

# The marine upper Palaeozoic in Patagonia (Tepuel–Genoa Basin, Chubut Province, Argentina): 85 years of work and future prospects

M. Alejandra Pagani<sup>a,b,\*</sup>, Arturo C. Taboada<sup>a,c</sup>

<sup>a</sup> CONICET, Consejo Nacional de Investigaciones Científicas y Técnicas, Argentina

<sup>b</sup> Museo Paleontológico "Egidio Feruglio" (MEF). Av. Fontana no. 140, Trelew (U9100GYO), Chubut, Argentina

<sup>c</sup> Laboratorio de Investigaciones en Evolución y Biodiversidad (LIEB), Facultad de Ciencias Naturales, Sede Esquel, Universidad Nacional de la Patagonia "San Juan Bosco" (UNPSJB). RN 259, km 16,5, Esquel (U9200), Chubut, Argentina

## ARTICLE INFO

### Article history:

Received 16 October 2009

Received in revised form 9 August 2010

Accepted 26 August 2010

### Keywords:

Carboniferous

Permian

Tepuel–Genoa Basin

Patagonia

Argentina

## ABSTRACT

Argentina is a special place to study Late Palaeozoic life and environmental change because of the excellent exposures of Late Palaeozoic sedimentary sequences. In particular, Patagonia has an almost continuous Late Palaeozoic succession containing well-preserved faunal assemblages characterized by both strong endemism and distinctive palaeobiogeographic links to Australia and northeast Asia. In this contribution an overview of the current knowledge of the invertebrate faunas of Patagonia and their biostratigraphic and palaeobiogeographic significance are presented, along with comments on the future prospects of research in the light of new findings. The Late Palaeozoic outcrops in central-western Patagonia belong to the Tepuel–Genoa Basin (Chubut province, Argentina), then located in southwestern Gondwana during the Late Palaeozoic. In this basin the succession is >6000 m thick, and constitutes a continuous and complete succession from the Lower Carboniferous to lower Permian. As such, it has the potential to serve as an important reference section for regional and intercontinental correlations. The marine Late Palaeozoic of Patagonia has yielded abundant and well-preserved representatives of most invertebrate groups: brachiopods, bivalves, gastropods, cephalopods, hyolithids, pelmatozoans, ostracods and cnidarians. Recently, studies of the Patagonian faunas have resulted in different opinions on the ages of the faunas. Biostratigraphic correlation is complex due to strong faunal provincialism. For this reason, there are several hypotheses concerning the biostratigraphic zonation in the basin. Since 1920, when studies of Late Palaeozoic strata in Patagonia were first carried out, numerous papers on stratigraphic, palaeogeographic and taxonomic subjects have been published, but our knowledge of Carboniferous–Permian fossils from the Tepuel–Genoa Basin is still incomplete. At present, we are attempting to integrate and calibrate the different faunal associations with a view to achieving a unified biostratigraphic biozonation scheme and hence a much improved understanding of the palaeobiogeographic relationship of Patagonian faunas with those from western Argentina and other continents. Currently, detailed stratigraphic and palaeontological research is being done in the type section of the Tepuel–Genoa Basin. The aim of our studies is to integrate all partial sequences exposed throughout the basin and to propose a biostratigraphic chart based on key invertebrate taxa. Once this goal is achieved, a global correlation can be conducted, especially with other sections in Gondwana and the Arctic.

© 2010 Elsevier B.V. All rights reserved.

## 1. Introduction

The Carboniferous and Permian periods were geological intervals when the physical world underwent great palaeogeographic and palaeoclimatic changes. These changes had a strong but different impact on the biotas in the southern and northern hemispheres. For many years, researchers have been trying to determinate the links between the two biotas. In this regard, the Late Palaeozoic basins of

southwestern South America are considered particularly important for reconstructing Gondwana's complex history. These basins contain a nearly complete Late Palaeozoic stratigraphic record that documents not only the different glacial episodes, but also the transition from cold to semiarid and arid climatic conditions through the Carboniferous–Permian interval. The extensive magmatic activity registered in the western margin of southern South American during the Late Palaeozoic is among the most important recorded on the Gondwana supercontinent. Thus, the combination of a rich palaeontological record within many of these basins and the potential for absolute age dates make these strata extremely important for linking the different biostratigraphic schemes, providing regional correlations among the numerous Gondwana basins, and for constraining the age of the major geologic events during the Late Palaeozoic.

\* Corresponding author. Museo Paleontológico "Egidio Feruglio" (MEF). Av. Fontana no. 140, Trelew (U9100GYO), Chubut, Argentina. Tel.: +54 2965 432100x51; fax: +54 2965 432100x28.

E-mail addresses: [apagani@mef.org.ar](mailto:apagani@mef.org.ar) (M.A. Pagani), [ataboada@unpata.edu.ar](mailto:ataboada@unpata.edu.ar) (A.C. Taboada).

Marine Late Palaeozoic outcrops in Argentina are preserved throughout most of the western margin of the country, but only two areas of deposition (Sauce Grande–Colorado and the La Golondrina basins) are registered in the eastern margin, where the *Eurydesma* fauna has been recorded (Harrington, 1955; Pagani, 1998, 2000) (Fig. 1). Recently an updated overview of the palaeogeographic and palaeoenvironmental evolution of the Late Palaeozoic basins in South America was presented by Limarino and Spalletti (2006). In the last few years, numerous papers about the invertebrate faunas from the Tepuel–Genoa Basin have been published, and the palaeobiogeographical and biostratigraphic significance of these new findings have stimulated the interest of many researchers. The occurrence of many of these palaeobiological records associated with several glacial-related horizons and interglacial intervals in Patagonia, displays key evidence for a better understanding of the palaeobiogeographic, palaeogeographic and palaeoclimatic evolution of this part of southern Gondwana.

The marine Late Palaeozoic of Patagonia has yielded representatives of most invertebrate groups: brachiopods, bivalves, gastropods, cephalopods, hyolithids, echinoderms, bryozoans, cnidarians, ostra-

cods and rare trilobites. In the type section of the Tepuel–Genoa Basin the faunal succession is relatively well known (although not yet completely described), but in recent years, very important discoveries were made. However, some southernmost localities have insufficient sampling of marine strata due to the predominance of continental facies. In this way, it will be necessary to carry out a more detailed research to improve and complement the marine biostratigraphical scheme in Patagonia. There are more than one hundred species of marine invertebrate fossils published from the Late Palaeozoic of Patagonia. In this contribution an overview on the current knowledge of these Patagonian invertebrate faunas and their biostratigraphic and palaeobiogeographic significance is presented. Also, some suggestions for future work are also outlined. An additional aim of this contribution is to put the fossiliferous beds in stratigraphic order, supported by new collections made by the authors in recent years.

Argentine Patagonia provides a unique view of Late Paleozoic life under cold palaeoclimatic conditions because it contains a continuous Lower Carboniferous to Lower Permian succession with abundant fossils deposited in high palaeolatitudinal setting. The Tepuel–Genoa

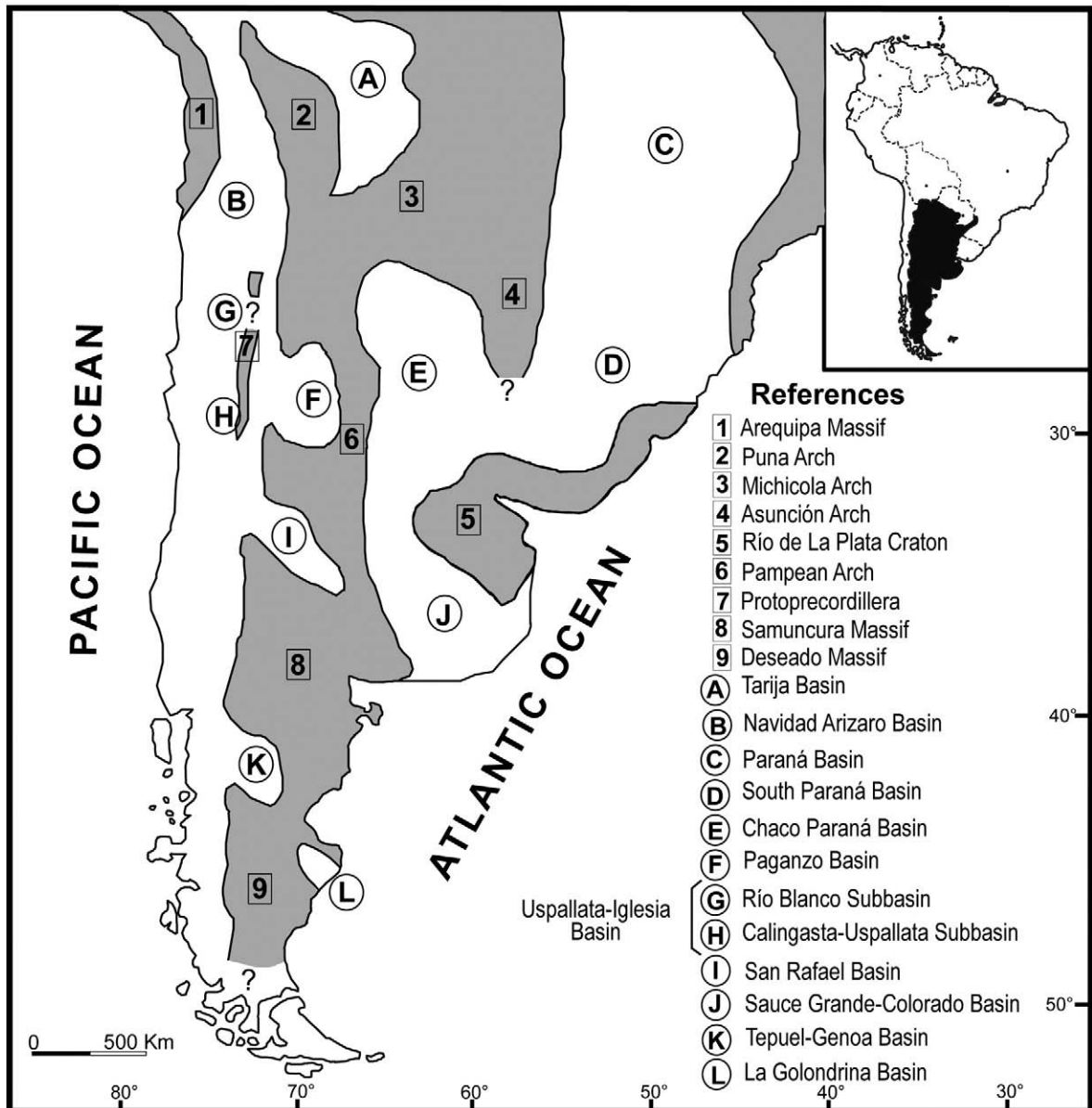


Fig. 1. Major basins of Argentina (modified from Limarino and Spalletti, 2006).

Basin (Fig. 2) has different faunal assemblages, from a middle Carboniferous cold water fauna characterized by the brachiopod *Lanipustula* Klets, a genus also present in western Argentina, Antarctic Peninsula, eastern Australia, to highly endemic Pennsylvanian–early Asselian faunal communities typified by such brachiopod genera as *Verchojania* Abramov and *Amosia* Simanaukas, among others. On the other hand, younger, Sakmarian–Artinskian, cool to cold water faunas from Patagonia exhibit strong palaeobiogeographic links to western Australia and the Cimmerian regions of south and southeast Asia, especially exemplified by the common occurrence of the brachiopod genus *Cimmeriella* Archbold and Hogeboom. Over the same period, the migration pathway between the southwestern margin of Gondwana and eastern Australia also appears to have been re-established as evident from the appearance in both regions of the brachiopods *Costatumulus* Waterhouse and *Coolkilella* Archbold, among other elements.

## 2. Geological and stratigraphic setting, and key biota content

In central-west Patagonia, Late Palaeozoic rocks extend over extensive areas between 43°–44° 20'S and 69° 30'–71°W, and are distributed from north–northwest to south–southeast for approximately 250 km. The Late Palaeozoic overlies unconformably the Catreleo Devonian granite (Robbiano, 1971) and underlies Lower Jurassic marine strata. The principal outcrops in the basin are located in the Tepuel, Languiño, Tecka, Valle Chico and Excursión hills and in the Río Genoa Valley. Other important fossiliferous sections are exposed at the El Molle area and the Cañadón Hondo localities in the Pampa de Agnia region (Fig. 2).

The stratigraphic succession and nomenclature for the Late Palaeozoic of the basin have been referred to and discussed in numerous studies. The sequence was first described by Keidel (1922), Piatnitzky (1933, 1936), and Suero (1948, 1953, 1958). Suero

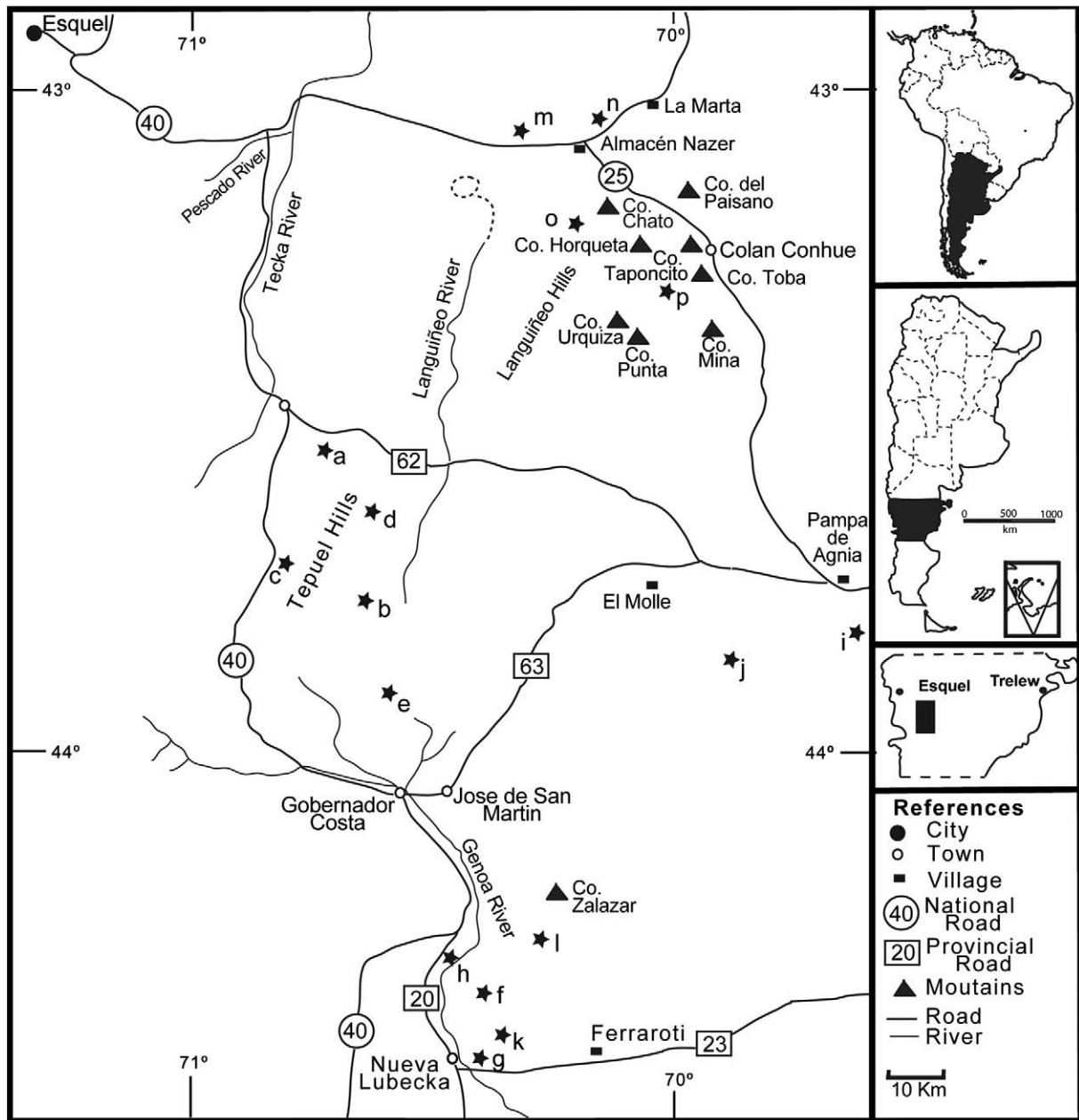


Fig. 2. Tepuel–Genoa Basin, location map. References. a, Puesto La Carlota. b, Puesto Tres Lagunas. c, Puesto Estancia La Mimosa (Puesto Pampa de Tepuel, Puesto Pardo or Puesto Curzio of some papers). d, Puesto Palenque. e, Puesto Garrido. f, Piedra Shotel. g, Cerro La Trampa. h, La Casilda, i, Pampa de Agnia (Cañadón El Culero). j, Quebrada Honda. k, Betancourt. l, Lomas Chatas. m, Puesto Santiago Moreno. n, Puesto Fuente Alba. o, Puesto Benito Aleman. p, Casa Zarza.

Suero (1948)	Freytes (1971)	Lesta and Ferello (1972)		Page et al. (1984)	Andreis et al. (1987) and Andreis et al. (1996)				Taboada and Pagani (2009)				
Tepuel Hill	Tepuel Hill	Tepuel Hill	Río Genoa Valley	Tepuel Hill	Tepuel Hill	Río Genoa Valley	Languiño Hill	Esquel Area	Tepuel Hill	Río Genoa Valley			
Tepuel System	Upper Part	Arroyo Garrido Fm.	Mojón de Hierro Fm.	Nueva Lubecka Fm. Piedra Shotle Fm.	Río Genoa Group	Mojón de Hierro Fm.	Mojón de Hierro Fm.	Río Genoa Fm.	Languiño Hill	Esquel Fm.	Tepuel Group	Mojón de Hierro Fm.	Río Genoa Fm.
	Lower Part	Pampa de Tepuel Fm.				Pampa de Tepuel Fm.	Pampa de Tepuel Fm.	Pampa de Tepuel Fm.	Pampa de Tepuel Fm.	Las Salinas Fm.		Jaramillo Fm.	Jaramillo Fm.

Fig. 3. Correlation of Late Palaeozoic lithostratigraphic units as proposed by different authors.

recognized the Late Palaeozoic age of these deposits and outlined the general stratigraphy of the basin. Later, Freytes (1971), Lesta and Ferello (1972), Franchi and Page (1980) and Page et al. (1984) described the stratigraphic aspects in the Tepuel Hill. In the Río Genoa Valley the uppermost sections of the Late Palaeozoic were described

by Suero (1953, 1958) and Ugarte (1966). Other stratigraphic studies were later published for the El Molle area (Perrot, 1960), the Las Salinas area (González, 1972a) and the Esquel locality (Cucchi, 1980a,b; López Gamundi, 1980a,b; González Bonorino and González Bonorino, 1988). During the 20th century other papers

Amos and Roller (1965)		Simanaukas and Sabattini (1997)		Taboada (2001)		Pagani and Sabattini (2002)		
Brachiopoda		Brachiopoda and Bivalvia		Brachiopoda		Gastropoda-Bivalvia		Cephalopoda
Cancrinella Zone	Pm	Neochonetes Zone	Pm	Costatumulus Zone	Neochonetes Subzone	Pm	Euphemites chubutensis-Palaeoneilo aff. concentrica Zone	Mooreoceras zalazarense Zone
		Cancrinella Faunule			Tuberculatella Subzone			Sueroceras irregulare Zone
Levipustula Zone	Cb	Tuberculatella Zone	Cb	Levipustula Zone	Cb	Cb	Callitomaria tepuelensis-Streblochondria sp. Zone	Pyramus primigenius-Mourlonia sp. II Zone
		Pyramus Faunule						
		Lanipustula Zone						

Fig. 4. Correlation chart showing biostratigraphic units recognized for marine Late Palaeozoic in Patagonia.

Series/Epoch	Stage/Age	PATAGONIA, TEPUEL-GENOA BASIN		
CISURALIAN	Kungurian			
	Artinskian	<i>Costatumulus</i> Biozone		<i>Jakutoproductus australis</i> Fauna
				<i>Jakutoproductus sabattinae</i> Fauna
	Sakmarian			<i>Cimmeriella willi</i> Fauna
	Asselian			
				<i>Verchojania archboldii</i> Fauna

Fig. 5. Faunal associations proposed by Taboada and Pagani (in press).

were added to the stratigraphic and palaeoenvironmental data base of the Tepuel–Genoa Basin, such as contributions by López Gamundi (1980a,b), González Bonorino (1986, 1988), and González Bonorino and González Bonorino (1988) for the Esquel area, as well as Frakes and Crowell (1969), Frakes et al. (1969), González Bonorino et al. (1988), López Gamundi (1989) for Tepuel Hill and Andreis and Cúneo (1985, 1989, 1990), Cortiñas and Arbe (1982), Cúneo and

Sabattini (1987) and Franchi and Page (1980), for the Río Genoa Valley, among others.

The current and largely accepted stratigraphic nomenclature was proposed by Page et al. (1984), with a tripartite succession of the Jaramillo, Pampa de Tepuel and Mojón de Hierro formations. These formations constitute the Tepuel Group, a major lithostratigraphic unit with its type section in the Tepuel Hill (Fig. 3). Following Andreis et al. (1987, 1996) and our own observations, the Jaramillo Formation consists of medium to coarse-grained sandstones with some intercalated shales, bearing plant remains and some marine invertebrates. It is overlain erosively by diamictites and shales with dropstones and fine to coarse-grained sandstones of the lower part of the Pampa de Tepuel Formation. Several glacial-related intervals with coarse diamictites and black shales with dropstones, together with intercalated conglomerates and siltstones, characterize the middle and upper third of the Pampa de Tepuel Formation. Intercalated black shales contain marine invertebrate fossils of the *Lanipustula* fauna, and *Verchojania* and *Amosia* appear toward the top of the unit. The Pampa de Tepuel Formation was interpreted to be deposited under glacial influence (González Bonorino et al., 1988; González Bonorino, 1992), as supported by glacial pavements and dropstones occurring throughout the unit (González et al., 1995, 2003; González and Glasser, 2008; Taboada and Pagani, 2010). Widespread glacial-related horizons associated with Carboniferous and early Asselian faunas have suggested a high palaeolatitudinal setting for Patagonia (Taboada, 2008; Taboada and Pagani, 2010), with probable influence from an ice center peripheral to the main polar Gondwana ice sheet (González Bonorino, 1992; Taboada et al. 2005). In turn, the Pampa de Tepuel Formation is overlain by thick black shales with yellowish to greenish sandstones and minor intercalated conglomerates and siltstones of the Mojón de Hierro Formation. The upper section of the unit also exhibits a glacial-related interval with diamictites and shales with dropstones. The Mojón de Hierro Formation contains the late Sakmarian *Cimmeriella* fauna intercalated with beds bearing the *Glossopteris* flora below a deglacial-related horizon, as well as the earliest Artinskian *Kochiproductus*–*Costatumulus* faunal assemblage and the *Glossopteris* flora immediately above the glaciomarine beds. On the other hand, the lower section of the Mojón de Hierro Formation is considered to have been deposited during a postglacial event (López Gamundi, 1989, 1990), and related to the major eustatic sea level rise during the late Asselian–Tastubian (Dickins, 1985, 1996; Taboada, 2001, 2008).

Late Palaeozoic strata are also exposed in the east–northeast portion of the basin, in the Sierra de Languiño (Fig. 2), where the strata are at least 2400 m thick and are assigned to the Las Salinas Formation (González, 1972a). Farther south, in the Río Genoa Valley (Fig. 2), crops out the Río Genoa Formation which consists of yellowish to greenish sandstones and black shales with some intercalated conglomerates and siltstones (Andreis y Cúneo, 1989), bearing faunal associations estimated to be early to middle Artinskian in age and characterized by the brachiopods *Jakutoproductus* Kaschirtzev, *Costatumulus* Waterhouse, *Piatnitzkya* Taboada and *Magniplicatina* Waterhouse, as well as profuse *Glossopteris* floras. Page et al. (1984) considered the Río Genoa Formation as a lateral equivalent of the middle and upper parts of the Mojón de Hierro Formation. Furthermore, Andreis and Cúneo (1989) and Hlebszevitch and Sabattini (2005) have suggested that both formations are at least partially equivalent. Taboada and Pagani (2010) described two new faunal associations and proposed that the Río Genoa Formation mostly overlay the Mojón de Hierro Formation, but with possible minor lateral interfingering between the uppermost part of the Mojón de Hierro Formation and the lowermost part of the Río Genoa Formation (Fig. 3).

### 3. Biostratigraphy

Several different biostratigraphic schemes have been proposed for the Tepuel–Genoa Basin. Amos and Rolleri (1965) established the first marine invertebrate zonation for the basin, the use of which has

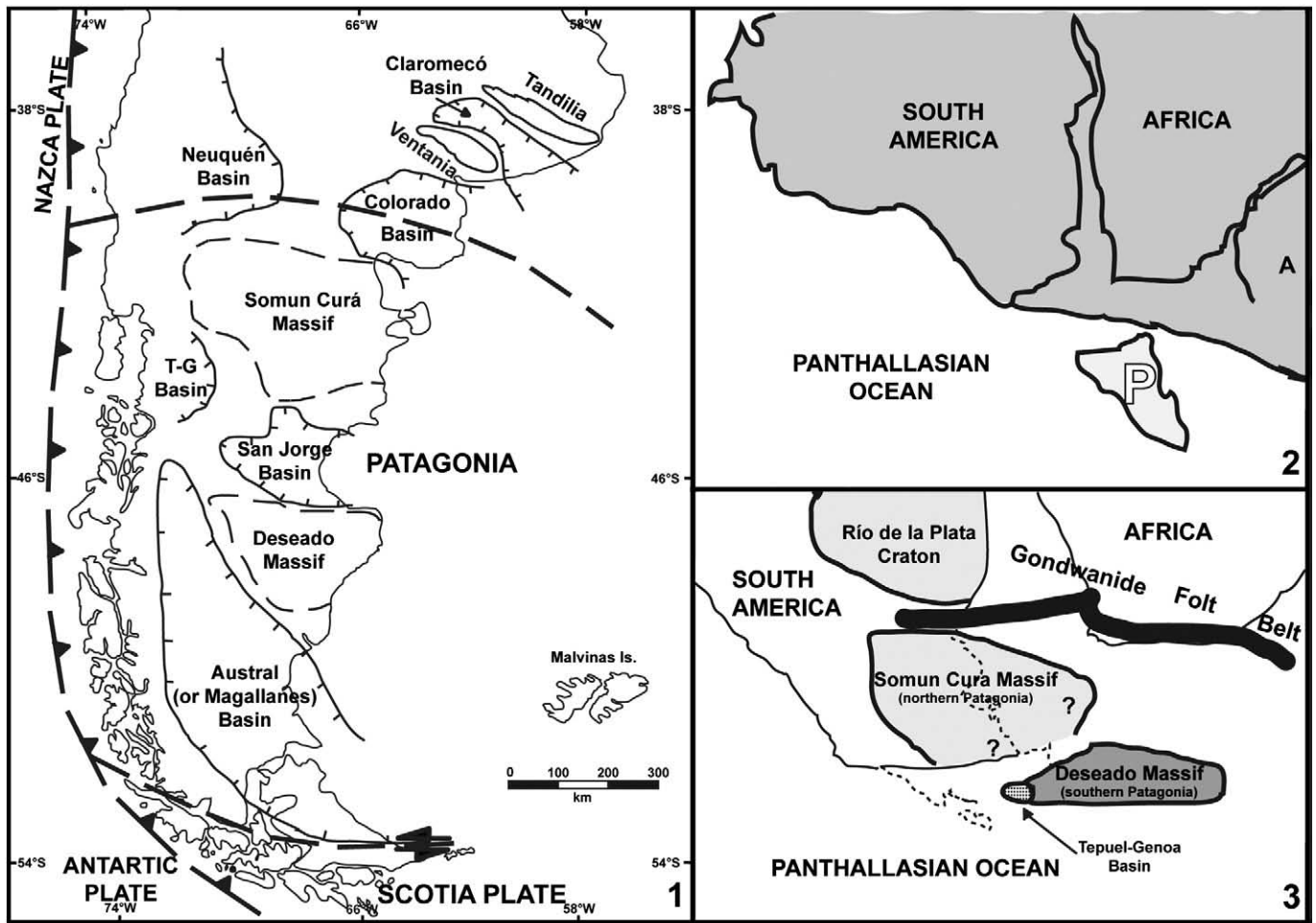


Fig. 6. Palaeogeographic map. 1, Map showing main topographic features of Patagonia (modified from Ramos, 2008). 2, Schematic palaeogeographic reconstruction following Ramos (2008), fide Rapalini (2005) (modified from Ramos, 2008). 3, Schematic palaeogeographic reconstruction following Pankhurst et al. (2006) and Taboada and Shi (in revision) (modified from Pankhurst et al. 2006). References. T-G Basin, Tepuel-Genoa Basin. P, Patagonian block (Somun Cura Massif + Tepuel-Genoa Basin + Deseado Massif).

persisted for more than three decades. This was based on the stratigraphic distribution of two distinctive brachiopod species, resulting in the recognition of two biozones: *Levipustula levis* (Moscovian) Zone and *Cancriella* Zone (i.e. *C. farleyensis*, late Carboniferous). Later Amos et al. (1973) adjusted the ages of these two biozones, reassigning the *Levipustula* Zone to the Westphalian and the *Cancriella* Zone to Early Permian. Further, González (1981) refined the former unit to the Namurian-Westphalian by correlation with the *Levipustula* Zone from Australia, and the *Cancriella* Zone to Asselian. González supported the Sakmarian age of the *Cancriella* Zone by the discovery of a Lubeckense A plant association (Archangelsky and Marrquez Toigo, 1980) which was stratigraphically located above but close to the beds bearing the “*Cancriella*” fauna in the Río Genoa Formation (Fig. 4).

Thirty two years after the first biostratigraphic proposal was published, the biostratigraphic zonation was changed considerably by Simanaukas and Sabattini (1997) who introduced a new scheme with five units (Fig. 4) based on brachiopods and bivalves. These authors proposed the *Lanipustula* Zone (Namurian-Stephanian; formerly *Levipustula levis* Zone of Amos and Roller 1965), *Pyramus* faunule (Asselian), *Tuberculatella* Zone (Sakmarian), *Cancriella* faunule (Sakmarian-Artinskian; formerly *Cancriella cf. farleyensis* Zone of Amos and Roller 1965) and *Neochonetes* Zone (Artinskian-Kungurian). Simanaukas and Sabattini (1997) assigned the age of these biozones on the basis of the faunal associations and affinities of brachiopods, bryozoans, bivalves

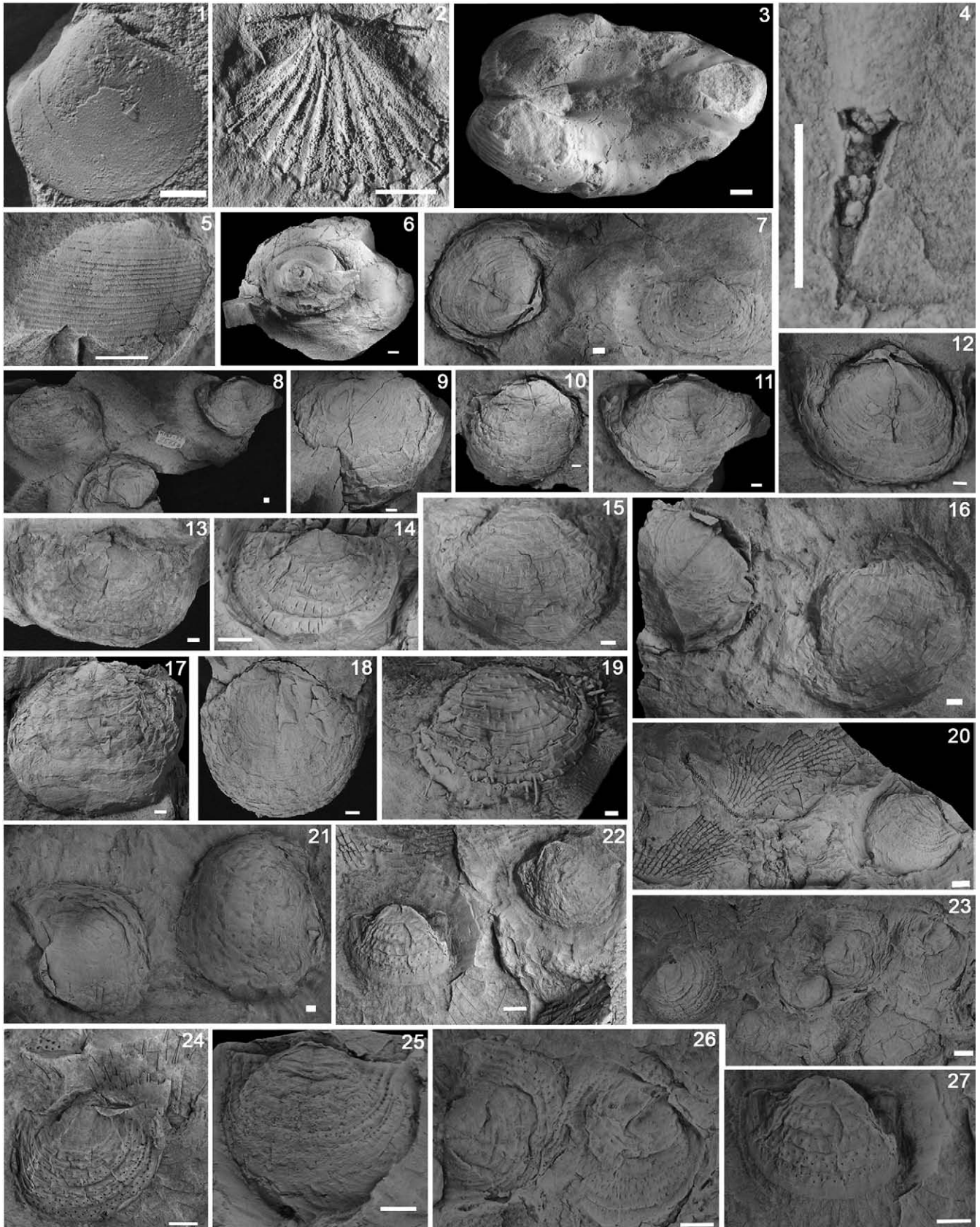
and gastropods. Later, specimens of *Cancriella cf. C. farleyensis* (Etheridge and Dunn) from Patagonia were included in the synonymy of *Costatumulus amosi* by Taboada (1998). Afterward, Taboada (2001) modified some biostratigraphic units and the ages of the biozones previously proposed, based on revised and updated brachiopod taxonomy. He suggested that the *Lanipustula* Zone is not younger than Westphalian, and that the *Tuberculatella* Zone be regarded as a subzone within the *Lanipustula* Zone (Fig. 4).

On the basis of subsequent advances in mollusk studies, Pagani and Sabattini (2002) proposed two new correlations (Fig. 4). The first takes into consideration the distribution of cephalopods: *Sueroceras irregulare* and the *Mooreoceras zalazarense* Zones. The second considers the distribution of bivalves and gastropods: *Mourlonia* sp. II-*Pyramus primigenius*, *Callitormaria tepuelensis*-*Streblochondria* sp., and *Euphemites chubutensis*-*Palaeoneilo aff. concentrica* Zones. The Pagani and Sabattini biozones were together regarded as Early Permian age (Cisuralian).

To date, all the various biostratigraphic schemes and correlations are based on the distribution of faunas in the northern section from the Tepuel-Genoa Basin, with only a few isolated data from the Río Genoa Valley. However, recently Taboada and Pagani (2010) described two new brachiopod species with important biostratigraphic implications. Consequently, three new Cisuralian faunal associations were recognized by Taboada and Pagani (2010) (Fig. 5): the *Cimmeriella willi* fauna represented in the Mojón de Hierro

Formation, and the *Jakutproductus sabattinae* and *J. australis* faunas. The last species was originally recognized by Simanaukas and Archbold (2002) from the Río Genoa Formation. Also, these new

discoveries allowed an adjustment to the important global correlation of Patagonia with the Siberian–Arctic territory and Australian regions (see Taboada and Pagani, 2010).



#### 4. Palaeogeographic setting of Patagonia

In the last 20 years, two opposing hypotheses have been proposed to explain Patagonia's Late Palaeozoic palaeogeographic position. One hypothesis proposed that Patagonia was an autochthonous block (e.g. Forsythe, 1982), whereas the other hypothesis interpreted Patagonia as an accreted terrane (Ramos, 1983, 1984, 1986, 1988, 1996; Ramos and Palma, 1996; Ramos, 1999, 2004a,b; Ramos et al. 2004). Pankhurst et al. (2006) have also suggested that the Deseado Massif, which constituted the southern Patagonian continental block on which the Tepuel–Genoa Basin was formed, would not have been separated very far from southern South America margin during Palaeozoic times. More recently, Ramos (2008) regarded Patagonia as a para-autochthonous terrane. Ramos's idea is supported by the fact that zircon studies indicated that the basement of Patagonia is not exotic to Gondwana. In this model, Ramos proposed several episodes of fragmentation and rifting, convergence and accretion, followed by renewed periods of rifting during Palaeozoic times, and final re-accretion of Patagonia to the margin of Gondwana during the Late Palaeozoic. This scenario includes two magmatic arcs developed around Patagonia: a western magmatic belt that was active from the Devonian to the mid Carboniferous, and a partially coeval northern belt that led to the collision of Patagonia with the southwestern margin of Gondwana in the Early Permian. In addition, Hervé et al. (2006) and Ramos (2008) have both hypothesized that the termination of tectonic activity in the western magmatic arc was linked to the collision of the Antarctic Peninsula and associated terranes with Patagonia (Fig. 6).

At the moment non-palaeontological data have been employed to support or refute the allochthonous or para-autochthonous hypothesis. However, our recent analysis of the Tepuel–Genoa marine faunas shows strong evidence in support of Patagonia being as a para-autochthonous entity for at least Late Palaeozoic times. This scenario is supported especially by our recent discoveries of new fossils (Shi et al., 2008; Taboada, 2008; Taboada and Pagani, 2010). These new fossil records show distinct contemporaneous difference to faunas of western Argentina during the Pennsylvanian–earliest Permian (Taboada and Shi, 2010; Taboada, 2010–this issue), suggesting the allochthony of Patagonia with respect to mainland South America. For instance, we have found that the faunal similarity between Patagonia and western Argentina significantly decreased through Pennsylvanian–Artinskian, while over the same interval significant palaeobiogeographic interchanges appear to have occurred between Patagonia and northeast Asia and, to some degree, also western Australia. These facts, especially the Australian connection, evidenced for example by the joint occurrence of the *Cimmeriella* fauna (see Taboada and Pagani, 2010), would support the scenario proposed by Pankhurst et al. (2006), that the Tepuel–Genoa Basin was located at the western border of the Deseado Massif, where it constituted a discrete terrane detached from the northern Somuncura Massif. This scenario is opposite to the model of Ramos (2008), who advocates Patagonia as an integral part of a larger tectonic block which then also comprised the Somuncura and Deseado massifs (Fig. 6).

#### 5. Invertebrate faunas from Patagonia

Most invertebrate groups are represented and well-preserved throughout the Tepuel–Genoa Basin. However, the most abundant and highly diversified groups are brachiopods, bivalves, bryozoans and gastropods. Suero (1947, 1948) provided the first reports of marine

invertebrate fossils in the basin, mainly from the Tepuel Hill and Puesto La Carlota localities (Fig. 2). Suero's correlations were applied to other localities in the basin by Perrot (1960) and Ugarte (1965, 1966).

The first systematic studies on Carboniferous and Permian faunas were carried out by Amos (1958, 1961a,b) who described the brachiopod associations. Later, work by numerous researchers has revealed the high diversity of the different invertebrate groups present in the basin, and in Patagonia in general. The brachiopod fauna was studied by Simanuskas (1991, 1993, 1996a,c), Simanuskas and Archbold (2002), Taboada (1993, 2008) and Taboada and Pagani (2010). The bivalves fauna was studied by González (1969, 1972b, 1974, 1975a,b, 1977, 1978, 1980, 1983, 1984, 2006), González and Waterhouse (2004) and Pagani (2004a,b, 2005, 2006a,b) and Pagani and Ferrari (in press). The gastropod fauna was examined by Cúneo and Sabattini (1987), Ferrari and Sabattini (2008), Pinilla et al. (2007), Sabattini (1975, 1978, 1984, 1992, 1995a,b, 1997) and Sabattini and Noirat (1969). The bryozoan fauna was described by Sabattini (1972, 1982, 1983, 1984, 1990, 2002). The cephalopod fauna, which is relatively rare and endemic, was first reported by Miller and Garner (1953) and later in the contributions by Closs (1967), Riccardi and Sabattini (1975), Sabattini and Riccardi (1984) and Sabattini et al. (2006). Other invertebrate groups such as echinoderms, cnidarians and scaphopods were studied by Sabattini and Noirat (1967), de Mariñelarena (1970), and Sabattini (1986). In addition, Sabattini and Hlebszevitch (2004, 2005) studied cnidarians, while Amos (1958b, 1961a,b) and Sabattini and Aguirre (1985) described inarticulate brachiopods. Gonzalez and Sabattini (1972), Pagani and Sabattini (1999) and Pagani et al. (2002) reported on hyolithids. Sabattini (1979) registered scaphopods, Hoare and Sabattini (2000) studied polyplacophorans and Sabattini and Castillo (1989) reported on the first studies of echinoderms. Recently, Hlebszevitch (2004a,b,c, 2005) described the crinoid fauna. Only a single species of trilobite has been described (Hahn and Hahn, 1969), as well as one insect by Pinto (1972). Finally, microfossils were described by Rossi de García (1972) and later by Díaz Saravia and Jones (1999).

Most systematic studies mentioned above were made on the basis of materials collected by Dr. Suero (field works for the Geological Survey of Argentina and Yacimientos Petrolíferos Fiscales), who carefully emphasized their geographic locations but did not provide stratigraphic details in terms of their positions in the overall stratigraphic succession/sections. Therefore, the biostratigraphic and palaeogeographic significance of Suero's collections has been limited and new collections have long been considered necessary for detailed biostratigraphic analysis and palaeogeographic understanding. Following Suero's pioneering work, additional materials were obtained by several palaeontologists, and these are currently housed mainly in the Museo de Ciencias Naturales de La Plata (MLP), Museo Paleontológico Egidio Feruglio (MPEF-PI) and in the Fundación Miguel Lillo (PIL). For biostratigraphic and regional and global correlations it is necessary to have an accurate stratigraphic control of all the collections. Thus, in recent years the authors have undertaken extensive field work in Tepuel–Genoa Basin to recover new information about the faunal associations. Some of our results are reported in this contribution. These new collections have allowed an adjustment of the taxonomic position of different taxa previously recorded from the basin, especially those key groups that are useful in defining the biostratigraphy of the basin.

New faunal connections of Patagonia with Siberia, recently updated by Taboada and Pagani (2010), were first suggested by Archbold (2005)

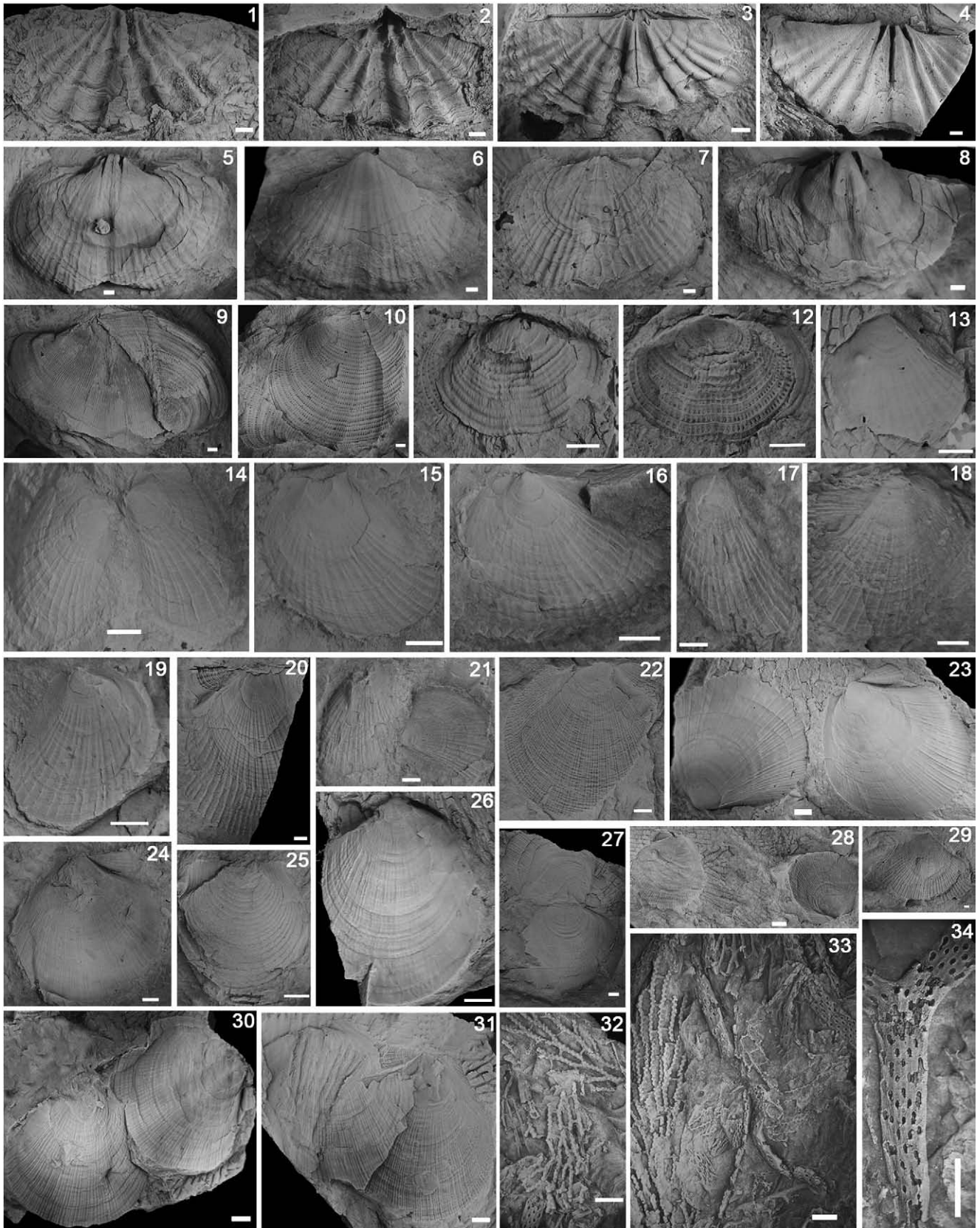
**Fig. 7.** 1–3, Bivalves from Arroyo Garrido locality (specimens described by Pagani, 2005, 2006a,b); 1, *Streblopteria lagunensis* Pagani, MLP 24136. 2, *Heteropecten argentinaensis* Pagani, MLP 29859. 3, *Sueroa andreisi*? González, MLP 29822. Scale bar 3 mm. 4–6, scarce fossils recovered near the base of Pampa de Tepuel Formation (specimens collected by the authors, undescribed); 4, *Hyolithes* sp., MPEF-PI 2083. 5, *Phestia tepuelensis*? González, MPEF-PI 2078. 6, Archaeogastropoda indet., MPEF-PI 2082. Scale bar 2 mm. 7–27, Strophomenata brachiopods from Pampa de Tepuel Formation, at 770 m. from the base (specimens collected by the authors, under revision); 7–19, 21, *Lanipustula patagoniensis* Simanuskas; 7, 10, 12, MPEF-PI 2446. 8, 13, 11, MPEF-PI 2573. 9, MPEF-PI 1947. 14, MPEF-PI 1980. 15–17, MPEF-PI 2499. 18, MPEF-PI 2460. 19, MPEF-PI 2472. 21, MPEF-PI 2624. 20, 22–27, *Krotovia*? sp.; 20, 25, MPEF-PI 2725. 23, 26, MPEF-PI 2593. 24, MPEF-PI 2724. 22, 27, MPEF-PI 2671. Scale bar 2 mm.



and Taboada et al. (2005), who suggested potential correlations between northern and southern hemispheres. Nevertheless, our investigation of the emerging complex Late Palaeozoic biogeographic relationship between Patagonia and others regions of the Northern

Hemisphere is in its initial stage and further studies are required in order to achieve a more comprehensive understanding of the relationships.

Faunal associations are presented below based on data from different key areas within the basin and in the order in which they



appear in the stratigraphic record. In each area, descriptions of the previous and current research are provided.

### 5.1. Tepuel Hill

In this area, the thickest sequence is exposed, although the youngest sections of the basin are absent due to Permo-Triassic erosion. However, the upper strata can be correlated with the youngest strata in the southern part of the basin. Tepuel Hill is the type locality for strata defining this basin, and where the type section was described. Because of this, most of the new researches have concentrated on new fossil collections for biostratigraphic correlations in this area. Thus an exhaustive study of this area will allow a better correlation with the northern and southern parts of the basin, and will allow the authors to make better stratigraphic and palaeogeographic interpretations.

Special attention has been paid to the Arroyo Garrido locality (Fig. 2), which is a key locality in the Tepuel Hill due to the palaeontological links it provides between the type section and the southern basin localities. The Arroyo Garrido sequence was first described by Freytes (1971) and later by Andreis and Cúneo (1985) and Andreis et al. (1996). From this locality a small fauna was described by Pagani (2004a, 2005, 2006a,b) (See Appendix A for species list, locality 11) (Fig. 7.1 to 3). Recently, several additional specimens have been collected, highlighting the potential for more collections to be made from this locality and the need for detailed bed by bed sampling.

#### 5.1.1. The type section (W–E through Puesto La Mimosa–Puesto Tres Lagunas; Fig. 2)

**5.1.1.1. Jaramillo Formation.** At Tepuel Hill the sequence starts with the Jaramillo Formation with poor fossil remains. Freytes (1970, 1971) reported some invertebrates. Later, only two bivalves and a single gastropod mould were reported but not described by González (1987). More conspicuous are plant fossils, which include *Gylboaphytum argentinum* Carrizo and Azcuy (2006) and *Archaeosigillaria conferta* (Menéndez), identified by Petriella and Arrondo (1978).

**5.1.1.2. Pampa de Tepuel Formation.** The type section continues with the Pampa de Tepuel Formation overlying the Jaramillo Formation. However, Carrizo and Azcuy (2006) suggested that a hiatus separated the two formations. The faunal succession in this formation was estimated to be from middle Carboniferous to earliest Permian age (Simanaukas and Sabattini, 1997; Taboada et al., 2005; Taboada, 2008). Near the base of the formation (at approximately 400 m above the base), we have recently found a few fossil remains, including one fragment of *Phestia tepuelensis* González (1969), a specimen of *Nuculopsis* sp., two different specimens of *Hyalolithes* sp. and two gastropods of *Mourlonia?* sp. (Fig. 7.4 to 6).

The next fossiliferous bed occurs at approximately 770 m above the base of the formation. It is the richest fossiliferous bed in this formation, in terms of both faunal abundance and diversity. This bed of 20 m of dark shales with a sandstone bed containing trace fossils corresponds with Complex B, bed 8 of Suero (1948). The unit has yielded an abundant fauna, yet undescribed, comprising brachiopods, bivalves, bryozoans and scarce gastropods. The brachiopods are Strophomenata and Rhynchonellata, the former group represented

by *Krotovia?* sp. and *Lanipustula patagoniensis* Simanaukas (1996b) based on Suero's original collection. New material collected recently has revealed a higher species diversity within Productidina than previously known (Fig. 7.7 to 27). Rhynchonellata in the fauna are tentatively assigned to *Kitakamithyris* cf. *K. immensa* (Campbell), *Spiriferellina?* sp., *Alispirifer?* sp. and Spiriferidae spp. (Fig. 8.1 to 13). The species *Kitakamithyris* cf. *K. immensa* (Campbell), recently discovered, is significant because it constrains the age of this bed to Namurian.

The bivalve fauna from this first bed, which is still under study, includes exclusively species of Limoidea and Aviculopectinoidea (Fig. 8.14 to 32). However, the Limoidea could be assigned to *Palaeolima* sp., with possibly more than one species, while the Aviculopectinoidea were preliminary assigned to *Limipecten* sp., *Streblochondria sueroi?* González (1969), and Euchondriidae. An extraordinarily abundant and diverse fauna of bryozoans has also been recovered from this bed. All samples collected contain numerous specimens and at least three or four species. The most representative forms are *Fistulamina bifurcata* Sabattini (2002), *Fistulamina amosi* Sabattini (2002), *Fistulamina* sp., *Septatopora freytsi* Sabattini (1983), *Septatopora* sp., *Rhombopora* sp., *Australofenestella* sp., *Fenestella* sp. and *Penniretepora* sp. (Figs. 8.32 to 34 and 9.11 to 14). The gastropods are scarce in this bed and some representatives are figured here (Fig. 9.15 to 18). This entire fauna is still under revision.

Suero (1948) collected numerous fossil samples from the lower beds of the Pampa de Tepuel Formation that he labeled as “Fenestrata Bed” and “4 km to East Casa Herrera”. Although it is possible that the new collection made by us came from the same levels as Suero's collection (at least from the Fenestrata Bed) but we note that it has not been possible to confirm it. For this reason, the new collections are necessary for biostratigraphic and palaeobiogeographic studies. Suero's collection has been described by different researchers: Sabattini (1972, 1982, 1983, 1990, 2002) who described the bryozoans; Amos (1979) and Simanaukas (1996a) documented the brachiopods; and González (1969) and Pagani (2004b, 2005, 2006a,b) the bivalves. Other groups contained in Suero's collection included a few gastropods (Sabattini, 1995a) and echinoderm (blastoid) (Sabattini and Castillo, 1989). Appendix A provides a detailed list of all the described species collected from Suero's localities 1 and 2.

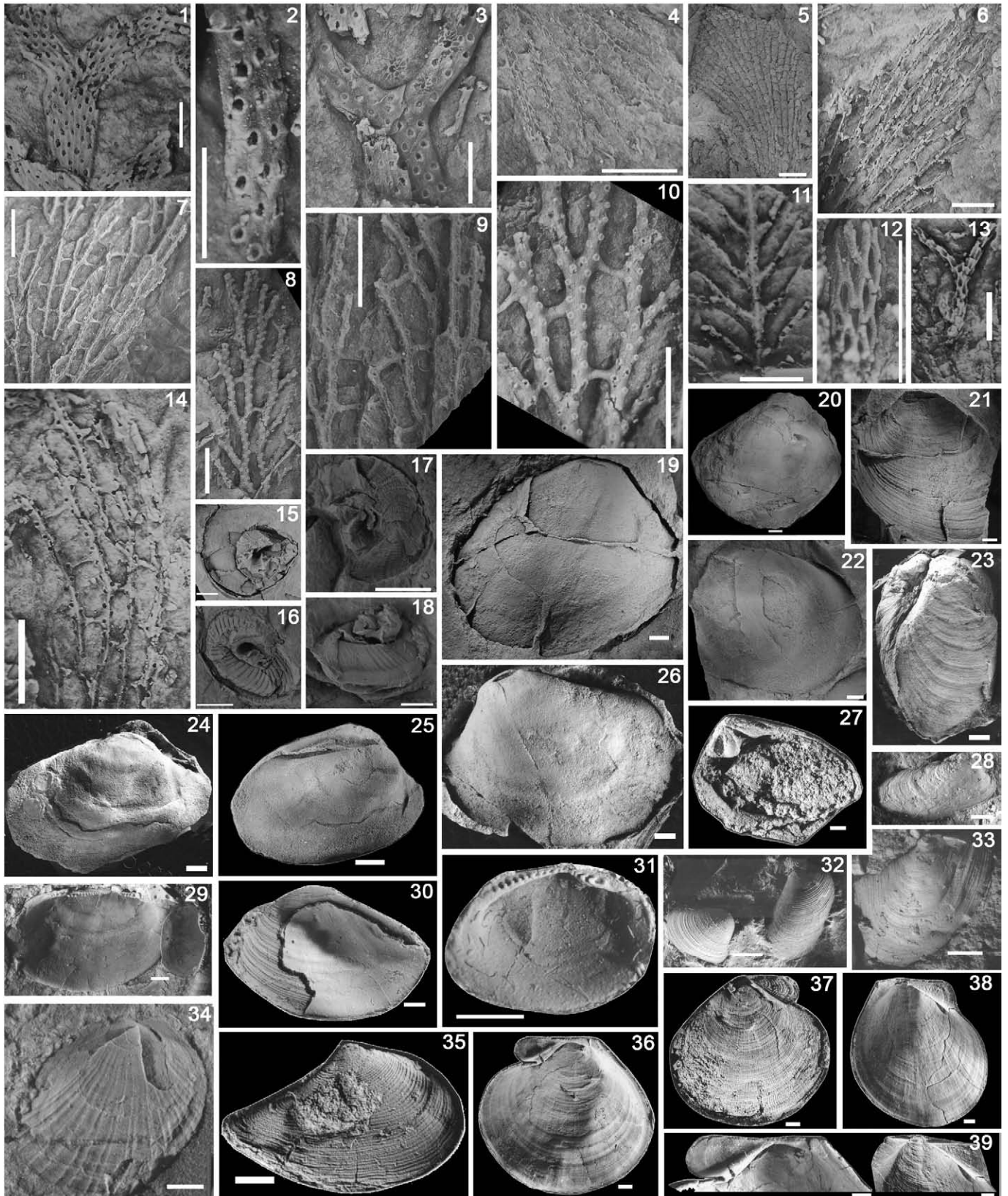
The second bed at 850 m above the base of the Pampa de Tepuel Formation was recognized in the type locality of Tepuel Hill. Probably, this bed corresponds with Complex B, bed 9 described by Suero (1948) as “quartzites with bivalves.” Strata of fine sandstones with calcareous lenses bearing only bivalves of *Pyramus primigenius* González (1972b) and *Pyramus tehuelchis* González (1972b) (see Pagani, 2006b) were recognized (Fig. 9.19 to 26). New material was collected by us in 2009 that could be assigned to the genus *Pyramus*. But, a careful revision of this material is necessary because the species of *Pyramus* Dana so far are known only from the earliest Permian faunas around the world. The *Pyramus* fauna in Tepuel Hill corresponds to the brachiopod *Lanipustula* fauna; in this sense the Patagonian fauna of *Pyramus* could be another example of Late Palaeozoic bipolar genera. (See Appendix A for the species described of Suero's collection, locality 3).

The next bed in the Pampa de Tepuel Formation is approximately 1100 m above the base; it was first recognized by Freytes in 1971 (FT1–13 Bed). This is the best known and most fossiliferous bed in the formation. Numerous species have been described from this bed by

**Fig. 8.** Fossils from Pampa de Tepuel Formation, at 770 m. from the base (specimens collected by the authors, under revision). 1–12, Rhynchonellata brachiopods. 1–3, *Spiriferellina?* sp. 1, MPEF-PI 2074a. 2, MPEF-PI 2074b. 3, MPEF-PI 2017. 4, *Alispirifer?* sp., MPEF-PI 2000. 5–8, Spiriferidae indet. spp. 5, MPEF-PI 2038 specimen 1. 6, MPEF-PI 2038 specimen 2. 7, MPEF-PI 2585. 8, MPEF-PI 2039. 9–12, *Kitakamithyris* cf. *K. immensa*. 9, MPEF-PI 2584a. 10, MPEF-PI 2584b. 11, MPEF-PI 2707a. 12, MPEF-PI 2707b. 13–31, Bivalves. 13–19, 21, *Palaeolima* spp. 13, MPEF-PI 1926. 14, MPEF-PI 3640. 15, MPEF-PI 3639. 16, MPEF-PI 3643. 17, MPEF-PI 2450. 18, MPEF-PI 2444. 19, MPEF-PI 3650. 21, MPEF-PI 2447. 20, 22, 25, 29, Euchondriidae indet. 20, MPEF-PI 2613. 22, MPEF-PI 2723. 25, MPEF-PI 2582a. 29, MPEF-PI 3225. 23–26, *Streblochondria?* sp. 23, MPEF-PI 1900. 26, MPEF-PI 1923. 24, 27–28, 30–31, *Limipecten* spp. 24, MPEF-PI 2587. 27, MPEF-PI 3398. 28, MPEF-PI 3464. 30, MPEF-PI 1925. 31, MPEF-PI 3405. 32–34, Bryozoa. 32–33, MPEF-PI 1972, general view of typical bryozoan associations. 34, *Fistulamina bifurcata* Sabattini, MPEF-PI 1977. Scale bar 2 mm.

several researchers over the past 35 years (González 1977, 1978; Simanauskas, 1996a; Díaz Saravia and Jones, 1999; Sabattini, 2002; Pagani, 2004a,b, 2005, 2006a,b; Pagani et al., 2002) (see some new selected material recently collected, here illustrated in Fig. 9.27 to 39).

The bed is characterized by a very abundant, diverse, well-preserved fauna. Additional materials recovered in 2008–2009 include brachiopods, bivalves, gastropods and ostracods. In contrast with the lower bryozoan bed, bryozoans are absent in this bed. The fauna from



this bed as a whole is currently being studied by the authors. Strophomenata brachiopods include *Janipustula patagoniensis* Simanaukas (1996b) (Fig. 10.14 to 20). Rhynchonellata brachiopods are diverse and represented by *Spiriferellina octoplicata?* (Sowerby), *Costuloplica* sp., *Spiriferiidae* spp., *Beecheria?* sp. (Fig. 10.1 to 13). The bivalves in the fauna are more diverse than that in the lower bed, and are characterized by *Nuculopsis* (*Nuculopsis*) *patagoniensis* González (1969), *Phestia tepuelensis* González (1969), *Orbiculopecten parma* González (1983), *Streblochondria sueroi* González (1969) and *Euchondria* sp., among others (Fig. 10.21 to 32). Many ostracods and a few gastropods were also recovered (Fig. 10.33 to 41). A full list of species from this bed is provided in Appendix A (Locality 4).

The uppermost beds of the Pampa de Tepuel Formation are located near the Puesto Tres Lagunas locality (bed 2 of Taboada, 2001). From these beds Taboada (2008) described *Verchojanina archboldi*, *Tuberculatella?* *laevicaudata* (Amos, 1960) and *Amosia sueroi* Simanaukas (1996c), and assigned the fauna to Asselian in age. In 2008/2009 new specimens of productid brachiopods and bivalves were collected but they have not yet been taxonomically examined.

A fauna was also listed by Suero from a locality west of Puesto Tres Lagunas, belonging to the upper beds of the Pampa de Tepuel Formation. However, it is not sure that the Suero's stratigraphic level is the same level recently sampled by the authors. The gastropods fauna in the original collection (Suero, 1948) were described by Sabattini (1995a) and Sabattini and Noirat (1969); cephalopods by Riccardi and Sabattini (1975), Sabattini and Riccardi (1984) and Sabattini et al. (2006); and bivalves by González (1969, 1972b) and Pagani (2004a, 2006a,b). For a full list of species described see Appendix A, Suero's locality 5.

**5.1.1.3. Mojón de Hierro Formation.** The first bed within the Mojón de Hierro Formation in this area is a concretionary bed that contains remains of bivalves, brachiopods (Productida, Chonetida, and Spiriferida), gastropods, cephalopods and pelmatozoans. Some material collected by Suero was mentioned as from north of the Puesto Tres Lagunas locality and corresponds to the lower beds of this formation. It is not possible to confirm that this fauna came from the same beds sampled by us. The gastropods from Suero's collection were described by Sabattini (1978, 1997), brachiopods by Simanaukas (1991), cephalopods by Riccardi and Sabattini (1975), Sabattini and Riccardi (1984) and Sabattini et al. (2006), hyolithids by Pagani and Sabattini (1999) and bivalves by Pagani (2006a) (Appendix A, locality 6).

The upper part of this formation corresponds to the classical bed described by Suero (1948), 4 km east of the Puesto Tres Lagunas locality (bed 6 in Taboada, 2001). Suero's collections were later described by Sabattini and Noirat (1969), Sabattini (1978) and Ferrari and Sabattini (2008) for the gastropods, Simanaukas (1991) and Taboada (1998, 2001) for the brachiopods, Pagani (2004a,b, 2005, 2006a,b) and González (2006) for the bivalves fauna, and Pagani et al. (2002) for the hyolithids. This bed is characterized by an important and diverse fauna and was resampled in the last few years by the authors. As a result, we are sure that the fauna recovered by us and the Suero's fauna came from the same bed. The new collection allowed us to describe a new species *Cimmeriella willi* Taboada and Pagani (2010) (formerly *Globiella*

by Taboada, 2001) from this outcrop. The occurrence of *Cimmeriella* Archbold and Hogeboom points to an important regional and global stratigraphic correlation (Fig. 11.1 to 7) with faunas in Australia. During the 2008–2009 field seasons we collected new specimens of *Cimmeriella* and its associated fauna. These samples are currently in revision and correspond to the brachiopoda *Costatumulus* sp. (Amos, 1960), *Spirelytha* sp. Taboada and Cisterna (1996), *Quinquenella* sp. (Amos, 1960; Taboada and Shi 2009), and several brachiopods still undescribed, possibly *Brachythyridina* cf. *B. occidentalis* Thomas, *Arctitreata* sp. and *Neochonetes* sp. Bivalvia, gastropoda and pelmatozoans are also present and await detailed taxonomic study. These recent findings have been added to the list of known species from this locality (Appendix A, locality 7).

#### 5.1.2. Puesto Palenque Region (Fig. 2)

In this area, the contact between the Pampa de Tepuel and the Mojón de Hierro formations is exposed. Approximately 100 m above this contact, a few specimens of bivalves were collected in 2009 (Taboada, 2001; González, 2006). The next bed consists of silicified sandstones that contain an exceptionally well-preserved pelmatozoan fauna. This fauna was studied by Helbszevitsch (2004a, 2005). Finally, a bed located above the pelmatozoan bed occurs, containing brachiopods (Orthotocida) and bivalves. All of the beds mentioned above are placed below the level of the *Cimmeriella* Fauna that was described by Taboada and Pagani (2010). This suggests a pre-Late Sakmarian age, although this suggestion cannot be confirmed until the faunal revision is completed. Recently, González (2006) described a bivalve fauna from three different beds, all of which came from the lower part of the Mojón de Hierro Formation (see Appendix A, locality 8 for species list).

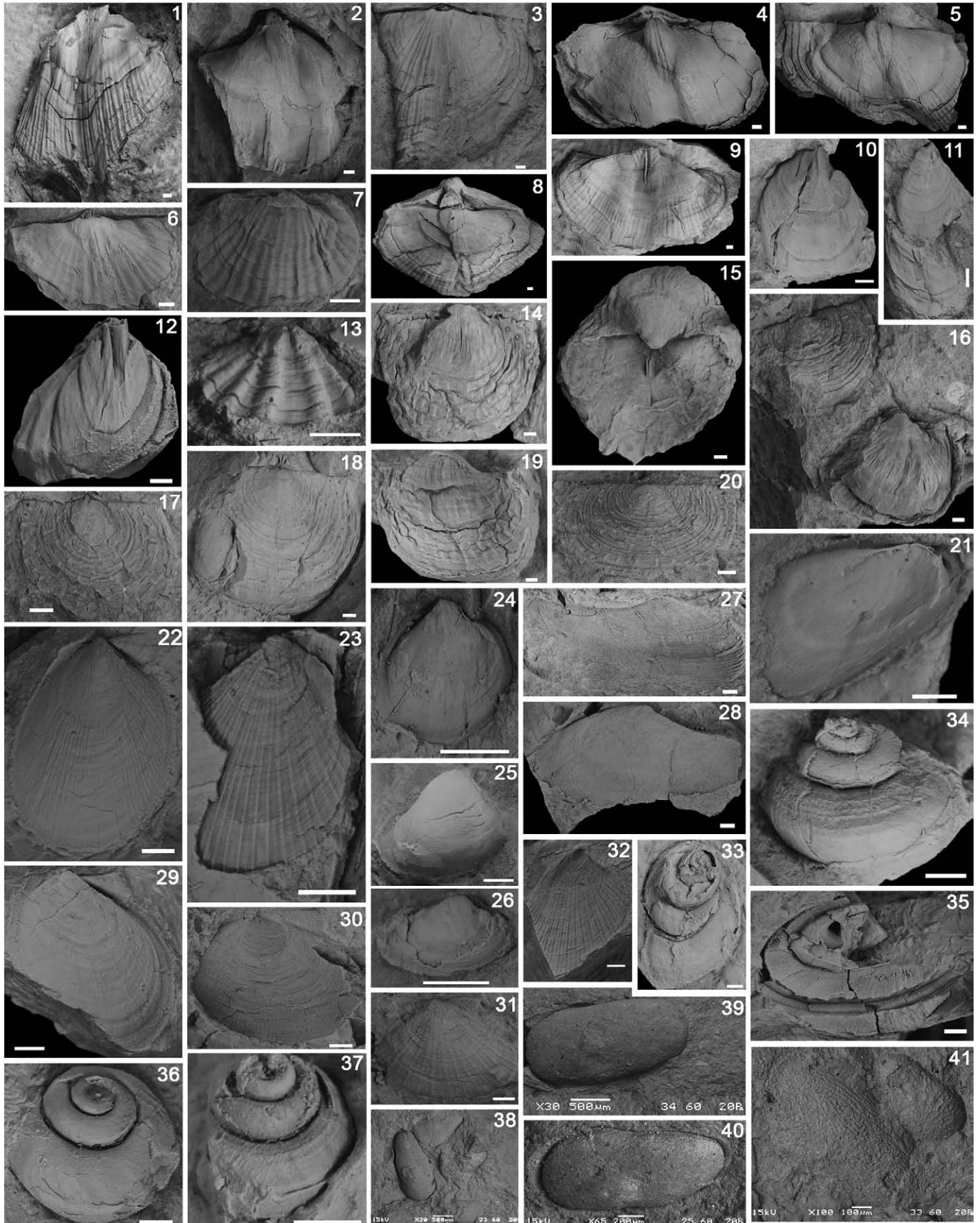
#### 5.1.3. At Puesto La Carlota Region (Fig. 2)

In this area, the upper part of the Pampa de Tepuel Formation crops out, and many reports have been published describing the fauna. Suero (1948) was the first to report on this locality. He described four beds, three of which contained fossils. The fossils have been described by numerous authors over the last 40 years. In this area the Pampa de Tepuel Formation and the upper beds in the Mojón de Hierro Formation are recognized. The fauna contained in the middle beds of the Pampa de Tepuel Formation has been described by numerous authors: Sabattini and Noirat (1969), Sabattini (1978, 1995a,b, 1997) and Ferrari and Sabattini (2008) who described the gastropods; González (1969, 1972b) and Pagani (2004a,b, 2005, 2006b) on bivalves; Riccardi and Sabattini (1975), Sabattini and Riccardi (1984) and Sabattini et al. (2006) the cephalopods; de Mariñelarena (1970) and Sabattini (1986) the conularids; Simanaukas (1996c) the brachiopods; Sabattini (1972) the bryozoans, and recently Helbszevitsch (2004a, 2005) the pelmatozoan fauna. Several different taxonomic interpretations on the brachiopods from this section led to a controversy over the stratigraphic position and the age of these faunas. Recently, Taboada (2008) described a new brachiopod species, *Verchojanina inacayali*. In 2009, a new collection was made from this key section (Fig. 11.8 to 24) which, once fully documented, will potentially provide additional constraints on the age of the brachiopod fauna. The fauna from the Mojón de Hierro Formation comprises gastropods (Sabattini, 1978,

**Fig. 9.** 1–18, Fossils from Pampa de Tepuel Formation, at 770 m. from the base (specimens collected by the authors, undescribed). 1–14, Bryozoa. 1, *Fistulammina bifurcata* Sabattini, MPEF-PI 1919. 2–3, *Fistulammina amosi* Sabattini. 2, MPEF-PI 1982. 3, MPEF-PI 1973. 4–6, *Fenestella* spp. 4, MPEF-PI 1974. 5, MPEF-PI 3486. 6, MPEF-PI 1979. 7–10, *Septatopora freytesi?* Sabattini, MPEF-PI 1972. 11, *Penniretepora?* sp. MPEF-PI 2015. 12–13, *Rhombopora?* sp. 12, MPEF-PI 1972. 13, MPEF-PI 2015. 14, *Australofenestella* sp., MPEF-PI 1987. 15–18, Gastropoda, Archaeogastropoda indet. 15, MPEF-PI 2971. 16, MPEF-PI 3466. 17, MPEF-PI 3612. 18, 3666. Scale bar 2 mm. 19–26, Bivalvia from Pampa de Tepuel Formation, at 850 m. from the base. 19–22, *Pyramus* sp. (specimens collected by the authors, under revision). 19, MPEF-PI 2077a. 20, MPEF-PI 2608. 21, MPEF-PI 2077b. 22, MPEF-PI 2606. 23–26, specimens described by González (1972b) and Pagani (2006b). 23, *Pyramus primigenius* González, MLP 29849. 24–26, *Pyramus tehuelchis* González. 24, MLP 11025. 25, MLP 11022. 26, MLP 29837. Scale bar 5 mm. 27–39, Bivalvia association from Pampa de Tepuel Formation, at 1100 m. from the base (FT1-13 Bed, Freytes, 1971) described previously. 27, *Schizodus paucus* González, PIL 11539. 28, *Sanguinolites freytesi* González, MLP 26199. 29–30, *Palaeoneilo amosi* González. 29, PIL 11432a. 30, PIL 11432b. 31, *Quadratonucula parva* González, PIL 11436. 32, *Nuculopsis* (*Nuculanella*) *camacho* González, MLP 29711. 33, *Leptodesma* (*Leiopteria*) *variabilis* González, MLP 26199. 34, *Palaeolima antinaensis* González, MLP 29768. 35, *Phestia tepuelensis* González, MLP 29729. 36–39, *Orbiculopecten parma* González. 36, PIL 11507b. 37, 39 PIL 11507a. 38–39, PIL 11510. Scale bar 2 mm.

1992; Hlebszevitch and Sabattini, 2005); brachiopods (Simanauskas, 1991; Taboada and Pagani, 2010); bivalves (González, 1974, 2006; Pagani, 2004a,b, 2005, 2006a,b) and hyolithids (Pagani and Sabattini,

1999). For a list of the species registered in this area see Appendix A, localities 9 and 10; selected specimens also illustrated in Fig. 11.25 to 32).



## 5.2. Languiño Hill (Fig. 2)

The Languiño Hill is located in the northern part of the Tepuel–Genoa Basin. Suero (1948, 1953) first described the outcrops in the Colán–Conhue and Languiño Hill areas and collected several specimens from a few localities. However, during our recent field works, some of the localities sampled by Suero could not be located. Consequently, it is impossible to use Suero's fossils to constrain the age of these beds. Therefore, it will be necessary to conduct more fieldwork, especially near the south part of Languiño Hill. Nevertheless, much has been published in the last 40 years describing the fauna collected by Suero near Colán–Conhué. Sabattini and Noirat (1969) and Sabattini (1978, 1997) described the gastropods; González (1969, 1972b) and Pagani (2004a,b, 2005, 2006a,b) described the bivalves; the cephalopods were described by Riccardi and Sabattini (1975), Sabattini and Riccardi (1984) and Sabattini et al. (2006); hyolithids and scaphopods by González and Sabattini (1972), Pagani and Sabattini (1999), Pagani et al. (2002) and Sabattini (1979); Simanaukas (1996b,c) adjusted the taxonomy of brachiopods; in 1972, 1983 and 2002 Sabattini described the bryozoans fauna, and the cnidarian fauna was described by de Mariñelarena (1970), Sabattini (1986) and Sabattini and Noirat (1967). A detailed list of fossil species from different localities is given Appendix A, localities 12 to 24.

A detailed study of the northern part of Languiño Hill was done by González (1972a), who included the outcrops in the Las Salinas Formation, and described nine members within the formation. Several important fossiliferous beds were discovered by González, who first described the bivalve fauna (González, 1969, 1972b, 1975b, 1977, 1983). Later González and Waterhouse (2004) and Pagani (2004a, b, 2005, 2006a, b) revised the fauna; Sabattini (1978, 1995) and Pinilla et al. (2007) described the gastropods. Other mollusks were described by González and Sabattini (1972) and Pagani and Sabattini (1999) described the hyolithids and Sabattini (1979) the scaphopods. The bryozoan fauna was described by Sabattini (1972, 1982, 1983, 2002); and Sabattini and Castillo (1989) described an echinoderm (blastoid). Helbszevitch (2004a,b, 2005) described the pelmatozoans. A detailed list of species in the members of the Las Salinas Formation is given in Appendix A, localities 25 to 29.

In 2007/2008 we made new collections from the key members of the Las Salinas Formation in an attempt to correlate this section with the type section at Tepuel Hill. The members LS-3, LS-5 and LS-9 were sampled during our field work. In the LS-3 Member only bivalves were found, represented by *Pyramus primigenius* González and *Pyramus tehuelchis* González (Figs. 11.33 to 38 and 12.1 to 2). The LS-5 Member is characterized by a bryozoan fauna, especially Fenestrata, along with blastoid. However, the most enigmatic fauna we have collected from this member are large bivalves (approximately 15 cm long) that are currently being studied. The most abundant and diverse fauna at this site comes from the LS-9 Member. This stratigraphic unit was sampled throughout, and a different faunal composition was found. In the upper beds of this member, the specimens are primarily productid brachiopods: *Lanipustula* sp. There are also gastropods: Archaeogastropoda, *Mourlonia* sp.; Bivalvia: *Nuculopsis* sp., *Phestia tepuelensis* González, *Phestia regularis* Pagani, *Streblopteria* sp.; and Ostracoda: *Graphiactylloides* sp. (Fig. 12.3 to 11).

## 5.3. Río Genoa Valley (Fig. 2)

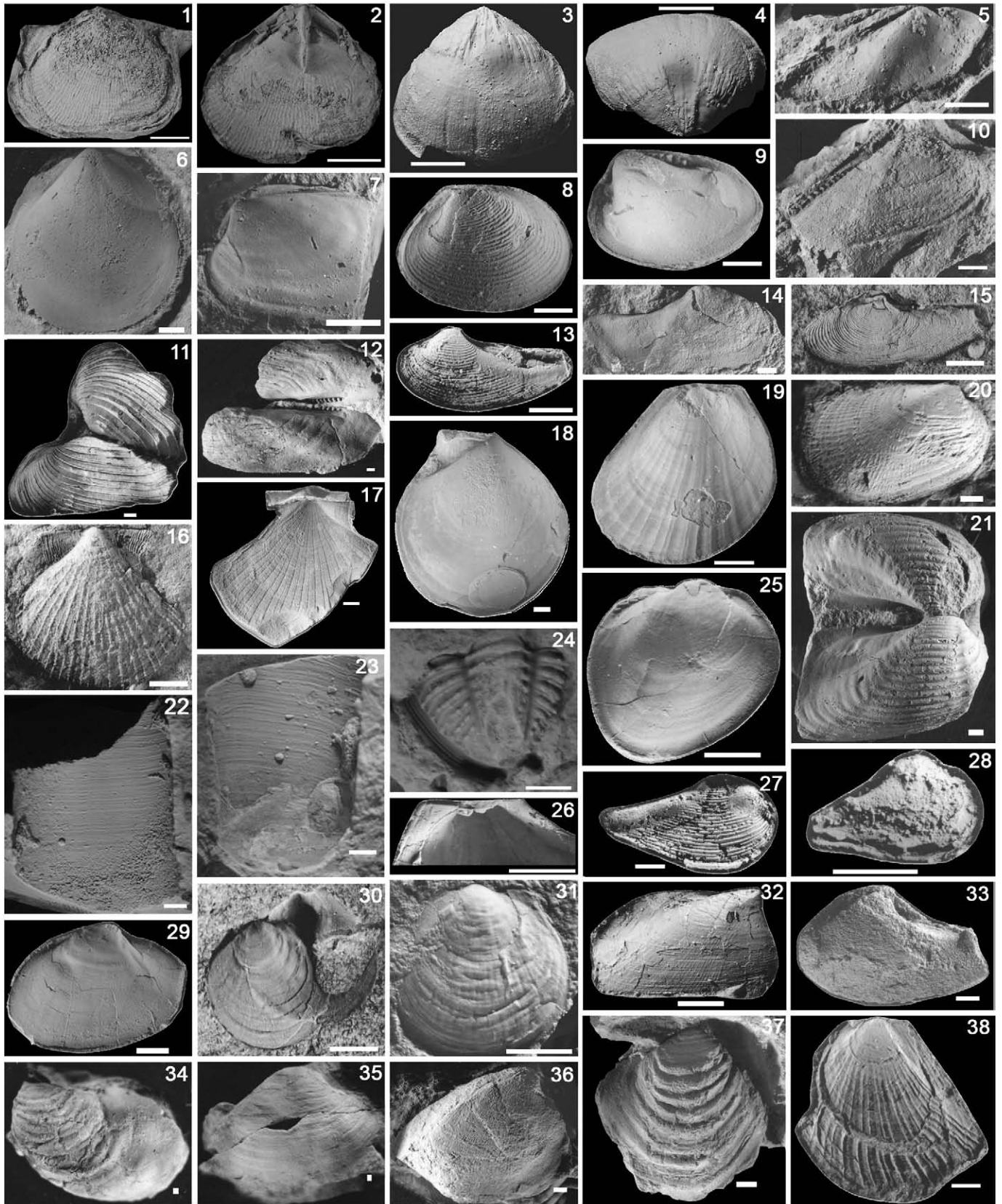
The Río Genoa Valley is in the southern portion of the basin, and corresponds to the upper part of the Tepuel Group. This formation was deposited in both marine and continental environments. The first studies in this area were conducted by Suero (1953), and then Ugarte (1966). Ugarte's work consisted of a detailed description of several partial sequences of the Río Genoa Formation from which he suggested a deltaic palaeoenvironment. Later, Cortiñas and Arbe (1982) described a highly-constructive deltaic complex for this unit. Later, Andreis and Cúneo (1989) modified Cortiñas and Arbe's model by proposing that deposition occurred within a fluvially dominated lobate delta. This area has significant palaeofloras, and traditionally the area was better known by plant fossils. The abundant records of plant fossil remains in this area have allowed important studies on fossil floras for numerous ecological and biostratigraphic interpretations (see Archangelsky and Cúneo, 1984, 1986, 1987; Archangelsky et al., 1982; Cúneo, 1983, 1989). In contrast, the fossil record of marine invertebrates has been limited due to the predominance of continental facies. The fauna described in the past comes from mostly the Ferraroti locality (Fig. 2) (Gastropoda: Sabattini, 1992, 1997, Cúneo and Sabattini, 1987, Hlebszevitch and Sabattini, 2005 and Ferrari and Sabattini, 2008; Bivalvia: Pagani, 2004a, b, 2005, 2006a, b; Cephalopoda: Sabattini and Riccardi, 1984 and Sabattini et al., 2006; Polyplacophora: Hoare and Sabattini, 2000; Brachiopoda: Cúneo and Sabattini, 1987, Simanaukas, 1991, Simanaukas and Archbold, 2002 and Taboada, 1993; Cnidaria: Cúneo and Sabattini, 1987; Crinoidea: Helbszevitch, 2005) (Appendix A, locality 30 for species list, also specimens illustrated in Fig. 12.12 to 29). The fauna from several other localities (localities 31 to 34 in Appendix A) of the Río Genoa Formation was studied by Sabattini (1978, 1992), Sabattini and Noirat (1969) and Hlebszevitch and Sabattini (2005) who described the gastropods; Pagani (2004a, 2005, 2006a,b) and González (2006) described the bivalves fauna; the cephalopods were described by Sabattini and Riccardi (1984) and Sabattini et al. (2006); Simanaukas (1991) and Taboada (1998) described the brachiopods and Sabattini (1972) the bryozoans.

During 2003–2008 new marine beds were found, at the Cerro La Trampa and Piedra Shotel localities (Fig. 2) and a significant invertebrate fauna was recovered. These localities provide an opportunity to correlate fossil floras with faunas and to combine both into an integrated biostratigraphic framework. Although the fauna is still under study, some results have been presented on the gastropods, brachiopods and more recently the bivalves. The gastropods were studied by Ferrari and Sabattini (2008), who described a new species, *Mourlonia cuneoi* Ferrari and Sabattini, and three new records of *Peruvispira sueroi* (Sabattini and Noirat, 1969), *Strobeos* sp. and *Glabrocingulum?* sp. The bivalves were studied by Pagani and Ferrari (in press), who described a new species *Fletcheripecten genoensis* and several new records for the area (Fig. 12.30 to 41) (see Appendix A, localities 35 and 36). Presently, the most important new information from a biostratigraphic and palaeobiogeographic aspect corresponds to a new Levipustulini brachiopod fauna, described by Taboada and Pagani (2010), including a new species, *Jakutoproductus sabattinia* Taboada and Pagani (Fig. 12.42 to 44). Elsewhere, this genus is known only from the Northern Hemisphere where it consists of twenty species. Simanaukas and Archbold

**Fig. 10.** Fossils from Pampa de Tepuel Formation, at 1100 m. from the base (FT1–13 Bed, Freytes, 1971) (specimens collected by the authors, under revision). 1–20, Brachiopoda. 1–9, Spiriferidae indet spp. 1–3, MPEF-PI 2423. 1, specimen 1. 2, specimen 2. 3, specimen 3. 4, MPEF-PI 3301. 5, MPEF-PI 3343. 6, MPEF-PI 3393. 7, MPEF-PI 3212. 8, MPEF-PI 3354 specimen 1. 9, MPEF-PI 3354 specimen 2. 10–12, *Beecheria?* sp. 10, MPEF-PI 2129. 11, MPEF-PI 2086. 12, MPEF-PI 2382. 13, *Spiriferellina?* sp. MPEF-PI 2094. 14–20, *Lanipustula patagonieniensis?* Simanaukas. 14, MPEF-PI 3328. 15, MPEF-PI 2368. 16, MPEF-PI 3342. 17, MPEF-PI 2830. 18, MPEF-PI 3175. 19, MPEF-PI 3216. 20, MPEF-PI 2829. 21–32, Bivalvia. 21, Edmondiidae indet. MPEF-PI 3215. 22, *Streblochondria* sp., MPEF-PI 3334a. 23, *Euchondria* sp., MPEF-PI 3336. 24, *Nuculopsis (Nuculanella)* sp., MPEF-PI 3335. 25, *Nuculopsis* sp., MPEF-PI 3276. 26, *Nuculopsis (Nuculopsis) teckaensis?* Pagani, MPEF-PI 3180. 27–28, *Phestia tepuelensis* González. 27, MPEF-PI 2108b. 28, MPEF-PI 2108a. 29, *Limipecten?* sp., MPEF-PI 2281. 30, *Orbiculopecten* sp., MPEF-PI 2407. 31–32, *Euchondria* sp. 31, MPEF-PI 2406a. 32, MPEF-PI 2441. 33–37, Gastropoda, Archaeogastropoda indet. 33, MPEF-PI 2321. 34, MPEF-PI 2436. 35, MPEF-PI 2109. 36, MPEF-PI 2437. 37, MPEF-PI 3383. Scale bar 2 mm. 38–41, Ostracoda, *Graphiactylloides?* sp., MPEF-PI 2147. 38, specimen 1. 39, specimen 8. 40, specimen 7. 41, specimen 6.

(2002) described another species, *J. australis* Simanaukas and Archbold, from the Río Genoa Formation at the Ferraroti locality. The new discoveries by Taboada and Pagani (2010) have an important

palaeobiogeographic significance and permits identification of Early Permian biotic events in Patagonia, which are valuable for regional and intercontinental correlations. Particularly, this fauna occurs at



presently high latitudes in both hemispheres, and this allowed Taboada and Pagani (2010) to propose a correlation chart between Late Palaeozoic high-latitude areas of both hemispheres.

The *Jakutoproductus* fauna and the *Cimmeriella* fauna described by Taboada and Pagani (2010) from the Río Genoa and Mojón de Hierro formations respectively, have allowed us to reconsider the stratigraphy of the Tepuel–Genoa Basin. Taboada and Pagani (2010) rejected the total equivalency between the Río Genoa and Mojón de Hierro formations as was previously reported. Instead, considering no boundary between the two formations has been located precisely, we propose a lateral interfingering relationship between the uppermost part of the Mojón de Hierro Formation and the lowermost part of the Río Genoa Formation (especially at the key sections of Arroyo Garrido and Lomas Chatas, Fig. 2). At the moment, the fauna at the Lomas Chatas locality is in revision as a new collection was made during the summer of 2008–2009.

Other brachiopods have been collected, but yet to be fully described, from the Cerro La Trampa and Piedra Shotel localities, including: *Crurithyris?* sp., *Atenuatella?* sp., *Leiorhynchus?* sp., among others (Fig. 12.30 to 38). It is important to note that the most significant fossil plant remains came from the Río Genoa Valley. Archangelsky and Cúneo (1986), Andreis et al. (1996), Escapa and Cúneo (2005, 2006), Cúneo and Escapa (2006), Gutiérrez et al. (2005) and Vergel and Cúneo (2006) provided a detailed study of this flora and its biostratigraphic and palaeobiogeographic significance.

#### 5.4. El Molle region (Fig. 2)

This area was described for the first time by Perrot (1960). Page et al. (1984) later revised the stratigraphy for the area and recognized that the Pampa de Tepuel and Mojón de Hierro formations occurred in the area, but with important facies changes with respect to the type section. According to Page et al. (1984), the Pampa de Tepuel Formation is composed of polymict conglomerates and diamictites, grading to massive sandstones and siltstones. This formation appears to have been deposited in submarine fans with some glacial influence. However, others suggest a more direct glacial influence (González Bonorino, 1992). This conclusion was later supported by the discovery of glacial pavement within the sequence (González et al., 2003; Taboada and Pagani, 2010). On the other hand, the Mojón de Hierro Formation is composed of massive sandstones with some conglomerate lenses, and greenish gray limestone with fossiliferous concretions.

Within this succession, a number of different fossiliferous beds have been recorded in a number of papers. Recently, we conducted field works in the Pampa de Tepuel Formation and numerous specimens were collected from laminated shales. In this unit, Taboada (2008) described *Verchojanina archboldi*, but other brachiopods collected are not yet described (Fig. 12.45 to 50). The best preserved fossils come from the concretionary bed of the Mojón de Hierro Formation. The fauna described from this bed, from collections of Perrot and Hlebszevitch, consist of gastropods (Sabattini, 1978, 1992; Hlebszevitch and Sabattini, 2005; Pinilla et al., 2007); bivalves (González, 1975a); cephalopods (Riccardi and Sabattini, 1975; Sabattini and Riccardi, 1984; Sabattini et al.,

2006); cnidarians (Hlebszevitch and Sabattini, 2005); and pelmatozoans (Hlebszevitch, 2005) (Appendix A, locality 37).

#### 5.5. Quebrada Honda (=Cañadón Hondo) region (Fig. 2)

The Quebrada Honda (“Deep Creek”) locality has a marginal position within the basin and is located 20 km from El Molle (Fig. 2). These Late Palaeozoic outcrops in this area were discovered by Nullo (1983), who argued that they belonged to the Tepuel Group, but he did not distinguish the various stratigraphic units at this site. Recently, the outcrops at this locality were revised by Hlebszevitch and Sabattini (2005) and Pinilla et al. (2007). These authors subdivided the strata at Quebrada Honda into the Pampa de Tepuel, Mojón de Hierro and Río Genoa formations. A composite column was made by Hlebszevitch and Sabattini (2005), who assigned the lower beds (silicified black shales) to the Pampa de Tepuel Formation. Overlying conglomerate and sandstones were described and assigned to the Mojón de Hierro Formation. Finally, an important interval of black shales at the top of the succession was assigned to the Río Genoa Formation. The Quebrada Honda succession contains an interesting, well-preserved invertebrate marine fauna. The fossils mainly come from two beds, one being a concretionary bed in the Mojón de Hierro Formation and the other occurring in the upper black shales in the Río Genoa Formation. Hlebszevitch and Sabattini (2005) correlated the concretionary bed with those found in the El Molle and Lomas Chatas localities (Fig. 2) belonging to the Mojón de Hierro Formation, and the black shales bed with a similar bed described at the Ferraroti locality (Fig. 2), belonging to the Río Genoa Formation (Cúneo and Sabattini, 1987). The Quebrada Honda faunal association was described, in part, by Hlebszevitch (2005), Hlebszevitch and Sabattini (2005), Pinilla et al. (2007) and Pagani and Hlebszevitch (2008). The fauna consists of gastropods, bivalves, brachiopods, hyolithids, cephalopods, bryozoans and pelmatozoans (see Appendix A, locality 38).

Recently, we have collected more samples, and found an interesting faunal assemblage from the concretionary bed. This fauna includes bivalvia: *Phestia tepuelensis* González, *Phestia regularis* Pagani, *Euchondria sabattinii* González, *Streblopteria lagunensis* Pagani, *Nuculopsis* sp., *Streblopteria* sp., *Cosmomya* (*Palaeocosmomya*) sp., *Pleurophorella* sp., Malletidae indet., *Heteroconchia* indet.; Brachiopoda: *Costatumulus amosi*? Taboada, *Neochonetes?* sp., *Tivertonia* sp., *Discinoidea* indet.; Cephalopoda: *Amosiceras?* sp., *Glaphyrites?* sp., *Orthocerida* indet., *Nautilida* indet., *Goniatitida* indet.; gastropods, cnidarians and ostracods were recorded too (Figs. 12.51 to 58 and 13.1 to 13). At the moment, the brachiopods, bivalves and cephalopods are under revision.

#### 5.6. Other regions

It is important to briefly comment on other areas where faunal associations have been identified in the past. These include: the Cerro Excursion, Arroyo Pescado, Pampa de Agnia and Alto Río Senguer regions.

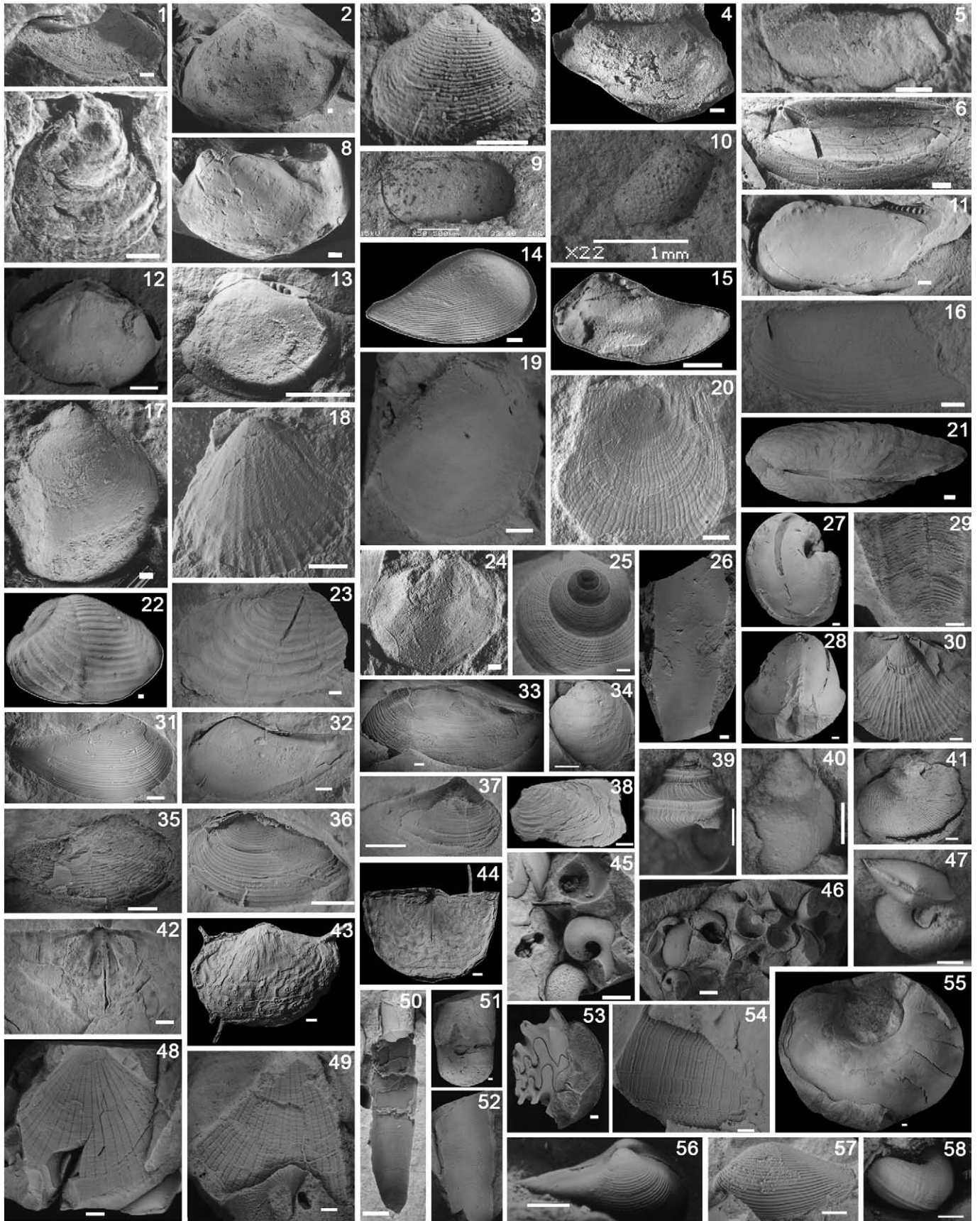
The Cerro Excursión locality near the city of Esquel and the Arroyo Pescado area crops out in the northwestern portion of the Tepuel–Genoa Basin. These outcrops were first described by Suero (1948). Later Roller (1970), Spikermann (1978), Cucchi (1980a,b), López

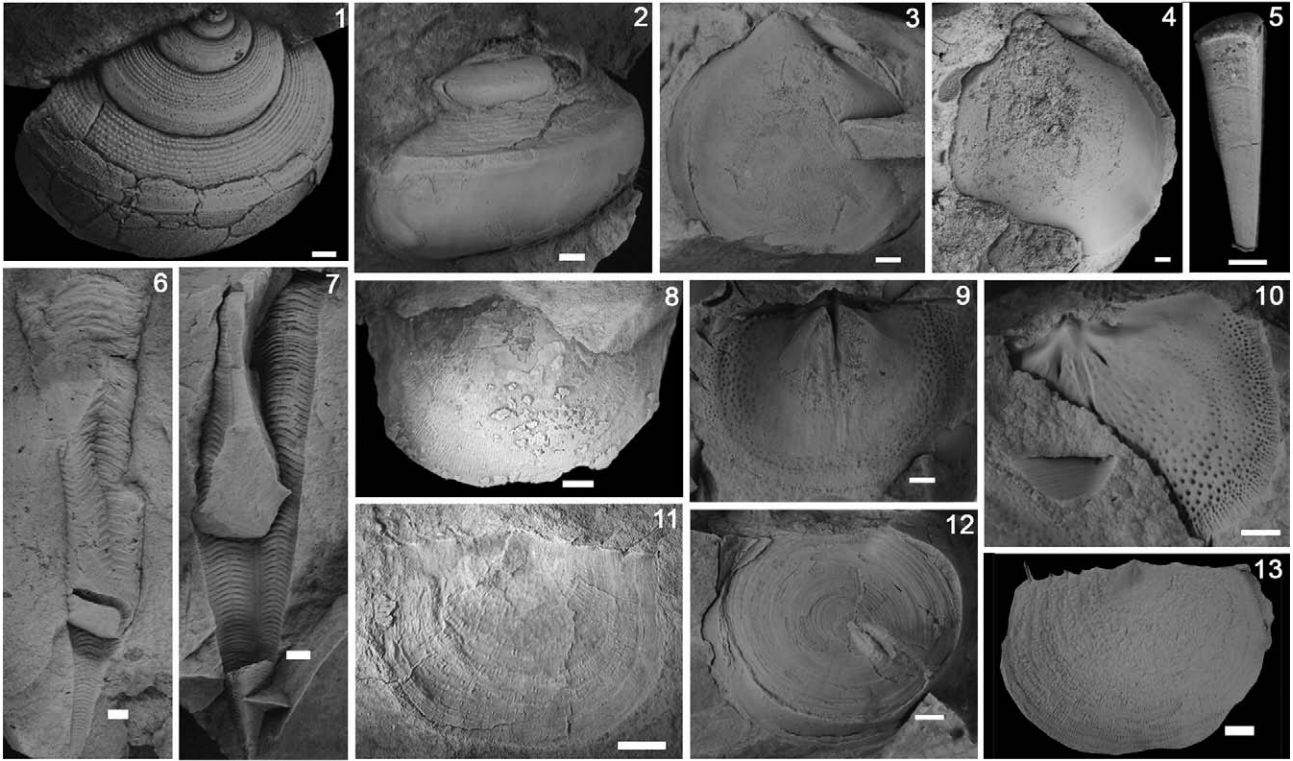
**Fig. 11.** 1–7, Brachiopoda and Bivalvia from Upper part of Mojón de Hierro Formation at 4 km. to the east of Puesto Tres Lagunas locality (specimens described by Pagani, 2004b, 2006a–b, and Pagani and Taboada, 2009). 1–4, *Cimmeriella willi* Taboada and Pagani. 1, FML-PI 2564. 2–4, LIEB-PI 209. 5, *Palaeoneilo amosi* González, MLP 29757. 6, *Streblopteria lagunensis* Pagani, MLP 29783a. 7, *Cypricardinia? elegantula* Dickinson, MLP 29783b. Scale bar 5 mm. 8–24, Fossils from middle part of Pampa de Tepuel Formation at Puesto La Carlota locality (the specimens 22–24 were recovered by the authors, under revision; others described by Pagani 2004a–b, 2005, 2006a–b). 8–21, Bivalvia. 8, *Nuculopsis* (*Nuculopsis*) *patagoniensis* González, MLP 29364. 9, *Nuculopsis* (*Nuculanella*) *camacho* González, MLP 11431. 10, *Palaeoneilo* sp., MLP 29759. 11–12, *Palaeoneilo gonzalezi* Pagani. 11, MLP 11032. 12, MLP 11030. 13, *Phestia regularis* Pagani, MLP 29744. 14–15, *Phestia tepuelensis* González. 14, MLP 29736. 15, MLP 29735. 16–17, *Euchondria sabattinii* González. 16, MLP 20107. 17, MLP 11167. 18, *Streblochondria sueroi* González, MLP 11083. 19, *Palaeolima antinaoensis* González, MLP 11173. 20, *Cypricardinia? elegantula* Dickinson, MLP 11014. 21, *Sueroa andreisi?* González, MLP 29815. 22–23, Cephalopoda, *Pseudorthoceratidae* indet. 22, MPEF-PI 2302. 23, MPEF-PI 2247. 24, Trilobita, *Australosutura?* sp., MPEF-PI 2248. 25–32, Bivalvia from Mojón de Hierro Formation at Puesto La Carlota locality (specimens described by Pagani, 2004a–b, 2005, 2006a–b). 25, *Quadratonucula argentinensis* González, MLP 10942. 26, *Palaeolima antinaoensis* González, PIL 10623. 27–28, *Phestia sabattinii* Pagani. 27, MLP 29697. 28, MLP 29747. 29, *Nuculopsis* (*Nuculopsis*) *teckaensis* Pagani, MLP 29679. 30–31, *Streblopteria minuta* Pagani. 30, MLP 29787. 31, MLP 29785. 32, *Naidites teckaensis* González, MLP 10937. 33–38, Bivalvia from Las Salinas Formation at LS-3 Member (specimens described by Pagani, 2004b, 2005, 2006b). 33, *Phestia* sp. II, MLP 11528. 34, *Exochorhynchus* sp., MLP 29876. 35, *Pyramus primigenius* González, MLP 11504. 36, *Lyrroschizodus?* sp., MLP 29868. 37, *Atomodesma* (*Intomodesma*)? sp., MLP 29763. 38, *Palaeolima antinaoensis* González, MLP 11435. Scale bar 2 mm.



Gamundi (1980a,b) and González Bonorino and González Bonorino (1990) provided more stratigraphic information about this area. More recent studies are by González et al. (1995) and Vizán et al. (1996),

who discussed the stratigraphy. A stratigraphic column was described by González et al. (1995), who mentioned but not described the fossiliferous content of these units.





**Fig. 13.** Brachiopoda, Cnidaria and Mollusca from Quebrada Honda locality (specimens collected by the authors, under revision). 1–2, Archaeogastropoda indet. 1, MPEF-PI 3076. 2, MPEF-PI 1658. 3–4, *Streblopteria* sp., 3, MPEF-PI 3106. 4, MPEF-PI 3107. 5, *Hyolithes* sp., MPEF-PI 1652. 6–7, *Paraconularia* sp., 6, MPEF-PI 3117. 7, MPEF-PI 3119. 8–11, Chonetida indet. 8, MPEF-PI 1639. 9, MPEF-PI 1643a. 10, MPEF-PI 1643b. 11, MPEF-PI 1629. 12, Discinoidea indet., MPEF-PI 1641.13, Chonetida indet. MPEF-PI 1638. Scale bar 2 mm.

The Pampa de Agnia region has the most eastern outcrops of the Tepuel Group. The first mention of neopalaeozoic sediment in this area was by Musacchio (in *Herbst, 1968*). Later, *Robbiano (1971)* mentioned bivalves. *González et al. (1972)* reported a fauna, consisting of brachiopods, bryozoans and bivalves (Appendix A, locality 39). A small flora was reported by *González et al. (1972)* for the Pampa de Agnia region.

The Alto Río Senguer region has the southernmost outcrops in the basin. This area was studied first by *Bergmann (1956)* who described the Mesozoic rocks. Later, *Cortiñas and Arbe (1982)* reported the presence of *Paranoeladus* cf. *P. hallei* with neopalaeozoic age. Finally in *1989, Pujana* described the stratigraphy and fauna collected in this area. More recently, *González and Taboada* described new species of bivalves and cephalopods (*Pagani, 2004a, 2006b*) and cephalopods (*Sabattini et al., 2006*) (Appendix A, locality 40).

## 6. Concluding remarks

Field work has been conducted in the Tepuel–Genoa Basin since 1920, when the first studies of Late Palaeozoic in Patagonia were carried out. In the past 85 years, numerous stratigraphic, palaeogeographic and taxonomic papers have been published, but our knowledge of Carboniferous and Permian fossils from the Tepuel–Genoa Basin is still limited. The studies of the Late Palaeozoic of the Tepuel–Genoa Basin are characterized by four stages. During the first stage, from the 1920s to the early 20th century, outcrops were discovered and described, and numerous fossils were collected with special emphasis on locations but not so on the detailed stratigraphic positions of the various fossil collections. The second stage, from early to the mid-20th century, was marked by numerous studies describing the various groups of the fauna and flora recovered before. The third

**Fig. 12.** 1–2, Bivalvia from Las Salinas Formation at LS-3 Member (specimens described by *Pagani, 2004b, 2005, 2006b*). 1, *Phestia regularis* Pagani, MLP 11503. 2, *Pyramus primigenius* González, MLP 11502. 3–11, Bivalvia and Ostracoda from Las Salinas Formation at LS-9 Member (the specimens 10–11 were recovered by the authors, under revision; others described by *Pagani 2004a, 2005, 2006b*). 3, *Nuculopsis (Nuculanella) camacho* González, MLP 29712. 4, *Merismopteria salinensis* González, PIL 11215. 5, *Palaeoneilo* sp., MLP 29758. 6, *Permophorus* sp., MLP 29873. 7, *Euchondria sabattinii* González, MLP 29758. 8, *Oriocrassatella* sp., MLP 11811. 9–10, Ostracoda indet. 9, MPEF-PI 3058, specimen 1. 10, MPEF-PI 3059. 11, *Palaeoneilo gonzalezi* Pagani. 12–29, Fossils from Ferraroti locality (the specimens 12, 16, 19, 21–23, 25–29 were recovered by the authors, under revision; others described by *Pagani, 2004a, 2005, 2006b*). 12–24, Bivalvia. 12, *Nuculopsis (Nuculanella) teckaensis* Pagani, MPEF-PI 2771. 13, *Nuculopsis (Nuculanella) camacho* González, MLP 29768. 14, *Phestia regularis* Pagani, MLP 29746. 15, *Phestia tepuelensis* González, MLP 29734. 16, *Permophorus* sp., MPEF-PI 1841. 17, *Streblopteria lagunensis* Pagani. 18, *Heteropecten argentinaensis* Pagani, MLP 29864. 19, *Streblopteria lagunensis* Pagani, MPEF-PI 2778. 20, *Leptochondria* sp., MLP 20769. 21, *Sueroa andreisi* González, MPEF-PI 2768a. 22, *Sueroa chubutensis* (González), MLP 20758b. 23, *Sueroa andreisi* González, MLP 1836b. 24, *Schizodus* sp., MLP 29812. 25, 27–28, Gastropoda. 25, *Glabrocingulum?* sp., MPEF-PI 2786a. 27–28, Bellerophontoidea indet., MPEF-PI 3904a–b. 26, Cephalopoda, Pseudorthoceratidae indet., MPEF-PI 1725b. 29, Cnidaria, *Paraconularia* sp., MPEF-PI 1745. 30–44, fossils from Piedra Shotel and Cerro La Trampa localities (the specimens 30–38 were recovered by the authors, under revision; others described by *Ferrari and Sabattini, 2008* and *Taboada and Pagani, 2009*). 30–38, Bivalvia. 30, *Heteropecten argentinaensis* Pagani, MPEF-PI 1814a. 31–32, *Phestia regularis* Pagani. 31, MPEF-PI 1643b. 32, MPEF-PI 1643a. 33, *Phestia tepuelensis* González, MPEF-PI 1806. 34, *Streblopteria lagunensis* Pagani, MPEF-PI 1808. 35–37, *Phestia regularis* Pagani. 35, MPEF-PI 1482. 36, MPEF-PI 1793. 37, MPEF-PI 1828. 38, *Myofossa antiqua* Gozáñez, MPEF-PI 1506. 39–41, Gastropoda. 39, *Peruvispira sueroi* (Sabattini and Noirat), MPEF-PI 1447. 40, *Strobeos* sp. (*Ferrari and Sabattini, 2008*), MPEF-PI 1460. 41, *Mourlonia cuneoi* Ferrari and Sabattini, MPEF-PI 1789a. 42–44, Brachiopoda, *Jakutoproductus sabattinae* Taboada and Pagani. 42, MPEF-PI 1801a. 43, MPEF-PI 1443. 44, MPEF-PI 1829. 45–50, Bivalvia, Gastropoda and Cephalopoda from El Molle locality (specimens under revision). 45–46, Archaeogastropoda indet., MPEF-PI 1654. 47, *Nuculopsis* sp., MPEF-PI 1654. 48–49, *Euchondria sabattinii* González. 48, MPEF-PI 1654. 49, MPEF-PI 1633. 50, *Mooreoceras salazarense* Sabattini and Riccardi, MPEF-PI 1634. 51–58, Brachiopoda, Bivalvia, Gastropoda and Cephalopoda from Quebrada Honda locality (specimens collected by the authors, under revision). 51–52, Pseudorthoceratidae indet. 51, MPEF-PI 1677. 52, MPEF-PI 3093. 53, *Glaphyrites?* sp., MPEF-PI 1645. 54–55, *Amoceras?* sp., MPEF-PI 1681a–b. 56–57, *Phestia regularis* Pagani. 56, MPEF-PI 1650. 57, MPEF-PI 1660. 58, Archaeogastropoda indet., MPEF-PI 1651. Scale bar 2 mm.

period from the mid- to end-20th century, involved new biostratigraphic approaches with revision of the fauna. At the present time, in the early 21st century, the focus of research is placing Patagonia's Late Palaeozoic stratigraphy and biotas into the global context. This new stage of research involves new efforts in field mapping using previous works as a starting point. New collections are being made that are based on much tight stratigraphic control, complemented with detailed and abundant illustrations of the faunas. Finally it is possible to say that with the preliminary results obtained in the last four years this new stage has begun.

The study of the Carboniferous–Permian sequence in Patagonia and their global correlation is an ongoing challenge, because it is difficult to establish the relative ages of widely separated rock units and to be able to correlate their ages using the worldwide scale. The few common elements between the classic northern hemispheric faunas and the Patagonian faunal assemblages are due to high provinciality, and this makes global correlation difficult. Carboniferous and Permian chronologic units defined in Europe, United States and Russia had been and are used in Gondwana. However, these scales have been debated, due to the endemic biotas and scarce common fossil elements shared with the equatorial belt, where the global epochs and stages were proposed and defined, as noted by Archbold (2002, 2005). Now our researches have two goals: one is to focus efforts on obtaining radiometric data, and the other is to define regional stages for local correlation.

The composition of the Late Palaeozoic biota was affected by important tectonic and climatic changes. A global decrease in temperature during the Late Palaeozoic Ice Age caused marked differences between the biotas of palaeopolar regions (Gondwana and northeastern end of the Canadian Angara–Arctic) and those in the palaeoequatorial belt. Compared to other areas of Gondwana, the Tepuel–Genoa Basin of Patagonia contains a diverse record of palaeobiological events, which seems to indicate a very different evolutionary pattern and more palaeoclimatic fluctuations (relative to other adjoining Gondwana areas). This may reflect some unique palaeogeographic features of Patagonia still to be revealed. Therefore, continuing effort in studying the Tepuel–Genoa Basin faunas is essential especially in terms of constraining the various existing palaeogeographic models for Patagonia (allochthony/para-autochthony/autochthony). Ongoing research should be aimed at expanding knowledge of the palaeobiological events in the Late Palaeozoic of Patagonia, with more detailed taxonomic study of the faunas and their recognition as biochronologic, palaeobiogeographic and palaeoclimatic indicators.

In addition, there is a critical need to continue palaeontologic studies in order to define the Carboniferous–Permian boundary in Argentina and, therefore, in Gondwana at large.

Finally, the goal of these studies is to achieve a regional and global correlation of the strata in the Tepuel–Genoa Basin with other sections in Gondwana, northeast Asia and the Arctic, and to establish regional stratotypes in Gondwana which will improve global correlations. In this sense, the Tepuel–Genoa Basin in Patagonia is best positioned to serve as a possible reference area for Late Palaeozoic Gondwana biostratigraphy as it possesses an excellently exposed and continuous succession containing diverse marine faunas and in places floras.

## Acknowledgment

We are deeply indebted to Prof. Guang R. Shi for his editorial assistance and help. We also thank the Guest Editors for their kind invitation to publish in Palaeogeography, Palaeoclimatology, Palaeoecology. All comments by two anonymous reviewers helped to improve the manuscript. We thank Drs. C. González for field discussions, Dr. R. Cúneo for fruitful discussions about different stratigraphic and biostratigraphic aspects. P. Diaz Saravia, I. Escapa, M. Ferrari, P. Puerta, L. Canessa, M. Caffa, J. Gallego and D. Menghini

participated in fieldtrips, and their help is greatly acknowledged. Many thanks are expressed to Mr. E. Ruigomez (MEF Collection Manager) for his help in the laboratory, and to L. Canessa who prepared the specimens and casts. The pictures of ostracods were made using the Scanning Electronic Microscope at ALUAR S.A. with special thanks to Jaime Grozar for his help. Special thanks are also extended to owners of the following farms for allowing access to their properties during field works: La Casilda, Blanche, Los Rosales and Don Guillermo. Financial support and logistics were provided by the MEF (Trelew, Argentina) and through ANPCyT (Argentina) with support from the Projects PICT 33080 “Quantitative paleobiogeographic analysis of bivalve and cephalopod fauna from the Upper Palaeozoic of Tepuel–Genoa Basin (Patagonia, Argentina)”, and PICTR2003-00313 “Biodiversity of the taphofloras and invertebrate faunas in Upper Palaeozoic basins of Argentina and southern South America: Systematic, Biostratigraphic and Correlation”.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at doi:10.1016/j.palaeo.2010.08.017.

## References

- Amos, A.J., 1958. Some lower Carboniferous brachiopods from the Volcan Formation, San Juan Argentina. *Journal of Paleontology* 32, 828–845.
- Amos, A.J., 1960. Algunos Chonetacea y Productacea del Carbonífero inferior y superior del Sistema de Tepuel, Provincia de Chubut. *Revista de la Asociación Geológica Argentina* 15, 81–107.
- Amos, A.J., 1961a. Una nueva especie de *Nudirostra* del Carbonífero de San Juan y Patagonia. *Ameghiniana* 2, 49–52.
- Amos, A.J., 1961b. Algunos Chonetacea y Productacea del Carbonífero inferior y superior del Sistema Tepuel, provincia de Chubut. *Revista de la Asociación Geológica Argentina* 15, 81–107.
- Amos, A.J., 1979. Guía Paleontológica Argentina. Parte I. Paleozoico. Faunas Carbónicas y Pérmicas. Consejo Nacional de Investigaciones Científicas y Técnicas. 154pp.
- Amos, A.J., Rolleri, E.O., 1965. El Carbónico Marino en el Valle Calingasta–Uspallata (San Juan–Mendoza). *Boletín de Informaciones Petroleras* 368, 50–71.
- Amos, A.J., Antelo, B., González, C.R., Mariñelarena, M.P., Sabattini, N., 1973. Síntesis sobre el conocimiento bioestratigráfico del Carbónico y Pérmico de Argentina. *Actas 5° Congreso Geológico Argentino, Carlos Paz*, 3, pp. 3–20.
- Andreis, R.R., Cúneo, R., 1985. Estratigrafía de la Formación Mojón de Hierro en Puesto Garrido, extremo sudoriental de la Sierra de Tepuel, Chubut, Argentina. *Annual Meeting of the Working Group Project No. 211-IGCP*, pp. 22–24.
- Andreis, R.R., Cúneo, R., 1989. Late Paleozoic high-constructive deltaic sequences from northwestern Patagonia, Argentine Republic. *Journal of South American Earth Sciences* 2, 19–34.
- Andreis, R.R., Cúneo, N.R., 1990. Las facies deltaicas de la Formación Río Genoa (Neopaleozoico, Chubut, República Argentina). *Annual Meeting Working Group Project No. 211 IGCP*, pp. 1–3.
- Andreis, R.R., Archangelsky, S., González, C.R., López Gamundi, O., Sabattini, N., 1987. Cuenca Tepuel–Genoa. In: Archangelsky, S. (Ed.), *El Sistema Carbonífero en la República Argentina*. Academia Nacional de Ciencias, Córdoba, pp. 169–196.
- Andreis, R.R., Cúneo, R., López Gamundi, O., Sabattini, N., González, C.R., 1996. Cuenca Tepuel–Genoa. In: Archangelsky, S. (Ed.), *El Sistema Pérmico en la República Argentina y en la República Oriental del Uruguay*. Academia Nacional de Ciencias, Córdoba, pp. 65–92.
- Archangelsky, S., Cúneo, N.R., 1984. Zonación del Pérmico continental de Argentina sobre la base de sus plantas fósiles. *Memorias 3er. Congreso Latinoamericano de Paleontología, México*, p. 193–153.
- Archangelsky, S., Cúneo, R., 1986. *Corynepteris australis* sp. nov. primer registro de una Coenopterid en el Pérmico inferior de Chubut, Argentina. *Actas IV Congreso Argentino de Paleontología y Bioestratigrafía, Mendoza*, 1, pp. 177–185.
- Archangelsky, S., Cúneo, R., 1987. *Ferugliocladaeae*, a new conifer family from the Permian of Gondwana. *Review of Palaeobotany and Palynology* 51, 3–30.
- Archangelsky, S., Marrquez Toigo, M., 1980. La palinología y el límite Carbónico–Pérmico en el Gondwana sudamericano. *Actas 2do. Congreso Argentino de Paleontología y Bioestratigrafía y 1er. Congreso Latinoamericano de Paleontología*, 4, pp. 221–229.
- Archangelsky, S., Archangelsky, A., Cúneo, R., 1982. Algunos elementos paleoflorísticos de las formaciones Piedra Shotel y Nueva Lubecka, Pérmico inferior, Estancia La Casilda, provincia de Chubut. *Ameghiniana* 18, 207–220.
- Archbold, N.W., 2002. Peri-Gondwanan Permian correlations: the Meso-Tethyan Margins. In: Keep, M., Moss, S.J. (Eds.), *The Sedimentary Basins of Western Australia 3: Proceedings of the Petroleum Exploration Society of Australia Symposium, Perth, WA*, pp. 223–240.
- Archbold, N.W., 2005. The Permian Time Scale: correlation of the marine Permian of Greater Gondwana. In: Pankhurst, R.J., Veiga, G.D. (Eds.), *Gondwana 12: Geological and Biological Heritage of Gondwana (Mendoza, 2005)*, Abstracts, Academia Nacional de Ciencias, Córdoba, Argentina, p. 47.

- Bergmann, T.A., 1956. Fáunula neocomiana de Laguna Salada en la zona de Apeleg Senguer del Chubut occidental. *Soc. Arg. Min. y Geol. Rev. Min.* 23, 8–20.
- Carrizo, H., Azcuy, C.L., 2006. *Gilboaphyton argentinum* sp. nov.: a herbaceous lycopod from the Early Carboniferous of Argentina. *Revista Brasileira de Paleontología* 9, 33–40.
- Closs, D., 1967. Orthocone cephalopods from the Upper Carboniferous of Argentine and Uruguay. *Ameghiniana* 5, 123–129.
- Cortiñas, J.S., Arbe, A., 1982. Facies y paleoambientes sedimentarios del Grupo Río Genoa, Pérmico inferior de la región Nueva Lubecka, provincia de Chubut. *Revista de la Asociación Geológica Argentina* 37, 300–312.
- Cucchi, R., 1980a. La Formación Esquel: nueva interpretación estratigráfica. *Revista de la Asociación Geológica Argentina* 35, 167–173.
- Cucchi, R., 1980b. Réplica: La Formación Esquel y la Formación Valle Chico. *Revista de la Asociación Geológica Argentina* 35, 588–590.
- Cúneo, R., 1983. Paleoecología de microsecuencias plantíferas del Grupo Río Genoa, Pérmico de Chubut, Argentina. *Ameghiniana* 20, 111–131.
- Cúneo, R., 1989. Phytogeography and Paleocology of Late Paleozoic floras from southern South America and their relationships with other floral realms. XXVIII International Geological Congress, Washington, 1, p. 351.
- Cúneo, N.R., Escapa, I., 2006. The equisetalean genus *Cruciaethca* nov. from the Lower Permian of Patagonia, Argentina. *International Journal Plant Sciences* 167, 167–177.
- Cúneo, R., Sabattini, N., 1987. Flora y fauna de la base de la Formación Río Genoa en la localidad de Ferraroti, Pérmico inferior de Chubut, Argentina. *Memorias del 4to. Congreso Latinoamericano de Paleontología, Santa Cruz de la Sierra*, 1, pp. 283–298.
- de Mariñelarena, M.P., 1970. Algunas especies de *Paraconularia* Sinclair del "Sistema de Tepuel" (Chubut) y sus relaciones con faunas del hemisferio austral. *Ameghiniana* 7, 139–150.
- Díaz Saravia, P., Jones, P.J., 1999. New Carboniferous (Namurian) glacial marine ostracods from Patagonia, Argentina. *Journal of Micropalaeontology* 18, 97–109.
- Dickins, J.M., 1985. Late Paleozoic glaciation. Bureau of Mineral Resources. *Journal of Australian Geology and Geophysics* 9, 163–169.
- Dickins, J.M., 1996. Problems of a Late Palaeozoic glaciation in Australia and subsequent climate in the Permian. *Palaeogeography, Palaeoclimatology, Palaeoecology* 125, 185–197.
- Escapa, I., Cúneo, N.R., 2005. A new equisetalean plant from the early Permian of Patagonia, Argentina. *Review of Palaeobotany and Palynology* 137, 1–14.
- Escapa, I., Cúneo, N.R., 2006. Primer registro de Neocalamites (Halle) Vladimirovich en el Pérmico de Gondwana. *Ameghiniana* 43, 85–92.
- Ferrari, S.M., Sabattini, N., 2008. Nuevos Gastrópodos (Eotomariidae y Subulitidae) en las localidades de Piedra Shotel y Cerro La Trampa, Formación Río Genoa, Pérmico Inferior del Chubut. *Ameghiniana* 45, 241–246.
- Forsythe, R., 1982. The Late Paleozoic to Early Mesozoic evolution of Southern South America: a plate tectonic interpretation. *Journal Geological Society* 139, 671–682.
- Frakes, L.A., Crowell, J.C., 1969. Late Paleozoic Glaciation, 1. South America. *Bulletin Geological Society of America* 80, 1007–1042.
- Frakes, L.A., Amos, A.J., Crowell, J.C., 1969. Origin and Stratigraphy of Late Paleozoic Diamictites in Argentina and Bolivia. *Gondwana Stratigraphy (IUGS Symposium, 1967)*, Paris, pp. 821–843.
- Franchi, M., Page, R., 1980. Los basaltos Cretácicos y la evolución magmática del Chubut occidental. *Revista de la Asociación Geológica Argentina* 35, 208–229.
- Freytes, E., 1970. Informe parcial sobre los trabajos realizados en la zona Ch.PRG-7 (Sierra de Tepuel, Chubut). Technical report, Informe Yacimientos Petrolíferos Fiscales, Buenos Aires.
- Freytes, E., 1971. Informe geológico preliminar sobre la Sierra de Tepuel (Deptos. Languineo y Tehuelches, prov. de Chubut). Technical report, Informe Y.P.F., Buenos Aires.
- González, C.R., 1969. Nuevas especies de Bivalvia del Paleozoico superior del Sistema Tepuel, provincia de Chubut (Argentina). *Ameghiniana* 6, 236–250.
- González, C.R., 1972a. La Formación Las Salinas del Paleozoico superior de Patagonia (República Argentina). Parte I: Estratigrafía, facies y ambientes de sedimentación. *Revista de la Asociación Geológica Argentina* 27, 95–115.
- González, C.R., 1972b. La Formación Las Salinas del Paleozoico superior de Patagonia (República Argentina). Parte II: Bivalvia: taxonomía y paleoecología. *Revista de la Asociación Geológica Argentina* 27, 188–213.
- González, C.R., 1974. Bivalvos del Pérmico inferior de Chubut, Argentina. *Acta Geológica Lilloana* 12, 231–274.
- González, C.R., 1975a. *Promitilus patagonicus* nov. sp. (Mytilidae, Bivalvia) del Paleozoico superior de El Molle, provincia de Chubut (Argentina). *Actas del 1er. Congreso Argentino de Paleontología y Bioestratigrafía I, Tucumán*, pp. 329–339.
- González, C.R., 1975b. Nuevos Bivalvia de la Formación Las Salinas, Paleozoico superior de Chubut, Argentina. *Actas del 1er. Congreso Argentino de Paleontología y Bioestratigrafía I, Tucumán*, pp. 341–355.
- González, C.R., 1977. Bivalvos del Carbonico superior de Chubut, Argentina. *Acta Geológica Lilloana* 14, 105–147.
- González, C.R., 1978. *Orbiculopecten* gen. nov. (Aviculopectinidae, Bivalvia) from the upper Carboniferous of Patagonia, Argentina. *Journal of Paleontology* 52, 1086–1092.
- González, C.R., 1980. Los Eurydesmidae y Deltopectininae (Bivalvia) de la República Argentina. *Actas 2do. Congreso Argentino de Paleontología y Bioestratigrafía y 1er. Congreso Latinoamericano de Paleontología, Buenos Aires*, 4, pp. 11–21.
- González, C.R., 1981. El Paleozoico superior marino de la República Argentina, bioestratigrafía y paleoclimatología. *Ameghiniana* 18, 51–65.
- González, C.R., 1983. Especies de Atomodesmidae (Bivalvia) del Paleozoico superior de Patagonia. *Ameghiniana* 20, 154–160.
- González, C.R., 1984. Rasgos paleogeográficos del Paleozoico superior de la Patagonia. *Actas 9no. Congreso Geológico Argentino, San Carlos de Bariloche, Argentina*, 1, pp. 181–205.
- González, C.R., 1987. Nuevas faunas de invertebrados del Carbónico Inferior de la República Argentina. Annual Meeting of Working Group, Project 211, IGCP, Santa Cruz, Bolivia, pp. 66–68.
- González, C.R., 2006. Lower Permian bivalves from central Patagonia, Argentina. *Paläontologische Zeitschrift* 80, 130–155.
- González Bonorino, G., 1986. Geología de la Patagonia. Estudio regional de la Cordillera Andina, vertiente atlántica y pacífica, entre los paralelos 40° y 52° de latitud sur. *Capricornio* 1, 1–38.
- González Bonorino, G., 1988. Sedimentología de la glaciación de Gondwana en el Oeste de Argentina. 2da. Reunión Argentina de Sedimentología. *Actas*, pp. 265–268.
- González Bonorino, G., 1992. Carboniferous glaciation in Gondwana. Evidence for grounded marine ice and continental glaciation in southwestern Argentina. *Palaeogeography, Palaeoclimatology, Palaeoecology* 91, 363–375.
- González Bonorino, G., González Bonorino, F., 1988. La base del Grupo Tepuel en las cercanías de Esquel, Chubut. *Revista de la Asociación Geológica Argentina* 43, 518–528.
- González Bonorino, F., González Bonorino, G., 1990. La base del Grupo Tepuel en las cercanías de Esquel, Chubut. *Revista de la Asociación Geológica Argentina* 43, 518–528.
- González Bonorino, G., Rafine, G., Veega, V., Guerin, D., 1988. Ambientes e eplataforma nerítica dominada por tormentas en la sección glaciática del Grupo Tepuel, Chubut. *Revista de la Asociación Geológica Argentina* 43, 239–252.
- González, C.R., Glasser, N.F., 2008. Carboniferous glacial erosional and depositional features in Argentina. *Geologica et Paleontologica* 42, 39–54.
- González, C.R., Sabattini, N., 1972. *Hyolithes amosi* nov. sp. (Calyptoptomatida, Mollusca) del Paleozoico superior del Grupo Tepuel, Provincia de Chubut, Argentina. *Ameghiniana* 9, 183–189.
- González, C.R., Waterhouse, B., 2004. A new Carboniferous bivalve from Gondwana. *Paläontologische Zeitschrift* 78, 355–360.
- González, C.R., Musacchio, E.A., Amos, A.J., 1972. Hallazgo de una fauna y una flora del Paleozoico Superior en la Sierra de Aña, Chubut. *Ameghiniana* 9, 298–304.
- González, C.R., Taboada, A.C., Díaz Saravia, P.G., Aredes, M.A., 1995. El Carbónico del sector noroccidental de la provincia del Chubut. *Revista de la Asociación Geológica Argentina* 50, 40–46.
- González, C.R., Taboada, A.C., Díaz Saravia, P., 2003. El Paleozoico superior de la región de El Molle. 3er Simposio del Paleozoico superior de Argentina y 2ª Reunión del Proyecto IGCP 471, La Plata, Argentina, p. 13.
- Gutiérrez, P.R., Balarino, M.L., Escapa, I., Cúneo, R., 2005. Formación Río Genoa (Pérmico Inferior), nuevos datos sobre su contenido palinológico. *Ameghiniana (Suplemento)* 42, 32R.
- Hahn, G., Hahn, R., 1969. Tilobitae carbonici e permici. I. (Brachymetopidae; Otarionidae; Proetidae; Proetinae; Dechenellinae, Drevermannuunae, Cyrtosymbolinae). *Fossilium Catalogus I. Animalia* 118, 1–160.
- Harrington, H.J., 1955. The Permian *Eurydesma* fauna of Eastern Argentina. *Journal of Paleontology* 24, 112–128.
- Helbszevitch, J.C., 2004a. Análisis fractal de los brazos de crinoideos paleozoicos. Aproximación y análisis matemático de la eficiencia de los distintos tipos de ramificación. *Ameghiniana* 41, 251–254.
- Helbszevitch, J.C., 2004b. La familia Acrocrinidae (Echinodermata, Crinoidea) y el límite Carbonífero–Pérmico en las secuencias neopaleozoicas de la cuenca Tepuel–Genoa (Chubut, Argentina). *Ameghiniana* 41, 381–391.
- Helbszevitch, J.C., 2004c. Columnales asignables a la familia Anthinocrinidae Schewtschenko (Crinoidea, Pentamerata) en el Carbonífero Superior de la Cuenca Tepuel–Genoa, Chubut, Argentina. *Ameghiniana* 41, 501–504.
- Helbszevitch, J.C., 2005. Crinoideos de la subclase Camerata (Camptocrininae, Dichocrininae y Glyptocrinina) de la cuenca Tepuel–Genoa, Paleozoico superior de la Patagonia, Argentina. *Ameghiniana* 42, 597–610.
- Herbst, R., 1968. Las floras liásicas argentinas con consideraciones estratigráficas. *Actas 3ras. Jornadas Geológicas Argentinas, Comodoro Rivadavia, Argentina*.
- Hervé, F., Fanning, C.M., Yaxley, G.M., Pankhurst, R.J., 2006. U–Pb and Lu–Hf isotopic constraints on the provenance of Permian detritus in metasedimentary rocks of Southern Chile and Livingston Island, Antarctica. *Actas 11 Congreso Geológico Chileno, Antofagasta, Chile*, 1, pp. 259–260.
- Hlebszevitch, J.C., Sabattini, N., 2005. Aportes al conocimiento de las faunas pérmicas en la cuenca Tepuel–Genoa. Localidad de quebrada Honda. 16º Congreso Geológico Argentino, La Plata, Argentina, 3, pp. 423–430.
- Hoare, R., Sabattini, N., 2000. Lower Permian Polyplacophora (Mollusca) from Argentina. *Journal of Paleontology* 74, 189–191.
- Keidel, J., 1922. Sobre la distribución de los depósitos glaciares del Pérmico conocidos en la Argentina y su significación para la estratigrafía de la Serie de Gondwana y la paleogeografía del hemisferio austral. *Boletín de la Academia Nacional de Ciencias* 25, 239–368.
- Lesta, P.J., Ferello, R., 1972. Región extrandina de Chubut y Norte de Santa Cruz. In: Leanza, A.F. (Ed.), *Geología Regional Argentina, Academia Nacional de Ciencias de Córdoba*, pp. 601–654.
- Limarino, C.O., Spalletti, L.A., 2006. Paleogeography of the upper Paleozoic basins of southern South America: an overview. *Journal of South American Earth Sciences* 22, 134–155.
- López Gamundi, O.R., 1980a. La Formación Esquel, litología y estructura. *Prov. de Chubut. Revista de la Asociación Geológica Argentina* 35, 187–194.
- López Gamundi, O.R., 1980b. La interpretación estratigráfica de la Formación Esquel. *Revista de la Asociación Geológica Argentina* 35, 586–587.
- López Gamundi, O., 1989. Postglacial transgressions in Late Palaeozoic basins of Western Argentina: a record of glaciostatic sea level rise. *Palaeogeography, Palaeoclimatology, Palaeoecology* 71, 257–270.
- López Gamundi, O.R., 1990. Mecanismos de formación, registro sedimentario y jerarquía estratigráfica de las transgresiones post-glaciales en secuencias

- neopaleozoicas de Argentina. *Anales de la Academia Nacional de Ciencias Exactas, Físicas y Naturales* 42, 165–182.
- Miller, A.K., Garner, M.F., 1953. Upper Carboniferous Goniatites from Argentina. *Journal of Paleontology* 27, 821–823.
- Nullo, F., 1983. Descripción geológica de la Hoja 45c, Pampa de Agnia, Provincia del Chubut. *Boletín del Servicio Geológico y Minero Argentino* 199, 1–94.
- Pagani, M.A., 1998. Braquiópodos y gastrópodos Pérmicos de las Formaciones Piedra Azul y Bonete (provincia de Buenos Aires). *Ameghiniana* 35, 265–270.
- Pagani, M.A., 2000. Bivalvos del Pérmico Inferior de la Formación Bonete, Sierras Australes (provincia de Buenos Aires, Argentina). *Ameghiniana* 37, 301–320.
- Pagani, M.A., 2004a. Los bivalvos carboníferos y pérmicos de Patagonia (Chubut, Argentina). Parte I: Familias Introducción, familias Nuculidae y Malletidae. *Ameghiniana* 41, 225–244.
- Pagani, M.A., 2004b. Los bivalvos carboníferos y pérmicos de Patagonia (Chubut, Argentina). Parte II: Familias Malletidae, Polidevciidae, Myalinidae e Inoceramidae. *Ameghiniana* 41, 271–288.
- Pagani, M.A., 2005. Los bivalvos carboníferos y pérmicos de Patagonia (Chubut, Argentina). Parte III: Familias Mytilidae, Pterineidae, Limidae, Leptoconchidae, Etheropectinidae, Euchondriidae y Streblochondriidae. *Ameghiniana* 42, 579–596.
- Pagani, M.A., 2006a. Los bivalvos carboníferos y pérmicos de Patagonia (Chubut, Argentina). Parte IV: Familias Aviculopectinidae, Deltopectinidae y Schizodidae. *Ameghiniana* 43, 461–476.
- Pagani, M.A., 2006b. Los bivalvos carboníferos y pérmicos de Patagonia (Chubut, Argentina). Parte V: Familias Trigonidae, Permophoridae, Cardiniidae, Crassatellidae, Pholadomyidae, Sanguinolitidae y Megadesmidae. *Conclusiones. Ameghiniana* 43, 539–556.
- Pagani, M.A., Ferrari, S.M., in press. New Early Permian Bivalvia fauna from the Río Genoa Formation (Patagonia, Chubut Province, Argentina). *Alcheringa* 35.
- Pagani, M.A., Hlebszevitch, J.C., 2008. Los crinoideos del Paleozoico Superior de Patagonia y su fauna asociada: una síntesis. *Ameghiniana* 45, 30R (suplemento).
- Pagani, M.A., Sabbatini, N., 1999. Los Hyolitha (Mollusca?) del Paleozoico superior de la Cuenca Tepuel–Genoa, Provincia del Chubut, Argentina. *Ameghiniana* 36, 275–280.
- Pagani, M.A., Sabbatini, N., 2002. Biozonas de moluscos del Paleozoico superior de la Cuenca Tepuel–Genoa (Chubut, Argentina). *Ameghiniana* 39, 351–366.
- Pagani, M.A., Sabbatini, N., Taboada, A.C., 2002. Nuevos registros de Hyolitha (Mollusca?) del Paleozoico superior en las sierras de Tepuel y Languiño, Chubut, Argentina. *Ameghiniana* 39, 111–116.
- Page, R., Limarino, C.O., López Gamundi, O.R., Page, S., 1984. Estratigrafía del Grupo Tepuel en su perfil tipo y en la región de El Molle, provincia de Chubut. *Actas del 9º Congreso Geológico Argentino, Bariloche, Argentina*, 1, pp. 619–632.
- Pankhurst, R.J., Rapela, C.W., Tassone, A., 2006. Gondwanide continental the origin of Patagonia. *Earth-Science Reviews* 76, 235–257.
- Perrot, C.J., 1960. Estudio geológico de las inmediaciones del paraje El Molle Departamento Tehuelches, Provincia de Chubut). *Revista de la Asociación Geológica Argentina* 15, 53–79.
- Petriella, B.T., Arrondo, O.G., 1978. Presencia de *Archaeosigillaria conferta* (Frenguelli) Menéndez en el Carbónico inferior de Argentina. *Ameghiniana* 15, 406–408.
- Piatnitzky, A., 1933. Rético y Liásico de los valles de los ríos Genoa y Tecka y sedimentos continentales de la sierra de San Bernardo. *Boletín de Informaciones Petroleras* 10, 151–182.
- Piatnitzky, A., 1936. Estudio geológico de la región del Río Chubut y del Río Genoa. *Boletín de Informaciones Petroleras* 13, 83–118.
- Pinilla, K., Sabbatini, N., Hlebszevitch, J.C., 2007. Nuevos gastrópodos del Pérmico Inferior de la Formación Mojón de Hierro, provincia del Chubut, Argentina. *Ameghiniana* 44, 399–406.
- Pinto, I.D., 1972. A new insecta, *Archangelskyblatta vishniakovae* Pinto, gen. nov., sp. nov., a Permian blattoid from Patagonia, Argentina. *Ameghiniana* 9, 79–89.
- Pujana, I., 1989. Hallazgo de invertebrados marinos neopaleozoicos en Tres Lagunas (Departamento Río Senguer, provincia del Chubut) y sus implicancias paleogeográficas. *Actas del 4to. Congreso Argentino de Paleontología y Bioestratigrafía, Mendoza, Argentina*, 4, pp. 11–28.
- Ramos, V.A., 1983. Evolución tectónica y metalogénesis de la Cordillera Patagónica. *Actas 2do. Congreso Nacional Geología Económica, San Juan, Argentina*, 1, pp. 108–124.
- Ramos, V.A., 1984. Patagonia: Un continente paleozoico a la deriva? *Actas 9no. Congreso Geológico Argentino, Bariloche, Argentina*, 2, pp. 311–325.
- Ramos, V.A., 1986. Tectonostratigraphy, as applied to analysis of South African Phanerozoic Basins by H. de la R. Winter, discussion. *Transactions Geological Society South Africa* 87, 169–179.
- Ramos, V.A., 1988. Tectonics of the Late Proterozoic–Early Paleozoic: a collisional history of Southern South America. *Episodes* 11, 168–174.
- Ramos, V.A., 1996. Evolución tectónica de la Plataforma Continental. In: Ramos, V.A., Turic, M.A. (Eds.), *Geología y Recursos Naturales de la Plataforma Continental Argentina: Asociación Geológica Argentina e Instituto Argentino del Petróleo, Buenos Aires*, pp. 359–368.
- Ramos, V.A., 1999. Las provincias geológicas del territorio argentino. I. In: Caminos, R. (Ed.), *Geología Argentina, Anales del Instituto de Geología y Recursos Minerales*, 29, pp. 41–96.
- Ramos, V.A., 2004a. Tectonics of the southernmost Andes: a comparison between the Patagonian and the Fuegian Cordilleras. *Bollettino di Geofisica Teorica ed Applicata* 45, 1–10 (2, supplement, Trieste).
- Ramos, V.A., 2004b. La Plataforma Patagónica y sus relaciones con la Plataforma Brasileña. In: Mantesso-Neto, V., Bartorelli, A., Ré Carneiro, C.D., Brito Neves, B.B. (Eds.), *Geologia do Continente Sul-Americano, Sao Paulo*, vol. 22, pp. 371–381.
- Ramos, V.A., 2008. Patagonia: a paleozoic continent adrift? *Journal of South American Earth Sciences* 26, 235–251.
- Ramos, V.A., Palma, M.A., 1996. Tectónica del Pérmico de Argentina. In: Archangelsky, S. (Ed.), *El sistema Pérmico en la República Argentina y en la República Oriental del Uruguay. Academia Nacional de Ciencias, Córdoba*, pp. 239–254.
- Ramos, V.A., Riccardi, A.C., Rölleri, E.O., 2004. Límites Naturales de la Patagonia. *Revista de la Asociación Geológica Argentina* 59, 785–786.
- Rapalini, A.E., 2005. The accretionary history of southern South America from the latest Proterozoic to the Late Paleozoic: some paleomagnetic constraints. *Terrane Processes at the Margins of Gondwana: In: Vaughan, A.P.M., Leat, P.T., Pankhurst, R.J. (Eds.), Geological Society, London, Special Publications*, vol. 246, pp. 305–328.
- Riccardi, A.C., Sabbatini, N., 1975. Cephalopods from the Carboniferous of Argentina. *Palaeontology* 18, 117–136.
- Robbiano, J.A., 1971. Contribución al conocimiento estratigráfico de la sierra del Cerro Negro, Pampa de Agnia, provincia de Chubut, Argentina. *Revista de la Asociación Geológica Argentina* 26, 41–52.
- Rölleri, E.O., 1970. Discordancia en la base del Neopaleozoico al este de Esquel. *Actas 4 Jornadas Geológicas Argentinas, Mendoza, Argentina*, 2, pp. 273–319.
- Rossi de García, E., 1972. Ostrácodos del Carbonífero del Sistema de Tepuel. *Revista Española de Micropaleontología* 4, 27–29.
- Sabbatini, N., 1972. Los Fenestellidae, Acanthocladiidae y Rhabdomesidae (Bryozoa, Cryptostomata) del paleozoico superior de San Juan y Chubut, Argentina. *Revista del Museo de La Plata (n.s.) 6. Paleontología* 42, 255–377.
- Sabbatini, N., 1975. *Austroneilsonia* gen. nov. (Gastropoda) del Paleozoico superior de Argentina. *Ameghiniana* 12, 337–342.
- Sabbatini, N., 1978. Gastrópodos Carboníferos y Pérmicos del grupo Tepuel (Provincia de Chubut, Argentina). *Obra Centenario del Museo de La Plata* 5, 39–62.
- Sabbatini, N., 1979. Presencia de Scaphopoda (Mollusca) en el Paleozoico superior de Argentina. *Ameghiniana* 16, 109–119.
- Sabbatini, N., 1982. *Eliasporella* Blasser (Bryozoa, Ctenostomida) en el Carbónico del Grupo Tepuel, provincia de Chubut, Argentina. *Ameghiniana* 19, 259–262.
- Sabbatini, N., 1983. Especies de *Septatopora* Engel (Bryozoa?) del Carbónico de la provincia de Chubut, Argentina. *Ameghiniana* 20, 61–71.
- Sabbatini, N., 1984. Distribución geográfica de los Gastropoda, Scaphopoda y Calyptostomatida del Carbonífero y Pérmico de la Argentina. *Revista del Museo de La Plata (n.s.) 8, paleontología* 49, 33–46.
- Sabbatini, N., 1986. Distribución geográfica y estratigráfica de los Cnidaria y Bryozoa del Carbonífero y Pérmico de la Argentina. *Revista del Museo de La Plata (n.s.) 8, Paleontología*, 33–46.
- Sabbatini, N., 1990. Nueva especie de *Pennireteropora* D’Orbigny (Fenestrata, Bryozoa) del Carbonífero de la Cuenca Tepuel–Genoa (Chubut, Argentina). *Ameghiniana* 27, 185–187.
- Sabbatini, N., 1992. Bellerophonacea (Gastropoda) del Pérmico inferior de la Cuenca Tepuel–Genoa, Provincia de Chubut, Argentina. *Notas del Museo de La Plata 21 (Paleontología 108)*, pp. 209–215.
- Sabbatini, N., 1995a. *Straparollus (Straparollus) perminutus* (Gastropoda, Euomphalacea) de las Sierras de Tepuel y Languiño, provincia de Chubut, República Argentina. *Notas del Museo de La Plata (n.s.) 21, paleontología* 110, 225–233.
- Sabbatini, N., 1995b. Una nueva especie de *Nordospira* Yochelson (Gastropoda) del Pérmico de la Cuenca Tepuel–Genoa (Chubut, Argentina). *Ameghiniana* 32, 365–367.
- Sabbatini, N., 1997. Gastrópodos pérmicos (Pleurotomarioidea, Trochoidea, Platyceratoidea y Subulitoidea) de la Cuenca Tepuel–Genoa, Provincia del Chubut, Argentina. *Revista de la Asociación Geológica Argentina* 52, 17–23.
- Sabbatini, N., 2002. Cystoporata (Bryozoa) del Carbonífero de la cuenca Tepuel–Genoa, Provincia de Chubut, Argentina. *Ameghiniana* 39, 201–211.
- Sabbatini, N., Aguirre, M., 1985. Contribución al conocimiento de los braquiópodos inarticulados del Paleozoico superior de Argentina. *Annual Meeting of the Working Group Project No. 211-IGCP*, pp. 23–24.
- Sabbatini, N., Castillo, E., 1989. Equinodermo blastoideo en el Carbonífero de las Sierras de Tepuel y Languiño, provincia de Chubut, Argentina. *Ameghiniana* 26, 219–224.
- Sabbatini, N., Hlebszevitch, J.C., 2004. Agrupamientos radiales de conúlidos del Pérmico inferior de la Provincia de Chubut, Argentina. *Ameghiniana* 41, 399–404.
- Sabbatini, N., Hlebszevitch, J.C., 2005. Nueva evidencia sobre el modo de vida de los Conulariida. *Ameghiniana* 42, 627–632.
- Sabbatini, N., Noirat, S., 1967. Hallazgo de *Cladochonus* en el Carbonífero de Tepuel, provincia de Chubut. *Ameghiniana* 5, 174–178.
- Sabbatini, N., Noirat, S., 1969. Algunos Gastropoda de las Superfamilias Euomphalacea, Pleurotomarioidea y Platyceratoidea del Paleozoico superior de Argentina. *Ameghiniana* 6, 348–361.
- Sabbatini, N., Riccardi, A.C., 1984. Los cefalópodos del Carbonífero y Pérmico de la Argentina. *Actas del 9º Congreso Geológico Argentino, Bariloche, Argentina*, 4, pp. 348–361.
- Sabbatini, N., Riccardi, A.C., Pagani, M.A., 2006. Cusuralian cephalopods from Patagonia, Argentina. *Journal of Paleontology* 80, 1142–1151.
- Shi, G.R., Taboada, A.C., Klets, A.G., 2008. Gondwana–Eurasian Permian biogeographic links: implications for Permian global marine biogeography, inter-continental correlations and climate change. *Gondwana 13: Programs and Abstracts*, pp. 186–187. Xiao, W.J., Zhai, M.G., Li, X.H., Liu, F. (Eds.), 2008. *Institute of Geology and Geophysics, Chinese Academy of Sciences, Dali, Yunnan Province, China (September 15–17, 2008)*.
- Simanaukas, T., 1991. *Lissochonetes jachalensis* Amos, 1961. (Brachiopoda, Chonetacea). *Redescripción Morfológica y Ontogenia. Ameghiniana* 28, 135–143.
- Simanaukas, T., 1993. Las Superfamilias Chonetacea y Productacea (Brachiopoda) del Paleozoico superior de la Cuenca Tepuel–Genoa, Provincia de Chubut. Tesis de la Facultad de Ciencias Naturales de la UNLP.
- Simanaukas, T., 1996a. Acerca de *Levipustula levis* y otros braquiópodos del Paleozoico superior de la Cuenca Tepuel–Genoa (Chubut). *Reunión anual del Grupo Argentino de Trabajo del Paleozoico superior, Buenos Aires, Argentina*, pp. 1–2.

- Simanaukas, T., 1996b. Una nueva especie de *Lanipustula* (Productoidea, Brachiopoda) del Paleozoico superior de Patagonia, Argentina. *Ameghiniana* 33, 301–305.
- Simanaukas, T., 1996c. Un supuesto Chonetioidea del Pérmico de Patagonia reasignado a un género de Productoidea (Brachiopoda). *Ameghiniana* 33, 349–351.
- Simanaukas, T., Archbold, N.W., 2002. Early Permian *Jakutoproductus* (Productida: Brachiopoda) from Patagonia, Argentina. *Alcheringa* 26, 465–474.
- Simanaukas, T., Sabbatini, N., 1997. Bioestratigrafía del Paleozoico superior marino de la Cuenca Tepuel–Genoa, provincia de Chubut, Argentina. *Ameghiniana* 34, 49–60.
- Spikermann, J.P., 1978. Geología de los alrededores de la estancia Arroyo Pescado, Chubut. *Revista de la Asociación Geológica Argentina* 32, 265–276.
- Suero, T., 1947. Reconocimiento geológico de la zona comprendida entre Cordón Cherque–Cordón Putrachoique–Río Tecka y Sierra de Languiño (Departamentos Tehuelches y Languiño). Y.P.F., informe inédito.
- Suero, T., 1948. Descubrimiento de Paleozoico superior en la zona extraandina de Chubut. *Boletín de Informaciones Petroleras* 287, 31–48.
- Suero, T., 1953. Las sucesiones sedimentarias suprapaleozoicas de la zona extraandina de Chubut. *Revista de la Asociación Geológica Argentina* 8, 37–53.
- Suero, T., 1958. Datos Geológicos sobre el Paleozoico superior en la zona de Nueva Lubecka y alrededores (Chubut Extra–andino, Provincia de Chubut). *Revista del Museo de la Plata* 5 (Geología 30), pp. 1–28.
- Taboada, A.C., 1993. Un nuevo Linoproductidae (Brachiopoda) del Pérmico temprano de Patagonia. *Compte Rendus XII Congrès International de Stratigraphie et de Geologie du Carbonifère et Permien*, Buenos Aires, Argentina, 1, pp. 589–598.
- Taboada, A.C., 1998. Dos nuevas especies de Linoproductidae (Brachiopoda) y algunas consideraciones sobre el Neopaleozoico sedimentario de las cercanías de Uspallata. *Acta Geológica Lilloana* 18, 69–80.
- Taboada, A.C., 2001. Bioestratigrafía del Neopaleozoico del Valle de Tres Lagunas, sierra de Tepuel, Provincia de Chubut. *Acta Geológica Lilloana* 18, 291–304.
- Taboada, A.C., 2008. First record of the Late Paleozoic brachiopod *Verchojanina* in Patagonia, Argentina. *Proceedings of the Royal Society of Victoria* 120, 305–319.
- Taboada, A.C., 2010. Mississippian–Early Permian brachiopods from western Argentina: Tools for middle to high-latitude correlation, paleobiogeographic and paleoclimatic reconstruction. *Palaeogeography, Palaeoclimatology, Palaeoecology* 298, 152–175 (this issue).
- Taboada, A.C., Cisterna, G., 1996. Elythinae (Brachiopoda) del Paleozoico superior de Argentina. *Ameghiniana* 33, 111–118.
- Taboada, A.C., Pagani, M.A., 2010. The coupled occurrence of *Cimmeriella-Jakutoproductus* (Brachiopoda: Productidina) in Patagonia: implications for Early Permian high to middle paleolatitudinal correlations and paleoclimatic reconstruction. *Geologica Acta* 8.
- Taboada, A.C., Shi, G.R., 2009. *Yagonia* Roberts (Brachiopoda: Chonetidina) from the Malimán Formation, Lower Carboniferous of western Argentina: paleobiogeographical implications. *Alcheringa* 33, 223–235.
- Taboada, A.C., Shi, G.R., 2010. Taxonomic review and evolutionary trends of Levipustulini and Absenticostini (Brachiopoda) from Argentina: paleobiogeographic and paleoclimatic implications. Program & Abstracts, 6th International Brachiopod Congress, 1–5 February 2010, Melbourne, Australia: Geological Society of Australia Abstracts, 95, p. 115.
- Taboada, A.C., Archbold, N.W., González, C.R., Sabbatini, N., 2005. The Late Carboniferous–Early Permian Tepuel fauna of Patagonia: updated brachiopods records. In: Pankhurst, R.J., Veiga, G.D. (Eds.), *Gondwana 12: Geological and Biological Heritage of Gondwana*, Mendoza, Argentina. Academia Nacional de Ciencias, Córdoba, Argentina, p. 349.
- Ugarte, F., 1965. El suprapaleozoico del Río Genoa (Chubut) e inmediaciones. *Acta Geológica Lilloana* 7, 379–406.
- Ugarte, F., 1966. La cuenca compuesta Carbonífero–Jurásica de la Patagonia Meridional. *Anales de la Universidad de la Patagonia "San Juan Bosco"*. Ciencias Geológicas 1, 37–68.
- Vergel, M.M., Cúneo, N.R., 2006. Microflora pérmica temprana en la Formación Río Genoa, Ferraroti, Chubut, Argentina. 13º Simposio Argentino de Paleobotánica y Palinología, Bahía Blanca, Argentina, p. 9.
- Vizán, H., Alberti, R., Revol, P., Conti, E., Spikermann, J.P., 1996. Geología del extremo septentrional de la sierra de Tecka (Chubut). Nueva interpretación para la estratigrafía del área de Ap Iwan. *Revista de la Asociación Geológica Argentina* 51, 365–377.