	.1	tr	3.7	.2	.1	.2			.5		tr	.3
ED-18	13	.7	5.1	43		1.0		1.0	20	.7	3.1		1.6		.1	5.9	.2		.4		.1	.6	.1	.1	2.6
ED-19	7.3	.7	6.3	27	.7	1.0		2.1	52	.7	.7		1.0	.1	tr	.1	tr					.1	tr	tr	.1
ED-20	9.2	.6	2.3	43	.3	1.1		.6	27	.3	2.6		1.5	.1		7.6	.9		1.0			.4			1.5
ED-21	5.9		3.7	37	.3	.6		.3	41	.9			1.5	.1	tr	4.6	.5	tr	.5	.4		.5			1.6
ED-22	7.9	.6	1.7	37		1.1		1.7	37	2.6	1.4		.9	tr	tr	4.7	.2	tr	2.0			.4			.9
ED-23	4.8	.3	3.3	45		.3		.9	39	2.4			.8	tr		1.8	.2		.7			.2		tr	.7
ED-24	5.2		3.1	52		1.4		.7	32	1.7			.8	tr	tr	1.4	.1	.1	.6		tr	.2		tr	.4

Fig. B.5 Playa El Doradillo detritic minerals

Appendix C
Distribution Charts

H. Marengo, *Neogene Micropaleontology and Stratigraphy of Argentina*,
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DIAMANTE	PPD3-15	PPD3-16	PPD3-17	PPD3-18	PPD3-19	PPD3-20	PPD3-22	PPD3-23	PPD3-24	PPD3-26	PPD2-5	PPD2-6	PPD2-7	PPD2-8	PPD2-9	PPD2-10	PPD2-13	PPD1-10	D1-5	D1-6	D1-7	D1-8
Miliammina sp.			1																			
Textularia candeiana			3	2												2						
Textularia gramen													1									
Cycloforina angulata			2																			
Pyrgo peruviana ?		9	21									2		8							9	
Pyrgo spp.													3									
Pyrgoella sp.		5												2								
Quinqueloculina lamarckiana												1									3	
Quinqueloculina seminulina		6										1	4	9							7	
Quinqueloculina spp.			11									3	3						4		26	1
Ammonia parkinsoniana	28	12	206	19	2		7	14	6	3	18	15	83	18	1	8	2	58	40	3	42	5
Bolivina sp.			1																			
Buccella peruviana campsi		1	2	1						2	3	1	1	1								
Buliminella elegantissima			1	1								1				1						
Cibicides sp.	1			1																		
Cribroelphidium discoidale	3	1	27	2							4	1	11						9		1	
Disconorbis bulbosa	1		6	2								2	5			2			1		1	2
Fissurina quadricostulata											2											
Guttulina lactea													1									
Guttulina problema	1										1											
Hanzawaia boueana	14	9	9			3					46	9	26			3			19	1	3	
Lagena sp.		1																				
Neoeponides sp.			1	1																		1
Nonion sp.				1																		
Nonionella auricula																			2			
Nonionella auris													1									
Protelphidium tuberculatum	44	25	202	39	4	7	4	1	2	4	24	16	97	19		15	1	41	60	5	39	12
Rosalina floridana													1									
Rosalina spp.	1		2		2	2																
Undetermined foraminifera		11	24	11	1			1													3	
Bensonia miocenica												4				1						
Bensonia reticulata		1																		1		
Buntonia entrerriensis		3	5																			
Buntonia sp.																					1	
Callistocythere litoralensis						1						1										
Caudites kennedyi			1										7	1					2			
Cornucoquimba lutziana			5									1	1									
Cyamocytheridea ovalis												2	1	1					1	1		
Cyprideis camachoi			4	5								14	10	1		1		1	2	1		2
Cytherella (C.) punctata												1										
Cytheretta argentinensis												4	3									
Cytheretta punctata			5									8	7						3	1	3	
Cytheretta sp.												1										
Cytheropteron aff. *newportense*			2										2									
Cytheropteron sp.			1																			
Cytherura elegans			1																			
Echinocythereis boltovskoyi																1						
Henryhowella alwinae			1									2							2			
Henryhowella aff. *evax*			2																1			
Henryhowella sp.			2																			
Murrayina grekoffi												3	13									
Murrayina sp.																			1			
Neocytherideis sp.													6									
Paijenborchella aff. *punctacostata*		1		1																		
Paracypris spp.		1		1								10	14						2			
Patagonacythere anzoteguiana			26										3									
Patagonacythere paranensis		1	4									1	5									
Patagonacythere spp.			17																			
Pellucistoma santafesinensis			3									2										
Perissocytheridea ornata			10																			
?*Platella fragilis*			3															1				
Pumilocytheridea sp.												1										
Trachyleberis nova													1									
Undetermined ostracoda		13	13	1								8	12	5	1		1	1	1	1	7	2

Fig. C.1 Microfossils of PPD1, PPD2, PPD3, and D1

	Protelphidium tuberculatum	*Ammonia parkinsoniana*	*Buliminella elegantissima*	*Cribroelphidium discoidale*	*Bucella peruviana campsi*	*Quinqueloculina bicornis*	*Cycloforina contorta*	*Cibicidoides* spp.	*Quinqueloculina* sp.	*Melonis* sp.	*Elphidium macellum*	*Peneroplis* sp.	*Fissurina* sp.	*Bolivina ?* spp.	*Rosalina* spp.	*Nonion?* sp. 1	*Nonion* spp.	*Nonion depressulus*	*Pygmaeoseistron* cf. *laevis*	*Lagena* spp.	*Quinqueloculina seminulina*	*Elphidium* sp.	Undetermined foraminifera	Ostracoda	Oogonia
O3-16		1																							
O3-30a												1													
O3-38											1														
O3-42																	2							24	
O3-44												1													
GL1-19		13																							
SF1-13	47	50						1															1		
SF1-14	13	646																						1	
SF1-15	489	74	55																					1	
SF1-16	212	103	7				1																	1	
SF1-17	143	107	39		5																		1	2	
SF1-18	148	66							1															3	
SF1-19	190	152			1																			1	
SF1-20	140	130																						2	
SF1-41		1																						2	35
SF1-42																8								13	12
SF1-43		2														58								6	2
SF1-44																1								1	
SF1-46		2										2				2							2	1	7
SF1-47		5																			1				4
SF1-48		300						1								1		3			60		10	91	4
SF1-49		55																			16	1	7	30	1
SF1-50		26																			18		3	23	
SF1-51		18																			8			10	
SF1-52		13														1					1		1	1	
SF1-54		2																			1		1	1	
SF1-58		1																							
SF1-60																1								1	
S2-24	63	79																							
S2-30	238	37			2	1							1						1		23			52	
S2-31	73	46		2						5					4										
S2-33	136	30		2										1			6				6		1	50	
SC1-6	3	5																				1			
SC1-15		1154	38											13	9	584					1		9	38	
PT1-86		3																						2	3
PT1-87	5	235															36							3	
PT1-88	16	82																						4	1
PT1-89	17	75		1																			12	3	
PT1-90	30	96															17	12					5	2	
PT1-91	34	83						1									43	39					11	2	
PT1-92	3	17															3	10					31		
PT1-93	2	40															34	36					9	1	
PT1-94		11															4	11							
PT1-95		14															2	3						1	
PT1-96		1																2						1	
PT1-97		1																2						12	
PT1-98																		1						9	
PT1-99																								9	
PT1-100		14															1	9					1	50	
PT1-101		7																4					6	29	
PT1-102		1																4						5	
PT1-103		7																12						46	
PT1-104		3																7						5	
PT1-105		18																24		3			8	41	1
PT1-106		7															1	4						13	4
PT1-107																								6	2
PT1-108																								4	

Fig. C.2 Foraminifera of the Chacoparanense Basin. Values show the number of specimens. TLP samples in *grey*, TEP samples in *white*

+ This work	SOUTHWESTERN ENTRE RIOS		SANTA FE		CORRIENTES/ CHACO/FORMOSA		CORDOBA		SANTIAGO DEL ESTERO		TUCUMAN	SOUTH BOLIVIA
	++	+	++	+	++	+	++	+	++	+	++	++
Miliammina sp.		●										
Textularia candeiana		●										
T. gramen	●	●										
Trochammina sp.											●	
Cycloforina contorta	●	●						●				
Pyrgo elongata			●									
P. patagonica			●									
P. peruviana ?		●										
P. ringens	●											
Pyrgo spp.		●										
Pyrgoella sp.		●										
Quinqueloculina aff. *Q. Implexa*			●									
Q. bicornis			●						●	●		
Q. lamarckiana		●	●						●			
Q. seminulina	●	●	●				●		●	●		
Quinqueloculina spp.	●	●						●				
Scutuloris sp.			●									
Ammonia compacta											●	
A. parkinsoniana	●	●	●	●	●	●	●	●	●	●	●	●
Bolivina costata			●									
Bolivina spp.		●								●		
B. sp. aff. *B. robusta*			●									
B. sp. cf. *B. spathulata*			●									
B. striatula									●			
Buccella peruviana campsi	●	●						●		●		
B. peruviana frigida	●		●								●	
Bulimina affinis			●									
B. pseudoaffinis			●									
Buliminella elegantissima		●	●				●	●	●			
Cancris sagra	●						●					
Cibicides sp.		●										
C. variabilis	●		●									
Cibicidoides sp.						●		●				
Cribroelphidium discoidale	●	●	●			●				●		
Disconorbis bulbosa		●										
Elphidium sp.				●								
Fissurina bicarinata			●									
F. quadricostulata		●										
Fissurina spp.										●		
Globigerina juvenilis			●									
Globulina caribea	●											
Guttulina lactea	●	●										
G. problema		●										
Hanzawaia boueana	●	●					●					
Lagena spp.		●								●		
Melonis sp.										●		
Neoeponides sp.		●										
Nonion demens f. *santamariana*			●						●		●	
Nonion spp.	●	●				●				●	●	
Nonionella atlantica	●											
N. auricula	●	●										
Nonionella auris		●	●									
"Nonionella" sp.											●	
Protelphidium tuberculatum	●	●	●	●	●	●	●	●	●	●	●	
Rosalina floridana	●	●	●						●			
Rosalina spp.		●								●		
Aurila sp.	●											
Bensonia miocenica	●	●	●		●				●			
B. reticulata		●	●									
Bensonia spp.	●						●					
Bradleya aff. *prodictyonites*	●											
Buntonia entrerriensis	●	●										
Buntonia spp.	●	●										

++ Data from previous works	SOUTHWESTERN ENTRE RIOS		SANTA FE		CORRIENTES/ CHACO/FORMOSA		CORDOBA		SANTIAGO DEL ESTERO		TUCUMAN	SOUTH BOLIVIA
	++	+	++	+	++	+	++	+	++	+	++	++
Bythocypris sp.												●
Callistocythere litoralensis	●	●	●						●			
C. marginalis			●						●			
Caudites kennedyi	●	●	●						●			
Clithrocytheridea? sp.	●											
Copytus spp.	●		●									
Coquimba spp.	●	●										
Cornucoquimba lutziana	●	●	●						●			
Cyamocytheridea ovalis	●	●	●									
Cyprideis camachoi	●	●	●		●							
C. herbsti											●	
Cyprideis spp.	●				●				●		●	●
Cytherella (C.) damotteae	●		●						●			
Cytherella (C.) punctata		●	●									
Cytherella spp.	●		●						●			
Cytherelloidea sp.	●											
Cytheretta argentinensis	●	●										
C. punctata		●	●									
Cytheretta spp.	●	●										
Cytheridea spp.	●						●					
Cytheropteron aff. *newportense*	●	●										
C. benedictus	●											
Cytheropteron spp.	●	●										
C. victoriensis	●											
Cytherura elegans		●	●									
C. rossiana			●									
Cytherura sp.	●						●					
Darwinula sp.											●	
Echinocythereis boltovskoyi	●	●										
Eucytherura sp.	●											
Hemicytherura costulosa	●		●									
Henryhowella alwinae		●	●				●					
H. aff. *evax*	●	●	●				●		●			
Henryhowella spp.	●	●					●					
Leptocythere sp.	●		●						●			
Loxoconcha paranensis	●											
Loxoconcha sp.	●											
Minicythere sp.			●									
Munseyella argentina			●									
Murrayina grekoffi	●	●										
Murrayina sp.		●										
Neocytherideis sp.		●	●									
Paijenborchella punctacostata	●		●						●			
P. aff. *punctacostata*		●										
Paracypris sp.		●	●									
Paracytheridea? laudata	●											
Patagonacythere anzoteguiana	●	●	●									
P. paranensis	●	●	●									
Patagonacythere spp.	●	●										
Pellucistoma santafesinensis		●	●									
Perissocytheridea alvareziana			●									
P. ornata		●	●									
Perissocytheridea spp.	●				●				●		●	
P. victoriensis	●		●									
?Platella fragilis	●	●										
Pumilocytheridea herbsti			●						●			
Pumilocytheridea sp.	●	●										
Puriana sp.	●											
Scherochilus sp.	●											
Trachyleberis nova	●	●										
Trachyleberis sp.	●											
Wichmanella deliae	●											

Fig. C.3 Marine microfossils of the Paraná formation: Chacoparanense Basin and Northwestern Argentina (NOA)

YPF Palermo 10	51-52,5	60-61	61-62	62-63	64-65	65-66	67-68	69-70
Cancris sagra	4	3		4	31	50	7	21
Glandulina ovula		2	1	1	3	18	1	1
Bucella peruviana s.l.		1	2		14			
Pyrgo spp.				1		1		
Lenticulina calcar?						1		
Textularia spp.						2		
Quinqueloculina spp.						3		
Fissurina spp.						1		
Lagena sulcata						2		
Pygmaeoseistron laevis f. *perlucida*						1		
Dentalina antenula						5		
Laevidentalina communis						4	1	
Bucella peruviana typica						793	41	15
Cribroelphidium discoidale						114	1	3
Nonionella atlantica						76	5	38
Hanzawaia boueana						109	3	86
Cibicidoides pseudoungerianus						33	1	125
Bucella peruviana campsi						332		232
Lagena spp.						1		4
Fissurina sp. A						3		3
Guttulina problema						1		1
Protelphidium tuberculatum						63		84
Cribroelphidium articulatum ?						1		2
Lenticulina rotulata						4		3
Globocassidulina subglobosa						5		8
Disconorbis bulbosa						7		15
Lenticulina limbosa						1		1
Nonion ? *tisburyensis*						1		5
Nonionella sp. A						2		5
Bulimina marginata						1		2
Protoglobobulimina pupoides						1		2
Lagena ex gr. *substriata*								1
Quinqueloculina lamarckiana								1
Nodosaria sp.								1
Lagena alcocki								2
Milliamina sp.								7
Angulogerina angulosa angulosa								3
Bolivina spp.								24

Fig. C.4 Foraminifera of YPF Palermo 10 borehole. Values show the number of specimens

Riachuelo II	RII-47	RII-50	RII-51	RII-53	RII-89	RII-90	RII-91	RII-94
Angulogerina angulosa angulosa	1							
Protelphidium tuberculatum	12	28						
Nonionella atlantica	4	15	6					
Hanzawaia boueana	9	18	25					
Cassidulina laevigata	2	2	1					
Cribroelphidium discoidale	6	5	1	2				
Ammonia parkinsoniana	2	11	1	3	2			
Bucella peruviana s.l.	18				14			
Fissurina spp.	5	1				1		4
Bolivina spp.	1	1						2
Rosalina spp.	2							5
Procerolagena caudata		1						
Pygmaeoseistron hispidula		1						
Fursenkoina pontoni		1						
Lenticulina limbosa		1						
Gyroidina sp. 1		14						
Protoglobobulimina pupoides		1						
Cancris sagra		32	7					
Glandulina ovula		5	2					
Bucella peruviana typica		157	95	4				
Textularia candeiana		6	6	1		1		
Quinqueloculina spp.		5	25		5	43		1
Spiroloculina depressa			2					
Pyrgo spp.			19					
Cycloforina contorta			48					
Cornuspira involvens			1					
Lagena spp.			1					
Globocassidulina subglobosa			2					
Rosalina spp.			4					
Nonionella sp. A			1					
Nonion sp.			1					
Lenticulina rotulata			3					
Cibicidoides pseudoungerianus			143		1	1		
Quinqueloculina lamarckiana			7			1		
Quinqueloculina boueana					21			
Triloculina spp.					6			
Massilina secans f. 2					5			
Massilina secans f. 1					23	6		
Quinqueloculina cf. *patagonica*					30	12		
Cycloforina brongniartiana					24	5		
Cribroelphidium sp. nov.					18	8		
Elphidium cf. *lens*					58	127		1
Cribroelphidium dicoidale f. *pausicamerata*					15	162	675	1512
Nonion depressulus						3		
Elphidium macellum						5		
Bucella peruviana campsi						14		26
Quinqueloculina cf. *seminulina*								5
Pygmaeoseistron laevis								6
Undetermined benthonic foraminifera	14	114	74		106	15		3
Planctonic foraminifera		143	12					
Ostracoda		36	76		95	65		174

Fig. C.5 Foraminifera of Riachuelo II borehole. Values show the number of specimens. TLP samples in *grey*, TEP samples in *white*

Riachuelo VI	RVI-17	RVI-18	RVI-19	RVI-21	RVI-22	RVI-24	RVI-25	RVI-27	RVI-28	RVI-30	RVI-31	RVI-32	RVI-34	RVI-35	RVI-36
Pygmaeoseistron laevis	1														
Lagena ex gr. *substriata*	1														
Cycloforina badenensis	3														
Cycloforina sp.	1														
Miliammina sp.	9	2					6								
Cancris sagra	7	1					15	6							
Protelphidium tuberculatum	16	1	2				64	10		8	1				1
Bucella peruviana typica	66	11	2	3	1		9	12	2					1	1
Nonion ? *tisburyensis*	1		1												
Hanzawaia boueana	25		1	1		1	63	5		1	1			1	1
Cibicidoides pseudoungerianus	10			2	1		6	2					1		1
Lenticulina rotulata	1				1		1								
Bucella peruviana campsi	34				4		76	6	1	2	1		2	1	
Lagena spp.	1						2								
Guttulina problema	1						1								
Fissurina sp. A	1						1								
Nonionella sp. A	1						2								
Nonionella atlantica	9						7	1			1		1		
Cribroelphidium discoidale	14						9							3	
Rosalina spp.		1													
Cycloforina contorta		2			1		2								
Laevidentalina communis							2								
Glandulina ovula							2								
Lagena sulcata							1								
Cribroelphidium articulatum ?							2								
Amphicoryna scalaris							1								
Guttulina sp.							1								
Lenticulina limbosa							2								
Fissurina spp.							2								
Angulogerina angulosa angulosa							5								
Protoglobobulimina pupoides							1								
Globocassidulina subglobosa							1								
Disconorbis bulbosa							1								
Cassidulina laevigata							2								
Ammonia parkinsoniana							1						1		
Quinqueloculina spp.							1							1	
Nonion depressulus										1			1		
Cribroelphidium discoidale f. *pausicamerata*										55	1	2	1	2	
Nodosaria sp.											1				
Cycloforina brongniartiana															1
Quinqueloculina sp. cf. *Q patagonica*															1
Undetermined benthonic foraminifera	3			2			11						2		
Planctonic foraminifera	3						29	1							
Ostracoda	14	4	1	4	4		13		2	4	3	1	1	1	

Fig. C.6 Foraminifera of Riachuelo VI borehole. Values show the number of specimens. TLP samples in *grey*, TEP samples in *white*

	Acanthoica sp.	*Braarudosphaera bigelowi*	*Calcidiscus premacintyrei*	*Coccolithus pelagicus*	*Coccolithus pelagicus grande*	*Cyclicargolithus abisectus*	*Discoaster broweri*	*Dyctiococcites antarticus*	*Dyctiococcites productus*	*Helicosphaera carteri*	*Helicosphaera orientalis*	*Helicosphaera walbersdorfensis*	*Holodiscolithus macroporus*	*Micrantholithus pinguis*	*Pontosphaera multipora*	*Rahbdosphaera clavigera*	*Reticulofenestra haquii*	*Reticulofenestra minuta*	*Reticulofenestra procera*	*Reticulofenestra pseudoumbilicus*	*Spherolithus abies*	*Syracosphaera pulchra*	*Thoracosphaera* cf. *T. tuberosa*	*Thoracosphaera heimii*	*Triquetrorhabdulus carinatus*	*Umbilicosphaera jafari*	*Umbilicosphaera rotula*
P10 - 69-70		X	X	X	X	X	X	X		X	X	X	X		X	X	X		X	X	X	X	X	X		X	X
R II - 50				X					X								X	X		X	X						
R VI-25	X	X		X	X			X		X		X			X	X		X		X	X						
R II - 94		X		X		X								X				X							X		

Fig. C.7 Nannofossils of YPF Palermo 10, Riachuelo II and Riachuelo VI boreholes. TLP samples in *grey*, TEP samples in *white*

	RII-89	RII-90	RII-94	RV-45	RVI-30	RVI-31	RVI-32	RVI-34	PT1-91	PT1-98	PT1-99	PT1-100	PT1-101	PT1-103	PT1-105	PT1-106	PT1-107	PT1-108	SF1-42	SF1-48	SF1-49	SF1-60	SC1-15
Ambostracon aff. *Patagonacythere* sp. 1				1																			
Ambostracon (*P*.) aff. *P. rionegrensis*				1																			
Argenticytheretta miocenica				4		1																	
Argenticytheretta spp.	2	2		1																			
Callistocythere marginalis		4																					
Callistocythere spp.	1		3	61	1		1																
Candona ? sp.																			1				
Caudites aff. *diagonalis*		1																					
Cornucoquimba aff. *conulata*		1																					
Cyamocytheridea sp.	1																						
Cyamocytheridea ? spp.		1								4													
Cyprideis aff. *multidentata*																				6			
Cyprideis spp.				1				1															
Cyprideis ? spp.											4	40	11	37	30	1	2	2	2	2			
Cytherella sp.		1																					
Cytheretta punctata	17	18																					
Cytheropteron ? sp.		2																					
Cytherura aff. *C.* cf. *purperae*		1																		1			28
Eucyprinotus ? sp.									1														
Garciaella sp.	5																						
Garciaella leoniana	5	5																					
Hemicytherura sp.	1																						
Hemicytherura aff. *sanmatiasensis*				2																			
Henryhowella aff. *evax*	8	2																					
Henryhowella spp.				7																1			
Huillicythere ? sp.																			1				
Leptocythere ? sp.				1																			
Loxoreticulatum ? sp.		2																					
Munseyella spp.	1		8	3																			
Neocytherideis ? sp.				3																			
Paradoxostoma ? sp.				1																			
Patagonacythere paranensis	2																						
Patagonacythere ? sp.	1																						
Pellucistoma aff. *elongata*	3																						
Perissocytheridea ? spp.	3	2	1	3																44	5		
Quadracythere neali	1																						
Radimella ? sp.	1																						
Rotundracythere ? sp.									1														
Semicytherura sp.	1																						
Soudanella cleopatrae																					1		
Undet sp. 1	2	1																					
Undet sp. 2				7																			
Undeterminable	17	12	130	30		1	1			4	3		12	6		10	3	2	7	26		1	

Fig. C.8 TLP ostracoda of Riachuelo II, V, and VI, Pozo del Tigre 1, San Francisco 1, and San Cristóbal 1 boreholes. Values show the number of specimens

	RVI-17	RVI-18	RVI-22	RVI-25	RVI-28	RI-50	RI-51	P10 65-66	P10 67-68	P10 69-70	D1-5	D1-6	D1-7	D1-8	PPD1-10	PPD2-6	PPD2-7	PPD2-8	PPD3-16	PPD3-17	PPD3-18	PPD3-20	SF1-15	SF1-16	SF1-17	SF1-18	S2-30	S2-33	PT1-88	PT1-89
Ambostracon paranensis				1			3									1	6		1	4										
Ambostracon ? sp.																3														
Argenticytheretta miocenica																6				1						1				
Argenticytheretta aff. *miocenica*																	2													
Argenticytheretta aff. *Patagoniensis*																									1					
Argenticytheretta aff. *Argenticytheretta* sp. 1	1																													
Argenticytheretta ? sp.																			1											
Argilloecia ? sp.						1	1																							
Aurila sp. 3						1	2			3																				
Aurila spp.	1				1			2																						
Austrocytheridea sp.											5					11														
Bradleya aff. *normani*						1				2																				
Bradleya aff. *pelotensis*							1	3																						
Brasilicythere aff. *retisculispinosa*	5							8		5																				
Brasilicythere sp.			1				3																							
Buntonia sp.									1															1						
Buntonia ? aff. *Buntonia* ? sp.										2																				
Callistocythere marginalis				2			6	1																						
Callistocythere aff. *marginalis*	4		1							3												1								
Callistocythere aff. *multicellulosa*								1																						
Callistocythere spp.	1							1								1														
Caudites aff. *Caudites* sp. 1																1	3	1		10										
Caudites sp.																	5			13										
Coquimba rionegrensis																				1										
Coquimba spp.					1	1	1	2																						
Coquimba ? sp.										2																				
Cornucoquimba lutziana																	1	1			5									
Cornucoquimba aff. *Cornucoquimba* sp. 2			1	2				6																						
Cyamocytheridea ovalis											1	1					2	1	1											
Cyamocytheridea ? sp.												1																		
Cyprideis camachoi											2	1		2	1	14	10	1			4	5								
Cyprideis aff. *camachoi*												2		2																
Cyprideis aff. *riograndensis*											2																			
Cyprideis sp.															2															
Cyprideis ? sp.																								1					1	
Cytherella spp.						1				1																				
Cytheretta argentinensis											2																			
Cytheridea ? sp.																													1	
Cytheridella ilosvayi																														2
Cytheropteron ? sp.		1																												
Cytherura rossiana																1					1									
Cytherura ? sp.																				1										
Garciaella leoniana												2																		
Garciaella ? sp.													2	1																
Hemicytherura aff. *chuiensis*	1									2																		1		
Hemicytherura aff. *costulosa*				1																										
Henryhowella rectangulata											3					2														
Henryhowella aff. *evax*				1				3	2	1										4										
Henryhowella sp.																					1									
Krithe sp.								1																						
Leptocythere ? sp.																1														
Loxoconcha paranensis																				5										
Loxoconcha aff. *playabonitaensis*																1														
Loxoconcha sp.																			2											
Loxoreticulatum ? aff. *L. cacothemon*																											4			
Loxoreticulatum ? sp.																				1										
Meridionalicythere ? aff. *discophora*																	12			9										
Munseyella aff. *josti*										1																				
Munseyella sp.						3													1											
Oculocytheropteron ? aff. *melicerion*				2																										
Paradoxostoma ? sp.								1																						
Pellucistoma aff. *elongata*																1														
Pellucistoma aff. *gibosa*																2														
Pellucistoma sp.																				3										
Perissocytheridea ? aff. *krömmelbeini*																				3										
Perissocytheridea aff. *Perissocytheridea* sp.																									1		37	38	2	
Perissocytheridea ? sp.																											2			
Propontocypris ? sp.							1	1																						
Semicytherura aff. *clavata*																												1		
Semicytherura ? sp.							1														1									
Urocythereis sp.								2																						
Wichmannella deliae	1							2		1																				
Wichmannella juliana									2											2										
Wichmannella sp.								2																						
Xestoleberis ? sp.								1								1														
Undetermined 1																											1			
Undetermined 2																											1			
Undetermined 3																1	3	1		16										
Undetermined 4																			1											
Undeterminable	1	1		5		3	17	9		6	2		5		1	7	9	5	12	17	1		1				3	1		

Fig. C.9 TEP ostracoda of the Salado and Chacoparanense basins. Values show the number of specimens

Eje Tentativo San José	ET-31	ET-30	ET-29	ET-28	ET-25	ET-22	ET-21	ET-20	ET-19	ET-18	ET-16	ET-15	ET-3	ET-S/N	ET-BM	ET-BG	SJ-2	SJ-1
Cribroelphidium discoidale	1	81	10									6			3	223	69	76
Protelphidium tuberculatum	21	81	14	29								154				251	63	96
Dentalina antennula		1																
Uvigerina bifurcata		1														3		
Angulogerina angulosa angulosa		3														28		
Uvigerina peregrina		1														18		
Fursenkoina pontoni		15														17		
Fissurina spp.		9														48		
Cassidulina laevigata		15												4		36	1	4
Rosalina sp. cf. *R. vilardeboanus*		13														71		
Glandulina ovula		32	4	3											9	26		1
Bucella peruviana campsi		121	9	22								8				163	2	16
Globocassidulina subglobosa		1					1									2		
Cibicides aknerianus		2						6	3	19				996		36		
Lagena spp.		2										1				21	1	
Bolivina ? spp.		2										1		2	1	17		
Protoglobobulimina pupoides		4										1		1		9	1	1
Lenticulina rotulata		5										1			1	4		
Laevidentalina communis		3										1				4		
Planorbulina variabilis			1													15		
Cycloforina contorta				9	1											30		
Pyrgo spp.				5	1	2							1		2	11		1
Quinqueloculina lamarckiana				2			1		1									
Rosalina spp.				1					1	1								3
Bucella peruviana frigida					1													
Pyrgo elongata						7												
Quinqueloculina sp. cf. *Q. patagonica*						15		13										
Marginulinopsis sp.							1											
Textularia aglutinans							2											
Quinqueloculina spp.							1	32	8	1				5	5	5	49	26
Textularia candeiana							5		2		4				4	5		
Pyrgo sp. 1							1			1								
Triloculina spp.								20	3							15		
Spiroloculina depressa								1					1			2		
Bucella peruviana s.l.									1	1				7	13			
Textularia spp.									2		2							
Nonionella atlantica										3								
Nonion sp. A												1		6				
Cancris sagra												1		2		130		
Milliamina sp.														5				
Cibicidoides pseudoungerianus														9				
Asterigerinata sp.														45				
Trifarina sp.														25		2		
Ammonia parkinsoniana																18		
Cribroelphidium sp.																43		
Gyroidina sp. 2																117		
Guttulina sp.																1		
Hyalinonetrion distoma f. *typica*																1		
Pyrgo ringens																8		
Cribrolenticulina ? sp.																12		
Neoeponides sp.																4		
Lenticulina limbosa																6		
Orthomorphina calomorpha																8		
Orthomorphina filiformis																4		
Orbulina ? sp.																5		
Sigmoidella sp.																2		
Cornuspira involvens																	2	
Pygmaeoseistron hispidula																		1
Rosalina peruvianus																	4	
Procerolagena caudata																	1	1
Undetermined benthonic foraminifera	5	9	1	14		13	8	27	6	19		35	1		76	189	3	
Planctonic foraminifera					2											215		
Ostracoda		25		60	10	8	35	14	27	40	35	20	2	62	34	175	98	85

Fig. C.10 Foraminifera of Eje Tentativo and Puerto San José localities. Values show the number of specimens

Puerto Pirámide	PP-29	PP-25	PP-22	PP-21	PP-20	PP-19	PP-18	PP-17	PP-16	PP-12	PP-9	PP-4	PP-2	PP-1
Bucella peruviana campsi	23	1	1	6	1	1		4	1			4	25	14
Protelphidium tuberculatum	16	16		2	1	3	3	6	3	3	3	35	56	15
Quinqueloculina sp. cf. *Q. patagonica*	8		2				12							
Rosalina sp. cf. *R. vilardeboanus*	1												5	
Cassidulina laevigata		1		1										
Ammonia parkinsoniana		2									2	23	25	1
Cribroelphidium discoidale				1								30	13	4
Cibicides aknerianus				2							3		1	1
Bolivina spp.				1							4			
Rosalina peruvianus				5									2	
Laevidentalina communis				1										
Guttulina problema				2										
Rosalina spp.											10			
Glandulina ovula												4	9	11
Gyroidina sp. 2												3	7	2
Hyalinonetrion distoma f. *typica*												1	2	
Lenticulina rotulata												4	2	
Nonion sp. A												2	5	
Oolina sp.												3		
Lagena striata													1	
Fissurina spp.													1	
Globocassidulina subglobosa													1	
Lenticulina calcar?													1	
Textularia candeiana													1	
Miliammina sp.													1	
Neoeponides sp.													2	
Pygmaeoseistron hispidula													1	
Undetermined benthonic foraminifera	2		1	2	1	1					12	3	10	4
Planctonic foraminifera				1									18	
Ostracoda	13	3	14	12	72	11	43	8	21	2	32	2	7	1

Fig. C.11 Foraminifera of Puerto Pirámide locality. Values show the number of specimens

Playa El Doradillo	ED-24	ED-22	ED-21	ED-20	ED-18	ED-15	ED-14	ED-13	ED-12	ED-4	ED-3
Protelphidium tuberculatum		1	1	5	4	3			8	6	14
Elphidium sp. cf. *E. macellum*			2						2		
Triloculina sp.				3					1		
Quinqueloculina sp.				6							
Cribroelphidium discoidale						3				1	
Bucella peruviana campsi									1	3	3
Cibicides aknerianus										1	4
Bolivina spp.										1	2
Buliminella elegantissima										36	82
Rosalina spp.										1	
Cassidulina laevigata											1
Lagena sp.											1
Undetermined benthonic foraminifera	24	3		3	2	6	31		3		
Ostracoda	27	3	1	17	1	10	21	4	18		5

Fig. C.12 Foraminifera of Playa El Doradillo locality. Values show the number of specimens

San José Playa El Doradillo Puerto Pirámide	SJ-1	SJ-2	ED-12	ED-15	ED-20	PP-2	PP-9	PP-12	PP-16	PP-17	PP-18	PP-19	PP-20	PP-21	PP-22
Ambostracon paranensis			2											1	
Ambostracon aff. *anzoteguiana*			1												
Argenticytheretta miocenica	2														
Argenticytheretta sp.		1													
Argilloecia ? sp.	1														
Austrocytheridea sp.	9	7													
Callistocythere marginalis									1						
Callistocythere sp.			2				1								
Caudites aff. *diagonalis*														3	
Caudites sp.													1		
Copytus sp.		1													
Coquimba ? sp.			1												
Cushmanidea sp.			2										2	5	
Cushmanidea ? sp							1								
Cyamocyhteridea sp.			2							6			8		
Cyamocytheridea ? sp.									1		4			27	
Cytheretta punctata													8	3	
Cytherella aff. *punctata*							7								
Cytherella sp.	10	8	2										4	9	
Cytherelloidea ? sp.					1										
Cytheretta punctata			1		3		1								
Cytherois ? sp.		11					3		1	1					
Cytheropteron ? sp.	3														
Cytherura ? sp.	1		1												
Garciaella leoniana													6	1	2
Garciaella ? sp.											2	1			
Hemicytherura aff. *sanmatiasensis*	7	15													
Hemicytherura ? sp.			1												
Henryhowella aff. *evax*						1							2	4	3
Henryhowella aff. *beckerae*											3				
Henryhowella sp.	3	3			1										
Henryhowella ? sp.										1					
Loxoconcha sp.											1		1		
Loxoconcha ? sp.			1												
Loxoreticulatum ? aff. *cacothemon*									1						
Meridionalicythere ? aff. *discophora*			1												
Minicythere argentinensis	9								2						
Minicythere ? sp.		5	1												
Munseyella sp.							1								
Neocytherideis aff. *Copytus* ? sp.													7		
Neocytherideis sp.		2								1	5			3	
Neocytherideis ? sp.	1														
Paijenborchella punctacostata	1														
Papillosacythere sp.	2		1												
Papillosacythere ? sp.											1				
Paracytheridea ? sp.			2												
Pellucistoma aff. *gibosa*	1	2								2					
Pellucistoma sp.											1		2	1	
Pellucistoma ? sp.									2						
Perissocytheridea victoriensis	9	15													
Perissocytheridea ? sp.		2				1									
Protocytheretta aff. *multicostata*							8		1		3	1	2	5	1
Quadracythere ? sp.			1												
Semicytherura sp.		1												1	
Soudanella sp.											1			9	
Soudanella ? sp.													1		
Urocythereis ? sp.						1									
Uroleberis ? sp.										1					
Xestoleberis ? sp.		1													
Undet. 1		1													
Undet. 2			1												
Undet. 3			1												
Not determinable	21	8	20	4	6	3	7	2	10	2	21	7	26	28	8

Fig. C.13 Ostracoda of Puerto San José, Playa El Doradillo, and Puerto Pirámide localities

Eje Tentativo	ET-S/N	ET-BM	ET-BG	ET-15	ET-16	ET-18	ET-19	ET-20	ET-21	ET-22	ET-25	ET-28	ET-30	ET-39
Ambostracon aff. *paranensis*												5		
Argenticytheretta aff. *miocenica*									1			1		
Argilloecia? sp.			1											
Aurila magallanica												1		
Aurila aff. *A.* sp. 3			1				1							
Aurila aff. *A.* cf. *convexa*					1									
Aurila sp.												5		
Austroaurila ? sp.									1					
Bairdia sp.												1		
Bairdia ? sp.	1				1									
Brasilicythere aff. *bensoni*	1											3		
Brasilicythere aff. *reticulispinosa*									5		1			
Buntonia ? sp.			1											
Callistocythere marginalis	2					1								
Callistocythere sp.		1	5											
Caudites diagonalis						1								
Caudites sp.							1							
Caudites aff. *Caudites* sp.								1						
Coquimba aff. *bertelsae*		1		2										
Coquimba ? sp.			1			1								
Coquimba sp.													1	
Coquimba ? aff. *punctata*									1					
Coquimba ? sp.												1		
Cornucoquimba aff. *conulata*			1										1	
Cornucoquimba sp. 2							1							
Cornucoquimba ? sp.				2										
Cushmanidea sp.			1											
Cushmanidea ? sp.												1		
Cytherella sp.	1		10						2			2	3	
Cytherella ? sp.						1								
Cytherelloidea ? sp.							1							
Cytheropteron ? sp.					4	1	3							
Hemicytherura aff. *howei*													1	
Hemicytherura aff. *lapillata*		1												
Hemicytherura aff. *sanmatiasensis*			1								1			
Hemicytherura ? sp.		1												
Henryhowella aff. *evax*	2				10	1	2		1			3		
Meridionalicythere ? aff. *discophora*		1										1	1	
Meridionalicythere ? aff. *mesodiscus*													4	
Munseyella aff. *bermudezi*												1		
Munseyella aff. *josti*			2											
Munseyella aff. *sanmatiasensis*													2	
Munseyella aff. *santacrucensis*												1		
Munseyella sp.			2	1										
Nanocoquimba ? sp.	1													
Neocytherideis aff. *Copytus malumiani*			3											
Neocytherideis aff. *Copytus* ? sp.									1					
Neocytherideis sp.		1	2											
Oculocytheropteron macropunctatum			1											
Papillosacythere ? sp.	1													
Paracytheridea sp.			1			1			1					
Paracytheridea ? sp.	1													
Pelecocythere galleta			1											
Perissocytheridea victoriensis	6		4											
Quadracythere aff. *neali*												9		
Semicytherura aff. *Semicytherura* sp.1	1													
Semicytherura clandestina			2											
Soudanella sp.														1
Wichmannella ? sp.			1									1		
Xestoleberis aff. *ventribulata*	2													
Xestoleberis sp.	2		1						1				2	
Not determinable	22	20	36	8	13	28								

Fig. C.14 Ostracoda of Eje Tentativo locality

Appendix D
Systematics

Foraminifera

The synonymy is restricted to the original quote, to foreign quotes differing essentially from the original, and those of work done in Argentina or nearby countries. The generic classification is based on Loeblich and Tappan (1988), except in some doubtful cases where it was preferred to keep the original name of the genus.

Under the title "Material," the number and origin of specimens and the repository location (SGN) are grouped. In first place, the locations analyzed in this work are presented; secondly (marked by an asterisk), the locations otherwise cited by previous authors are listed. The source of the material is identified using the following abbreviations: P10: Palermo 10; RII: RiachueloII; RVI: Riachuelo VI; D1: Diamante 1; PPD1: Puerto Diamente 1; PPD2: Puerto Diamante 2; PPD3: Puerto Diamante 3; SC1: San Cristóbal 1; O3: Ordóñez 3; GL1: General Levalle 1; SF1: San Francisco 1; S2: Selva 2; PT1: Pozo del Tigre 1; SJ: Puerto San José; ET: Eje Tentativo; PP: Puerto Pirámide; ED: Playa El Doradillo. *D: Diamante; P: Paraná; VU: Villa Urquiza; V: Victoria; SF: subsurface of Santa Fe Province (Zabert 1978); SB: Salado Basin (Malumián 1970); CB: Colorado Basin (Malumián 1970); GB: Gran Bajo del Gualicho (Náñez 1994); BF: Barranca Final Formation (Malumián et al. 1998); SM: valle de Santa María, San José Formation (Bertels and Zabert 1980; Vergani et al. 1991; Gavriloff and Bossi 1992); PF: Paraná Fm. (Zabert and Herbst 1977).

Genus ***Ammonia*** Brünnich 1772

Ammonia parkinsoniana (d'Orbigny 1839a) (Plate I, Figs. h, i; Plate IV, Fig. h)

1839a *Rosalina parkinsoniana* d'Orbigny, p. 99, pl. 4, Figs. 25–27
1930 *Rotalia becarii* var. *parkinsoniana* (d'Orbigny). Cushman, p. 56, pl. 11, Fig. 3

Material: about 4200 specimens. SGN 2466, 2467, 2497. TEP of RII, VI, D1, PPD1, PPD2, PPD3, O3, GL1, SF1, S2, SC1, PT1, ET, PP; TLP of RII, VI, SF1, SC1, PT1. *TEP of SM, V, D, P, VU, PF

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Genus ***Amphycorina*** Schlumberger 1881

Amphycorina scalaris (Batsch 1791) (Plate V, Fig. d)

1791 *Nautilus* (*Orthoceras*) *scalaris* Batsch., p. 1, pl. 2, Fig. 4
1980 *Amphycorinascalaris* (Batsch). Boltovskoy et al., p. 15, pl. 1, Figs. 10–12

Description: Elongated uniserial test, circular cross-section. Rounded base, 4 globular chambers. Bright, strongly ribbed wall with very depressed sutures. Radiated circular opening in the end of a neck with lip. It has the typical characteristics of the species
Material: 1 specimen. SGN 2503. TEP of RVI. *TEP of GB

Genus ***Angulogerina*** Cushman 1927

Angulogerinaangulosaangulosa (Williamson 1858) (Plate VI, Figs. c, d)

1858 *Uvigerina angulosa* Williamson, p. 67, pl. 5, Fig. 140
1980 *Angulogerina angulosa angulosa* (Williamson). Boltovskoy et al., p. 16, pl. 1, Figs. 13–16

Material: 40 small specimens moderately preserved. SGN 2516, 2517. TEP of P10, RII, VI, ET. *TEP of BF, GB

Genus ***Asterigerinata*** Bermúdez 1949

Asterigerinata sp.

Material: 45 strongly recrystallized specimens. TEP of ET

Genus ***Bolivina*** d'Orbigny 1839a

Bolivina spp. (Plate I, Fig. d; Plate III, Fig. f; Plate V, Figs. m, n)

Remarks: Apparently quite different forms
Material: 93 very small specimens. SGN 2462, 2482, 2512, 2513. TEP of P10, RII, PPD3, S2, ET, PP; TLP of RII, SC1. *TEP of BF

Genus ***Buccella*** Andersen 1952

Buccella peruviana (d'Orbigny 1839a), s. l.

1839a *Rotalina peruviana* d'Orbigny, p. 35, pl. 2, Figs. 3–5
1980 *Buccella peruviana* (d'Orbigny), s. l. Boltovskoy et al., p. 19, pl. 4, Figs. 5–22

Description: Biconvex test. Circular outline with convex spiral side and slightly convex umbilical side. A total of 7–9 chambers in the final round. Underdeveloped marginal edge. Thin wall, commonly dissolved, opaque to translucent and shiny to semi-matte. Slightly marked sutures, radial on the umbilical side and curved on the spiral side
Material: 71 poorly preserved specimens. TEP of P10, RII, ET; TLP of RII. *TEP of GB

Buccella peruviana (d'Orbigny) f. ***campsi*** Boltovskoy 1954b (Plate IV, Fig. g; Plate IX, Fig. e)

1954b *Eponides peruvianus campsi* Boltovskoy, p. 265, pl. 17, Figs. 6–8
1980 *Buccella peruviana* (d'Orbigny) f. *campsi*. Boltovskoy et al., p. 19, pl. 14, Figs. 7, 8, 12, 13, 18, 19

Material: About 1200 specimens. SGN 2496, 2545. TEP of P10, RVI, PPD2, PPD3, SF1, S1, ET, PP, ED; TLP of RII, VI. *TEP of SB, CB, GB

Buccella peruviana (d'Orbigny) f. ***frigida*** Cushman 1921 (Plate IX, Fig. f)

1865 *Pulvinulina repanda* Fitchel and Moll var. *karsteni* Reuss. Parker and Jones, p. 396, pl. 14, Figs. 14, 15, 17; pl. 16, Figs. 38–40
1980 *Buccella peruviana* (d'Orbigny) f. *frigida*. Boltovskoy et al., p. 19, pl. 4, Figs. 9, 14, 15, 20–22

Material: 1 specimen corresponding to the characteristics cited by Boltovskoy et al. 1980. SGN 2546. TEP of ET. *TEP of SM, V, VU, PF, SF, GB, BF, CB

Buccella peruviana (d'Orbigny) f. ***typica*** Boltovskoy et al. 1980

1980 *Buccella peruviana* (d'Orbigny) f. *typica*. Boltovskoy et al., p. 19, pl. 14, Figs. 5, 6, 10, 11, 16, 17

Material: More than 1200 specimens. TEP of RII, RVI, P10; TLP (2 specimens) of RVI

Genus ***Bulimina*** d'Orbigny 1826

Bulimina marginata d'Orbigny 1826

1826 *Bulimina marginata* d'Orbigny, p. 269, n° 4, pl. 12, Figs. 10–12
1954a *Bulimina marginata* d'Orbigny. Boltovskoy, 175–177, pl. 10, Figs. 1–4, 5a, b, 6–8

Remarks: It has more features related with *B. marginata* than with *B. patagonica*
Material: 3 moderately preserved specimens. TEP of P10

Genus ***Buliminella*** Cushman 1911

Buliminella elegantissima (d'Orbigny 1839a)

1839a *Bulimina elegantissima* d'Orbigny, p. 51, pl. 7, Figs. 13–14
1980 *Buliminella elegantissima* (d'Orbigny). Boltovskoy et al., p. 21, pl. 6

Description: Triseriate fusiform test, rounded at both ends and with elongated chambers. Recrystallized opaque wall
Material: 290 specimens. TEP of PPD2, PPD3, SF1, ED; TLP of SC1. *TEP of SF, GB

Genus ***Cancris*** de Montfort 1808

Cancris sagra (d'Orbigny 1839a)

1839a *Rotalina sagra* d'Orbigny, p. 91, pl. 5, Figs. 13–15
1972 *Cancris sagra* (d'Orbigny), Malumián, p. 100, pl. 5, Fig. 6

Description: Oblong trochospiral test. Flat to gently convex spiral side, convex umbilical side. Carinated peripheral margin. Triangular chambers in umbilical side with great development of the last chamber, lunate chambers in the spiral side. Translucent to opaque wall with arched and depressed sutures
Remarks: Differing from those illustrated by Malumián (1972) and Boltovskoy et al. (1980), which usually have a small curvature in the last chamber in the umbilical side. This latest camera is more elongated and globose
Material: More than 320 specimens, many well preserved. TEP of P10, RII, RVI, ET. *TEP of SB, East Córdoba and D (Zabert and Barbano 1984), GB, and BF

Genus ***Cassidulina*** d'Orbigny 1826

Cassidulina laevigata d'Orbigny 1826 (Plate VIII, Fig. g)

1826 *Cassidulina laevigata* d'Orbigny, p. 282, n° 1, pl. 15, Figs. 4, 5
1954a *Cassidulinalaevigata* d'Orbigny. Boltovskoy, p. 207, pl. 19, Figs. 3, 4

Remarks: It has the typical characteristics of the species. Most were found in samples from the Peninsula de Valdés, whereas Salado Basin specimens are very small
Material: 71 specimens. SGN 2536. TEP of RII, VI, ET, PP, ED, SJ. *TEP of SB

Genus ***Cibicides*** de Montfort 1808

Cibicides aknerianus (d'Orbigny 1846) (Plate IX, Fig. a)

1846 *Rotalina akneriana* d'Orbigny, p. 156, pl. 8, Figs. 13–15
1972 *Cibicides aknerianus* (d'Orbigny). Malumián, p. 102, pl. 5, Fig. 11

Material: 1075 specimens. SGN 2541. TEP of ET, ED, PP. *TEP of SB, CB

Cibicides sp. (Plate IX, Fig. b)

Material: 2 specimens. SGN 2542. TEP of PPD3, PP

Genus ***Cibicidoides*** Thalmann 1939

Cibicidoides pseudoungerianus (Cushman 1922) (Plate VI, Fig. g)

1922 *Truncatulina pseudoungeriana* Cushman, p. 97, pl. 20, Fig. 9
1972 *Cibicides pseudoungerianus* (Cushman). Malumián, p. 104, pl. 5, Fig. 12

Remarks: The identification of *C. aknerianus* and *C. pseudoungerianus* is complex because they are usually found forming a continuum. The separation into two different genera is done according to Loeblich and Tappan 1988
Material: 337 specimens. SGN 2518. TEP of RII, VI, P10, ET; TLP of RII, VI. *TEP of SB, CB, GB

Cibicidoides spp.

Material: 3 specimens. TEP of SF1; TLP of SF1, PT1

Genus ***Cornuspira*** Schultze 1854

Cornuspira involvens (Reuss 1850)

1850 *Operculina involvens* Reuss, p. 370, pl. 46, Fig. 20
1972 *Cyclogira involvens* (Reuss). Malumián, p. 105, pl. 1, Fig. 9

Material: 3 specimens, only one is well preserved. TEP of RII, SJ. *TEP of CB

Genus ***Cribroelphidium*** Cushman and Brönnimann 1948

Cribroelphidium articulatum (d'Orbigny 1839a)

1839a *Polystomella articulata* d'Orbigny, p. 30, pl. 3, Figs. 9, 10
1954a *Elphidium articulatum* (d'Orbigny). Boltovskoy, pp. 171–172, pl. 8, Figs. 6a, b, 7a, b

Material: 5 specimens. TEP of P10, RVI

Cribroelphidium discoidale (d'Orbigny 1839a) (Plate IV, Figs. i, j; Plate VI, Fig. l; Plate IX, Fig. g)

1839a *Polystomella discoidalis* d'Orbigny, p. 76, pl. 6, Figs. 23–24
1972 *Cribroelphidium discoidale* (d'Orbigny). Malumián, p. 106, pl. 4, Fig. 3

Description: Convex planoespiral test, involute and discoidal, 10–12 chambers on the last lap, slightly inflated. Transparent to translucent, bright delicate wall with ovoid pits and large pores
Remarks: TEP specimens are quite different from descriptions made on recent specimens from the coast of Argentina; the sutures are much less depressed and the peripheral margin is well rounded. It is preferred to maintain their specific name because it is a typical species of the TEP and has already been described on many occasions with this name
Material: More than 700 specimens. SGN 2498, 2499, 2525, 2547. TEP of RII, VI, P10, PPD2, PPD3, D1, S2, PT1, ET, SJ, PP, ED; TLP (3 specimens) of RVI. *TEP of V, VU (Zabert and Herbst 1977), GB, BF, CB

Cribroelphidium discoidale (d'Orbigny 1839a) forma ***pausicamerata*** f. nov. (Plate II, Fig. f)

Derivatio nominis: It refers to the lowest number of chambers in the last lap, in relation to the typical specimens of the species
Description: Involute planoespiral test, biconvex and discoidal. Slightly inflated 8–9 chambers in the last lap. Translucent bright and delicate wall, with large ovoid to rectangular pores and fossettes
Remarks: It has been found only in the TLP of the Gran Buenos Aires, as the dominant form and never associated with *C. discoidale ss*. Both current and Middle Miocene (TEP) and the f. *pausicamerata* (TLP) specimens could be considered as three distinct species due to morphological differences and the significant difference in their ages. It was preferred to keep them as a single species because of the moderate quality of the material and because more systematic detail is beyond the scope of this work
Material: 2365 specimens. SGN 2474 (Holotype). TLP of RII, VI

Cribroelphidium paivensis sp. nov. (Plate II, Figs. g1 and g2)

Derivatio nominis: It refers to the Laguna Paiva Formation, the only unit where this species was found
Description: Planoespiral biconvex test, involute, with discoidal periphery. Slightly inflated 12–14 chambers on the last lap. Thick and bright wall, with large circular to elongated fossettes. Curved and depressed radial sutures. Thick umbilical button. Diameter 0.2–0.4 mm
Material: 26 moderate to poorly preserved specimens. SGN 2475 (Holotype). TLP of RII. Abundant specimens were observed in the TLP of Riachuelo V

Cribroelphidium spp. (Plate III, Fig. i)

Material: 43 specimens. SGN 2485. TEP of ET, PPD3

Genus ***Cribrolenticulina*** Haman 1978

Cribrolenticulina sp. (Plate VIII, Fig. e)

Remarks: Boltovskoy (1959) illustrated a specimen of *Marginulina marginulinoides* (Goës), from the coast of Cabo Frio (Rio de Janeiro, Brazil) similar to juvenile specimens found in the TEP of Península de Valdés
Material: 12 specimens. SGN 2534. TEP of ET

Genus ***Cycloforina*** Luczkowska 1972

Cycloforina angulata (Williamson 1858)

1858 *Miliolina bicornis* var. *angulata* Williamson, p. 88, pl. 7, Fig. 196
1984 *Quinqueloculina angulata* (Williamson). Zabert and Barbano, p. 143, pl. 1, Fig. 1

Material: 2 specimens. TEP of PPD3

Cycloforina badenensis (d'Orbigny 1846)

1846 *Quinqueloculina badenensis* d'Orbigny, p. 299, pl. 20, Figs. 10–12
1974 *Cycloforina badenensis* (d'Orbigny). Luczkowska, pp. 73–74, pl. 11, Fig. 5

Remarks: The specimens are very similar to those of d'Orbigny (1846) and Luczkowska (1974). The latter cite this species from the Tortonian of Poland, Austria, former Czechoslovakia, Hungary, and Russia
Material: 3 specimens. TEP of RVI

Cycloforina brongniartiana (d'Orbigny 1839a) (Plate II, Fig. a)

1839a *Triloculina brongniartiana* d'Orbigny, p. 176, pl. 10, Figs. 6–8

Remarks: This species was invalidated by Le Calvez (1977), because the type in the collection of d'Orbigny (1839a) did not match with the description and illustration of the author. All specimens were collected in the lower marine levels of the Salado basin and perfectly match the description and illustration of d'Orbigny. The specimens are included with doubts within the genus *Cycloforina*. In addition, it can be considered synonymous to *Quinqueloculina linneiana* d'Orbigny f. *comis*, as seen in the illustrations of Wylie Poag (1981) of recent microfaunas from the Gulf of Mexico. He noted that this species is common in miliolids facies and very rare in other facies
Material: 25 typical specimens with marked longitudinal striations. Five specimens without ornamentation are provisionally placed as synonyms. SGN 2469. TLP of RII, RIV (striated specimens in RII-89 and RVI-36, flat specimens in RII-90)

Cycloforina contorta (d'Orbigny 1846) (Plate VIII, Fig. a)

1846 *Quinqueloculina contorta* d'Orbigny, p. 298, pl. 20, Figs. 4–6
1974 *Cycloforina contorta* (d'Orbigny). Luczkowska, pp. 74–76, part. I, pl. 12, Figs. 3a, b; part. II, pl. 11, Fig. 2a, b, 3a, b; text-Fig. 26

Remarks: The specimens are well preserved, sometimes partially dissolved. They are very similar to those described in the Miocene of Europe by Luczkowska (1974), who mentioned them from the Tortonian of Poland and Austria; the Tortonian and Sarmatian of Hungary and Late Eocene and Middle Miocene of Ukraine.

They are considered to be synonymous with *Quinqueloculina bicornis* var. *angulata* (Williamson 1858), illustrated by Zabert and Barbano (1984)
Material: 86 specimens. SGN 2530. TEP of RII, VI, S2, ET

***Cycloforina* sp.**

Remarks: A single specimen was found, which has some similarities with the illustration of *Quinqueloculina bicornis* (Walker and Jacob 1798) by Zabert (1978) in the Paraná Formation, Santa Fe Province
Material: 1 specimen. TEP of RVI

Genus ***Dentalina*** Risso 1826

Dentalina antennula d'Orbigny 1846

1846 *Dentalina antennula* d'Orbigny, p. 53, pl. 2, Figs. 29–30
1985 *Dentalina antennula* d'Orbigny. Papp and Schmid, p. 33, pl. 15, Figs. 7–9

Material: 6 well preserved specimens. TEP of P10, ET

Genus ***Disconorbis*** Sellier de Civrieux 1977

Disconorbis bulbosa (Parker 1954) (Plate III, Fig. h; Plate VIII, Fig. j)

1954 "*Discorbis*" *bulbosa* Parker, p. 532, pl. 8, Figs. 10–12
1972 "*Discorbis*" *bulbosa* Parker. Malumián, p. 106, pl. 6, Fig. 2

Remarks: This species is not currently found in the Atlantic Ocean coast of Argentina
Material: 45 moderately to well preserved specimens. SGN 2484, 2539. TEP of P10, RVI, PPD2, PPD3, D1. *TEP of SB

Genus ***Elphidium*** de Montfort 1808

Elphidium sp. cf. ***E. lens*** Galloway and Heminway 1941 (Plate II, Fig. h)

cf. 1941 *Elphidiumlens* Galloway and Heminway, p. 361, pl. 14, Fig. 10
1972 *Elphidium* sp. cf. *E. lens* Galloway and Heminway. Malumián, pp. 105–106, pl. 4, Fig. 5

Remarks: This species is not currently found in the Atlantic Ocean coast of Argentina
Material: 186 big specimens, generally very eroded. SGN 2476. TLP of RII. *TEP of CB

Elphidium macellum (Fichtel and Moll 1798) (Plate I, Fig. j)

1798 *Nautilus macellus* Fichtel and Moll, p. 66, pl. 10, Figs. e–k
1980 *Elphidium macellum* (Fichtel and Moll). Boltovskoy et al., p. 30, pl. 14, Figs. 1–6

Material: 6 specimens. SGN 2468. TLP of RII, O3

Elphidium cf. ***macellum*** (Fichtel and Moll 1798)

Material: 4 specimens. TEP of ED

Elphidium sp.

Material: 2 specimens. TEP of SC1; TLP of SF1

Genus ***Fissurina*** Reuss 1850

Fissurina quadricostulata (Reuss 1870) (Plate III, Fig. e)

1870 *Lagena quadricostulata* Reuss, p. 469, pl. 6, Figs. 25–30
1980 *Fissurina quadricostulata* (Reuss). Boltovskoy et al., p. 32, pl. 16, Figs. 5–7

Material: 2 well preserved specimens. SGN 2481. TEP of PPD2. *TEP of GB

Fissurina sp. A (Plate V, Fig. k)

Material: 8 specimens. SGN 2510. TEP of RVI, P10

Fissurina spp. (Plate V, Fig. l)

Material: 73 specimens SGN 2511. TEP of P10, RII, VI, S2, ET, PP; TLP of RII

Genus ***Fursenkoina*** Loeblich and Tappan 1961

Fursenkoina pontoni (Cushman 1932) (Plate VIII, Fig. i)

1932 *Virgulina pontoni* Cushman, p. 17, pl. 3, Fig. 7
1972 *Fursenkoina pontoni* (Cushman). Malumián, p. 108, pl. 6, Fig. 7

Remarks: The specimens have higher torsion than those founded by Malumián 1972
Material: 33 well-preserved specimens. SGN 2538. TEP of RII, ET. *TEP of SB, CB

Genus ***Glandulina*** d'Orbigny 1839

Glandulina ovula d'Orbigny 1846 (Plate V, Fig. j)

1846 *Glandulina ovula* d'Orbigny, p. 21, pl. 2, Figs. 6–7
1988 *Glandulina ovula* d'Orbigny. Náñez, p. 510

Remarks: whereas similar to *G. symmetrica* Stache, described by Malumián (1972), the founded specimens have more affinity with the hallmarks of *G. ovula*
Material: 155 specimens. SGN 2509. TEP of P10, RII, VI, ET, PP. *TEP of GB

Genus ***Globigerina*** d'Orbigny 1826

Globigerina cf. ***bulloides*** d'Orbigny 1826 (Plate IX, Figs. h, i)

cf. 1826 *Globigerinabulloides* d'Orbigny, p. 277
cf. 1970 *Globigerina* ex. gr. *bulloides* d'Orbigny. Malumián, p. 130, 132, pl. 8

Material: More than 300 very recrystallized specimens. SGN 2548, 2549. TEP of ET, PP. *TEP of SB

Genus ***Globocassidulina*** Voloshinova 1960

Globocassidulina subglobosa (Brady 1881) (Plate VI, Fig. a)

1881 Cassidulina subglobosa Brady, p. 60.
1972 *Cassidulina subglobosa* Brady. Malumián, p. 102, pl. 5, Fig. 1

Remarks: The specimens are identical to those of Malumián 1972
Material: 20 very small specimens. SGN 2514. TEP of P10, RII, VI, ET, PP. *TEP of SB, CB

Genus ***Globorotalia*** Cushman 1927

Globorotalia praescitula Blow 1959 (Plate VII, Figs. k and l)

1959 *Globorotalia scitula* (Brady) sub sp. *praescitula* (Blow), p. 221, pl. 19, Fig. 128a–c
1983 *Globorotalia* (*Globoconella*) *praescitula* (Blow). Kennett and Srinivasan, p. 108, pl. 24, Fig. 1, pl. 25, Figs. 4–6

Material: Few well-preserved specimens, but with very small dimensions. SGN 2528. TEP of P10

Genus ***Guttulina*** d'Orbigny 1839

Guttulina lactea (Walker and Jacob 1798) (Plate III, Fig. c)

1798 *Serpula lactea* Walker and Jacob, p. 634, pl. 14, Fig. 4
1977 *Guttulina lactea* (Walker and Jacob). Zabert and Herbst, p. 145, pl. 1, Fig. 7

Material: 1 well-preserved specimen. SGN 2479. TEP of PPD2. *TEP of V, PF

Guttulina problema d'Orbigny 1826

1826 *Guttulina problema* d'Orbigny, p. 266, n° 14, Fig. 61
1972 *Guttulina problema* d'Orbigny. Malumián, p. 104, pl. 2, Fig. 12

Material: 8 poorly preserved specimens. TEP of P10, RVI, PPD2, PPD3, PP. *TEP of SB, CB, GB

Guttulina spp. (Plate V, Figs. h, i)

Material: 4 specimens. SGN 2507, 2508. TEP of P10, RVI, ET. *TEP of GB

Genus ***Gyroidina*** d'Orbigny 1826

Gyroidina sp. 1

Material: 14 well-preserved specimens. TEP of RII

Gyroidina sp. 2 (Plate IX, Fig. d)

Remarks: It could be more than one taxa, but no suitable material for comparing was found
Material: 130 well-preserved specimens. SGN 2544. TEP of ET, PP

Genus ***Hanzawaia*** Asano 1944

Hanzawaia boueana (d'Orbigny 1846) (Plate IV, Fig. f; Plate VI, Fig. k)

1846 *Truncatulina boueana* d'Orbigny, p. 169, pl. 9, Figs. 24–26
1980 *Hanzawaia boueana* (d'Orbigny). Boltovskoy et al., p. 35, pl. 18, Figs. 4–8

Remarks: This species is usually very abundant in some levels, while in others is completely absent. It has a great morphological variability
Material: About 500 specimens. SGN 2495, 2524. TEP of RII, VI, P10, PPD2, D1; TLP (4 specimens) of RVI. *TEP of SB, GB, D (Zabert and Barbano 1984)

Genus ***Hyalinonetrion*** Patterson and Richardson 1987

Hyalinonetriondistoma (Parker and Jones 1864) f. ***typica*** Boltovskoy et al. 1980 (Plate V, Fig. e)

1864 *Lagena distoma* Parker and Jones. Brady, p. 467, pl. 48, Fig. 6
1980 *Lagena distoma* Parker and Jones, f. *typica*. Boltovskoy et al., pp. 36–37, pl. 19, Figs. 13–14

Material: 4 very well-preserved specimens. SGN 2504. TEP of ET, PP. *TEP of SB, CB, GB

Genus ***Laevidentalina*** Loeblich and Tappan 1986

Laevidentalina communis (d'Orbigny 1826) (Plate VIII, Fig. d)

1826 *Nodosaria* (*Dentalina*) *communis* d'Orbigny, p. 254
1980 *Dentalina communis* d'Orbigny. Boltovskoy et al., p. 26, pl. 10, Figs. 19–20

Description: Uniseriate, elongated and slightly arched test, circular cross section. Four to eight chambers increasing in diameter toward the apertural end. Opaque to translucent, dull luster wall with oblique and gently depressed sutures
Material: 16 specimens, only one moderately preserved. SGN 2533. TEP of P10, RVI, ET, PP. *TEP of GB

Genus ***Lagena*** Walker and Jacob 1798

Lagena alcocki White 1956 (Plate V, Fig. f)

1865 Entosolenia williamsoni Alcock, p. 195
1989 *Lagena alcocki* White. Malumián and Caramés, pp. 119–120, pl. IV, Figs. 4–5

Material: 2 well-preserved specimens. SGN 2505. TEP of P10

Lagena ex gr. ***substriata*** Williamson 1848

1848 *Lagena substriata* Williamson, p. 15, pl. 2, Fig. 12
1989 *Lagena* ex gr. *substriata* Williamson. Malumián and Caramés, pp. 121–122, pl. III, Figs. 7–11

Material: 2 specimens. TEP of P10, RVI *TEP of GB

Lagena striata (d'Orbigny 1839b) (Plate V, Fig. g)

1839b *Oolina striata* d'Orbigny, p. 21, pl. 5, Fig. 12
1972 *Lagena striata* (d'Orbigny). Malumián, p. 110, pl. 3, Fig. 4

Description: Unilocular test with subcircular base and elongated neck. Thin wall with fine ribs throughout the body, labyrinthine in some sectors. Small round opening
Material: 2 specimens. SGN 2506. TEP of RVI, PP. *TEP of SB, CB, GB

Lagena sulcata Walker and Jacob 1798

1798 *Serpula* (*Lagena*) *sulcata* Walker and Jacob, p. 634, pl. 14, Fig. 5
1954a *Lagena sulcata* Walker and Jacob. Boltovskoy, pp. 148–149, pl. 6, Fig. 10

Material: 3 poorly preserved specimens. TEP of P10, RVI

Lagena spp. (Plate I, Fig. c)

Material: 43 specimens. SGN 2461. TEP of P10, RII, VI, PPD3, S2, ED, ET; TLP of PT1

Genus ***Lenticulina*** Lamarck 1804

Lenticulina calcar (Linneo 1767)

1767 *Nautilus calcar* Linneo, p. 1162, n° 272
1972 *Lenticulina calcar* (Linneo). Malumián, p. 111, pl. 3, Fig. 9

Remarks: The specimens lack the spinal characteristics of the species and are probably eroded
Material: 2 specimens. TEP of P10, PP. *TEP of SB, CB, BF

Lenticulina limbosa (Reuss 1863) (Plate VIII, Fig. f)

1863 *Robulina limbosa* Reuss, p. 55, pl. 6, Fig. 69
1978 *Lenticulina limbosa* (Reuss). Sprechmann, p. 61, pl. 2, Fig. 15a–b

Material: 10 well-preserved specimens. SGN 2535. TEP of P10, RII, VI, ET

Lenticulina rotulata (Lamarck 1804) (Plate V, Fig. c)

1804 *Lenticulites* (*rotulata*) Lamarck, p. 188, pl. 62, Fig. 11
1972 *Lenticulina rotulata* (Lamarck). Malumián, p. 111, 112, pl. 3, Fig. 8

Material: 30 specimens. SGN 2502. TEP of P10, RII, VI, ET, PP. *TEP SB, CB

Genus ***Marginulinopsis*** Silvestri 1904

Marginulinopsis sp.

Material: one very recrystalized specimen. TEP of ET

Genus ***Massilina*** Schlumberger 1893

Massilina secans (d'Orbigny 1826)

1826 *Quinqueloculina secans* d'Orbigny, p. 303, n° 43, pl. 96
1980 *Massilina secans* (d'Orbigny). Boltovskoy et al., p. 38, pl. 21, Figs. 1–4

Remarks: Although Luczkowska (1974) showed that *Massilina* is a particular form of *Quinqueloculina*, here we preferred to keep it as a separate genus; their specific location within *Quinqueloculina* would require detailed studies beyond the scope of this work. Two distinct forms were found, although Boltovskoy et al. (1980) did not identify it; in this work, they were described separately because they may have different paleoecological meanings

Massilina secans (d'Orbigny 1826) f. **1** (Plate II, Fig. c)

Remarks: The specimens match the description given by Boltovskoy et al. 1980. The wall lacks ornamentation
Material: 6 moderately preserved specimens, some of them with abrasion signs. SGN 2471. TLP of RII

Massilina secans (d'Orbigny 1826) f. **2** (Plate II, Fig. d)

Remarks: The specimens match the description given by Boltovskoy et al. 1980. The wall has a strong striation across its surface
Material: 28 moderately preserved specimens, some of them with abrasion signs. SGN 2472. TLP of RII

Genus ***Melonis*** de Montfort 1808

Melonis sp. (Plate IV, Fig. b)

Material: 5 specimens. SGN 2491 TEP of S2

Genus ***Miliammina*** Heron-Allen and Earland 1930

Miliammina spp.

Remarks: Is not possible to observe the apertural characteristics
Material: 35 poorly preserved specimens. SGN 2314. TEP of P10, RVI, PPD3, ET, PP

Genus ***Neoeponides*** Reiss 1960

Neoeponides spp.

Material: 9 moderately preserved specimens. TEP of PPD3, D1, ET, PP

Genus ***Neogloboquadrina*** Bandy, Frerichs and Vincent 1967

Neogloboquadrina continuosa (Bolli 1959) (Plate VII, Figs. b–h)

1959 *Globorotalia opima* Bolli subsp. *continuosa* Blow, p. 218, pl. 19, Fig. 125
1983 *Neogloboquadrina continuosa* (Blow). Kennett and Srinivasan, p. 192, pl. 47, Figs. 3–5

Remarks: The specimens were classified as transitional between *Neogloboquadrina continuosa* (Blow 1959) and *Paragloborotalia mayeri* (Cushman and Ellisor 1939)
Material: Several well-preserved, very small specimens. SGN 2526. TEP of P10

Genus ***Nodosaria*** Lamarck 1812

Nodosaria sp.

Remarks: It was found one uniserial specimen with two subspherical chambers. The wall is thick, and it has radial ribs in the lower half of the chambers. It could be a fragment of a larger specimen
Material: 1 specimen. TLP of RVI

Genus ***Nonion*** de Montfort 1808

Nonion depressulus (Walker and Jacob 1798)

1798 *Nautilus depressulus* Walker and Jacob, p. 641, pl. 14, Fig. 33
1980 *Nonion depressulus* (Walker and Jacob). Boltovskoy et al., p. 39, pl. 22, Figs. 1–5

Remarks: The specimens are very similar to those described by Boltovskoy et al. 1980, from the continental shelf of Argentina
Material: 188 specimens. TEP (12 specimens) of PT1; TLP of RII, VI, SF1, PT1

Nonion tisburyensis Butcher 1948 (Plate VI, Fig. f)

1958 *Nonion tisburyensis* Butcher. Boltovskoy, p. 18, pl. 6, Figs. 1–6
1978 *Nonion tisburyensis* Butcher. Sprechmann, p. 61, pl. 5, Fig. 6

Remarks: Although it has differences with the type species, is very similar to that illustrated by Sprechmann 1978
Material: 9 specimens. SGN 2519. TEP of RVI, P10

Nonion sp. ***1*** (Plate I, Figs. e, g)

Remarks: Along with *N. depressulus* and *A. parkinsoniana*, this is the most characteristic species of the TLP in the Chacoparanense basin, where it could be considered a useful guide fossil
Material: 656 recrystallized or partially dissolved specimens. SGN 2463, 2465. TLP of SF1, SC1

Nonion sp. A

Remarks: Is similar to the genus *Evolutononion*

Material: 14 moderately preserved specimens. TEP of ET, PP

Nonion spp. (Plate I, Fig. f; Plate III, Fig. m; Plate IX, Fig. c)

Material: 150 specimens. SGN 2464, 2489, 2543. TEP of P10, RII, S2, PT1; TLP of O3, SC1, PT1

Genus ***Nonionella*** Cushman 1926

Nonionella atlantica Cushman 1947 (Plate VI, Fig. g)

1947 *Nonionella atlantica* Cushman, p. 90, pl. 20, Figs. 4, 5
1972 *Nonionella atlantica* Cushman. Malumián, p. 114

Remarks: Great variability in size and shape
Material: 154 well-preserved specimens. SGN 2520. TEP of P10, RII, VI, ET; TLP (2 specimens) of RVI. *TEP of SB, CB, GB, D (Zabert and Barbano 1984)

Nonionella auricula Heron-Allen and Earland 1930 (Plate III, Fig. k)

1930 *Nonionella auricula* Heron-Allen and Earland, p. 192, pl. 5, Figs. 68–70
1984 *Nonionella auricula* Heron-Allen and Earland. Zabert and Barbano, p. 145, pl. 1, Fig. 4

Material: 2 well-preserved specimens. SGN 2487. TEP of D1. *TEP of D (Zabert and Barbano 1984)

Nonionella auris (d'Orbigny 1839b) (Plate III, Fig. l)

1839b *Valvulina auris* d'Orbigny, p. 47, pl. 2, Figs. 15–17
1978 *Nonionella auris* (d'Orbigny). Zabert, p. 119, pl. 3, Fig. 22

Material: 1 well-preserved specimen. SGN 2488. TEP of PPD2. *TEP of SF

Nonionella sp. ***A*** (Plate VI, Fig. i)

Remarks: Is very similar with *Nonion* sp. B Sprechmann 1978
Material: 11 specimens. SGN 2522. TEP of P10, RII, VI

Genus ***Oolina*** d'Orbigny 1839

Oolina sp.

Material: 3 specimens. TEP of PP

Genus ***Orbulina*** d'Orbigny 1839

Orbulina sp.

Material: 5 very recrystalized specimens
Origin: TEP of ET

Genus ***Orthomorphina*** Stainforth 1952

Orthomorphina calomorpha (Reuss 1866)

1866 *Nodosaria calomorpha* Reuss, p. 129, pl. 1, Figs. 15–19
1980 *Orthomorphina calomorpha* (Reuss). Boltovskoy et al., p. 42, pl. 24, Figs. 12–13

Remarks: The specimens have two chambers. They have all the characteristics of the species but are slightly laterally flattened
Material: 8 partially recrystallized specimens. TEP of ET

Orthomorphina filiformis (d'Orbigny 1826)

1826 *Nodosaria filiformis* Soldani. d'Orbigny, p. 253, n° 14
1980 *Orthomorphina filiformis* (d'Orbigny). Boltovskoy et al., p. 42, pl. 24, Figs. 14–16

Remarks: All the specimens have 4 chambers
Material: 4 well-preserved specimens. TEP of ET

Genus ***Paragloborotalia*** Cifelli 1982

Paragloborotalia mayeri (Cushman and Ellisor 1939) (Plate VII, Figs. b–h)

1939 *Globorotalia mayeri* Cushman and Ellisor, p. 11, pl. 2, Fig. 4a–c
2000 *Paragloborotalia mayeri* (Cushman and Ellisor). Chaisson and d'Hondt, p. 36, pl. 1, Figs. 14, 15

Remarks: The specimens were classified as transitional between *Neogloboquadrina continuosa* (Blow 1959) and *P. mayeri* (Cushman and Ellisor 1939)
Material: Several well-preserved, very small specimens. SGN 2526. TEP of P10

Genus ***Peneroplis*** de Montfort 1808

Peneroplis sp. (Plate I, Fig. b)

Material: 4 partially worn and dissolved specimens. SGN 2460. TLP of O3, SF1

Genus ***Planorbulina*** d'Orbigny 1826

Planorbulina variabilis (d'Orbigny 1826)

1826 *Truncatulina variabilis* d'Orbigny, p. 279
1980 *Cibicides variabilis* (d'Orbigny). Boltovskoy et al., p. 25, pl. 9, Figs. 12–17

Remarks: The specimens have great morphological variability
Material: 16 specimens. TEP of ET

Genus ***Procerolagena*** Puri 1954

Procerolagena caudata (d'Orbigny 1839)

1839a *Oolina caudata* d'Orbigny, p. 19, pl. 5, Fig. 6
1980 *Lagena caudata* (d'Orbigny). Boltovskoy et al., p. 36, pl. 19, Figs. 4–7

Description: Elongated unilocular test with a bulge in the lower portion. The upper portion is narrower toward the opening, forming a neck. Translucent to transparent thin wall
Remarks: One specimen is more elongated and has thin striations in the lower third. The other two have very short necks and are fully striated
Material: 3 specimens. TEP of RII, SJ. *TEP of GB

Genus ***Protelphidium*** Haynes 1956

Protelphidium tuberculatum (d'Orbigny 1846) (Plate IV, Figs. c–e; Plate VI, Fig. j)

1846 *Nonionina tuberculata* d'Orbigny, p. 108, pl. 5, Figs. 13–14
1972 *Protelphidium tuberculatum* (d'Orbigny). Malumián, p. 116, pl. 4, Fig. 4

Material: About 4000 specimens. SGN 2492, 2493, 2494, 2523. TEP of all the boreholes and outcrops, except O3. TLP (8 specimens) of RVI. *TEP of SM, SB, SW of Entre Ríos (Zabert and Herbst 1977; Zabert and Barbano 1984; Herbst and Zabert 1987), BF

Protelphidium sp. (Plate III, Fig. j)

Material: 1 specimen. SGN 2486. TLP of PT1

Genus ***Protoglobobulimina*** Hofker 1971

Protoglobobulimina pupoides (d'Orbigny 1846) (Plate VI, Fig. b)

1846 *Bulimina pupoides* d'Orbigny, p. 185, pl. 11, Figs. 11–12

1980 *Bulimina pupoides* d'Orbigny. Boltovskoy et al., p. 21, pl. 5, Figs. 20–21
Remarks: It has many similarities with the specimens from the Miocene of the Vienna Basin by d'Orbigny
Material: 21 moderately preserved specimens. SGN 2515. TEP of P10, RII, VI, ET, SJ

Genus ***Pygmaeoseistron*** Patterson and Richardson 1987

Pygmaeoseistron hispidula (Cushman 1913)

1913 *Lagena hispidula* Cushman, p. 14, pl. 5, Figs. 2–3
1980 *Lagena hispidula* Cushman. Boltovskoy et al., p. 37, pl. 19, Figs. 20–22

Material: 3 bad preserved specimens. TEP of RII, PP, SJ

Pygmaeoseistron laevis (Montagu 1803)

1803 *Vermiculum laeve* Montagu, p. 524
1980 *Lagena laevis* (Montagu), s. l. Boltovskoy et al., p. 37, pl. 20, Figs. 4–10

Description: Unilocular lageniform test, slightly asymmetrical. Thin and translucent wall without ribs. Circular aperture without phialine lip
Material: 7 poorly preserved specimens. TEP of RVI. TLP of RII. *TEP of GB

Pygmaeoseistron cf. ***laevis*** (Montagu 1803) (Plate III, Fig. d)

Material: 1 well preserved specimen. SGN 2480. TEP of S2

Pygmaeoseistron laevis (Montagu 1803) f. ***perlucida*** (Montagu 1803)

1803 *Vermiculum perlucidum* Montagu, p. 524

Material: 1 specimen. TEP of P10

Genus ***Pyrgo*** Defrance 1824

Pyrgo elongata (d'Orbigny 1826) (Plate VIII, Fig. b)

1826 *Biloculina elongata* d'Orbigny, p. 298, n° 4
1954a *Pyrgo elongata* (d'Orbigny). Boltovskoy, pp. 131–132, pl. III, Fig. 1a–c

Remarks: Boltovskoy et al. (1980) considered that this species is closely related to *P. ringens* and may be an ecological variant
Material: 7 poorly preserved specimens. SGN 2531. TEP of ET. *TEP of SF

Pyrgo peruviana (d'Orbigny 1839b) (Plate III, Fig. a)

1839b *Biloculina peruviana* d'Orbigny, p. 68, pl. 9, Figs. 1–3

1980 *Pyrgo peruviana* (d'Orbigny). Boltovskoy et al., p. 44, pl. 26, Figs. 1–3

Remarks: The opening is not clearly observed
Material: 49 moderately preserved specimens. SGN 2477. TEP of PPD2, PPD3, D1

Pyrgo ringens (Lamarck 1804)

1804 *Miliolites* (*ringens*) *subglobosa* Lamarck, p. 351, pl. 17, Fig. 1
1980 *Pyrgo ringens* (Lamarck). Boltovskoy et al., p. 44, 45, pl. 26, Figs. 7–9

Material: 8 very recrystallized specimens. TEP of ET. *TEP of V, D, PF

Pyrgo sp. 1

Description: Oval slightly rhomboid biloculine test. Little globular chambers. Rounded peripheral margin. The aperture characteristics are not observed
Material: 2 poorly preserved specimens. TEP of ET

Pyrgo spp.

Remarks: The aperture characteristics are not observed
Material: 47 poorly preserved specimens. TEP of P10, RII, PPD2, ET. *TEP of BF, GB

Genus ***Pyrgoella*** Cushman and White 1936

Pyrgoella sp. (Plate III, Fig. b)

Material: 7 partially dissolved specimens. SGN 2478. TEP of PPD2, PPD3

Genus ***Quinqueloculina*** d'Orbigny 1826

Quinqueloculina bicornis (Walker and Jacob 1798)

1798 *Serpula bicornis* Walker and Jacob, p. 633, pl. 14, Fig. 2
1978 *Quinqueloculina bicornis* (Walker and Jacob). Zabert, p. 106, pl. 1, Fig. 2

Material: 1 well-preserved specimen. TEP of S2. *TEP of SF

Quinqueloculina boueana d'Orbigny 1846 (Plate II, Fig. e)

1846 *Quinqueloculina boueana* d'Orbigny, p. 293, pl. 19, Figs. 7–9
1985 *Quinqueloculina boueana* d'Orbigny. Papp and Schmid, pp. 101–102, pl. 96, Figs. 8, 9, pl. 97, Figs. 1, 2

Remarks: The specimens are very similar to those of the Vienna Basin
Material: 21 specimens. SGN 2473. TLP of RII

Quinqueloculina lamarckiana d'Orbigny 1839a

1839a *Quinqueloculina lamarckiana* d'Orbigny, p. 164, pl. 11, Figs. 14–15
1972 *Quinqueloculina lamarckiana* d'Orbigny. Malumián, pp. 118–119, pl. 2

Remarks: The aperture is not observed
Material: 17 very poorly preserved specimens. TEP of RII, P10, PPD2, D1, ET; TLP of RII. *TEP of SF, SB, CB

Quinqueloculina sp. cf. ***Q. patagonica*** d'Orbigny 1839b (Plate II, Fig. b)

cf. 1839b *Quinqueloculina patagonica* d'Orbigny, p. 74, pl. 4, Figs. 14–16
cf. 1957 *Quinqueloculina patagonica* d'Orbigny. Boltovskoy, p. 23, pl. 3, Figs. 11–12

Remarks: The aperture is not observed
Material: 58 very poorly preserved specimens. SGN 2470. TEP of ET; TLP of RII, VI. *TEP of SB

Quinqueloculina seminulina (Linneo 1767) (Plate I, Fig. a)

1767 *Serpula seminulum* Linneo, p. 1264, n° 791
1972 *Quinqueloculina seminulum* (Linneo). Malumián, p. 119, pl. 2, Fig. 6

Material: 162 very poorly to moderately preserved specimens. SGN 2495. TEP of PPD2, PPD3, D1, S2; TLP of SF1, SC1. *TEP of V, D (Zabert and Herbst 1987), BF, SB, CB, SF, Córdoba and Santiago del Estero (Herbst and Zabert 1987)

Quinqueloculina cf. ***seminulina*** (Linneo 1767)

Remarks: The aperture is not observed
Material: 5 very poorly to moderately preserved specimens. TLP of RII. *TEP of SF

Quinqueloculina spp.

Material: 270 dissolved and or recrystallized specimens. TEP of RII, VI, P10, PPD2, PPD3, D1, SF1, ET, SJ, ED; TLP of RII, VI

Genus ***Rosalina*** d'Orbigny 1826

Rosalina floridana (Cushman 1922)

1922 *Discorbis floridanus* Cushman, p. 39, pl. 5, Figs. 11–12
1978 *Rosalina floridana* (Cushman). Zabert, pp. 115–116, pl. II, Fig. 17

Material: 1 well-preserved specimen. TEP of PPD2. *TEP of V, VU (Zabert and Herbst 1977), SF

Rosalina peruvianus d'Orbigny 1839b

1839b *Rosalina peruviana* d'Orbigny, p. 41, pl. 1, Figs. 12–14
1980 *Discorbis peruvianus* (d'Orbigny). Boltovskoy et al., p. 27, 28, pl. 11, Figs. 16–20

Material: 11 well-preserved specimen. TEP of SJ, PP

Rosalina sp. cf. ***R. vilardeboanus*** d'Orbigny 1839b (Plate VIII, Fig. k)

cf. 1839b *Rosalina vilardeboana* d'Orbigny, p. 44, pl. 6, Figs. 13–15
cf. 1978 *Discorbis* gr. *vilardeboanus* (d'Orbigny). Sprechmann, p. 60, pl. 3

Material: 84 very recrystallized specimens. SGN 2540. TEP of ET, PP

Rosalina spp. (Plate III, Fig. g; Plate IV, Fig. a)

Material: 44 specimens. SGN 2483, 2490. TEP of RII, VI, PPD3, S2, ET, SJ, PP, ED; TLP of RII, SC1. *TEP of BF

Genus ***Sigmoidella*** Cushman and Ozawa 1928

Sigmoidella sp.

Material: 2 very recrystallized specimens. TEP of ET

Genus ***Spiroloculina*** d'Orbigny 1826

Spiroloculina depressa d'Orbigny 1826 (Plate VIII, Fig. c)

1826 *Spiroloculina depressa* d'Orbigny, p. 298, Fig. 1
1972 *Spiroloculina depressa* d'Orbigny. Malumián, p. 122, pl. 1, Fig. 8

Material: 4 partially dissolved specimens. SGN 2532. TEP of RII, ET

Genus ***Tenuitella*** Fleisher 1974

Tenuitella sp. (Plate VII, Fig. m)

Material: Few moderately preserved, very small specimens. SGN 2529. TEP of P10

Genus ***Textularia*** Defrance 1824

Textularia agglutinans d'Orbigny 1839a

1839a *Textularia agglutinans* d'Orbigny, p. 144, pl. 1, Figs. 17, 18, 32–34
1980 *Textularia agglutinans* d'Orbigny. Boltovskoy et al., p. 51, pl. 32, Figs. 5–7

Material: 2 well-preserved specimens. TEP of ET

Textularia candeiana d'Orbigny 1839a (Plate V, Fig. a)

1839a *Textularia candeiana* d'Orbigny, p. 143, pl. 1, Figs. 25–27
1980 *Textularia candeiana* d'Orbigny. Boltovskoy et al., p. 51, pl. 32, Figs. 8–11

Material: 41 well-preserved specimens. SGN: 2500. TEP of RII, ET, PP, PPD2, PPD3; TLP of RII. *TEP of SB, CB

Textularia gramen d'Orbigny 1846

1846 *Textularia gramen* d'Orbigny, p. 248, pl. 15, Figs. 4, 6
1977 *Textularia gramen* d'Orbigny. Zabert and Herbst, p. 146, pl. 1, Fig. 3

Material: 1 well-preserved specimen. TEP of PPD2. *TEP of V (Zabert and Herbst 1987), SB, CB, BF

Textularia spp.

Material: 6 specimens. TEP of P10, ET

Genus ***Trifarina*** Cushman 1923

Trifarina sp.

Remarks: Is very similar to *T. bradyi* Cushman 1923 (Early Miocene to Holocene)
Material: 27 very recrystallized specimens. TEP of ET

Genus ***Triloculina*** d'Orbigny 1826

Triloculina spp.

Remarks: Apparently there could be two different species, but their very poor preservation prevents the identification
Material: 33 recrystallized specimens. TEP of ET, ED; TLP of RII. *TEP of GB

Genus ***Uvigerina*** d'Orbigny 1826

Uvigerina bifurcata d'Orbigny 1839b

1839b *Uvigerina bifurcata* d'Orbigny, p. 53, pl. 5, Fig. 113
1972 *Uvigerina bifurcata* d'Orbigny. Malumián, pp. 122–123, pl. 6, Fig. 10

Description: Triseriate elongated test, subcircular in cross-section. Very globose chambers, widened. Opaque wall with thick longitudinal ribs, interrupted at the sutures. Sutures depressed. Short neck
Material: 4 very recrystallized specimens. TEP of ET. *TEP of CB

Uvigerina peregrina f. ***parvula*** Cushman 1923 (Plate VIII, Fig. h)

1923 *Uvigerina peregrina* Cushman var. *parvula*, p. 166, pl. 42, Figs. 7–10
1972 *Uvigerina peregrina* Cushman. Malumián, p. 124, pl. 6, Fig. 9

Material: 19 moderately preserved specimens. SGN 2537. TEP of ET. *TEP of CB

Foraminifera of the TEP found by other authors:

SF: Subsurface of Santa Fe Province (Zabert 1978); SB: Salado Basin (Malumián 1970); CB: Colorado Basin (Malumián 1970); GB: Gran Bajo del Gualicho (Náñez 1994); V: Victoria (Zabert and Herbst 1977); BF: Barranca Final Formation (Malumián et al. 1998); SM: valle de Santa María, San José Formation (Vergani et al. 1991)

Astacolus sp.	GB
Bolivina costata d'Orbigny 1839b	SF
Bolivina aff. ***robusta*** Brady 1881	SF
Bolivina cf. ***spathulata*** (Williamson 1858)	SF
Bolivina striatula Cushman 1922	SF
Bulimina cf. ***affinis*** d'Orbigny 1839a	SF
B. cf. ***patagonica*** f. ***glabra*** Cushman and Wickenden 1929	SB, CB, GB
Bulimina pseudoaffinis Kleinpell 1938	SF
Cassidulina crassa d'Orbigny 1839b	SB, CB
Cassidulinacurvata Phleger and Parker 1951	SB
Cibicides variabilis (d'Orbigny 1839b)	SF
Cribroelphidium poeyanum (d'Orbigny 1839a)	SB
Cribrostomoides sp.	GB
Discorbis williamsoni (Chapman and Parr 1932)	GB
Discorbis spp.	GB
Epistominella pacifica (Cushman 1927)	SB
Eponides sp.	BF
Favolagena digitalis f. ***inordinata*** (Malumián et al. 1991)	GB
Fissurina bicarinata Terquem 1882	SF
Fursenkoina sp.	BF
Glandulina rotundata Reuss 1850	SB
Glandulina symmetrica Stache 1865	SB, CB, BF
Globigerina juvenilis Bolli 1957	SF
Globigerinita glutinata (Egger 1893)	SB
Globigerinoides quadrilobatus (d'Orbigny 1846) s. l.	SB
Lagenoglandulina sp.	BF
Lenticulina peregrina (Schwager 1866)	SB
Lenticulina spp.	GB
Nodosaria longiscata d'Orbigny 1846 s.l.	GB

(continued)

Nodosaria pyrula d'Orbigny 1826	GB
Nonion affine (Reuss 1851)	SB, CB
Nonion demens Bik 1964	SM
Nonion demens Bik f. ***santamariana*** Zabert 1984	SM
Nonion grapteloupi grapteloupi (d'Orbigny 1839a)	SB
"***Nonionella***" sp.	SM
Oolina hexagona (Williamson 1848)	SB
Oridorsalis umbonatus (Reuss 1851)	SB, CB
Planulina sp.	BF
Pullenia subcarinata quinqueloba Reuss 1851	BF
Pyrgo patagonica (d'Orbigny 1839b)	SF, SB, CB
Quinqueloculina glabrata Cushman 1922	GB
Quinqueloculina aff. ***implexa*** Terquem and Terquem 1886	SF
Scutuloris sp.	SF
Sigmomorphina trilocularis (Bagg 1912)	SB
Siphonina reticulata (Czjzek 1848)	SB, CB
Trochammina sp.	SM

Ostracoda

The synonymy is restricted to the original and to main local quotes. The morphological nomenclature proposed by Van Mokhoven (1963) was taken into account. The systematics list follows the criteria of the Treatise on Invertebrate Paleontology (Moore and Pitrat 1961).

Genus ***Ambostracon*** Hazel 1962

Ambostracon paranensis (Zabert 1978) (Plate XIII, Fig. e, Plate XV, Fig. k)

1977 *Orionina* sp. Zabert and Herbst, pp. 156–157, pl. II, Fig. 11
1978 *Patagonacythere paranensis* Zabert. Zabert: p. 121, pl. 4, 8

Material: 21 specimens. SGN 2435. TEP of RII, RVI, PPD2, PPD3, PP, ED; TLP of RII

Ambostracon aff. ***paranensis*** (Zabert 1978)

Material: 5 specimens. TEP of ET

Ambostracon aff. ***anzoteguiana*** (Zabert 1978)

aff. 1977 *Patagonacythere* sp. 1 Zabert: p. 157, pl. III, Fig. 11
aff. 1978 *Patagonacythereanzoteguiana* Zabert: pp. 142–143, pl. VII, X

Material: 1 specimen. TEP of ED

Ambostracon aff. ***Patagonacythere rionegrensis*** Echevarría 1988

aff. 1988 *Patagonacythere rionegrensis* Echevarría, pp. 333–334, pl. III, Fig. 8

Material: 1 specimen. TLP of Riachuelo V

Ambostracon aff. ***Patagonacythere*** sp. ***1*** Echevarría 1991 (Plate XI, Fig. a)

1991 *Patagonacythere* sp. 1 Echevarría, p. 277, pl. 2, Fig. d

Material: 1 specimen. SGN 2560. TLP of Riachuelo V

Ambostracon sp. (Plate XIII, Fig. f)

Material: 3 recrystallized specimens. SGN 2436. TEP of PPD2

Genus ***Argenticytheretta*** Rossi de García 1969b

Argenticytheretta miocenica Rossi de García 1969b (Plate X, Fig. a; Plate XII, Fig. a; Plate XV, Fig. a)

1969b *Argenticytheretta miocenica* Rossi de García, p. 221, pl. 1, Fig. 1
1976 *Bensonia miocenica* (Rossi de García). Bertels, pl. 2, Fig. 8

Material: 15 specimens. SGN 2429, 2550. TLP of Riachuelo V, RVI; TEP of PPD2, PPD3, SF1, SJ

Argenticytheretta aff. ***miocenica*** Rossi de García 1969b

Material: 2 specimens. TEP of PPD2, ET

Argenticytheretta aff. ***patagoniensis*** Rose 1975 (Plate XII, Fig. b)

aff. 1975 Argenticytheretta patagoniensis Rose, pp. 181–190
aff. 2000 *Argenticytheretta patagoniensis* Rose. Malumián et al., p. 92, pl. 8, Fig. 5

Material: 1 specimen. SGN 2570. TEP of SF1

Argenticytheretta sp. aff. ***Argenticytheretta*** sp. ***1*** Whatley et al. 1998 (Plate XII, Fig. c)

aff. 1998 *Argenticytheretta* sp. 1 Whatley et al., p. 112, pl. 6, Figs. 1–3

Material: 1 specimen. SGN 2571. TEP of RVI

Argenticytheretta sp.

Material: 1 specimen. TEP of PPD3

Argenticytheretta spp. (Plate X, Fig. b)

Material: 6 specimens. SGN 2551. TLP of RII, Riachuelo V; TEP of SJ

Genus ***Argilloecia*** Sars 1866

Argilloecia spp.

Material: 4 specimens. TEP of RII, SJ, ET

Genus ***Aurila*** Pokorný 1955

Aurila magallanica Kielbowicz 1988

1964 *Brachycythere* sp. 1 Becker, p. 337, pl. 5, Fig. 5a, b
1988 *Aurilamagallanica* Kielbowicz, p. 1139, pl. 2, Fig. a, c

Material: 1 specimen. TEP of ET

Aurila aff. ***A***. cf. ***convexa*** (Baird 1850)

aff. 1991 *Aurila* sp. cf. *Aurila convexa* (Baird 1850) Echevarria, p. 276, pl. 1

Material: 1 specimen. TEP of ET

Aurila sp. **3** Valicenti 1977 (Plate XIII, Fig. c; Plate XV, Fig. l)

1977 *Aurila* sp. 3 Valicenti, pl. 2, Fig. 10

Material: 8 specimens. SGN 2578. TEP of RI, P10, ET

Aurila spp.

Material: 9 specimens. TEP of P10, RVI, ET

Genus ***Austroaurila*** Whatley et al. 1987

Austroaurila sp.

Material: 1 specimen. TEP of ET

Genus ***Austrocytheridea*** Whatley et al. 1987

Austrocytheridea spp. (Plate XV, Fig. d)

Material: 32 specimens. TEP of D1, PPD2, SJ

Genus ***Bairdia*** McCoy 1844

Bairdia sp.

Material: 1 specimen. TEP of ET

Bairdia sp.

Material: 2 specimens. TEP of ET

Genus ***Bradleya*** Hornibrook 1952

Bradleya aff. ***normani*** (Brady 1880)

aff. 1880 *Bradleya normani* Brady, p. 101, pl. 17, Fig. 3a–d; pl. 26, Fig. 4a, b
aff. 1998 *Bradleya normani* Brady. Whatley et al., p. 108, pl. 5, Figs. 1–2

Material: 3 specimens. TEP of RII, P10

Bradleya aff. ***pelotensis*** Sanguinetti et al. 1991 (Plate XIV, Fig. f)

aff. 1991 *Bradleya pelotensis* Sanguinetti et al., p. 150, pl. 4, Figs. 22–28
aff. 1999 *Bradleya pelotensis* Sanguinetti et al. Carreño et al., pl. 1, Fig. 18

Material: 4 specimens. SGN 2587. TEP of RII, P10

Genus ***Brasiliythere*** Sanguinetti et al. 1991

Brasilicythere aff. ***bensoni*** (Sanguinetti 1979)

aff. 1979 *Australicythere bensoni* Sanguinetti, p. 152, pl. 1, Figs. 3–4

Material: 4 specimens. SGN 2587. TEP of ET

Brasilicythere aff. ***retisculispinosa*** Sanguinetti et al. 1991 (Plate XIII, Fig. g; Plate XV, Fig. m)

aff. 1991 *Brasilicythere retisculispinosa* Sanguinetti et al., p. 144, pl. 2, Figs. 6–16

Material: 24 specimens. SGN 2580. TEP of RVI, P10, ET

Brasilicythere sp.

Material: 4 specimens. TEP of RII, RVI

Genus ***Buntonia*** Howe and Chambers 1935

Buntonia aff. ***Buntonia*** sp. Echevarría 1991 (Plate XIV, Fig. h)

aff 1991 *Buntonia* sp. Echevarría, p. 278, pl. III, Fig. a

Material: 2 specimens. SGN 2589. TEP of P10

Buntonia spp. (Plate XIV, Fig. g)

Material: 3 specimens. SGN 2588. TEP of P10, SF1, D1

Buntonia sp.

Material: 1 specimen. TEP of ET

Genus ***Callistocythere*** Ruggieri 1953

Callistocythere marginalis Zabert 1978 (Plate XVI, Fig. f)

1978 *Callistocythere marginalis* Zabert, p. 134, pl. 6, Fig. 40; pl. 9, Fig. 61a–c

Material: 17 specimens. TLP of RII; TEP of RII, RVI, P10, PP, ET

Callistocythere aff. ***marginalis*** Zabert 1978 (Plate XIV, Fig. b)

Material: 9 specimens. SGN 2583. TEP of RVI, P10, PPD3

Callistocythere aff. ***multicellulosa*** Coimbra et al. 1995

aff. 1995 *Callistocythere multicellulosa* Coimbra et al., p. 123, pl. 3, Figs. 6–15

Material: 1 specimen. TEP of P10

Callistocythere spp.

Material: 79 specimens. TEP (12 specimens) of P10, RVI, PPD2, ED, PP, ET; TLP of RII, RV, RVI

Genus ***Candona*** Baird 1845

Candona sp.

Material: 1 specimen. TLP of SF1

Genus ***Caudites*** Coryell and Fields 1937

Caudites diagonalis Sanguinetti 1979

1970 *Caudites* sp. Rossi de García, p. 405, pl. 2, Fig. 10
1979 *Caudites diagonalis* Sanguinetti, p. 139, pl. 5, Fig. 4a–c, pl. 11, Fig. 5a–b

Material: 1 specimen. TEP of ET

Caudites aff. ***diagonalis*** Sanguinetti 1979 (Plate XI, Fig. b)

Material: 4 specimen. SGN 2561. TLP of RII; TEP of PP

Caudites aff. ***Caudites*** sp. **1** Valicenti and Cholich 1974 (Plate XIII, Fig. h)

aff. 1974 *Caudites* sp. 1 Valicenti and Cholich, pl. VIII, Fig. 1

Material: 16 specimens. SGN 2437. TEP of PPD2, PPD3, ET

Caudites sp. Echevarría 1988 (Plate XV, Fig. n)

1988 *Caudites* sp. Echevarría, pp. 330–331, pl. 2, Fig. 1

Material: 19 specimens. TEP of PPD2, PPD3, ET

Caudites sp.

Material: 1 specimen. TEP of PP

Genus ***Copytus*** Skogsberg 1939

Copytus sp.

Material: 1 specimen. TEP of SJ

Genus ***Coquimba*** Ohmert 1968

Coquimba aff. ***bertelsae*** Sanguinetti et al. 1991 (Plate XVI, Fig. a)

aff. 1975a *Patagonacythere* n. sp. 2 Bertels, p. 351, Fig. 10
aff. 1991. *Coquimba bertelsae* Sanguinetti et al., p. 146, pl. 3, Figs. 13–22

Material: 3 specimens. TEP of ET

Coquimba aff. ***punctata*** Feijó Ramos 1994

aff. 1994 *Coquimba punctata* Feijó Ramos, pp. 382–383, pl. 4, Figs. 1–15

Material: 1 specimen. TEP of ET

Coquimba rionegrensis Echevarría 1988

1988 *Coquimba rionegrensis* Echevarría, p. 331, pl. 2, Fig. j; Fig. 7

Material: 1 specimen. TEP of PPD3

Coquimba sp. Echevarría 1988 (Plate XIII, Fig. i; Plate XVI, Fig. b)

1988 *Coquimba* sp. Echevarría, p. 331, pl. 2; Fig. k

Material: 4 specimens. SGN 2581. TEP of P10, ET

Coquimba sp.

Material: 2 specimens. TEP of ET, ED

Coquimba spp.

Material: 6 specimens. TEP of RII, RVI, P10, ET

Genus ***Cornucoquimba*** Ohmert 1968

Cornucoquimba aff. ***conulata*** Feijó Ramos 1996 (Plate XI, Fig. c)

aff. 1996 *Cornucoquimba conulata* Feijó Ramos, p. 109, pl. 4, Figs. 1–21

Material: 3 specimen. SGN 2562. TLP of RII; TEP of ET

Cornucoquimba lutziana Zabert 1978 (Plate XIII, Fig. j)

1975b *Patagonacythere* sp. 1 Bertels, pl. 5, Fig. 7
1978 *Cornucoquimba lutziana* Zabert, p. 143, pl. 7, Fig. 48; pl. 8, Fig. 58a–d

Material: 5 specimens. SGN 2438. TEP of PPD2, PPD3

Cornucoquimba sp. **2** Valicenti 1977 (Plate XVI, Fig. c)

1977 *Cornucoquimba* sp. 2 Valicenti, pl. 2, Fig. 4

Material: 1 specimen. TEP of ET

Cornucoquimba aff. ***Cornucoquimba*** sp. **2** Valicenti 1977 (Plate XIII, Fig. k)

aff. 1977 *Cornucoquimba* sp. 2 Valicenti, pl. 2, Fig. 4

Material: 9 specimens. SGN 2582. TEP of RVI, P10

Cornucoquimba sp.

Material: 2 specimens. TEP of ET

Genus ***Cushmanidea*** Blake 1933

Cushmanidea sp. (Plate, XV, Fig. f)

Material: 10 specimens. TEP of ET, ED, PP

Cushmanidea sp.

Material: 2 specimens. TEP of ET, PP

Genus ***Cyamocytheridea*** Oertli 1956

Cyamocytheridea ovalis Rossi de García 1966

1966 *Cyamocytheridea ovalis* Rossi de García, p. 203, pl. 4, Fig. 4a, b.

Material: 56 specimens. TEP of PPD2, PPD3

Cyamocytheridea spp. (Plate X, Fig. d; Plate XII, Fig. e)

Material: 56 specimens. SGN 2431, 2553. TLP (1 specimen) of RII;TEP of D1, PPD2, PP; TLP of RII, PT1, ED, PP

Genus ***Cyprideis*** Jones 1857

Cyprideis camachoi Rossi de García 1966

1966 *Cyprideis camachoi* Rossi de García, p. 202, pl. 1, Fig. 5a

Material: 18 specimens. TEP of PPD2, PPD3

Cyprideis aff. ***camachoi*** Rossi de García 1966 (Plate XII, Fig. g)

Material: 16 specimens. SGN 2432. TEP of D1, PPD2, PPD3

Cyprideis aff. ***multidentata*** Hartmann 1955 (Plate X, Fig. e)

aff. 1955 *Cyprideis multidentata* Hartmann, p. 119, 121–123, Figs. 24, 34
aff. 1997 *Cyprideis multidentata* Hartmann. Whatley et al., p. 23, pl. 2, Fig. 20

Material: 6 specimens. SGN 2554. TLP of SF1

Cyprideis aff. ***riograndensis*** Pinto and Ornellas 1965 (Plate XII, Fig. h)

aff. 1965 *Cyprideis riograndensis* Pinto and Ornellas, pp. 14–23, pl. 1, Figs. 1–6; pl. 2, Figs. 1–8

Material: 2 specimens. SGN 2433. TEP of D1

Cyprideis sp.

Material: 2 specimens. TEP of SF1, PT1

Cyprideis spp. (Plate X, Fig. f)

Material: 135 specimens. SGN 2555. TEP of PPD1; TLP of SF1, PT1, RV, RVI

Genus ***Cytherella*** Jones 1849

Cytherella aff. ***punctata*** Brady 1880

aff. 1880 *Cytherella punctata* Brady, p. 125, pl. 44, Fig. 4e–g

Material: 7 specimens. TEP of PP

Cytherella spp. (Plate XI, Fig. j; Plate XIV, Fig. l; Plate XVI, Figs. l, m)

Material: 58 specimens. SGN 2569, 2592. TEP of RII, P10, PPD3, ET, ED, PP; TLP of RII

Cytherella sp.

Material: 1 specimen. TEP of ET

Genus ***Cytherelloidea*** Alexander 1929

Cytherelloidea sp.

Material: 2 specimens. TEP of ET, ED

Genus ***Cytheretta*** Müller 1894

Cytheretta argentinensis Rossi de García 1966

1966 *Cytheretta argentinensis* Rossi de García, p. 206, pl. 2, Fig. 4a, b

Material: 26 specimens. TEP of D1, PPD2, PPD3

Cytheretta punctata Sanguinetti 1979 (Plate X, Fig. c; Plate XV, Fig. b)

1979 *Cytheretta punctata* Sanguinetti, p. 126, pl. 2, Fig. 2a–e

Material: 46 specimens. SGN 2552. TLP of RII; TEP of PP

Genus ***Cytheridea*** Bosquet 1852

Cytheridea sp.

Material: 1 specimen. TEP of PT1

Genus ***Cytheridella*** Daday 1905

Cytheridella ilosvayi Daday 1905 (Plate XIV, Fig. c)

1905 *Cytheridella ilosvayi* Daday, pp. 262–267, pl. 17, Figs. 15–22; pl. 18

1990 *Cytheridella ilosvayi* Daday. Bertels and Martínez, pl. 1, Fig. 5

Material: 2 specimens. SGN 2584. TEP of PT1

Genus ***Cytherois*** Müller 1884

Cytherois sp.

Material: 16 specimens. TEP of SJ, PP

Genus ***Cytheropteron*** Sars 1866

Cytheropteron spp. (Plate XIII, Fig. d)

Material: 15 specimens. SGN 2579. TEP of PPD2, RVI, SJ, ET; TLP of RII

Genus ***Cytherura*** Sars 1866

Cytherura cf. ***purperae*** Ornellas and Fallavena 1978 (Plate X, Fig. h)

cf. 1978 *Cytherura* cf. *purperae* Ornellas and Fallavena, pp. 121–157, pl. I–IV

Material: 30 specimens. SGN 2557. TLP of RII, SF1, SC1

Cytherura rossiana Zabert 1978 (Plate XII, Fig. j)

1978 *Cytherura rossiana* Zabert, p. 130, pl. 5, Fig. 33; pl. 8, Fig. 56

Material: 2 specimens. SGN 2434. TEP of PPD2, PPD3

Cytherura spp.

Material: 3 specimens. TEP of PPD3, SJ, ED

Genus ***Eucyprinotus*** Sywula 1972

Eucyprinotus sp.

Material: 1 specimen. TLP of PT1

Genus ***Garciaella*** Dingle and Honigstein 1994

Garciaella leoniana (Bertels 1975a) (Plate XII, Fig. d)

1964 *Leguminocythereis* sp. 1 Becker, p. 335, pl. IV, Fig. 5
1975a *Bensonia leoniana* Bertels, p. 265, pl. 2, Figs. 6–9

Material: 21 specimens. SGN 2430. TLP of RII; TEP of D1, PP

Garciaella sp.

Material: 5 specimens. TLP of RII

Garciaella spp.

Material: 6 specimens. TEP of D1, PP

Genus ***Hemicytherura*** Elofson 1941

Hemicytherura aff. ***costulosa*** Zabert 1978 (Plate XII, Fig. l)

aff. 1978 *Hemicytherura costulosa* Zabert, p. 121, pl. 4, Fig. 25; pl. 8, Fig. 53a, b
Material: 1 specimen. SGN 2575. TEP of RVI

Hemicytherura aff. ***chuiensis*** Kotzian 1982 (Plate XII, Fig. k)

aff. 1982 *Hemicytherura chuiensis* Kotzian, p. 145, pl. IV, Fig. 3a–c
aff. 1997 *Oculocytheropteron reticulopunctatum* Whatley et al., p. 32, pl. 5, Figs. 1, 3

Material: 4 specimens. SGN 2574. TEP of RVI, P10, S2

Hemicytherura aff. ***howei*** (Puri 1953)

aff. 1953 *Kangarina howei* Puri, p. 346, pl. 4, Fig. 7, text-Figs. 6i, j

Material: 1 specimen. TEP of ET

Hemicytherura aff. ***lapillata*** Whatley et al. 1988

aff. 1988 *Hemycytherura lapillata* Whatley et al., p. 174, pl. I, Figs. 7–9

Material: 1 specimen. TEP of ET

Hemicytherura aff. ***sanmatiasensis*** Echevarría 1988 (Plate X, Fig. i)

aff. 1988 *Hemicytherura sanmatiasensis* Echevarría, pp. 328–329, pl. 2, Fig. d

Material: 26 specimens. SGN 2558. TLP of RV; TEP of SJ, ET

Hemicytherura sp.

Material: 1 specimen. TLP of RII

Hemicytherura sp.

Material: 2 specimens. TEP of ED, ET

Genus ***Henryhowella*** Puri 1957

Henryhowella aff. ***beckerae*** Bertels 1975b (Plate XVI, Fig. i)

aff. 1975b *Henryhowella beckerae* Bertels, p. 274, pl. V, Figs. 4–7

Material: 3 specimens. TEP of PP

Henryhowella. aff. ***evax*** (Ulrich and Bassler 1904) (Plate XI, Fig. g; Plate XIV, Fig. j; Plate XVI, Fig. j)

aff. 1904 *Cythere evax* Ulrich and Bassler, p. 119, pl. 36, Figs. 6–8
1966 *Henryhowella*. sp. aff. *H. evax* (Ulrich and Bassler). Rossi de García, p. 200, pl. 1, Fig. 3a–c

Material: 50 specimens. SGN 2566, 2590. TLP of RII; TEP of RVI, P10, PPD3, PP, ET

Henryhowellarectangulata Sanguinetti et al. 1991 (Plate XIV, Fig. i)

1991 *Henryhowella rectangulata* Sanguinetti et al., p. 152, pl. 6, Figs. 1–16

Material: 5 specimens. SGN 2440. TEP of D1, PPD2

Henryhowella spp.

Material: 16 specimens. TEP of PPD3, SJ, ED; TLP of RV, SF1

Henryhowella sp.

Material: 1 specimen. TEP of PP

Genus ***Huillicythere*** Musacchio 1978

Huillicythere sp.

Material: 1 specimen. TLP of SF1

Genus ***Krithe*** Brady et al. 1874

Krithe sp. (Plate XII, Fig. f)

Material: 1 specimen. SGN 2572. TEP of P10

Genus ***Leptocythere*** Sars 1922–1928

Leptocythere spp.

Material: 2 specimens. TEP of PPD2; TLP of RV

Genus ***Loxoconcha*** Sars 1866

Loxoconcha paranensis Rossi de García 1966

1966 *Loxoconcha paranensis* Rossi de García, p. 203, pl. 1, Fig. 4a

Material: 5 specimens. TEP of PPD3

Loxoconcha aff. ***playabonitaensis*** Echevarría 1988

aff. 1988 *Loxoconcha playabonitaensis* Echevarría, pp. 334–335, pl. III, Fig. d

Material: 1 specimen. TEP of PPD2

Loxoconcha spp.

Material: 4 specimens. TEP of PPD3, PP

Loxoconcha sp.

Material: 1 specimen. TEP of ED

Genus ***Loxoreticulatum*** Benson 1964

Loxoreticulatum aff. ***cacothemon*** Whatley et al. 1988 (Plate XIII, Fig. a)

aff. 1988 *Loxoreticulatum cacothemon* Whatley et al., p. 190, pl. 6, Figs. 7–11
aff. 2002 *Loxoreticulatum cacothemon* Whatley et al. Whatley and Cusminsky, p. 60, pl. 2, Figs. 10, 11

Material: 5 specimens. SGN 2576. TEP of S2, PP

Loxoreticulatum spp. (Plate X, Fig. j)

Material: 3 specimens. SGN 2559. TEP of PPD3; TLP of RII

Genus ***Meridionalicythere*** Whatley et al. 1987

Meridionalicythere aff. ***discophora*** (Skogsberg 1928) (Plate XIV, Fig. a; Plate XVI, Fig. d)

aff. 1928 *Meridionalicythere discophora* Skogsberg, p. 83, pl. 2, Fig. 1
aff. 1987 *Meridionalicythere discophora* (Skogsberg). Whatley et al., p. 8, pl. 2, Figs. 15–19

Material: 25 specimens. SGN 2439. TLP of PPD2, PPD3; TEP of ED, ET

Meridionalicythere aff. ***mesodiscus*** (Skogsberg 1928) (Plate XVI, Fig. e)

aff. 1928 *Cythereis* (*Cythereis*) *mesodiscus* Skogsberg, p. 87, pl. 2, Figs. 2, 3, Fig. 7, text-Fig. 14

Material: 4 specimens. TEP of ET

Genus ***Minicythere*** Ornellas 1974

Minicythere argentinensis Bertels and Martínez 1997 (Plate XV, Fig. g)

1997 *Minicythere argentinensis* Bertels and Martínez, pp. 336–337, pl II

Material: 4 specimens. TEP of SJ, PP

Minicythere sp.

Material: 6 specimens. TEP of SJ, ED

Genus ***Munseyella*** van den Bold 1957

Munseyella aff. ***bermudezi*** van den Bold 1966

aff. 1966 *Munseyella bermudezi* van den Bold, p. 22, pl. 2, Figs. a, b

Material: 1 specimen. TEP of ET

Munseyella aff. ***josti*** Kotzian 1982 (Plate XIV, Fig. e)

aff. 1982 *Munseyella josti* Kotzian (in Bertels et al. 1982), p. 153, pl. VIII, Fig. 4a–c

Material: 3 specimens. SGN 2586. TEP of P10, ET

Munseyella aff. ***sanmatiasensis*** Echevarría 1988

aff. 1988 *Munseyella sanmatiasensis* Echevarría, p. 335, pl. III, Fig. e; Fig. 10

Material: 2 specimens. TEP of ET

Munseyella aff. ***santacrucensis*** Kielbowicz 1988

aff. 1988 *Munseyella santacrucensis* Kielbowicz, pp. 1142–1143, pl. 2, Figs. M–O

Material: 1 specimen. TEP of ET

Munseyella spp.

Material: 20 specimens. TEP of RII, PPD3, PP, ET; TLP of RII, RV

Genus ***Nanocoquimba*** Ohmert 1968

Nanocoquimba sp.

Material: 1 specimen. TEP of ET

Genus ***Neocytherideis*** Puri 1952

Neocytherideis aff. ***Copytusmalumiani*** Echevarría 1987 (Plate XV, Fig. h)

aff. 1987 *Copytus malumiani* Echevarría, p. 133, pl. 1, Figs. h, i

Material: 3 specimens. TEP of ET

Neocytherideis aff. ***Copytus*** sp. Echevarría 1988

aff. 1988 *Copytus* sp. Echevarría, pp. 324–325, pl. I, Figs. b, c; Fig. 3

Material: 8 specimens. TEP of PP, ET

Neocytherideis spp.

Material: 24 specimens. TLP of RV; TEP of PPD2, SJ, PP, ET

Genus ***Oculocytheropteron*** Bate 1972

Oculocytheropteron macropunctatum Whatley et al. 1988

1988 *Oculocytheropteron macropunctatum* Whatley et al., pp. 184–185, pl. 4, Figs. 6–10

Material: 1 specimen. TEP of ET

Oculocytheropteron aff. ***melicerion*** Whatley et al. 1988 (Plate XIII, Fig. b)

aff. 1988. *Oculocytheropteron melicerion* Whatley et al., p. 185, pl. 4, Figs. 11–15
Material: 2 specimens. SGN 2577. TEP of RVI

Genus ***Paijenborchella*** Kingna 1948

Paijenborchella punctacostata Zabert 1978 (Plate XVI, Fig. h)

1977 *Paijenborchella* sp. Zabert, p. 159, pl. 3, Fig. 7

Material: 1 specimen. TEP of SJ

Genus ***Papillosacythere*** Whatley et al. 1987

Papillosacythere sp. (Plate XV, Fig. i)

Material: 3 specimens. TEP of SJ, ED

Papillosacythere sp.

Material: 2 specimens. TEP of PP, ET

Genus ***Paracypris*** Sars 1866

Paracypris spp.

Material: 28 specimens. TEP of PPD2, PPD3, D1

Genus ***Paracytheridea*** Müller 1894

Paracytheridea sp.

Material: 3 specimens. TEP of ET

Paracytheridea sp.

Material: 2 specimens. TEP of ED, ET

Genus ***Paradoxostoma*** Fischer 1855

Paradoxostoma spp. (Plate XIV, Fig. d)

Material: 2 specimens. SGN 2585. TEP of P10; TLP of RV

Genus ***Patagonacythere*** Hartmann 1962

Patagonacythere spp.

Material: 17 specimens. TEP of PPD3

Patagonacythere sp. (Plate XI, Fig. d)

Material: 1 specimen. SGN 2563. TLP of RII

Genus ***Pelecocythere*** Athersuch 1979

Pelecocythere galleta Whatley et al. 1988

1988 *Pelecocythere galleta* Whatley et al., pp. 187–188, pl. 5, Figs. 8–10

Material: 1 specimen. TEP of ET

Genus ***Pellucistoma*** Coryell and Fields 1937

Pellucistoma aff. ***elongata*** Whatley et al. 1997 (Plate XI, Fig. f)

aff. 1997 *Pellucistoma elongata* Whatley et al., p. 57, pl. 8, Figs. 14–18

Material: 4 specimens. SGN 2565. TLP of RII. TEP of PPD2

Pellucistoma aff. ***gibosa*** Sanguinetti 1979

aff. 1979 *Pellucistoma gibosa* Sanguinetti, p. 142, pl. 6, Fig. 3a–c; pl. 12, Fig. 2
aff. 1985 *Pellucistoma gibosa* Sanguinetti. Kotzian and Eilert, est. II, Figs. 20–21

Material: 7 specimens. TEP of PPD2, SJ, PP

Pellucistoma spp.

Material: 7 specimens. TEP of PPD3, PP

Pellucistoma sp. (Plate XVI, Fig. g)

Material: 2 specimens. TEP of PP

Genus ***Perissocytheridea*** Stephenson 1938

Perissocytheridea aff. ***krömmelbeini*** Pinto and Ornellas 1970

aff. 1970 *Perissocytheridea krömmelbeini* Pinto and Ornellas, p. 20

Material: 3 specimens. TEP of PPD3

Perissocytheridea aff. ***Perissocytheridea*** sp. Ferrero 1996 (Plate XII, Fig. i)

aff. 1996 *Perissocytheridea* sp. Ferrero, p. 218, pl. II, Fig. 2a–c

Material: 78 specimens. SGN 2573. TEP of SF1, S2, PT1

Perissocytherideavictoriensis Zabert 1978 (Plate XV, Fig. e)

1977 *Perissocytheridea* sp. Zabert, p. 149, pl. II, Fig. 5a, b

Material: 34 specimens. TEP of SJ, ET

Perissocyhteridea spp.

Material: 63 specimens. TEP (5 specimens) of S2, SJ, PP; TLP of RII, RV, SF1

Genus ***Propontocypris*** Sylvester-Bradley 1947

Propontocypris sp.

Material: 2 specimens. TEP of P10, RII

Genus ***Protocytheretta*** Sepkoski 2002

Protocytheretta aff. ***multicostata*** Whatley et al. 1997 (Plate XV, Fig. c)

aff. 1997 *Protocytheretta multicostata* Whatley et al., pp. 68–70, pl. 2, Figs. 9, 11

Material: 21 specimens. TEP of PP

Genus ***Pumilocytheridea*** van den Bold 1963

Pumilocytheridea sp.

Material: 1 specimen. TEP of PPD2

Genus ***Quadracythere*** Hornibrook 1952

Quadracythere neali Sanguinetti 1979 (Plate XI, Fig. h)

1979 *Quadracythere neali* Sanguinetti, p. 151, pl. 7, Fig. 3a–f; pl. 13, Fig. 3a–d
1985 *Quadracythere neali* Sanguinetti. Kotzian and Eilert, est. II, Figs. 22–23

Material: 1 specimen. SGN 2567. TLP of RII

Quadracythere aff. ***neali*** Sanguinetti 1979

Material: 9 specimens. TEP of ET

Quadracythere sp.

Material: 1 specimen. TEP of ED

Genus ***Radimella*** Pokorný 1968

Radimella sp. (Plate XI, Fig. e)

Material: 1 specimen. SGN 2564. TLP of RII

Genus ***Rotundracythere*** Mandelstam 1958

Rotundracythere sp. (Plate X, Fig. g)

Material: 1 specimen. SGN 2556. TLP of PT1

Genus ***Semicytherura*** Wagner 1957

Semicytherura clandestina Whatley et al. 1988

1988 *Semicytherura clandestina* Whatley et al., p. 177, pl. 2, Figs. 3–5

Material: 2 specimens. TEP of ET

Semicytherura aff. ***clavata*** Brady 1880

aff. 1880 *Semicytherura clavata* Brady, p. 133, pl. 29, Fig. 7a–d
aff. 1988 *Semicytherura clavata* Brady. Whatley et al., p. 178, pl. 2, Figs. 6–8

Material: 1 specimen. TEP of S2

Semicytherura aff. ***Semicytherura*** sp. **1** Whatley et al. 1997 (Plate XV, Fig. j)

aff. 1997 *Semicytherura* sp. 1 Whatley et al., pp. 33–36, pl. 5, Figs. 8–9

Material: 1 specimen. TEP of ET

Semicytherura spp.

Material: 3 specimens. TLP of RII; TEP of SJ, PP

Semicytherura sp.

Material: 2 specimens. TEP of RII, PPD3

Genus ***Soudanella*** Apostolescu 1961

Soudanella cleopatrae Bertels 1975a (Plate XI, Fig. i)

1975a *Soudanella cleopatrae* Bertels, p. 268, pl. 3, Figs. 7–10

Material: 1 specimen. SGN 2568. TLP of SF1

Soudanella sp. Bertels 1976 (Plate XVI, Fig. k)

Material: 10 specimens. TEP of PP

Soudanella sp.

Material: 2 specimens. TEP of ET, PP

Genus ***Urocythereis*** Ruggieri 1950

Urocythereis sp.

Material: 2 specimens. TEP of P10

Urocythereis sp.

Material: 1 specimen. TEP of PP

Genus ***Uroleberis*** Triebel 1958

Uroleberis sp.

Material: 1 specimen. TEP of PP

Genus ***Wichmanella*** Bertels 1969

Wichmanella deliae Bertels 1975b (Plate XIV, Fig. k)

1975b *Wichmanella deliae* Bertels, p. 272, pl. 4, Figs. 3–4

1998 *Wichmanella deliae* Bertels. Echevarría: p. 122, pl. 3, Fig. h

Material: 4 specimens. SGN 2591. TEP of RVI, P10

Wichmanella juliana Bertels 1975b

1975b *Wichmanella juliana* Bertels, p. 270, pl. IV, Figs. 1–2

Material: 4 specimens. TEP of P10, PPD3

Wichmanella sp.

Material: 2 specimens. TEP of P10

Wichmanella sp.

Material: 2 specimens. TEP of ET

Genus ***Xestoleberis*** Sars 1866

Xestoleberis aff. ***ventribullata*** Hartmann 1962

aff. 1962 *Xestoleberis ventribullata* Hartmann, pp. 227–230, pl. 9, Fig. 4, text-Figs. 114, 15

Material: 2 specimens. TEP of ET

Xestoleberis sp.

Material: 6 specimens. TEP of ET

Xestoleberis spp.

Material: 3 specimens. TEP of P10, PPD2, SJ

Calcareous nannoplancton

The specimens are from the collection of the Área de Paleontología, Departamento de Geología, Facultad de Ciencias Exactas and Naturales, Universidad de Buenos Aires. All specimens come from four samples: P10 69-70 (BAFC-NP 2209), RII-50 (BAFC-NP 2206), RVI-25 (BAFC-NP 2208), and RII-94 (BAFC-NP 2207).

Genus ***Braarudosphaera*** Deflandre 1947

Braarudosphaera bigelowii (Gran and Braarud 1935) Deflandre 1947

1935 *Pontosphaera bigelowi* Gran and Braarud, p. 388, Fig. 67

1947 *Braarudosphaera bigelowi* Deflandre, p. 439, Figs. 1–5

Source: P10 69-70, RVI-25 and RII-94

Genus ***Calcidiscus*** Kamptner 1950

Calcidiscus premacintyrei Theodoridis 1984

1984 *Calcidiscus premacintyrei* Theodoridis, p. 81, pl. 2 Figs. 1–3

Source: P10 69-70

Genus ***Coccolithus*** Schwarz 1894

Coccolithus pelagicus (Wallich 1877) Schiller 1930 (Plate XV, Figs. o, p; Plate XVI)

1877 *Coccosphaera pelagica* Wallich, p. 348
1930 *Coccolithus pelagicus* Schiller, p. 246, Figs. 123, 124

Source: P10 69-70, RVI-25 and RII-50 and 94

Genus ***Cyclicargolithus*** Bukry 1971

Cyclicargolithus abisectus (Müller 1970) Bukry 1973

1970 *Coccolithus abisectus* Müller, p. 92; pl. 9, Figs. 9, 10; pl. 12, Fig. 1
1973 Cyclargolithus abisectus Bukry, p. 703

Source: P10 69-70 and RII-94

Genus ***Discoaster*** Tan 1927

Discoaster brouweri Tan 1927, emend. Bramlette and Riedel 1954 (Plate XV, Fig. s, t)

1927 *Discoaster brouweri* Tan, p. 415, Fig. 8a, b; Figs. 5–7, 13
1954 *Discoaster brouweri* (Tan) Bramlette and Riedel, p. 402, pl. 39, Fig. 12

Source: P10 69-70

Discoaster sp. (Plate XV, Fig. n)

Source: P10 69-70

Genus ***Helicosphaera*** Kamptner 1954

Helicosphaera carteri (Wallich 1877) Kamptner 1954 (Plate XV, Figs. q, r; Plate XVI)

1877 *Coccosphaera carteri* Wallich, p. 348
1954 *Helicosphaera carteri* Kamptner, p. 21, 23, Figs. 17–19

Source: P10 69-70 and RVI-25

Helicosphaera orientalis Bukry 1971

1971 Helicosphaera orientalis Bukry, Fig. 22

Source: P10 69-70

Helicosphaera walbersdorfensis Müller 1974

1974 *Helicosphaera walbersdorfensis* Müller, pp. 392–393, pl. 2, Fig. 15, pl. 4, Figs. 35–37, 45–46

Source: P10 69-70 and RVI-25

Genus ***Holodiscolithus*** Roth 1970

Holodiscolithus macroporus (Deflandre, in Deflandre and Fert 1954) Roth 1970 (Plate XV, Figs. c, d)

1954 *Discolithus macroporus* Deflandre (in Deflandre and Fert), p. 138; pl. 11, Fig. 5
1970 *Holodiscolithus macroporus* Roth, pp. 866–867, pl. 11, Fig. 6

Source: P10 69-70

Genus ***Micrantholithus*** Deflandre 1950

Micrantholithus pinguis Bramlette and Sullivan 1961

1961 *Micrantholithus pinguis* Bramlette and Sullivan, pl. 1, Figs. 22, 23

Source: RII-94

Genus ***Pontosphaera*** Lohmann 1902

Pontosphaera multipora (Kamptner 1948) Roth 1970 (Plate XV, Figs. i, j)

1948 *Discolithus multiporus* Kamptner (invalid), p. 5, pl. 1, Fig. 9a, b
1970 *Pontosphaera multipora* (Kamptner). Roth, p. 860

Source: P10 69-70 and RVI-25

Genus ***Reticulofenestra*** Hay et al. 1966

Reticulofenestra haqii Backman 1978

1978 *Reticulofenestra haqii* Backman, p. 110; pl. 1, Figs. 1–4; pl. 2, Fig. 10

Source: P10 69-70 and RII-50

Reticulofenestra [=***Dictyococcites***] ***minuta*** Roth 1970

1970 *Reticulofenestra minuta* Roth, p. 850; pl. 5, Figs. 3, 4

Source: RVI-25 and RII-50 and 94

Reticulofenestra producta (Kapmtner 1963) Wei and Thierstein 1991

1963 *Ellipsoplacolithus productus* Kamptner, p. 172; pl. 8, Figs. 42, 44

Source: RII-50

Reticulofenestra pseudoumbilica (Gartner 1967) Gartner 1969

1967 *Coccolithus pseudoumbilicus* Gartner, p. 4; pl. 6, Figs. 1–2, 3a–c, 4a–c
1969 *Reticulofenestra pseudoumbilica* (Gartner) Gartner, pp. 587–589, 591, 592, 598, pl. 2, Fig. 4a–c

Source: P10 69-70, RVI-25 and RII-50

Genus ***Rhabdosphaera*** Haeckel 1894

Rhabdosphaera clavigera Murray and Blackman 1898

1898 *Rhabdosphaera claviger* Murray and Blackman, p. 438; pl. 15, Figs. 13–15

Source: P10 69-70 and RVI-25

Genus ***Sphenolithus*** Deflandre 1952

Sphenolithus abies Deflandre (in Deflandre and Fert 1954) (Plate XV, Figs. a, b)

1954 *Sphenolithus abies* Deflandre, pl. X, Figs. 1–4

Source: P10 69-70, RVI-25 and RII-50

Genus ***Syracosphaera*** Lohmann 1902

Syracosphaera pulchra Lohman 1902 (Plate XV, Figs. g, h)

1902 *Syracosphaera pulchra* Lohman, p. 133, 134, pl. 4, Figs. 33, 36, 37

Source: P10 69-70

Genus ***Thoracosphaera*** Kamptner 1927

Thoracosphaera tuberosa Kamptner 1963

1963 *Thoracosphaera tuberosa* Kamptner, p. 179, pl. 4, Fig. 26

Source: P10 69-70

Thoracosphaera heimii (Lohmann 1919) Kamptner 1954

1919 *Syracosphaera heimi* Lohmann, p. 117, Fig. 29
1954 *Thoracosphaera heimi* (Lohman) Kamptner, pp. 40–42, Figs. 41, 42

Source: P10 69-70

Genus ***Triquetrorhabdulus*** Martini 1965

Triquetrorhabdulus carinatus Martini 1965

1965 *Triquetrorhabdulus carinatus* Martini, p. 408; pl. 36, Figs. 1–3

Source: RII-94

Genus ***Umbilicosphaera*** Lohman 1902

Umbilicosphaera jafari (Müller 1974) (Plate XV, Figs. k, l)

1974 *Umbilicosphaera jafari* Müller, p. 394, pl. 1, Figs. 1–3, pl. 4, Figs. 43–44

Source: P10 69-70

Umbilicosphaera rotula (Kamptner 1956) Varol 1982

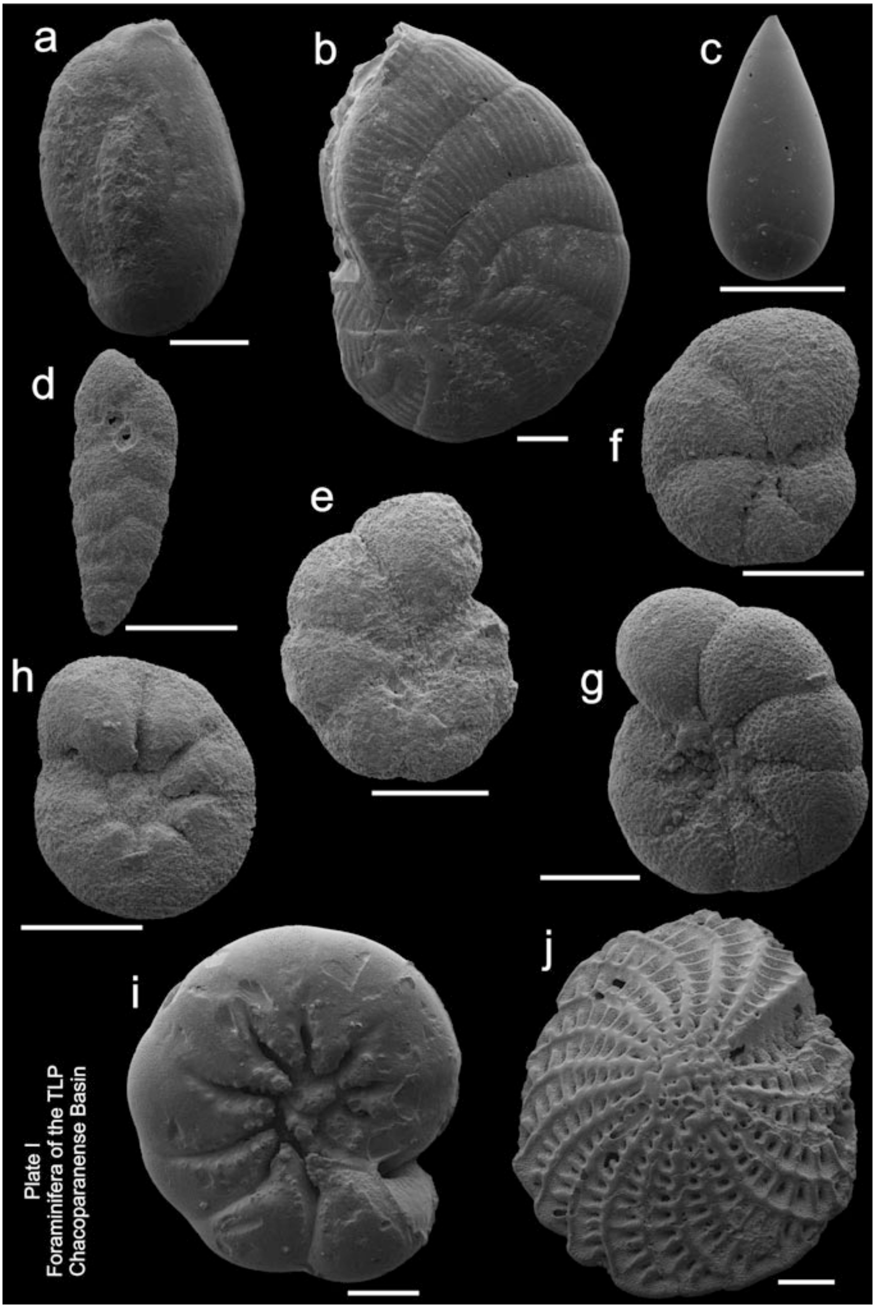
1956 *Cyclococcolithus rotula* Kamptner, p. 7
1982. *Umbilicosphaera rotula* (Kamptner) Varol, p. 248, pl. 4, Fig. 5

Source: P10 69-70

Appendix E
Plates

(The bar represents 100 μm in all photographs, unless otherwise specified.)

H. Marengo, *Neogene Micropaleontology and Stratigraphy of Argentina*,
SpringerBriefs in Earth System Sciences, DOI 10.1007/978-3-319-12814-6


a
b
c
d
e
f
g
h
i
j
Plate I
Foraminifera of the TLP
Chacoparanense Basin

◀ **Plate I Foraminifera of the TLP from the Chacoparanense Basin**. **a** ***Quinqueloculina seminulina*** (Linneo 1767). SF1 510-520 mb.g.s. **b** ***Peneroplis* sp.** SF1 490-500 mb.g.s. **c** ***Lagena* sp.** PT1 637-640, 85 mb.g.s. **d** ***Bolivina* sp.** SC1 415-420 mb.g.s. **e** ***Nonion* sp. 1.** SC1 415-420 mb.g.s. **f** ***Nonion* sp.** SC1 415-420 mb.g.s. **g** ***Nonion* sp. 1.** SF1 460-470 mb.g.s. **h** ***Ammonia parkinsoniana*** (d'Orbigny 1839a). PT1 543,05-568,5 mb.g.s. Ventral view. **i** ***Ammonia parkinsoniana*** (d'Orbigny 1839a). SF1 510-520 mb.g.s. Ventral view. **j** ***Elphidium macellum*** (Fichtel and Moll 1798). O3 480-490 mb.g.s

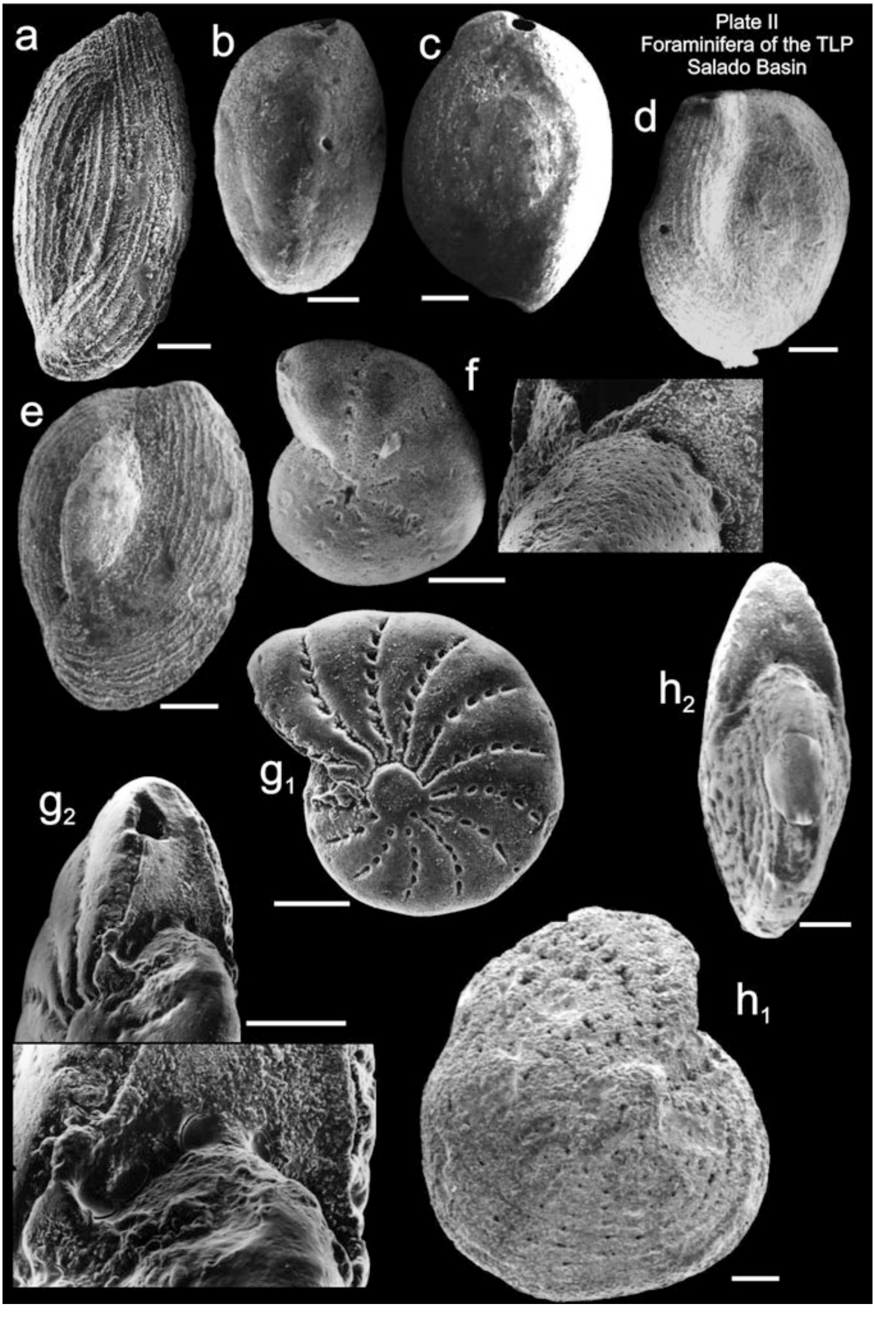


Plate II
Foraminifera of the TLP
Salado Basin
a
b
c
d
e
f
g1
g2
h1
h2

◀ **Plate II Foraminifera of the TLP from the Salado Basin**. **a** ***Cycloforina? brongniartiana*** (d'Orbigny 1839a). RII 188-189,3 mb.g.s. **b** ***Quinqueloculina*** **sp. cf**. ***Q. patagonica*** d'Orbigny 1839b. RII 188-189,3 mb.g.s. **c** ***Massilina secans*** (d'Orbigny 1826) **f. 1**. RII 188-189,3 mb.g.s. **d** ***Massilina secans*** (d'Orbigny 1826) **f. 2**. RII 188-189,3 mb.g.s. **e** ***Quinqueloculina boueana*** d'Orbigny 1846. RII 188-189,3 mb.g.s. **f** ***Cribroelphidium discoidale*** (d'Orbigny 1839a) **f.** ***pausicamerata***. RII 189,3-191 mb.g.s. Holotype, lateral view and detail of the aperture. **g** ***Cribroelphidium paivensis*** **sp**. **nov.** RII 189,3-191 mb.g.s. Holotype, $\mathbf{g_1}$ Lateral view, $\mathbf{g_2}$ Apertural view and detail of the aperture. **h** ***Elphidium*** **sp. cf.** ***E. lens*** Galloway and Heminway 1941. RII 189,3-191 mb.g.s. $\mathbf{h_1}$ Lateral view; $\mathbf{h_2}$ Apertural view

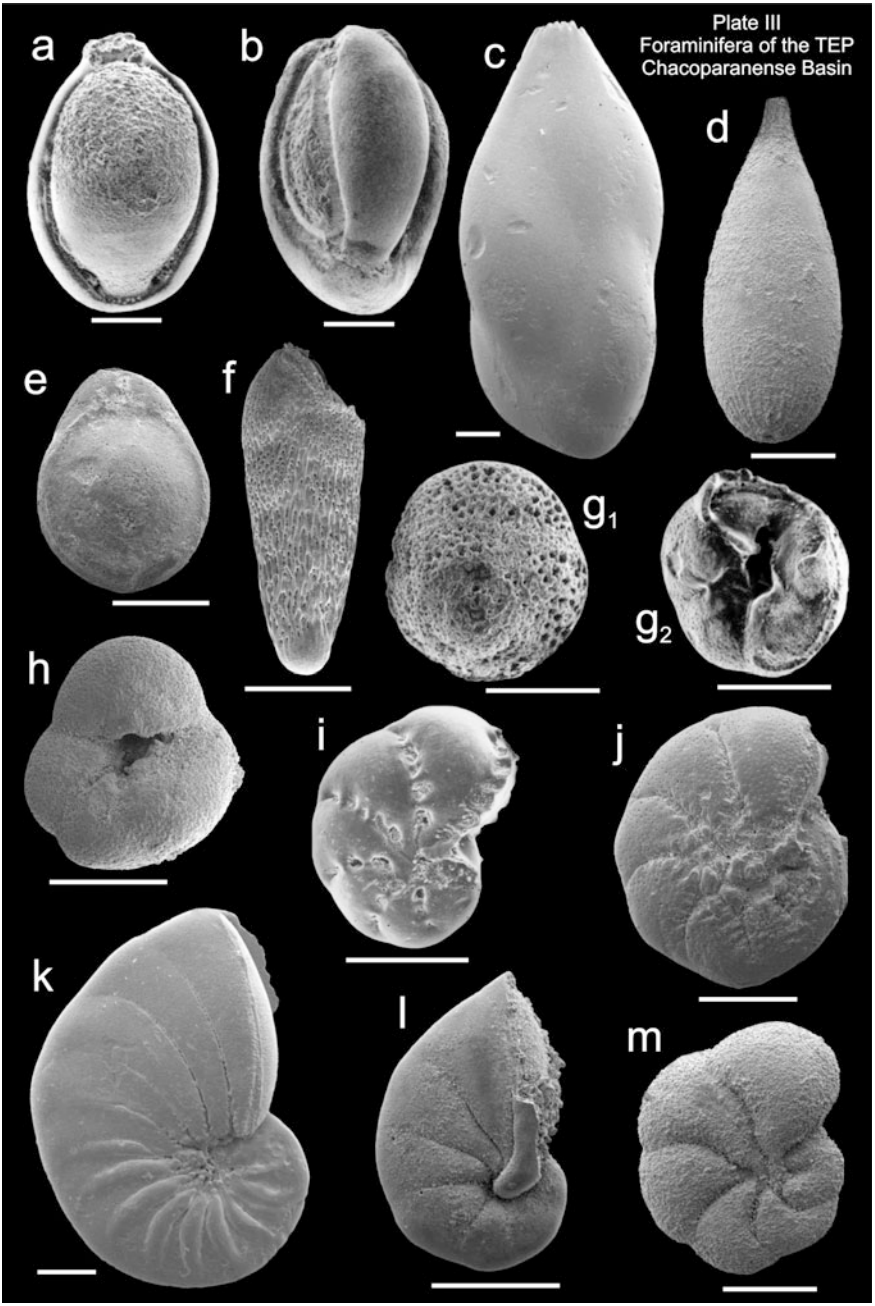
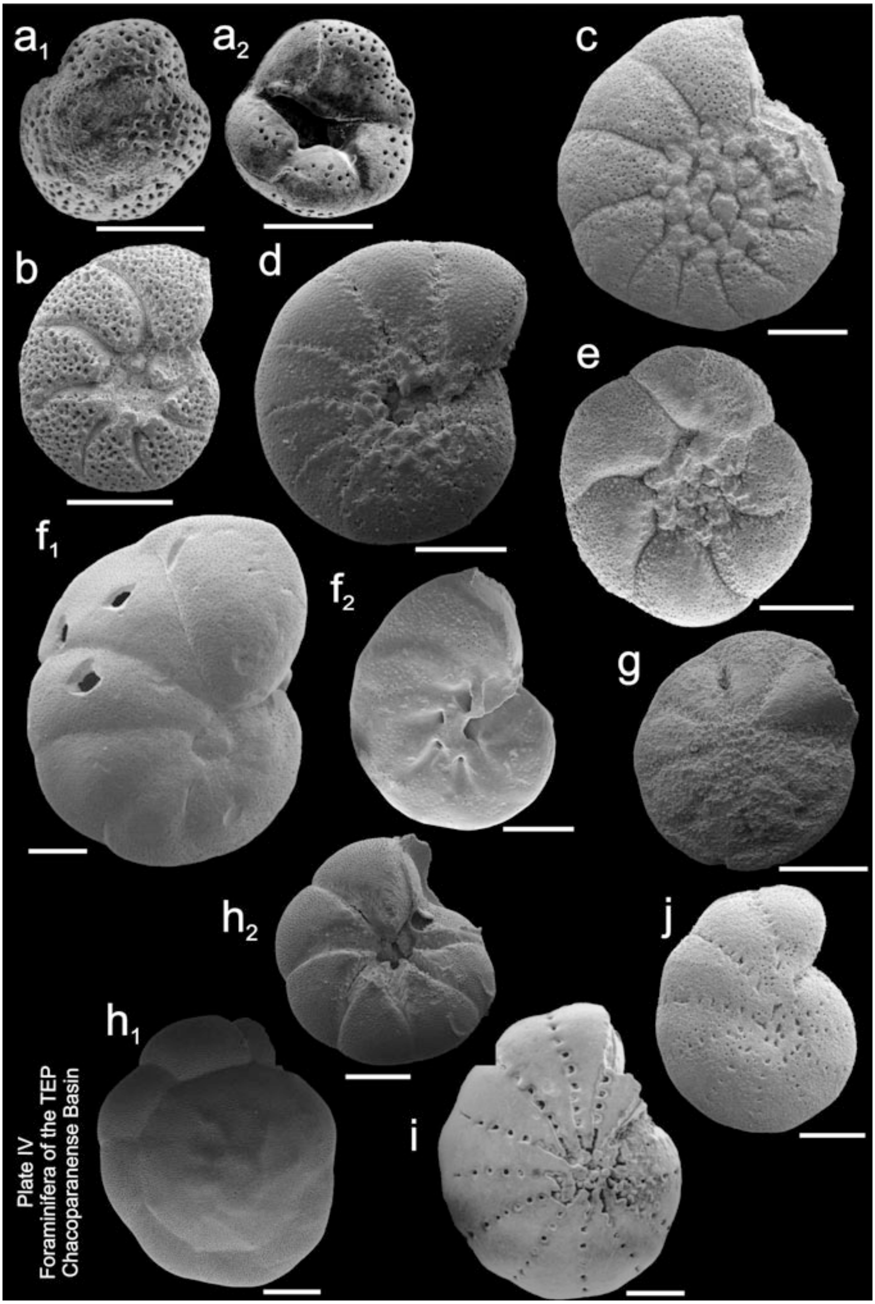
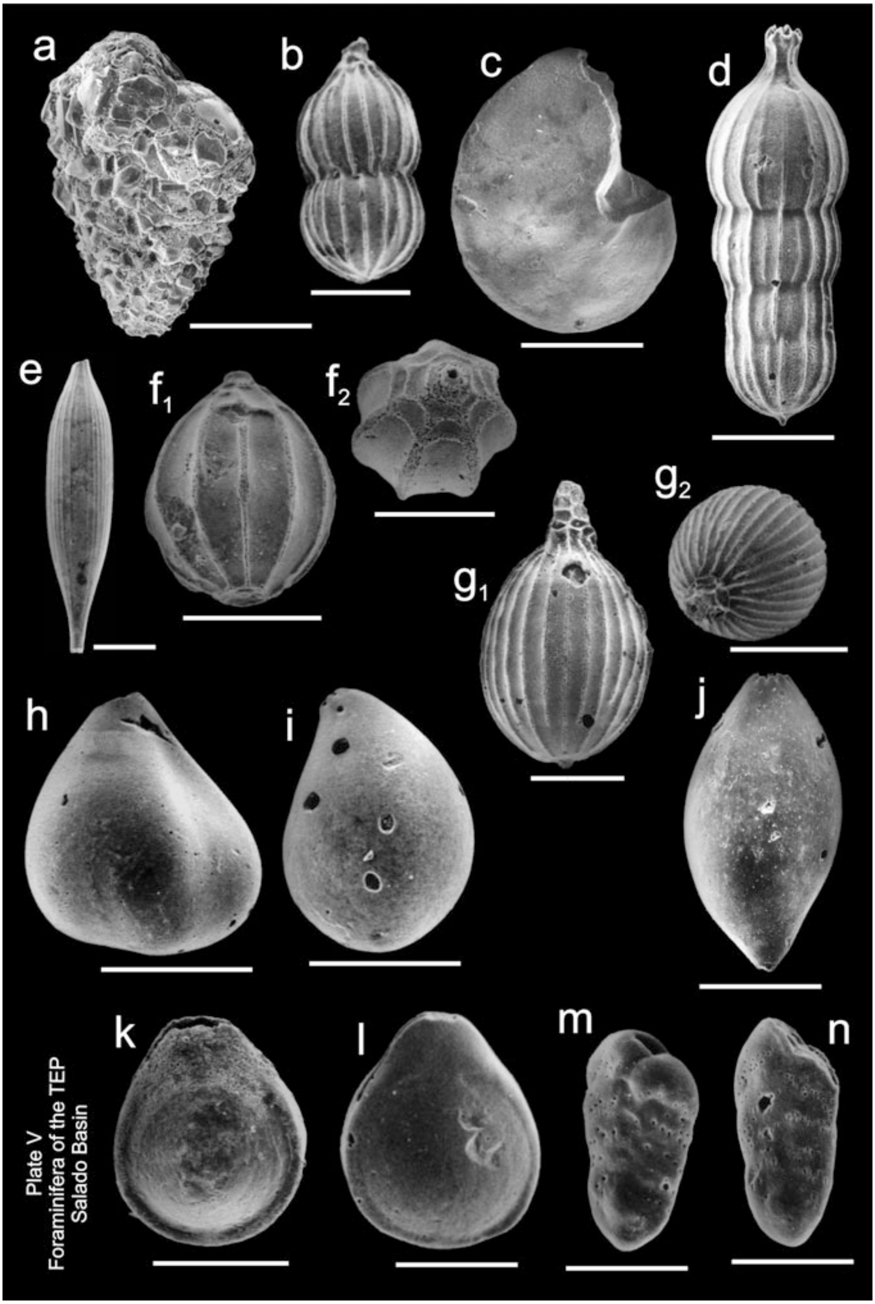


Plate III
Foraminifera of the TEP
Chacoparanense Basin
a
b
c
d
e
f
g1
g2
h
i
j
k
l
m

◀ **Plate III Foraminifera of the TEP from the Chacoparanense Basin. a *Pyrgo peruviana?*** (d'Orbigny 1839b). PPD3-16 (53 mb.g.s). **b *Pyrgoella* sp.** PPD3-16 (53 mb.g.s). **c *Guttulina lactea*** (Walker and Jacob 1798). PPD2-7 (12,5 mb.g.s). **d *Pygmaeoseistron* cf. *laevis*** (Montagu 1803). S2 164,7-179,5 mb.g.s. **e *Fissurina quadricostulata*** (Reuss 1870). PPD2-5 (11 mb.g.s). **f *Bolivina* sp.** S2 201,45-204,75 mb.g.s. **g *Rosalina* sp.** PPD3-20 (60 mb.g.s). $\mathbf{g_1}$ Dorsal view, $\mathbf{g_2}$ Umbilical view. **h *Disconorbis bulbosa*** (Parker 1954). PPD3-17 (53,5 mb.g.s). Umbilical view. **i *Cribroelphidium* sp.** PPD3-18 (54 mb.g.s). **j *Protelphidium* sp.** Borehole PT1 461,20-477,15 mb.g.s. **k *Nonionella auricula*** Heron-Allen and Earland 1930. D1 8,5 mb.g.s. **l *Nonionella auris*** (d'Orbigny 1839b). PPD2-7 (12,5 mb.g.s). **m *Nonion* sp.** S2 199,25-201,45 mb.g.s


a1
a2
c
b
d
e
f1
f2
g
h2
j
h1
i
Plate IV
Foraminifera of the TEP
Chacoparanense Basin

◀ **Plate IV Foraminifera of the TEP from the Chacoparanense Basin. a *Rosalina* sp.** PPD3-19 (57 mb.g.s). $\mathbf{a_1}$ Dorsal view, $\mathbf{a_2}$ Umbilical view. **b *Melonis* sp.** S2 179,5-199,25 mb.g.s. Umbilical view. **c *Protelphidium tuberculatum*** (d'Orbigny 1846). S2 125,7-143,7 mb.g.s. **d *Protelphidium tuberculatum*** (d'Orbigny 1846). SF1 150-160 mb.g.s. **e *Protelphidium tuberculatum*** (d'Orbigny 1846). SF1 200-220 mb.g.s. **f *Hanzawaia boueana*** (d'Orbigny 1846). $\mathbf{f_1}$ PPD3-15 (52 mb.g.s), dorsal view; $\mathbf{f_2}$ PPD2-5 (11 mb.g.s), umbilical view. **g *Buccella peruviana*** (d'Orbigny 1839a) **f. *campsi*** Boltovskoy 1954b. SF1 190-200 mb.g.s. Umbilical view. **h *Ammonia parkinsoniana*** (d'Orbigny 1839a). SF1 150-160 mb.g.s. $\mathbf{h_1}$ Dorsal view, $\mathbf{h_2}$ Umbilical view. **i *Cribroelphidium discoidale*** (d'Orbigny 1839a). PPD3-16 (53 mb.g.s). **j *Cribroelphidium discoidale*** (d'Orbigny 1839a). S2 164,7-179,5 mb.g.s


a
b
c
d
e
f_1
f_2
g_1
g_2
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i
j
k
l
m
n
Plate V
Foraminifera of the TEP
Salado Basin

◀ **Plate V Foraminifera of the TEP from the Salado Basin. a** ***Textularia candeiana*** d'Orbigny 1839a. RII 79-82,55 mb.g.s. **b** ***Amphycorina*** **sp.** P10 69-70 mb.g.s. **c** ***Lenticulina rotulata*** (Lamarck 1804). P10 65-66 mb.g.s. **d** ***Amphycorina scalaris*** (Batsch 1791). RVI 280-291,35 mb. g.s. **e** ***Hyalinonetrion distoma*** (Parker and Jones 1864) **f** ***typica***. Boltovskoy et al. 1980. P10 69-70 mb.g.s. **f** ***Lagena alcocki*** White 1956. P10 69-70 mb.g.s. $\mathbf{f_1}$ Lateral view, $\mathbf{f_2}$ Apertural view. **g** ***Lagena*** **ex gr.** ***substriata*** Williamson 1848. P10 69-70 mb.g.s. $\mathbf{g_1}$ Lateral view, $\mathbf{g_2}$ Apertural view. **h** ***Guttulina*** **sp.** P10 69-70 mb.g.s. **i** ***Guttulina*** **sp.** P10 69-70 mb.g.s. **j** ***Glandulina ovula*** d'Orbigny 1846. RII 70-74,6 mb.g.s. **k** ***Fissurina*** **sp. A.** P10 69-70 mb.g.s. **l** ***Fissurina*** **sp.** P10 69-70 mb.g.s. **m** ***Bolivina*** **sp.** P10 69-70 mb.g.s. **n** ***Bolivina*** **sp.** P10 69-70 mb.g.s

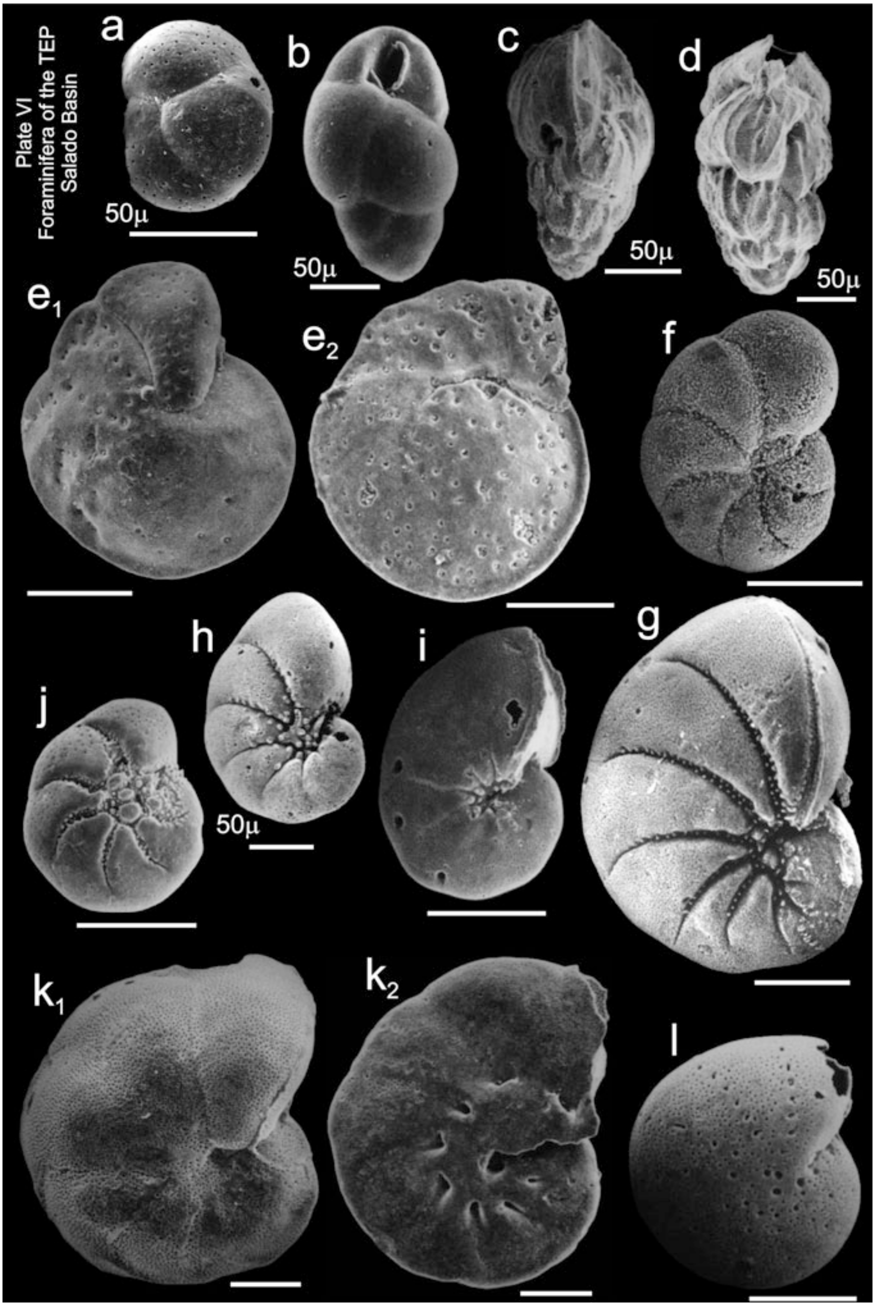


Plate VI
Foraminifera of the TEP
Salado Basin
a
b
c
d
50μ
50μ
50μ
50μ
e1
e2
f
g
h
i
j
50μ
k1
k2
l

◀ **Plate VI Foraminifera of the TEP from the Salado Basin. a** ***Globocassidulina subglobosa*** (Brady 1881). P10 69-70 mb.g.s. **b** ***Protoglobobulimina pupoides*** (d'Orbigny 1846). P10 69-70 mb.g.s. **c** ***Angulogerina angulosa angulosa*** (Williamson 1858). P10 69-70 mb.g.s. **d** ***Angulogerina angulosa angulosa*** (Williamson 1858). P10 69-70 mb.g.s. **e** ***Cibicidoides pseudoungerianus*** (Cushman 1922). RII 70-74,6 mb.g.s. $\mathbf{e_1}$ Dorsal view, $\mathbf{e_2}$ Apertural view. **f** ***Nonion tisburyensis*** Butcher 1948. RVI 280-291,35 mb.g.s. **g** ***Nonionella atlantica*** Cushman 1947. P10 65-66 mb.g.s. **h** ***Nonionella*** **sp.** P10 69-70 mb.g.s. **i** ***Nonionella*** **sp. A**. P10 69-70 mb.g.s. **j** ***Protelphidium tuberculatum*** (d'Orbigny 1846). P10 69-70 mb.g.s. **k** ***Hanzawaia boueana*** (d'Orbigny 1846). P10 69-70 mb.g.s. $\mathbf{k_1}$ Dorsal view, $\mathbf{k_2}$ Apertural view. **l** ***Cribroelphidium discoidale*** (d'Orbigny 1839a). P10 65-66 mb.g.s

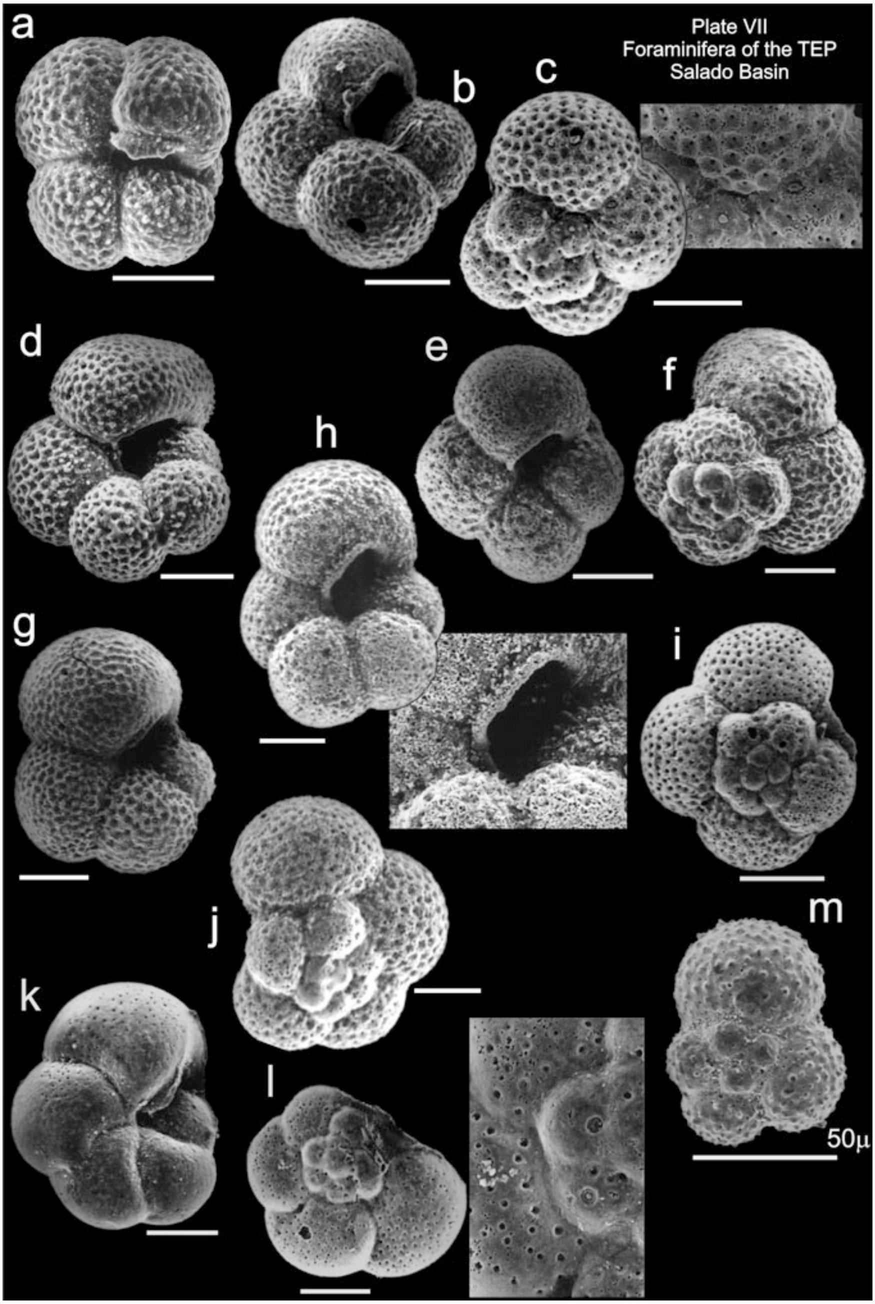


Plate VII Foraminifera of the TEP from the Salado Basin. a, i, j Indeterminate planktonic foraminifera. P10 69-70 mb.g.s. **b, c, d, e, f, g, h** ***Neogloboquadrina continuosa*** (Blow 1959) transitional to ***Paragloborotalia mayeri*** (Cushman and Ellisor 1939). P10 69-70 mb.g.s. **k, l** ***Globorotalia praescitula*** Blow 1959. P10 69-70 mb.g.s. **m** ***Tenuitella* sp.** P10 69-70 mb.g.s

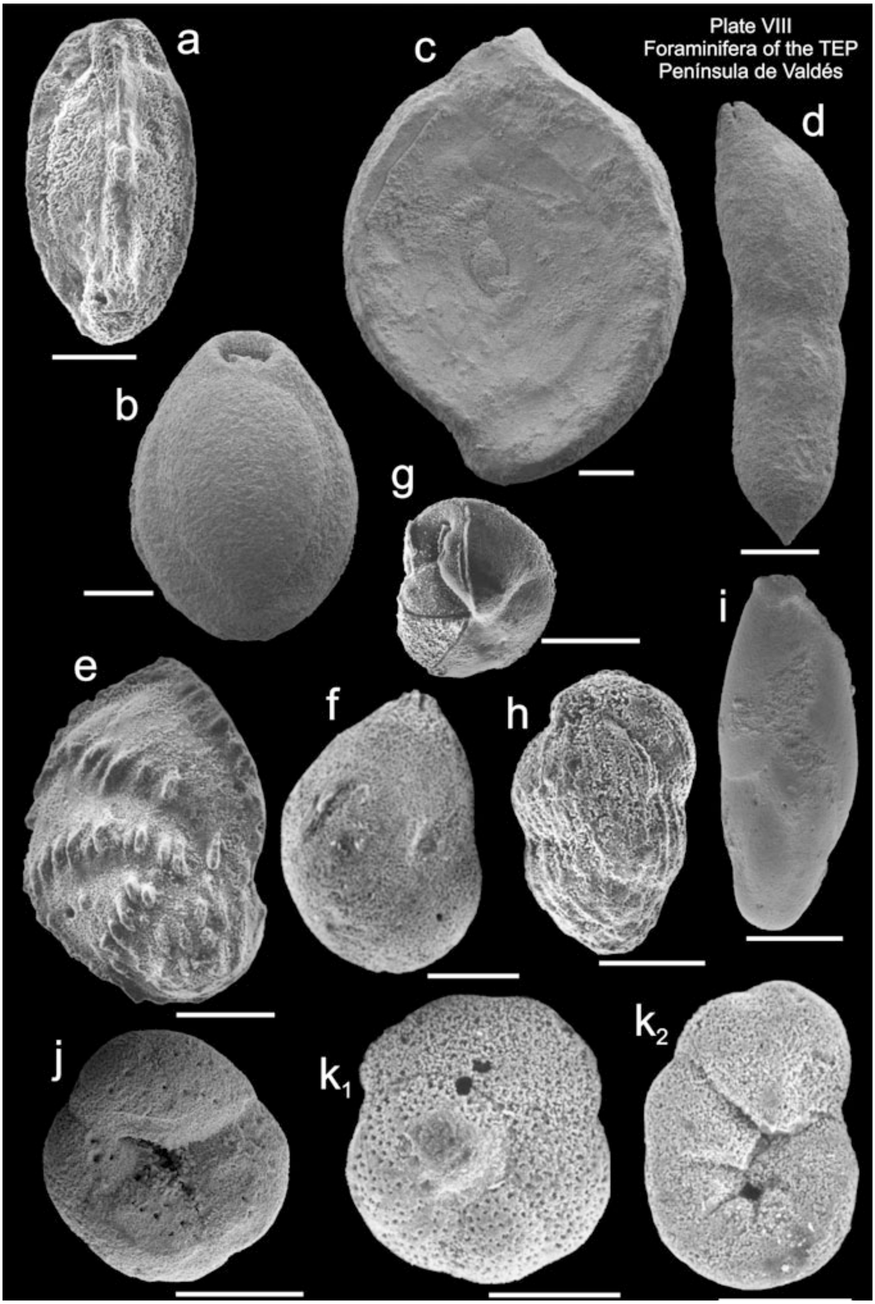


Plate VIII Foraminifera of the TEP from the Península de Valdés. a *Cycloforina contorta* (d'Orbigny 1846). ET-BG. **b** *Pyrgo elongata* (d'Orbigny 1826). ET-BG. **c** *Spiroloculina depressa* d'Orbigny 1826. ET-BG. **d** *Laevidentalina communis* (d'Orbigny 1826). ET-BG. **e** *Cribrolenticulina* sp. ET-BG. **f** *Lenticulina limbosa* (Reuss 1863). ET-BG. **g** *Cassidulina laevigata* d'Orbigny 1826. ET-30. **h** *Uvigerina peregrina* f. *parvula* Cushman 1923. ET-BG. **i** *Fursenkoina pontoni* (Cushman 1932). ET-BG. **j** *Disconorbis bulbosa* (Parker 1954). SJ-1, umbilical view. **k** *Rosalina* sp. cf. *R. vilardeboanus* d'Orbigny 1839b. ET-30. $\mathbf{k_1}$ Dorsal view, $\mathbf{k_2}$ Umbilical view

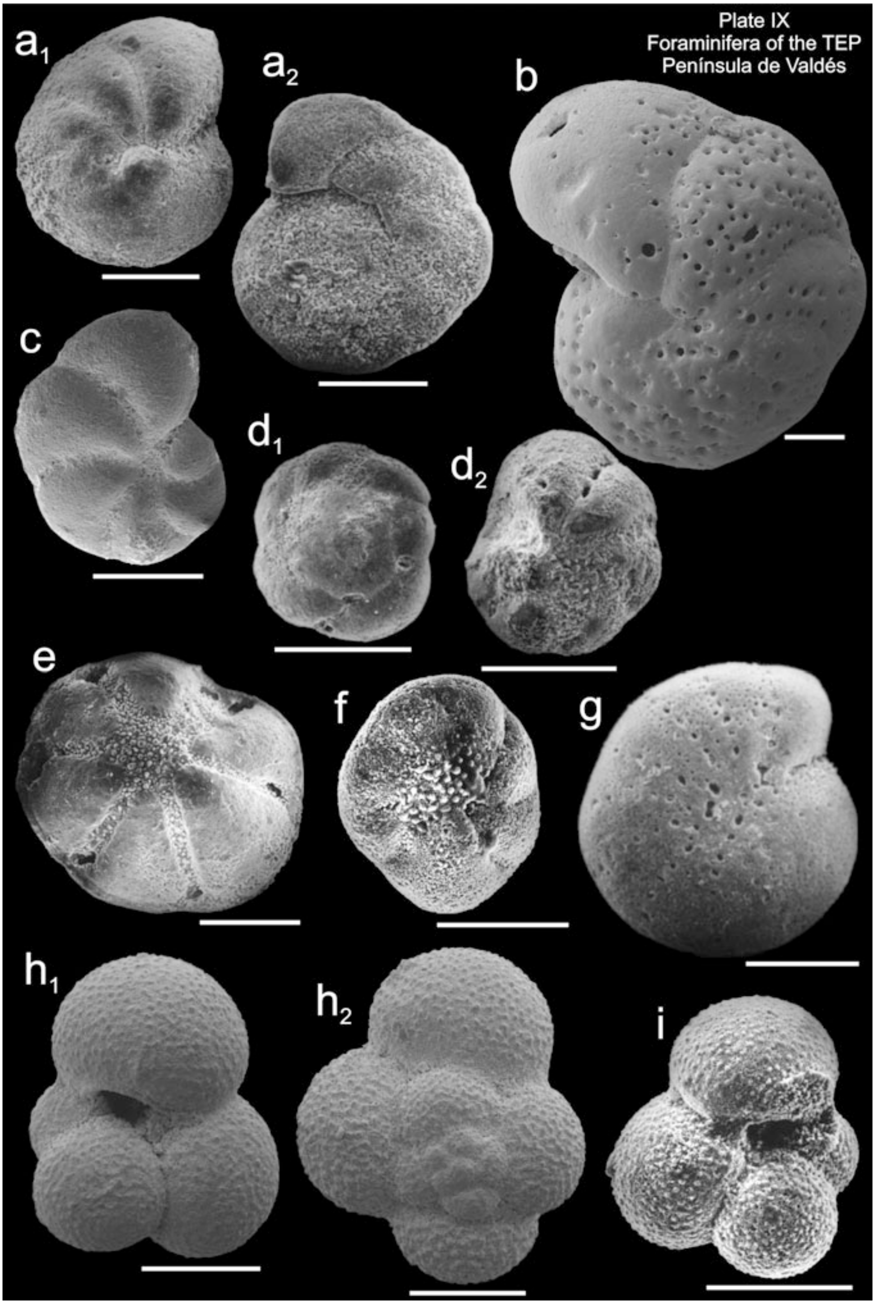
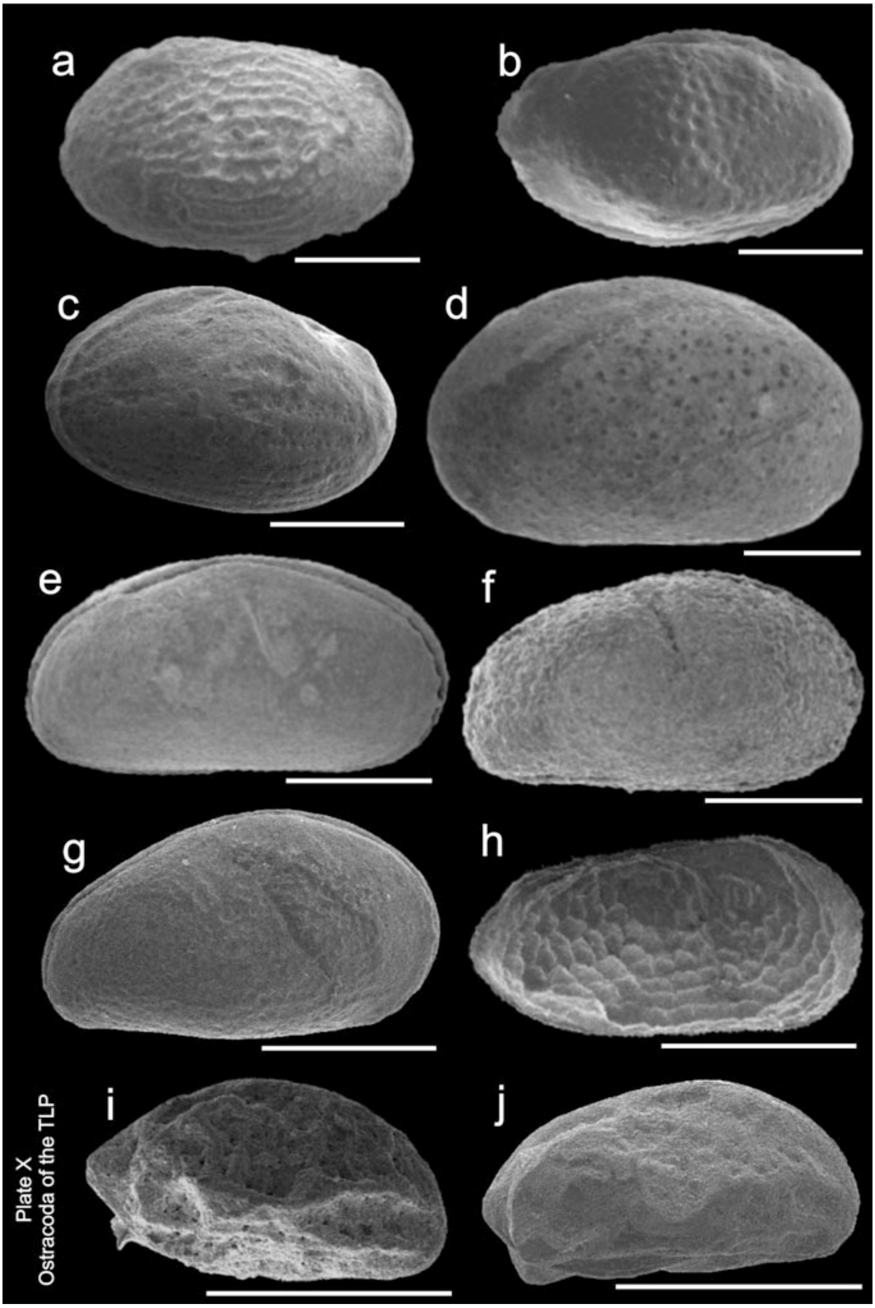


Plate IX Foraminifera of the TEP from the Península de Valdés. a *Cibicides aknerianus* (d'Orbigny 1846). ET-SN. **a_1** Dorsal view, **a_2** Umbilical view. **b *Cibicides* sp.** PP-1, dorsal view. **c *Nonion* sp.** ET-BG. **d *Gyroidina* sp. 2**. ET-BG. **d_1** Dorsal view, **d_2** Umbilical view. **e *Buccella peruviana*** (d'Orbigny 1839a) **f. *campsi*** Boltovskoy 1954b. ET-BG, umbilical view. **f *Buccella peruviana*** (d'Orbigny 1839a) **f. *frigida*** Cushman 1921. ET-25, umbilical view. **g *Cribroelphidium discoidale*** (d'Orbigny 1839a). SJ-1. **h *Globigerina* cf. *bulloides*** d'Orbigny 1826. ET-BG. **i *Globigerina* cf. *bulloides*** d'Orbigny 1826. ET-BG


a
b
c
d
e
f
g
h
i
j
Plate X
Ostracoda of the TLP

◀ **Plate X Ostracoda of the TLP. a *Argenticytheretta miocenica*** Rossi de García 1969. RVI 342,2-355,25 mb.g.s. *Left* valve, external view. **b *Argenticytheretta* sp.** RII 189,3-191 mb.g.s. Shell, *right* lateral view. **c *Cytheretta punctata*** Sanguinetti 1976. RII 189,3-191 mb.g.s. *Left* valve, external view. **d *Cyamocytheridea* sp.** PT1 607,5-612,45 mb.g.s. *Right* valve, external view. **e *Cyprideis* aff. *multidentata*** Hartmann 1955. SF1 510-520 mb.g.s. Shell, *right* lateral view. **f *Cyprideis* sp.** RV-45. Shell, *right* lateral view. **g *Rotundracythere* sp.** PT1 515,6-529,5 mb.g.s. Shell, *right* lateral view. **h *Cytherura* aff. *C* . cf. *purperae*** Ornellas and Fallavena 1978. SF1 510-520 mb.g.s. Shell, *right* lateral view. **i *Hemicytherura* aff. *sanmatiasensis*** Echevarría 1988. RV-45. Shell, *right* lateral view. **j *Loxoreticulatum* sp.** RII 189,3-191 mb.g.s. Shell, *right* lateral view

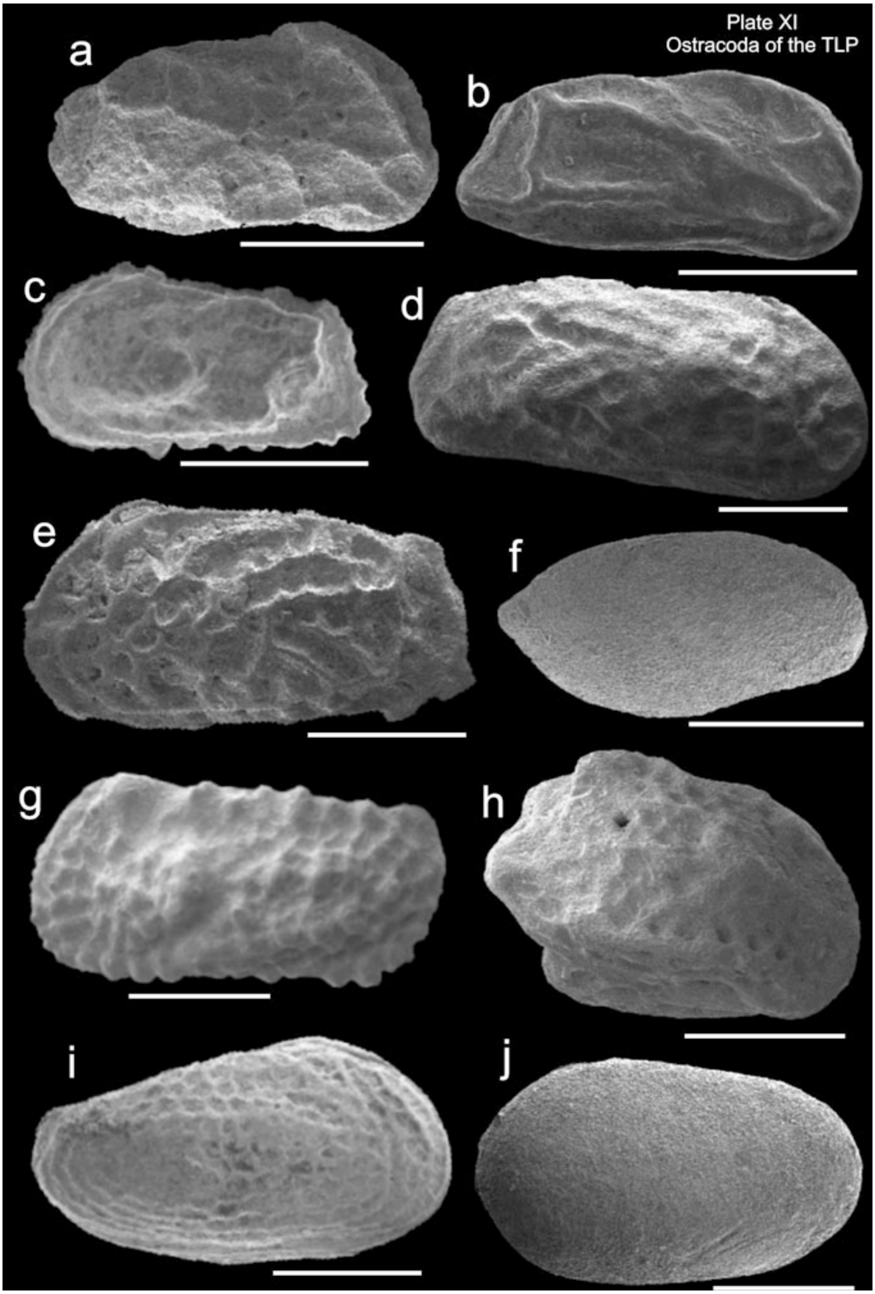
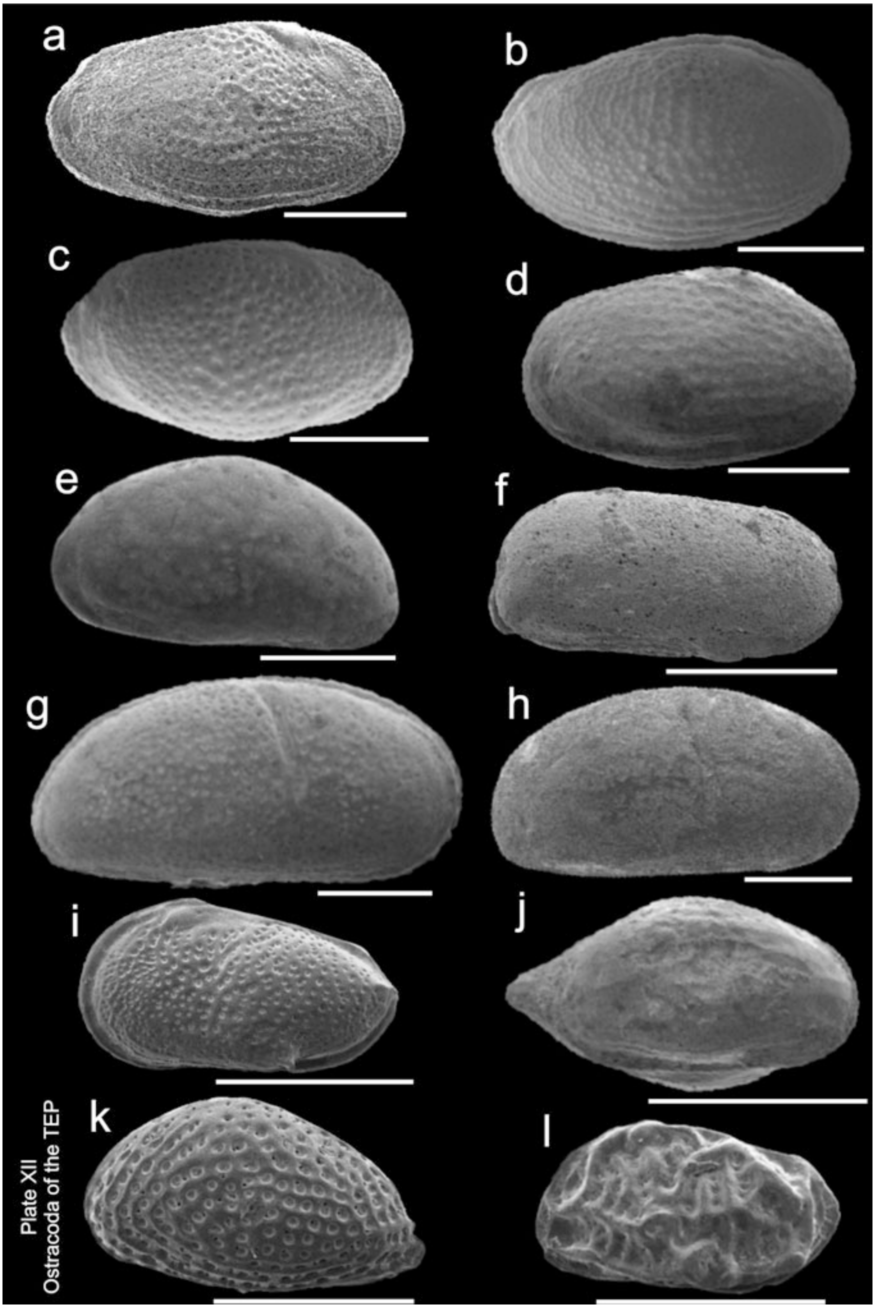


Plate XI
Ostracoda of the TLP
a
b
c
d
e
f
g
h
i
j

◀ **Plate XI Ostracoda of the TLP. a *Ambostracon* aff. *Patagonacythere* sp. 1** Echevarría 1991. RV-45. Shell, *right* lateral view. **b *Caudites* aff. *diagonalis*** Sanguinetti 1979. RII 189,3-191 mb.g.s. Shell, *right* lateral view. **c *Cornucoquimba* aff. *conulata*** Feijó Ramos 1996. RII 189,3-191 mb.g.s. *Left* valve, external view. **d *Patagonacythere* sp.** RII 188-189,3 mb.g.s. Shell, *right* lateral view. **e *Radimella* sp.** RII 188-189,3 mb.g.s. *Left* valve, external view. **f *Pellucistoma* aff. *elongata*** Whatley et al. 1997. RII 188-189,3 mb.g.s. Shell, *right* lateral view. **g *Henryhowella* aff. *evax*** (Ulrich and Bassler 1904). RII 188-189,3 mb.g.s. *Left* valve, external view. **h *Quadracythere neali*** Sanguinetti 1979. RII 188-189,3 mb.g.s. Shell, *right* lateral view. **i *Soudanella cleopatrae*** Bertels 1975. SF1 520-530 mb.g.s. Shell, *right* lateral view. **j *Cytherella* sp.** RII 189,3-191 mb.g.s. *Right* valve, external view


a
b
c
d
e
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g
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i
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k
l
Plate XII
Ostracoda of the TEP

◀ **Plate XII Ostracoda of the TEP. a** ***Argenticytheretta miocenica*** Rossi de García 1969. PPD2-6 (12 mb.g.s). *Right* valve, external view. **b** ***Argenticytheretta*** **aff .** ***patagoniensis*** Rose 1975. SF1 190-200 mb.g.s. Shell, *right* lateral view. **c** ***Argenticytheretta*** **sp. aff.** ***Argenticytheretta*** **sp. 1** Whatley et al. 1998. RVI 147-150 mb.g.s. *Right* valve, external view. **d** ***Garciaella leoniana*** (Bertels 1975). D1- 6 (11 mb.g.s). Shell, *right* lateral view. **e** ***Cyamocytheridea*** **sp.** D1-6 (11 mb.g. s). *Right* valve, external view. **f** ***Krithe*** **sp.** P10 65-66 mb.g.s. Shell, *right* lateral view. **g** ***Cyprideis*** **aff.** ***camachoi*** Rossi de García 1966. D1-6 (11 mb.g.s). Shell, *right* lateral view. **h** ***Cyprideis*** **aff.** ***riograndensis*** Pinto and Ornellas 1965. D1-5 (9 mb.g.s). *Right* valve, external view. **i** ***Perisso-cytheridea*** **aff.** ***Perissocytheridea*** **sp.** Ferrero 1996. S2 201,45-204,75 mb.g.s. *Left* valve, external view. **j** ***Cytherura rossiana*** Zabert 1978. PPD2-7 (12,5 mb.g.s). Shell, *right* lateral view. **k** ***Hemicytherura*** **aff.** ***chuiensis*** Kotzian 1982. P10 69-70 mb.g.s. *Left* valve, external view. **l** ***Hemicytherura*** **aff.** ***costulosa*** Zabert 1978. RVI 280-291,35 mb.g.s. *Left* valve, external view

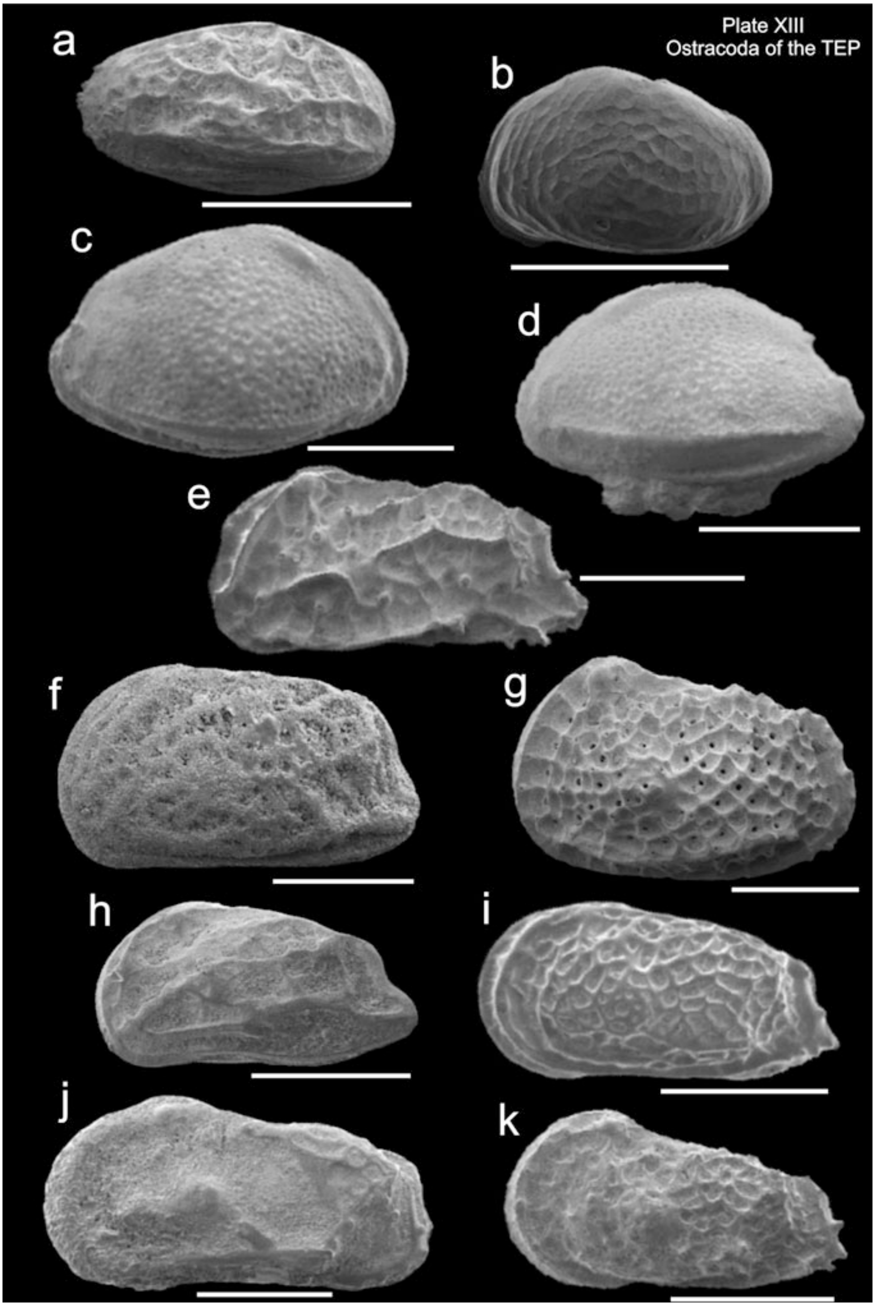
Plate XIII
Ostracoda of the TEP
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◀ **Plate XIII Ostracoda of the TEP. a *Loxoreticulatum* aff. *cacothemon*** Whatley et al. 1988. S2 164,7-174,5 mb.g.s. Shell, *right* lateral view. **b *Oculocytheropteron* aff. *melicerion*** Whatley et al. 1988. RVI 280-291,35 mb.g.s. *Left* valve, external view. **c *Aurila* sp. 3** Valicenti 1977. RII 70-74,6 mb.g.s. *Right* valve, external view. **d *Cyhteropteron* sp.** RVI 150-165,69 mb.g.s. *Left* valve, external view. **e *Ambostracon paranensis*** (Zabert 1978). PPD2-7 (12,5 mb.g.s). *Right* valve, external view. **f *Ambostracon* sp.** PPD2-6 (12 mb.g.s). Shell, *left* lateral view. **g *Brasilicythere* aff. *retisculispinosa*** Sanguinetti et al. 1991. RVI 147-150 mb.g.s. *Left* valve, external view. **h *Caudites* aff. *Caudites* sp. 1** Valicenti and Cholich 1974. PPD2-6 (12 mb.g.s). Shell, *left* lateral view. **i *Coquimba* sp.** Echevarría 1988. P10 69-70 mb.g.s. *Right* valve, external view. **j *Cornucoquimba lutziana*** Zabert 1978. PPD2-6 (12 mb.g.s). Shell, *right* lateral view. **k *Cornucoquimba* aff. *Cornucoquimba* sp. 2** Valicenti 1977. RVI 215,2-229,4 mb.g.s. *Left* valve, external view

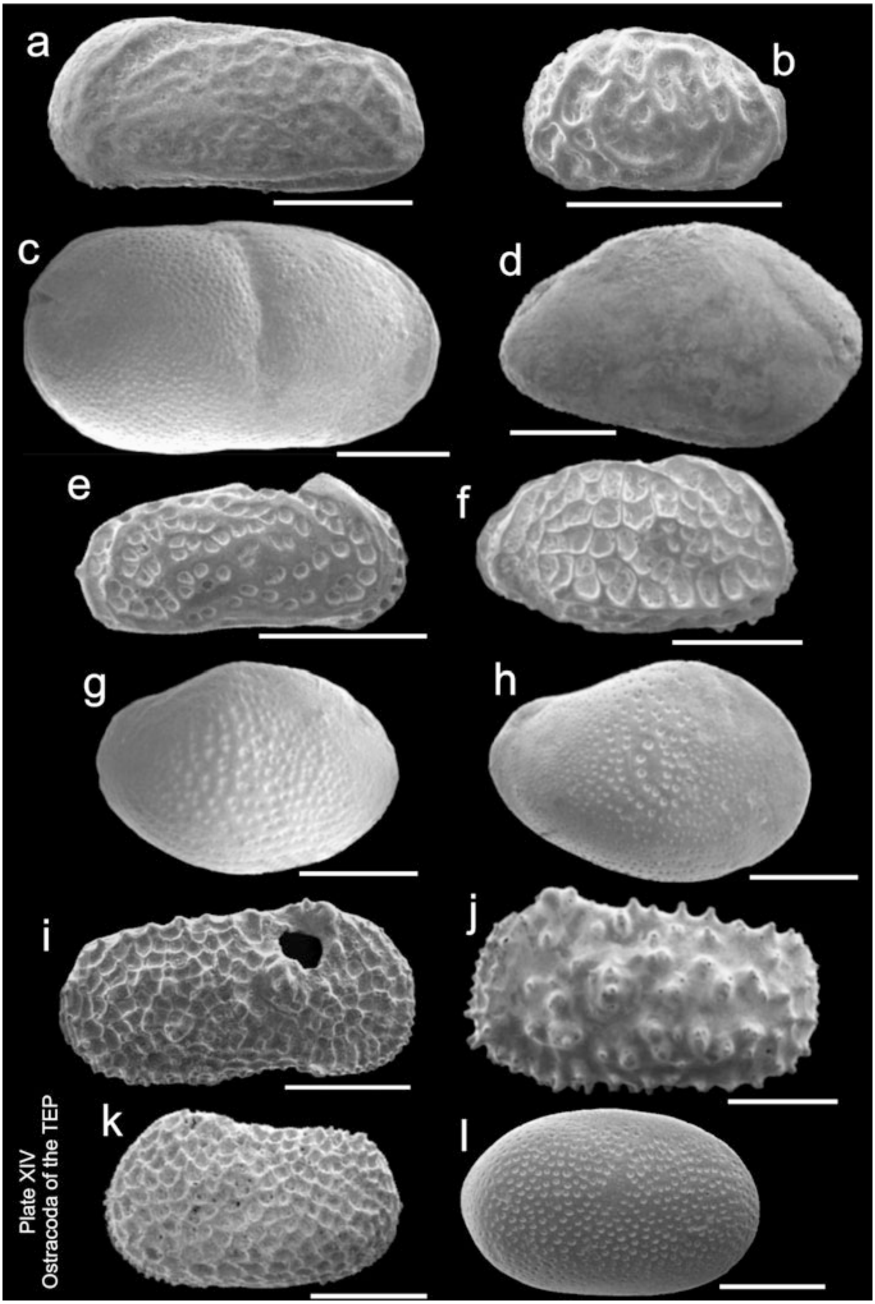
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Plate XIV
Ostracoda of the TEP

◀**Plate XIV Ostracoda of the TEP. a *Meridionalicythere* aff. *discophora*** (Skogsberg 1928). PPD2-7 (12,5 mb.g.s). *Left* valve, external view. **b *Callistocythere* aff. *marginalis*** Zabert 1978. RVI 215,2-229,4 mb.g.s. *Left* valve, external view. **c *Cytheridella ilosvayi*** Daday 1905. PT1 491,05-506,05 mb.g.s. Shell, *right* lateral view. **d *Paradoxostoma* sp.** P10 65-66 mb.g.s. Shell, *left* lateral view. **e *Munseyella* aff. *josti*** Kotzian 1982. P10 69-70 mb.g.s. *Right* valve, external view. **f *Bradleya* aff. *pelotensis*** Sanguinetti et al. 1991. RII 70-74,6 mb.g.s. *Right* valve, external view. **g *Buntonia* sp.** SF1 180-190 mb.g.s. *Left* valve, external view. **h *Buntonia* aff. *Buntonia* sp.** Echevarría 1991. P10 69-70 mb.g.s. *Left* valve, external view. **i *Henryhowella rectangulata*** Sanguinetti et al. 1996. D1-5 (9 mb.g.s). *Right* valve, external view. **j *Henryhowella* aff.. *evax*** (Ulrich and Bassler 1904). RVI 280-291,35 mb.g.s. *Left* valve, external view. **k *Wichmanella deliae*** Bertels 1975. P10 65-66 mb.g.s. Shell, *left* lateral view. **l *Cytherella* sp.** P10 69-70 mb.g.s. *Right* valve, external view

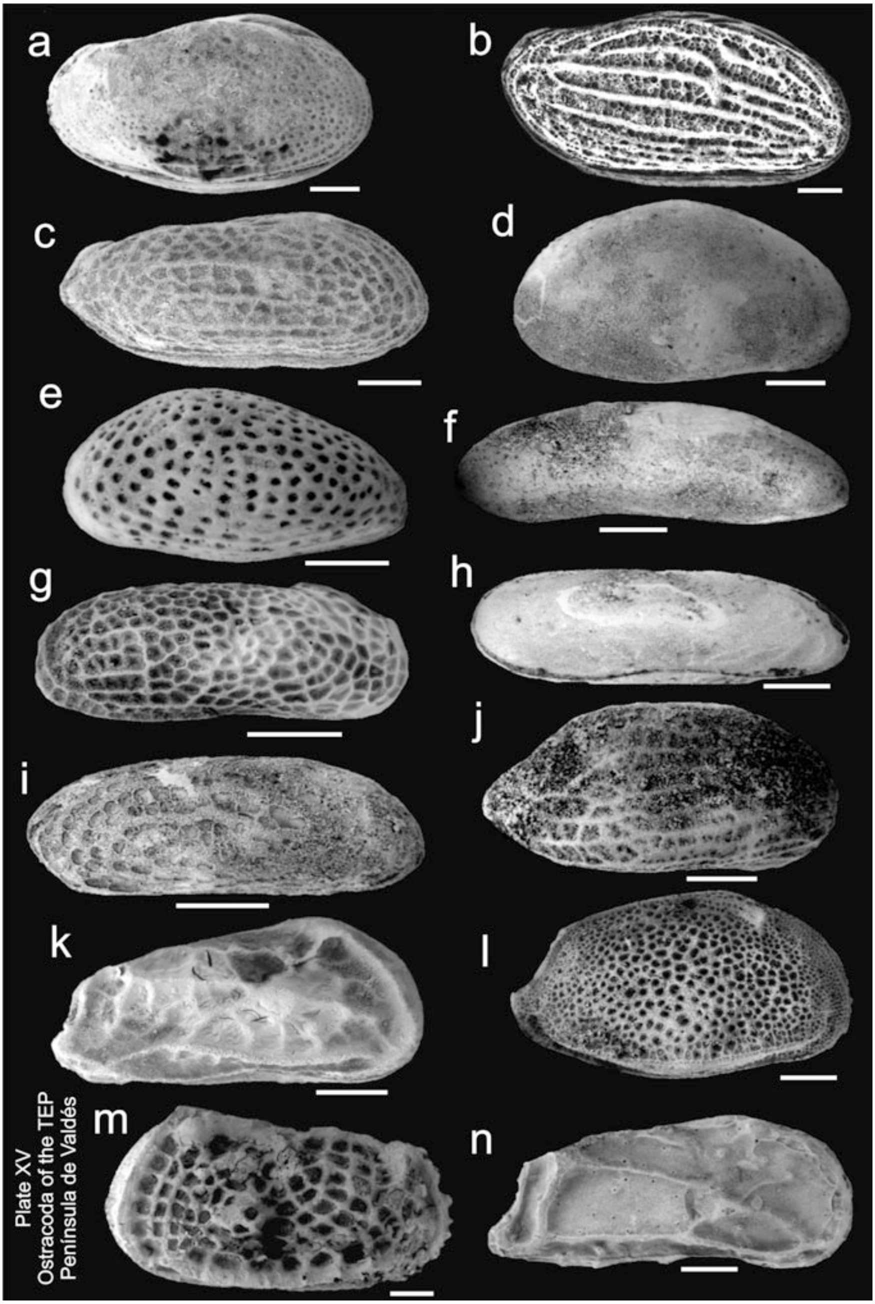
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Plate XV
Ostracoda of the TEP
Península de Valdés

◀**Plate XV Ostracoda of the TEP from the Península de Valdés. a *Argenticytheretta miocenica*** Rossi de García 1969. SJ-1. Shell, *right* lateral view. **b *Cytheretta punctata*** Sanguinetti 1979. PP-9. Shell, *right* lateral view. **c *Protocytheretta* aff. *multicostata*** Whatley et al. 1997. PP-16. Shell, *right* lateral view. **d *Austrocytheridea* sp.** SJ-1. Shell, *right* lateral view. **e *Perissocytheridea victoriensis*** Zabert 1978. SJ-1. Shell, *right* lateral view. **f *Cushmanidea* sp.** ET-BG. Shell, *left* lateral view. **g *Minicythere argentinensis*** Bertels y Martínez 1997 SJ-1. Shell, *right* lateral view. **h *Neocytherideis* aff. *Copytus malumiani*** Echevarría 1987. ET-BG. Shell, *right* lateral view. **i *Papillosacythere* sp.** SJ-1. Shell, *left* lateral view. **j *Semicytherura* aff . *S.* sp. 1** Whatley et al. 1997. ET, sample S/N. Shell, *right* lateral view. **k *Ambostracon paranensis*** (Zabert 1978). PP-21. Shell, *right* lateral view. **l *Aurila* aff . *A.* sp. 3** Valicenti 1977. ET-19. Shell, *right* lateral view. **m *Brasilicythere* aff . *reticulispinosa*** Sanguinetti et al. 1991. ET-21. Shell, *left* lateral view. **n *Caudites* sp.** Echevarría 1988. ET-19. Shell, *right* lateral view

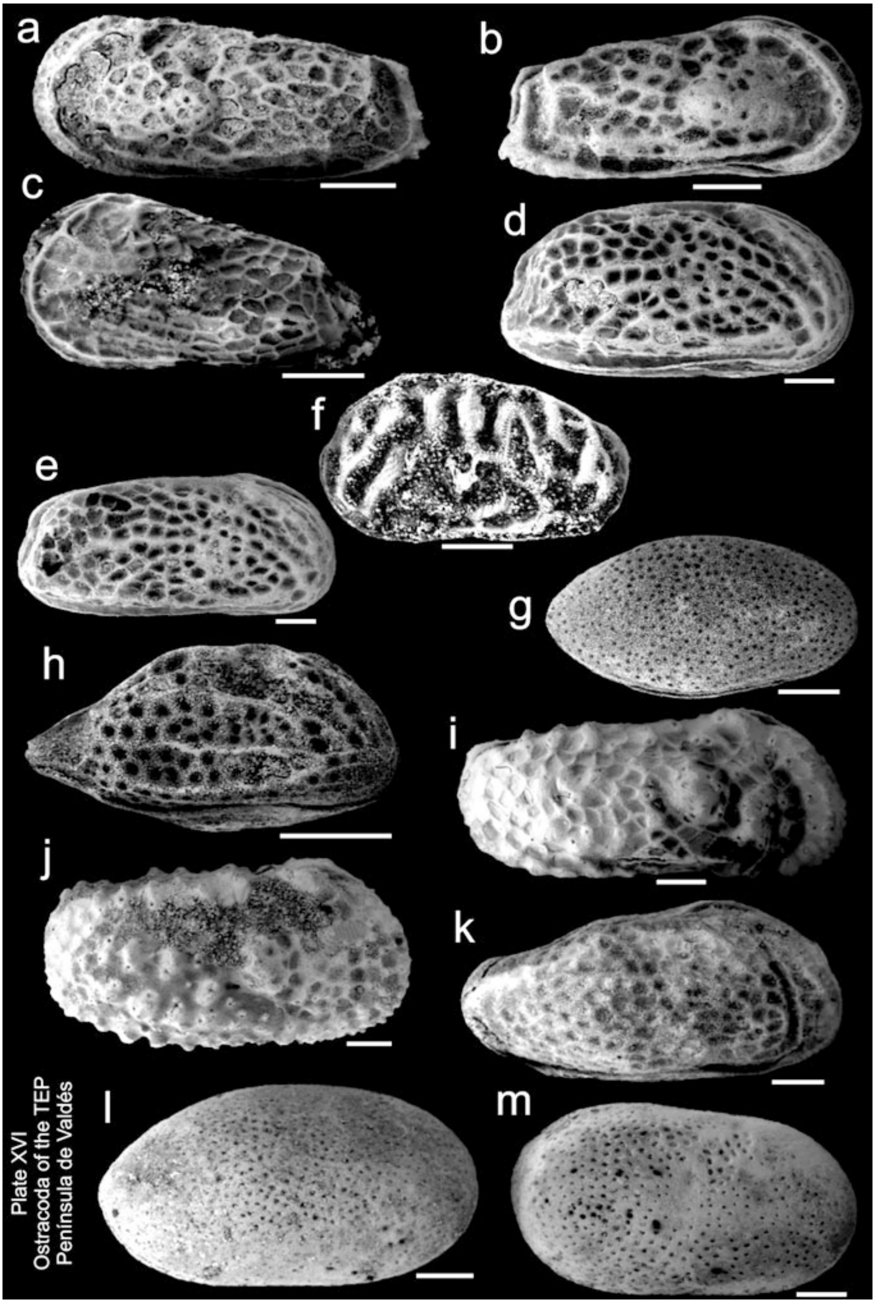
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Plate XVI
Ostracoda of the TEP
Península de Valdés

◀**Plate XVI Ostracoda of the TEP from the Península de Valdés. a *Coquimba* aff. *bertelsae*** Sanguinetti et al. 1991. ET-15. Shell, *right* lateral view. **b *Coquimba* sp.** Echevarría 1988. ET-BG. Shell, *right* lateral view. **c *Cornucoquimba* sp. 2** Valicenti 1977. ET-19. Shell, *left* lateral view. **d *Meridionalicythere* aff. *discophora*** (Skogsberg 1928). ET-30. Shell, *right* lateral view. **e *Meridionalicythere* aff. *mesodiscus*** (Skogsberg 1928). ET-30. Shell, *right* lateral view. **f *Callistocythere marginalis*** Zabert 1978. ET-S/N. Shell, *left* lateral view. **g *Pellucistoma* sp.** PP-16. Shell, *right* lateral view. **h *Paijenborchella punctacostata*** Zabert 1978. SJ-1. Shell, *right* lateral view. **i *Henryhowella* aff. *beckerae*** Bertels 1975b. PP-18. Shell, *right* lateral view. **j *Henryhowella* aff. *evax*** (Ulrich y Bassler 1904). PP-20. Shell, *right* lateral view. **k *Soudanella* sp.** Bertels 1976. PP-18. Shell, *right* lateral view. **l *Cytherella* sp.** SJ-1. Shell, *right* lateral view. **m *Cytherella* sp.** ET-BG. Shell, *left* lateral view

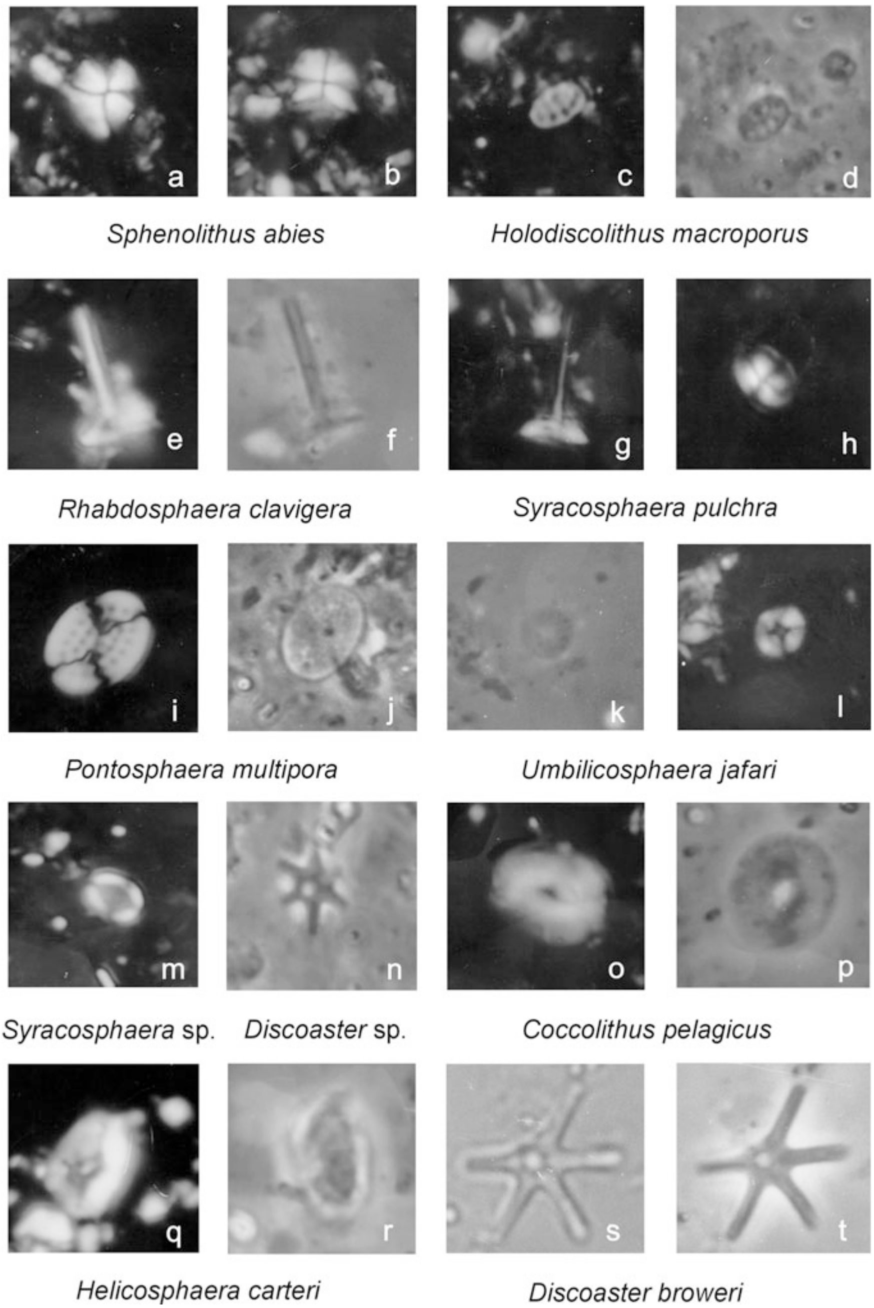
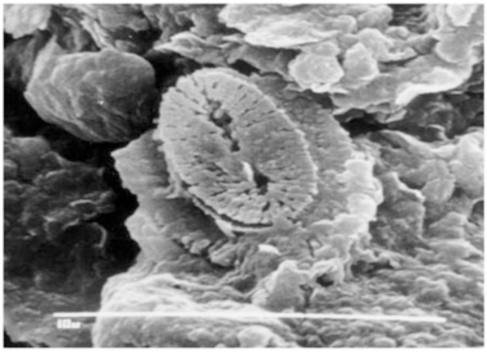
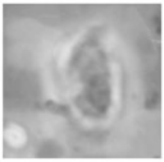
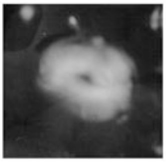


Plate XVII Calcareous nannofossils of the TLP and TEP from the Salado Basin

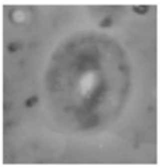




Helicosphaera carteri



Coccolithus pelagicus



Coccolithus pelagicus

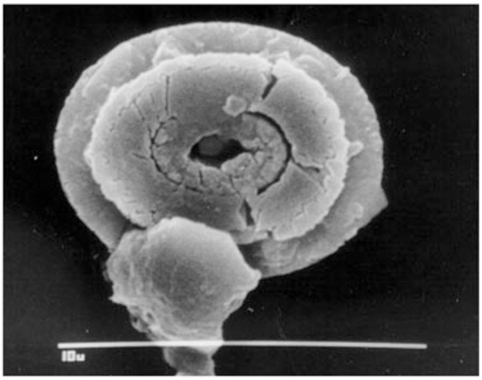


Plate XVIII Calcareous nannofossils of the TLP and TEP from the Salado Basin

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