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Dating late Miocene marine incursions across Argentina and Uruguay with Sr-isotope stratigraphy

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ABSTRACT

A Sr-isotope chronostratigraphy is presented for Miocene sediments deposited by the "Paranense" Sea along 1200 km of the southwestern Atlantic coast of Argentina and Uruguay. Numerical ages were obtained for shells of *Aequipecten paranensis* from the Argentinean Puerto Madryn Formation, Facies Balneario La Lobería, "Entrerriense Beds" of the Salado Basin, and Paraná Formation, and from the Camacho Formation (Uruguay). The $^{87}Sr/^{86}Sr$ ages fall into five age-groups that encompass the "Paranense" flooding in the latest Serravalian-Messinian interval. For the Puerto Madryn Formation, the ages span the latest Serravalian to the Tortonian and are stratigraphically coherent with the transgressive phase (11.9–10.4 Ma) and the regressive phase (10.2–9.82 Ma and 9.40–9.05 Ma) of that unit. Ages of 8.85–7.95 Ma for the "Entrerriense Beds" show them to be Tortonian while the Facies Balneario La Lobería, and the Paraná and Camacho formations span the age-range 7.50–6.00 Ma, comprising the Tortonian-Messinian interval. The regressive phase of the Puerto Madryn Formation, and the Facies Balneario La Lobería are respectively correlated with the basal and middle beds of the cliffs at Barranca Final, where the uppermost horizons of the Barranca Final Formation are exposed. The "Entrerriense Beds" are correlated with the "Cape Fairwheater Beds". Dating the "Paranense" marine incursion permits a reappraisal of its paleogeography and differentiation of its deposits from those of the "Patagoniense" Sea. The flooding area was smaller than previously thought, with its northwestern-most boundary in the surroundings of the Santa Fe Province and its southernmost boundary in southern Santa Cruz Province. Moreover, the Paranaian Molluscan Bioprovince was coeval with the Valdesian Molluscan Bioprovince for 2.35 Ma and species included in the *Aequipecten paranensis* Zone lived for at least 5.90 Ma.

1. Introduction

Neogene marine rocks are exposed along the southwestern Atlantic coast, where they are recorded in narrow areas along the coast stretching from southern Argentina to southeastern Brazil. In Argentina, at least two major transgressions have been recognized (Fig. 1A–B). The oldest, known as the "Patagoniense" Sea, occurred from the late Oligocene to the earliest middle Miocene and deposited - in eastern Patagonia - the sediments included today in the Monte León, Carmen Silva, Chenque and Gaiman formations (Bertels, 1970, 1977; 1980; Bellosi, 1990; Codignotto and Malumián, 1981; Parras et al., 2012; Cuitiño et al., 2017). A later transgression, known as the "Paranense" or "Entrerriense" Sea, mostly developed in the late Miocene, and its deposits are identified, from north to south, as Camacho Formation (Department of Colonia, Uruguay), and in Argentina as Paraná Formation (Entre Ríos Province), "Entrerriense Beds" (Salado Basin, subsurface of the Buenos Aires Province), Facies Balneario La Lobería of the Río Negro Formation (Río Negro Province) and Puerto Madryn Formation (Chubut, Province) (Wahnish, 1939; Serra, 1943; Goso and Bossi, 1966; Aceñolaza, 1976, 2000; Haller, 1978; Angulo and Casamiquela, 1982; Scasso and del Río, 1987; Marengo, 2015). The deposits of this transgression also include the "Cape Fairweather Beds" (Hatcher, 1897) (Santa Cruz Province), recently dated as late Miocene (del Río et al., 2013) (Fig. 2). Each of these "Paranense" units contains a well-documented molluscan assemblage (del Río, 1992, 1994; del Río and Martínez, 1998) that, since the middle of the 19th century, has been diagnostic of the "Paranense" rocks and assigned to the *Aequipecten paranensis* Zone by del Río (1988).

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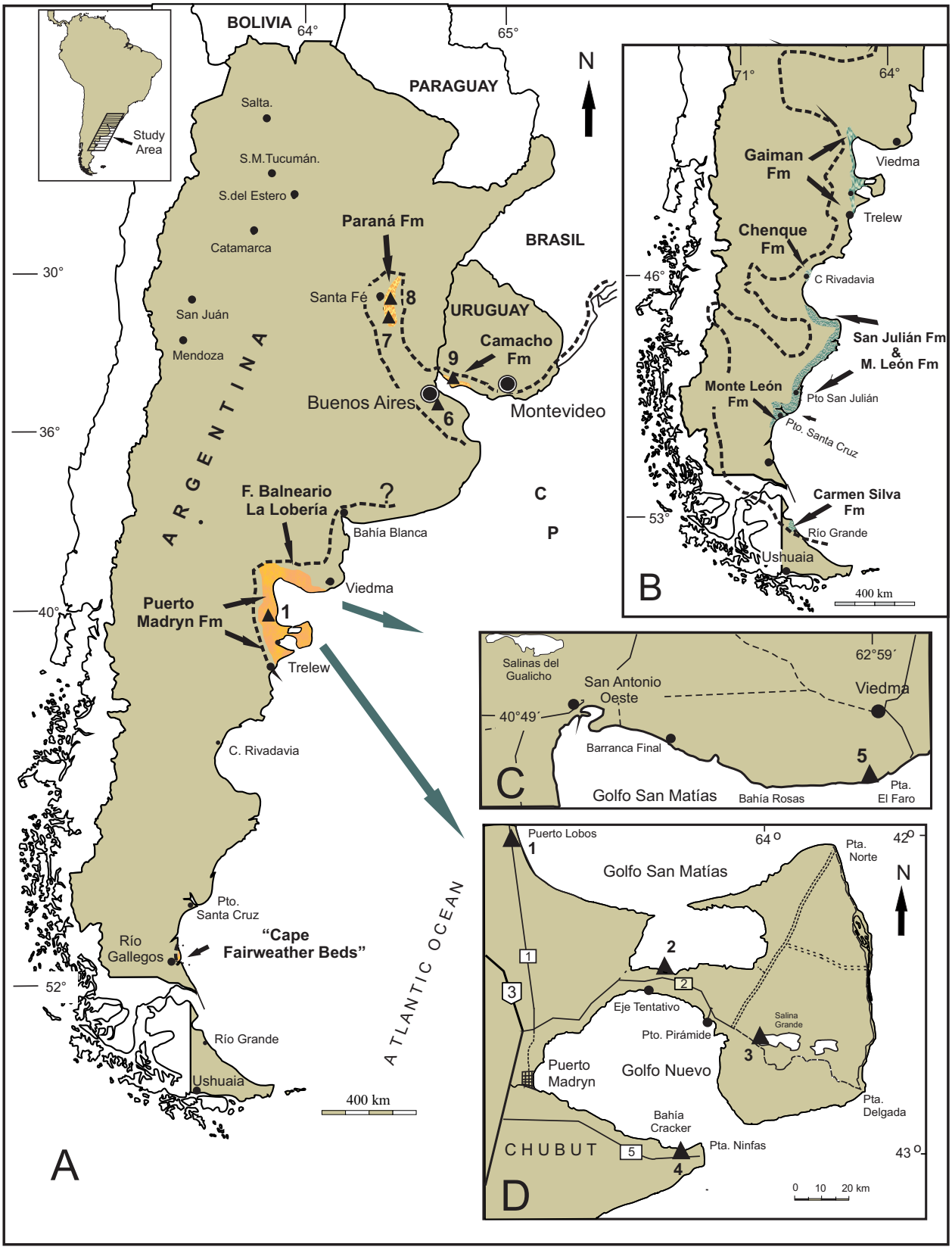

Fig. 1. A – Paleogeography of the late Miocene "Paranense" Sea (dotted line), exposures of the studied sedimentites (in orange) and location of measured lithological sections: 1- Cueva Los Leones; 6- Riachuelo IV; 7- Paraná; 8- Punta Gorda; 9- Cantera Geymonat. **B-** Paleogeography of the "Patagoniense" Sea and eastern exposures of lithological units mentioned in the text. **C-** Enlargment of northern coast of the San Matías Gulf: 5- Balneario La Lobería. **D-** Geographic location of the study sites in Península Valdes: 2- Punta Logaritmo; 3- Salina Grande; 4- Bahía Cracker. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

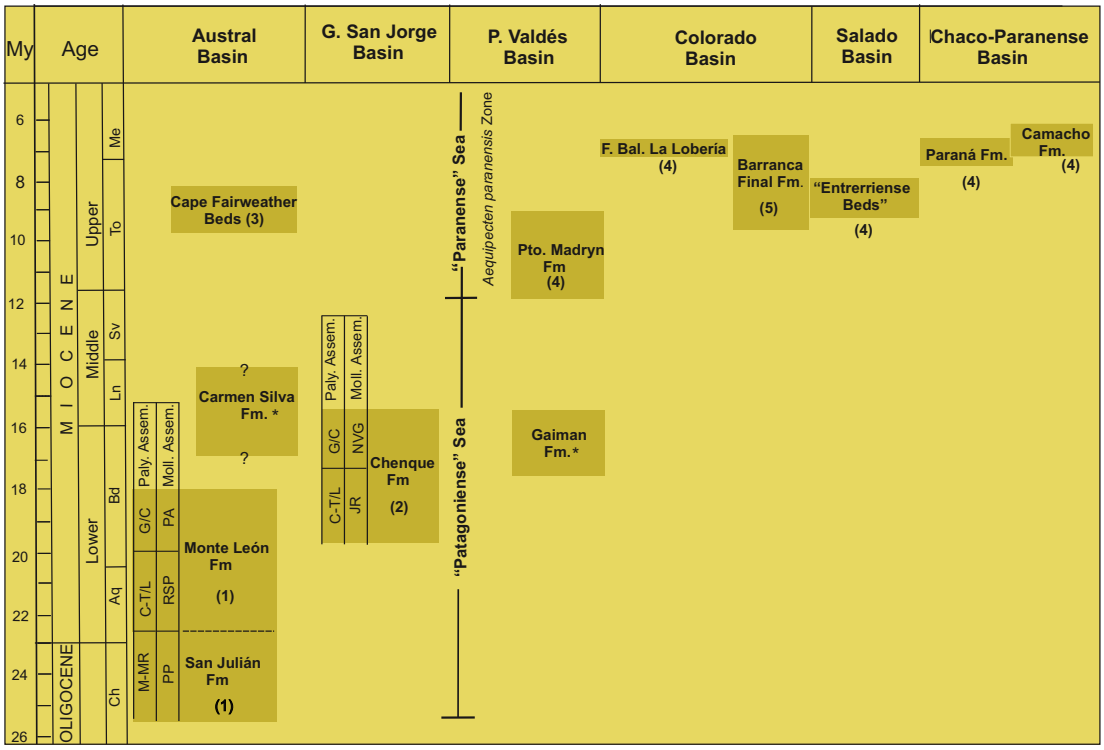

Fig. 2. Chronostratigraphic chart of deposits of the "Patagoniense" and "Paranense" seas on eastern Patagonia based on 87Sr/86Sr data calculated by: 1-Parras et al. (2012), 2- Cuitiño et al. (2015); 3- del Río et al. (2013); 4- this paper; 5- Palazzesi et al. (2014); (*) no isotopic data available for these units. Abbreviations: PP = *Panopea sierrana-Parinomya patagonensis* Assemblage; RSP = *Reticulochlamys zinsmeisteri-Struthiolarella patagoniensis- Pleuromeris cruzensis* Assemblage; JR = *Jorgechlamys centralis-Reticulochlamys borjasensis* Assemblage; NVG = *Nodipecten* sp.-*Venericor abasolensis-Glycymerita camaronesia* Assemblage; M-M/R = *Multisiappolis viteauensis-Margocolporites tenuireticulatus-Reticulatosphaera? actinocoronata* Assemblage; C-T/L = *Cypereaceaepollis neogenicus–Tricolpites trilobatus/Lingulodinium hemicystum* Assemblage; G/C = *Glencopollis ornatus/Cannosphaeropsis utinensis* Assemblage.

Although those Neogene horizons have largely drawn the attention of naturalists, through a dearth of accurate dates independent of biostratigraphy, authors regard some rocks of the "Patagoniense" Sea (i.e. Monte León, Carmen Silva, Chenque and Gaiman formations) as having been deposited by the later "Paranense" transgression (Windhausen, 1931; Yrigoyen, 1975; Uliana and Biddle, 1988; Ramos and Alonso, 1995; Aceñolaza and Aceñolaza, 1999; Sprechmann and Aceñolaza, 1999; Malumián, 1999; Alonso, 2000; Marengo, 2000; Aceñolaza and Sprechmann, 2002; Hernandez et al., 2005; Malumián and Nañez, 2011).

Controversy also surrounds the area covered by the "Paranense" Sea. Some geologists extended it to northwestern and western Argentina, but the age of rocks in those areas and whether they are even marine, is still matter of discussion. Correlation of those supposedly "Paranense" sediments with the middle Miocene Yecua Formation (southern Bolivia) (Marshall et al., 1993; Webb, 1995; Räsänen et al., 1995; Hernandez et al.; *op.cit.*; Hovikosky et al., 2007; Uba et al., 2009; Hulka et al., 2006) has been used to support the idea of Ihering (1927) and Boltovskoy (1991) who suggested that a major intra-continental seaway (*e.g.* "Paranense" Sea) crossed South America in the Miocene, connecting the southwestern Atlantic Ocean with the Caribbean Sea. However, a marine origin of the Yecua Formation, and thus an intra-continental seaway is not universally accepted (*e.g.* Nutall, 1990; Nicolaides and Coimbra, 2008; Tineo et al., 2015). See Gross et al. (2015) for a review of the matter. In reference to the southern limit of the "Paranense" Sea deposits, some authors placed it a few kilometers south of the Península Valdés (Camacho, 1967; Scasso and del Río, 1987; del Río, 2000; Bellosi, 1995; Cione et al., 2011; Cuitiño et al., 2017). Others, extended its southern limit to the southernmost tip of Argentina because they believe that the sediments of the "Patagoniense" Sea were deposited by the "Paranense" Sea (Uliana and Biddle, 1988; Ramos and Alonso, 1995; Malumián, 1999; Alonso, 2000; Hernandez et al., 2005; Malumián and Nañez, 2011).

As doubts persist still today concerning the age and paleogeography of the "Paranense" Sea, we have undertaken further dating of putative "Paranense" deposits along the southwestern Atlantic region in order to help resolve this uncertainty. We also review the correlation of the coastal "Paranense" units with sediments of western and northwestern Argentina previously thought to have been deposited by or related with the "Paranense" Sea.

2. Previous age's estimations for the "Paranense" beds

First reports of the "Paranense" deposits, and the description of their molluscs were by d'Orbigny (1842) and Darwin (1846). Since then, the timing of the transgression deserved most of the attention of geologists and paleontologists and the correlation among the "Paranense" deposits, have been controversial. In this section, we summarize previous ideas regarding the ages of the "Paranense" lithostratigraphic units.

2.1. Puerto Madryn formation

Sedimentary rocks of this unit crop out around the city of Puerto Madryn and Península Valdés, and from here northwards to Puerto Lobos (Cueva Los Leones area) (Chubut Province) (Fig. 1D). Initially described by Ameghino (1890), Frenguelli (1926) and Feruglio (1949), in Península Valdés these rocks and their molluscan faunas have been the center of detailed systematic and stratigraphic analyses, as well as paleoenvironmental and taphonomic interpretations (Scasso and del Río, 1987; del Río, 1991, 1992; 1994: del Río et al., 2001). Del Río et al. (*op.cit*) subdivided the unit identified between Eje Tentativo and the Puerto Piramides-Lobería´area into trangressive, highstand and

regressive phases. On account of its fossiliferous content, the Puerto Madryn Formation has been placed in the Miocene *s. l.*, middle Miocene or late Miocene. del Río (1988) firstly assigned the formation a middle Miocene age based on dominance of the typical Caribbean taxa from the Gatun Formation. This age was adopted by Malumián (1999), Malumián and Nañez (2011), Aceñolaza and Aceñolaza (1999), Aceñolaza (2000), and by Aceñolaza and Sprechmann (2002). Subsequently, those Caribbean faunas were placed in the late Miocene according to the associated foraminiferal assemblages (see discussion in Martínez, 1994) and since then a late Miocene age was accepted by del Río (2000) and Martínez and del Río (2002). On vertebrate evidence, Cione and Tonni (1981) assigned it to the late Miocene, while Cozzuol et al. (1993), Cozzuol (1996), and Riva Rossi (1997) placed it in the middle Miocene.

Subsequent refinements allowed age discrimination within the unit. Cione et al. (1996) and Azpelicueta et al. (2015) suggested a middle Miocene age for the highstand phase exposed at Puerto Pirámides. Cione et al. (2005a) recognized the Huayquerian Stage in the uppermost beds exposed in the surroundings of Punta Delgada (regressive phase), estimating that they were younger than 9 Ma. A late Miocene age for the same beds was also supported by Dozo et al. (2010, and bibliography therein). In a later work, a probable middle Miocene age for the lower and middle horizons of the Puerto Madryn Formation was suggested by Cione et al. (2011).

Palynomorphs and foraminifera place this unit in the late Miocene (Palazzesi and Barreda, 2004; Marengo, 2015) while dinoflagellate cysts recovered from the highstand phase at Puerto Pirámides would indicate a Serravalian-Tortonian age (Fuentes et al., 2016).

These age assignments were superseded by numerical dating. Zinsmeister et al. (1981) reported $^{40}K/^{40}Ar$ ages 9.11 ± 0,1 Ma; 9.56 ± 0,3 Ma; 9.55 ± 0,3 Ma (mean 9.41 Ma; not updated, so approximate) for three glass concentrates from tuffs at the top of the Bahía Cracker section (regressive phase). Later, Scasso et al. (2001) obtained an $^{87}Sr/^{86}Sr$ age of 10.0 ± 0.3 Ma (revised to 9.70 ± 0.3 Ma using McArthur et al., 2012) for shells of the scallops "*Chlamys" actinodes* and *Chesapecten crassus*, placing the transgressive and the lower part of the regressive phases in the middle Tortonian.

2.2. Facies Balneario La Lobería

The marine horizons at the base of the cliffs between Bahía Rosas and Punta del Faro (northern coast of the San Matías Gulf, Río Negro Province; Fig. 1 C) were described by De Ferraris (1966) and Angulo and Casamiquela (1982). The latter provided detailed lithological descriptions and placed them in the Facies Balneario La Lobería. Angulo and Casamiquela (*op.cit.*) considered it as a marine intercalation within the continental Río Negro Formation. It has been considered late Miocene, late Miocene-early Pliocene or Pliocene, depending on the mammal age assignment of the Río Negro Formation (Farinati et al., 1981; Angulo and Casamiquela, 1982; Echevarría, 1988; Pascual et al., 1996; see discussion in del Río et al., 2013). In these marine deposits, del Río (1988) recognized the *Aequipecten paranensis* Zone and suggested they are of late Miocene age (del Río, 2000).

2.3. "Entrerriense Beds"

This name was given by Tapia (1937) to sediments deposited by the "Paranense" transgression in the Salado Basin (subsurface city of Buenos Aires). They have been assigned an age of late Miocene (Yrigoyen, 1969) or middle-late Miocene (Yrigoyen, 1975). Foraminiferal assemblage suggests a late Miocene-early Pliocene age (Malumián, 1970), but later works restricted it to the middle Miocene (Malumián and Nañez, 1996; Malumián, 1999). According to its calcareous nannoplancton content, Marengo and Concheyro (2001) and Marengo (2015) proposed a middle Miocene (Serravalian) age.

2.4. Paraná Formation

This formation is exposed around the cities of Paraná and Diamante (Entre Ríos Province). Microfaunistic evidence placed it in the late Miocene (Rossi de García, 1966; Zabert and Herbst, 1977; Zabert, 1978; Herbst and Zabert, 1987), whilst molluscan assemblage deemed it middle Miocene in age (del Río, 1991), which was followed by Aceñolaza and Aceñolaza (1999) and Aceñolaza (2000), and later regarded as late Miocene (Martínez, 1994; del Río, 2000; Martínez and del Río, 2005). On vertebrate evidence it is ?middle Miocene-late Miocene (Cione et al., 2008) and later restricted to the late Miocene (Cione et al., 2000, 2005 b, 2011, 2012, 2013). The only known numerical dating ($^{87}Sr/^{86}Sr$) for the unit places it in the late Miocene (9.47 Ma) (Pérez, 2013).

2.5. Camacho Formation

This unit is exposed along the southern coast of Colonia Department (Uruguay). Molluscs, selachians and mammals indicate that it should be placed in the late Miocene (Figueiras and Broggi, 1971, 1973; Martínez, 1994; Martínez and del Río, 2002; Perea and Ubilla, 1989, 1990; Perea, 2005; Perea et al., 1994, 2013). An age of 17 Ma - 18 Ma was obtained by Sprechmann et al. (2010) using Sr-isotope stratigraphy, on two species of brackish oysters, placing the formation in the early Miocene.

3. Location and stratigraphy of samples dated

The sediments reported on here of the "Paranense" Sea include rocks exposed in the surroundings of the city of Puerto Madryn, Península Valdés and Cueva Los Leones (Puerto Madryn Formation, Chubut Province) (Fig. 1 D), Balneario La Lobería (Facies Balneario La Lobería of the Río Negro Formation) (Viedma, Río Negro Province) (Fig. 1C), the drill-hole Riachuelo IV ("Entrerriense Beds", Salado Basin, city of Buenos Aires) (Fig. 1A), and sedimentary rocks exposed near the cities of Paraná and Diamante (Paraná Formation, Entre Ríos Province) (Fig. 1A). Deposits of the "Paranense" Sea are also recognized in Uruguay at Cantera Geymonat (Colonia Department) (Fig. 1A). Fig. 3 illustrates lithological sections exposed at these localities.

3.1. Península Valdes

Samples dated here come from the Puerto Madryn Formation exposed at Punta Logaritmo, Salina Grande and Bahía Cracker (Fig. 1D).

At Punta Logaritmo (42° 25′ 17′′S; 64° 29′29′′W) there are exposures of the transgressive phase of the unit overlaying whitish tuffaceous sandstones of the Gaiman Formation (early Miocene). Samples for dating were collected from the only fossiliferous horizon, a medium and fine, ochreous sandstones up to 3 m thick that grades upwards to a multi-event shell-supported bed, where *Aequipecten paranensis* is associated to *Crassostrea patagonica*, *Cubitostrea alvarezi*, "*Chlamys" actinodes*, *Pachymagas piramidesia* and *Turritella piramidesia*. Fossils are abundant, and bivalves are disarticulated and well preserved (Fig. 4-F).

The lithological section at Salina Grande (42° 39′39′′S; 63° 57′ 07′′W) corresponds to the regressive phase of the Puerto Madryn Formation and comprises intercalations of muddy heterolithic or massive, bioturbated very fine sandstones, fine bioturbated sandstones and medium to fine multi-event, shell-supported beds up to a 0,8 m thick that have erosive lower and upper planar contacts. *Aequipecten paranensis* is associated to *Amusium paris*, *Crassostrea patagonica* and *Leopecten piramidesensis* (Fig. 4D–E).

At Bahía Craker (42° 57′23′′S; 64° 25′25′′W), the upper part of the regressive phase of the Puerto Madryn Formation is exposed as 30 m of intercalated gray heterolithic mudstones and very fine sandstones with fossiliferous, cross-bedded, fine sandstones. Fossils are usually broken except for the uppermost tuffaceous sandstones that carry shell-beds where *Aequipecten paranensis* is associated with oysters and

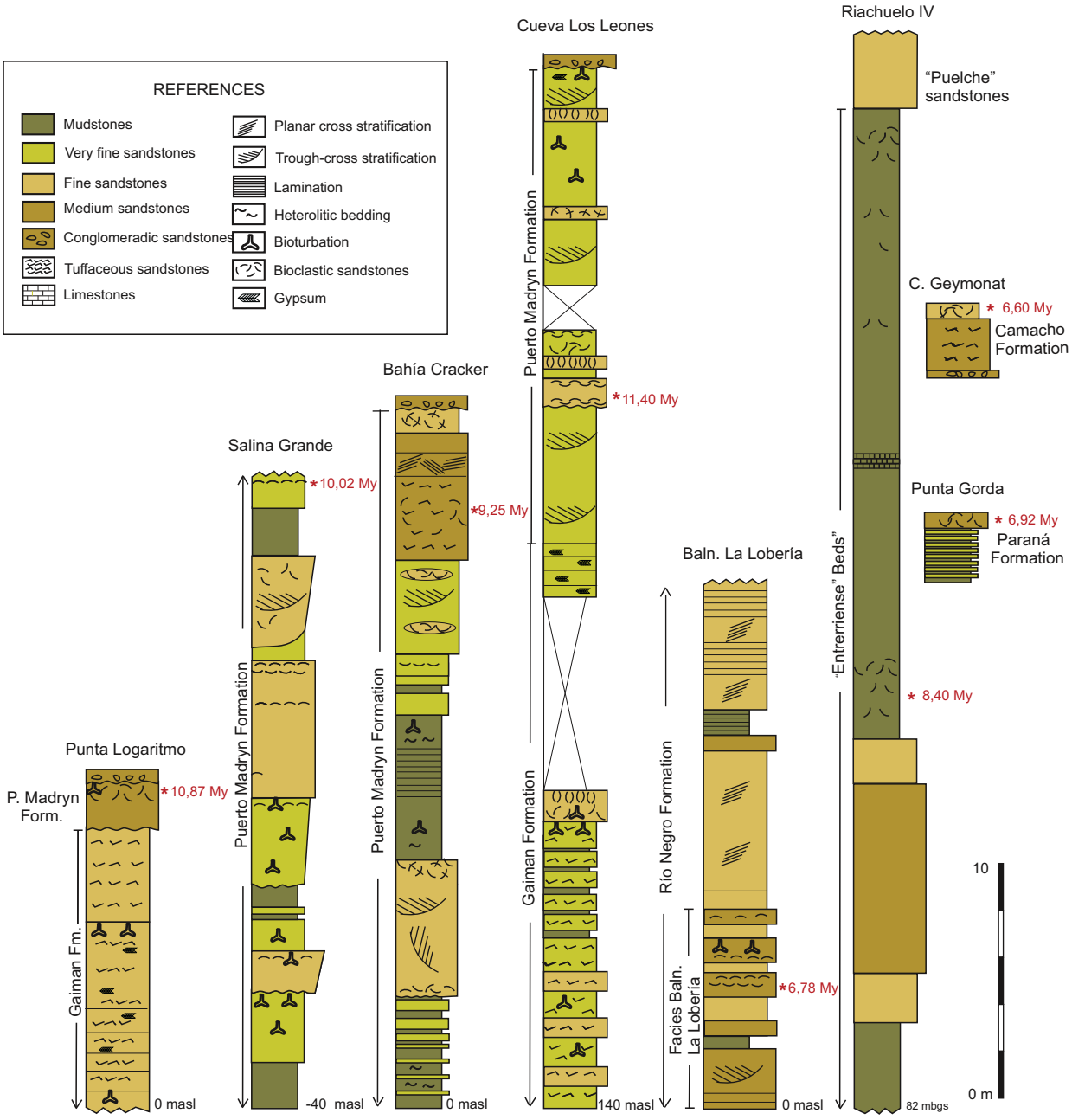

Fig. 3. Lithological sections of the studied "Paranense" deposits. Mean ages in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Monophoraster darwini.

3.2. Cueva Los Leones

Miocene marine fossiliferous beds are recorded 66,5 km north to the city of Puerto Madryn, and 25 km southwest of Puerto Lobos (Chubut Province). Exposures occur in a narrow strip stretching over 33 km between 42° 17′S and 42° 01′S, along the western side of Highway 3. Cortes (1987) placed the basal beds in the Gaiman Formation and the upper horizons in the Puerto Madryn Formation. The measured section of the Puerto Madryn Formation (42° 14′ 30″S and 65° 20′W) comprises a sequence of up to 22 m of cross-bedded or laminated, fairly loose, very fine and fine gray sandstones, and four 1.5 m thick shell-beds constituted by ochreous, fine or very fine sandstones. The shell-beds contain a rich invertebrate fauna which varies laterally from well-preserved to highly fragmented accumulations. The fossiliferous assemblage contains dense accumulations of *Aequipecten paranensis*, *Cubitostrea alvarezi* and *Crassostrea patagonica*, co-occurring with scarce *Monophoraster darwini, Pachymagas piramidesia,* rare *Trophon* sp. and isolated vertebrate remains. Capping the sequence there is a 0.8 m thick bed of gray cross-bedded sandstones bioturbated with *Skolitos* and *Ophiomorpha.*

3.3. Balneario La Lobería

The section is exposed at 41° 09′ 18.80´´S - 63° 07′ 28.84´´ W, some 40 km southwest of the city of Viedma and 225 m to the east of the stairway down to the beach at Balneario La Lobería. At the base of the section there is 1 m of laminated very fine sandstones followed by 2 m of barren ochreous, cross-stratified medium sandstones, overlain by 7 m of yellowish, massive, fine sandstones that contain three loosely packed fossiliferous horizons. The lowermost, of 1.5 m thick, was sampled for

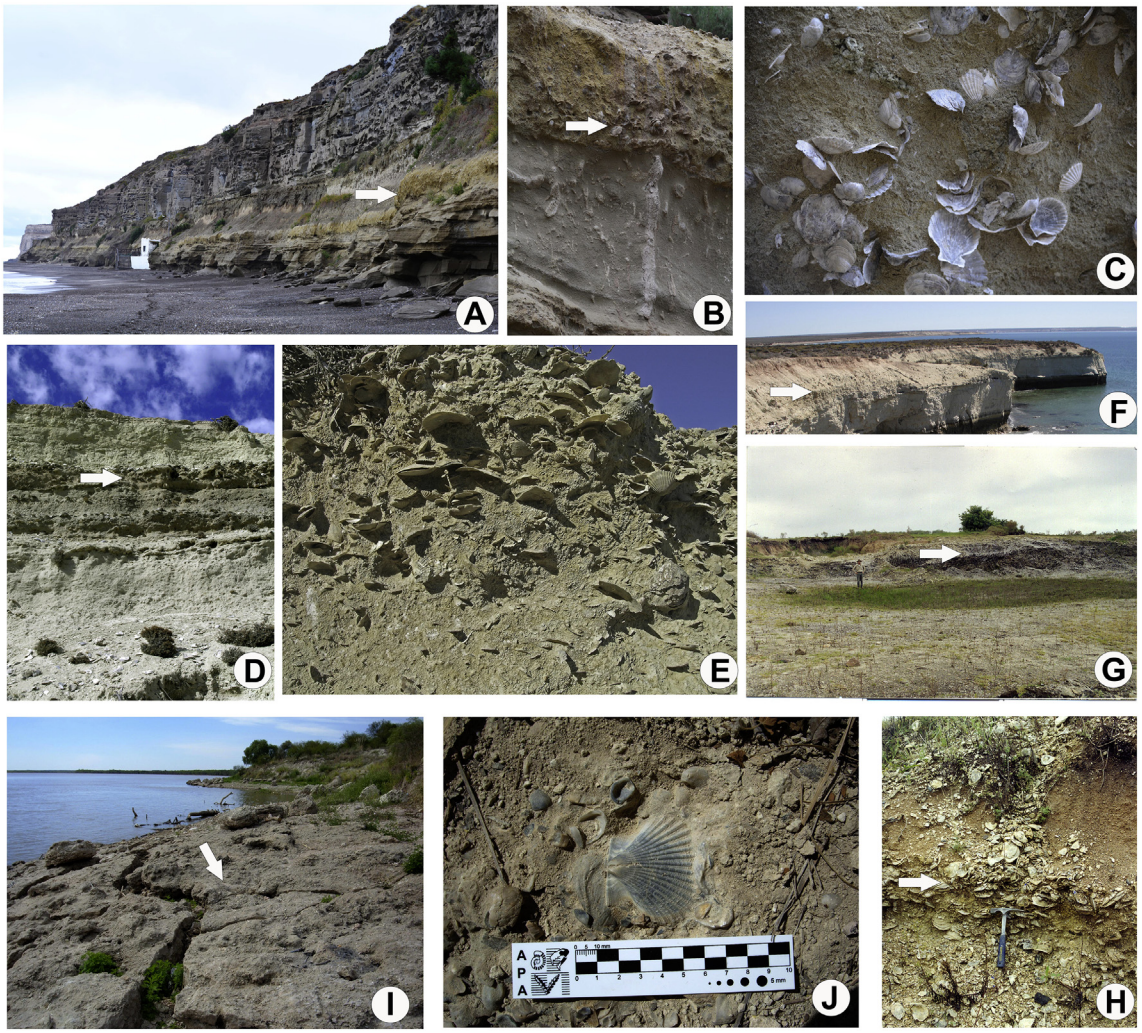

Fig. 4. Exposures of the "Paranense" rocks. **A-C**- Facies Balneario La Lobería of the Río Negro Formation at Balneario la Lobería (Viedma, Río Negro); **D-E**- Regressive phase of the Puerto Madryn Formation at Salina Grande and detail of the uppermost fossiliferous bed (Península Valdés, Chubut); **F**- Panoramic view of Gaiman and Puerto Madryn formations at Punta Logaritmo (Peninsula Valdés, Chubut); **G-H-** Panoramic view of Camacho Formation at Cantera Geymonat and detail of fossiliferous accumulation (Colonia, Uruguay); **I-J** –Exposure of the Paraná Formation and detail of shell-bed (Punta Gorda, Entre Ríos). White arrow indicates the stratigraphic location of the material dated herein.

Sr-isotope stratigraphy and contains concentrations of exceptionally well-preserved, both disarticulated and articulated shells of *Aequipecten paranensis*, *Ostrea* sp and *Pododesmus camachoi.* Laterally, this association is replaced by molds of the bivalves *Chionopsis* sp., *Ameghinomya* sp, and *Anadara* sp. This bed is capped by an horizon 10 cm thick, composed mostly of well-preserved *Monophoraster darwini* in life position and bunches of articulated oysters lying on the left valve. The middle and upper shell-beds comprise disarticulated and chaotically dispersed valves of *Ostrea* sp. The terrestrial deposits of the Río Negro Formation, which overlay in this section to the marine Facies Balneario La Lobería, are represented by 53.5 m of bluish gray, medium and fine cross-stratified sandstones, capped by a highly bioturbated, massive and compact white siltstones 50 cm in thickness (Fig. 4A–B).

3.4. Drill-hole Riachuelo IV

Drilled by the Dirección Argentina de Minas y Geología, this core recovered 280 m of the "Entrerriense Beds" at Puente Pueyrredón (34° 39′ 23´´S, 58° 22′ 13´´W). The section is mainly composed of ochreous-reddish or greenish mudstones, with fine and medium sandstones intercalated at its base (unpublished data provided by Dirección Argentina de Minas y Geología). Two fossiliferous beds are located between 44.8 – 54.40 mbgs and 68.10–72.70 mbgs. We analyzed shells of *A. paranensis* from the lower bed in which they are associated with *Chionopsis muensterii, Crassatella suburbana, Anadara lirata, Amusium darwinianum* and abundant bryozoans. Capping this section are the Quaternary "Puelchense Beds".

3.5. Paraná and Punta Gorda

Specimens of *Aequipecten paranensis* that we have dated were collected by B. Bicego in 1892 and A. Bravard between 1854 and 1856 from thin, isolated exposures of the uppermost horizons of the Paraná Formation along the left bank of the Paraná River, in the city of Paraná, and by C. del Río and L. Pérez in Punta Gorda Sur (Diamante, 32°04′15´´S, 60°39′11´´W). In Punta Gorda there is a small outcrop, 2.5 m thick that comprises from base to top, an intercalation of gray laminated, very fine sandstones and mudstones, followed by massive poorly fossiliferous medium sandstones. The section is capped by an amalgamated ochreous, compact, shell-bed that reaches up to 30 cm thick that contains *Anadara bonplandeana*, *Glycymeris minuta*, *Crassostrea* cf. *rhizophorae*, *Crassostrea patagonica*, *Cubitostrea alvarezii*, *Aequipecten paranensis*, *Leopecten oblongus*, *Miltha iheringiana*?, *Venericardia crassicosta*, *Dinocardium platense*, *Mactra bonariensis*?,

Table 1
Values of $^{87}Sr/^{86}Sr$ in 20 samples of *Aequipecten paranensis* from the "Paranense" sedimentary deposits. Values are normalized to a value of 0.710 248 for NIST987 (previously SRM987), which is equivalent to a value of 0.709 174 for EN-1.

LOCALITY	Sample No.	87Sr/86Sr	±	LOWESS Ages, My			Unit	
				Min	*Mean*	*Max*		
Cantera Geymonat	Arg Ar1	0.070896		6,00	6,60	7,20	Camacho Formation	
Punta Gorda		0.708957	0.000007				Paraná Formation	
		0.708950	0.000006					
Mean		0.708953						
2.s.e		0.000007		6.67	6.92	7.25		
Paraná	4957	0.708946	0.000007					
	4969	0.708951	0.000007					
	4973	0.708942	0.000006					
Mean		0.708946						
2.s.e		0.000005		6.95	7,20	7,50		
Riachuelo IV	BSAS	0.708920	0.000008				"Entrerriense" Beds	
	BSAS 1	0.708930	0.000014					
	BSAS 2	0.708925						
Mean		0.708925						
2.s.e		0.000006		7.95	8,40	8.85		
* analysis by Carleton University								
Balneario La Lobería	2918	0.708965	0,000011				Facies Balneario La Lobería	
	2918	0.708952	0,000007					
	2919	0.708968	0,000007					
	2920	0.708946	0,000007					
Mean		0.708958						
2.s.e		0.000010		6,50	6.78	7.08		
Cueva Los Leones	2936	0.708849	0.000008	10,9	11.4	11,9	Puerto Madryn Formation	Transgressive Phase
P. Logaritmo	1269 (a)	0.708861	0.000012	10,4	10.87	11,45		
Salinas Grandes	SG(1)	0.708880	0.000007					Regressive Phase
	SG(1)	0.708883	0.000007					
	SG(3)	0.708890	0.000007					
Mean		0.708884		9.82	10.02	10,2		
2.s.e		0.000006						
B. Cracker	1279	0.708907	0.000008					
	1280	0.708910	0.000007					
Mean		0.708908		9.05	9.25	9,40		
2.s.e		0.000003						

Chionopsis munsterii, and abundant bryozoans (Pérez, 2013) (Fig. 4I–J).

3.6. Cantera Geymonat (Uruguay)

Dated shells come from the Camacho Formation exposed at Cantera Geymonat (34° 25′ 57´´S; 57° 49′ 0.6´´W), near the city of Colonia del Sacramento. The exposures are small in areal extent, and consist of thin basal conglomeratic sandstone with abundant oysters. This is overlain by a 3 m thick layer of tuffaceous sandstones that grade upwards to highly fossiliferous, loose, fine sandstones containing a concentration of oysters associated with few terebratulids, balanids, *Pododesmus* sp., *Trophon* sp and *Aequipecten paranensis*. Capping the section there are barren fine sandstones (Fig. 4G–H).

4. Materials and methods

Twenty samples of *Aequipecten paranensis* were dated using Sr-isotope stratigraphy (Table 1). The specimens ranged from nearly-whole valves to fragments about 1 cm in size. Fragments lacking Fe-stain or Mn-stain, and appearing visually to be least altered, were selected for analysis; the hinge regions and umbo usually proved the best part of the shells to sample because the thicker shell in this region resists alteration best. Cleaned fragments were broken into mm-sized pieces in an agate pewstle-and-mortar, cleaned again by immersion for a few seconds in dilute nitric acid, washed with 18 MΩ water, and dried in a clean environment. The best preserved fragments were picked under the microscope to select 10 mg of thin, sheet-like, fragments that were the best preserved. The diagnostic features of good preservation are cleavage along the original layering, clear calcite, and an absence of Fe or Mn stain. The picked samples were dissolved in nitric acid, evaporated to dryness, and Sr was separated using Eichrom Sr-spec resin.

Measurements of $^{87}Sr/^{86}Sr$ were made on a Phoenix Isotopx magnetic-sector thermal-ionization mass-spectrometer using Re filaments. Values of $^{87}Sr/^{86}Sr$ were normalized to an $^{87}Sr/^{86}Sr$ value of 0.1194 using exponential correction for fractionation. The long-term value of NIST987 measured before, during, and after the analysis of our samples was 0.710 236 ± 0.000 007 (2s.d.) All values of $^{87}Sr/^{86}Sr$ reported in Table 1 have been normalized to a value for NIST987 of 0.710 248, which is equivalent to a value for EN-1 (modern seawater) of 0.709 174 (McArthur et al., 2012).

Numerical ages were derived from $^{87}Sr/^{86}Sr$ ratios using the LOWESS calibration curve of McArthur et al. (2012). The uncertainties on the numerical ages are derived by compounding the uncertainty of measurement with the uncertainty on the LOWESS calibration line, and are shown in Table 1 as standard errors of the mean values.

5. Results and discussion

5.1. Age of the "Paranense" sea

Numerical ages presented have been rounded to three significant figures, clustered into five age-group (Fig. 5 A): 11.9–10.4 Ma (latest Serravalian- Tortonian); 10.2–9.82 Ma (Tortonian); 9.40–9.05 Ma (Tortonian); 8.85–7.95 Ma (Tortoninan); 7.50–6.0 Ma (latest

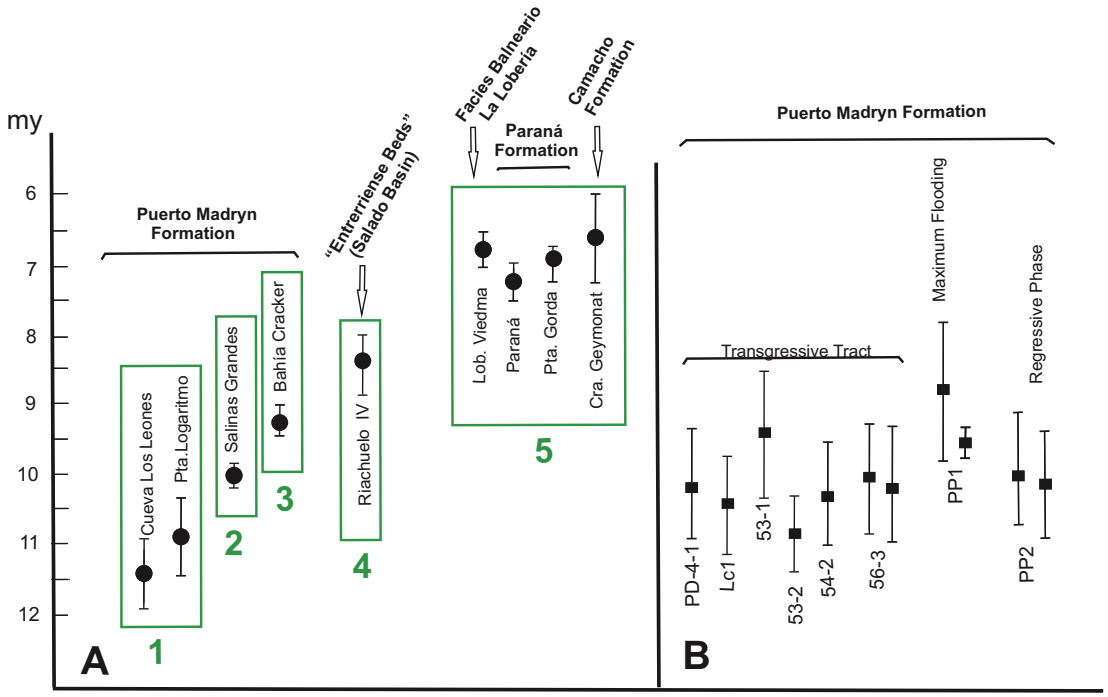

Fig. 5. A- $^{87}Sr/^{86}Sr$ numerical ages clustered into five groups. Groups 1, 2 and 3 are stratigraphically coherent with the transgressive (1) and regressive phases (2 and 3) of the Puerto Madryn Formation exposed at Cueva Los Leones and Peninsula Valdés; **B-** Numerical ages obtained by Sr-isotope stratigraphy Scasso et al. (2001)) who rejected dates based on oysters owing to their alteration.

Tortonian- Messinian).

The three older age-groups are recorded in the Puerto Madryn Formation and represent both the transgressive, and the entire regressive phases of this unit. The oldest ages of 11.9–10.9 Ma occur in the basal beds exposed at Cueva Los Leones, which is correlative with the transgressive phase at Punta Logaritmo. Ages of 10.2–9.82 Ma correspond to the middle portion of regressive phase at Salina Grande, and the youngest age of 9.40 to 9.05 Ma to the upper regressive phase at Bahía Cracker. This later age range was obtained on shells from the top of the unit at Bahía Cracker and are similar to the 9.41 Ma using $^{4}K/^{40}Ar$ determined by Zinsmeister et al. (1981), for samples coming from the same beds sampled for this paper.

Scasso et al. (2001) dated pectinid shells of the Puerto Madryn Formation but could not discriminate between the ages of the basal, middle and upper parts of the unit, which represent a complete transgressive-regressive cycle. The mean age given by those authors was 10.0 ± 0.3 Ma and comes from 1) lowest beds belonging to the transgressive phase, exposed at Eje Tentativo and El Doradillo; 2) horizons from the maximum flooding surface that crop out in the Puerto Piramides-Lobería´area, and in the upper section at Eje Tentativo; 3)-lowermost part of the regressive phase in Lobería Punta Pirámides (Fig. 5 B). Our determinations update that age, being more precise through use of more modern instumentation (VG 354 for Scasso et al., 2001- vs Phoenix Isotopx used here), which has reduced 2 s.d of external precision from ± 0.000 015 to ± 0.000 006. Moreover, the pectinds analyzed herein are preserved better than the pectinid samples of Scasso et al. (2001), who dated both pectinids and oysters and found that the latter did not give good ages. Confusingly, Fig. 1 of that paper presents both sets of ages.

The results obtained herein suggest that the basal beds of the transgressive phase of the Puerto Madryn Formation must be placed in the latest Serravalian, and the overlying in the Tortonian. This disagrees with Cione et al. (2011), who estimated a middle Miocene age for the basal and middle part of the unit (i.e. transgressive and highstand phases). It precludes a Serravalian age for the highstand phase as suggested on dinoflagellates evidence (Fuentes et al., 2016). Besides, these results given here also permits correlation of the upper portion of the Puerto Madryn Formation (regressive phase) with the basal section of the cliffs at Barranca Final, where the uppermost horizons of the Barranca Final Formation are exposed at its type area, which have a $^{87}Sr/^{86}Sr$ age of 9.61 Ma (Palazzesi et al., 2014).

The fourth age-group (8.85–7.95 Ma, Tortonian) comprises the first numerical ages for the "Paranense" Sea in the Salado Basin and is stratigraphically concordant with the other sections that yield the *Aequipecten paranensis* Zone such as the Paraná and Camacho formations and Facies Balnerario La Lobería. These ages are younger than the Serravalian age proposed by Marengo and Concheyro (2001) and Marengo (2015) on the basis of the calcareous nannoplancton NN5 Zone in the Riachuelo V drill-hole. Beds containing the NN5 Zone in that core correlate with Riachuelo IV core, that is situated laterally a few meters from Riachuelo V. (Marengo, *oral com.*), but these drill holes are old and the discrepancy in age could be attributed to curation errors, since foraminiferal evidence and the presence in the borehole of the *Aequipecten paranensis* Zone, indicate a late Miocene age that agrees with our numerical dating. The "Cape Fairweather Beds" were recently dated by means of Sr-isotope stratigraphy at 8.95 ± 0.82 Ma and correlated with the upper part of the Puerto Madryn Formation (del Río et al., 2013), but based on our new data, the "Cape Fairweather Beds" are now correlated with the top of the "Entrerriense Beds" in the Salado Basin.

The youngest deposits (7.50–6.00 Ma) of the "Paranense" transgression comprise the Facies Balneario La Lobería, and the Paraná and Camacho formations. We report here the first numerical ages of 7.08–6.55 Ma for the Facies Balneario La Lobería (early Messinian). This age makes it correlative with the middle beds of the cliff exposures at Barranca Final, located 117 km west from Balneario La Lobería, where the top of the Barranca Final Formation is exposed and has been recently dated at a $^{87}Sr/^{86}Sr$ age of 6.48 Ma by Palazzesi et al.(2014). These data show that those beds are not coeval with the highstand phase of the Puerto Madryn Formation as proposed by Palazzesi et al. (*op. cit.*).

The first report here of a typical open marine molluscan assemblage

(including *Aequipecten paranensis, Glycymerita magna*, *Ameghinomya argentina*, "*Chlamys" actinodes* and *Turritella pyramidesia)* in the lower and upper fossiliferous beds of the cliffs in Barranca Final indicates that the uppermost horizons of the Barranca Final Formation were deposited by the "Paranense" Sea. In this way the presence of that sea is recorded along the entire northern coast of the San Matías Gulf and northwards to the Salinas del Gualicho area, as initially proposed by Rizzolo (1967) and later discussed by Camacho (1987) and del Río (1988, 1990) on the base of paleontological and biostratigraphic information.

The ages obtained herein for the Paraná Formation (7.55–6.67 Ma, latest Tortonian-Messinian) based on five samples, is much younger than the 9.47 Ma provided by Pérez (2013) through Sr-isotope stratigraphy from a single valve of *Leopecten oblongus* collected in the same strata studied herein. The age discrepance may result from differences in preservational state; we have repeatedly found that altered samples from Argentina have lower $^{87}Sr/^{86}Sr$ (and so older ages) than do well-preserved samples.

The age range of 7.20–6.00 Ma (Messinian) for the Camacho Formation is concordant with the late Miocene age for the unit suggested by Martínez (1989, 1994) and Martínez and del Río (2002) on the basis of molluscan assemblages. A date of 17–18 Ma obtained by Sr-isotope stratigraphy on brackish oysters is given in an abstract by Sprechmann et al. (2010), but preservational assessment was lacking and we again suspect that the old age may be the consequence of alteration.

Our dates for the "Paranense Sea of 11.9–6.0 include beds at the top and base of the marine transgression/regression, and this age-range is smaller than that given by Hernández et al. (2005), who stated that the "Paranense" transgression spanned 15–5 Ma, and comprised two different events, *i.e.* at 15–13 Ma (middle Miocene) and 10–5 Ma (late Miocene). According to those authors the older event would have deposited the sediments of the Puerto Madryn, Camacho and Paraná formations. The late Miocene event would have also reached west and northwestern Argentina (see below).

5.2. Paleogeography of the "Paranense" sea

Some authors considered the Chenque, Monte León, Gaiman and Carmen Silva formations (Fig. 1B; Fig. 2) as deposited by the "Paranense" Sea and they therefore extend the area it covered from the southernmost tip of Patagonia to northwestern Argentina. Our new dating, along with those obtained for the deposits of the "Patagonian" Sea (Parras et al., 2012; Cuitiño et al., 2015) and the biostratigraphic information from palynomorphs and molluscs (Barreda and Palamarczuk, 2000; del Río, 2004), allow us to differentiate between the beds of the late Miocene "Paranense" Sea and the early-earliest middle Miocene "Patagoniense" Sea and reapprais the paleogeography of the "Paranense" Sea, as discussed below.

5.2.1. Southern extension

The lower section of the Chenque Formation, at its type section, records the early Miocene JR Molluscan Assemblage (del Río, 2004) and the C-T/L Palynological Assemblage (Barreda and Palamarczuk, 2000). The middle and upper sections of that unit contains the middle Miocene NVG Molluscan (del Río, *op.cit.*) and T-B/H Palynological Assemblages (Barreda and Palamarczuk, *op.cit.*) (Fig. 2). Cuitiño et al. (2015), obtained numerical ages of 19.69–19.02 Ma. (early Burdigalian) for the base and of 15.85–15.37 Ma (Langhian) for the middle part of the Chenque Formation in the Comodoro Rivadavia region (updated to the calibration curve of McArthur et al. (2012), these ages are 19.4 to 18.7, and 15.9 to 15.5 Ma respectively). These ages coincide with the age proposed for the JR Assemblage, and restrict the NVG Assemblage to the earliest Langhian. In reference to the Monte León Formation, molluscs (RSP and PA Assemblages) and palynomorphs (C-T/L and G/C Assemblages), place it in the early Miocene (Barreda and Palamarczuk, *op. cit.*; del Río, *op. cit*), an age supported by dates derived by Sr-isotope stratigraphy in the range 22 Ma −18 Ma (Parras et al., 2012) (updating to the revised calibration of McArthur et al. (2012) changes these ages by ≤ 0.3 Ma). There is no numerical dating or formal molluscan asemblages defined for the Carmen Silva Formation and Malumián and Olivero (2006) considered of middle Miocene and correlated it with the "Entrerriense" (= "Paranense") Sea.

The new ages obtained in this paper show that the oldest marine rocks of the "Paranense" Sea were deposited during the latest Serravalian, whilst most of the transgression occurred during the Tortonian-Messinian interval, being in this way, younger than the "Patagoniense" Sea. The sediments of the "Paranense" Sea are characterized by the *Aequipecten paranensis* Zone, whereas the Gaiman, Chenque, Monte León and Carmen Silva formations contain different molluscan associations. For reasons given above, it is unlikely that sedimentary rocks underlying the Puerto Madryn Formation were deposited by the "Paranense" transgression. Until now, no latest middle or late Miocene marine horizons have been recognized south of the city of Trelew, except for the geographically isolated Tortonian incursion of the sea detected at the latitude of Río Gallegos where the "Cape Fairweather Beds" are exposed in a very small area.

5.2.2. Northern extension

Whether the "Paranense" Sea extended into northwestern and western Argentina is still controversial. Roth (1908) was the first author to propose the presence of open marine facies in Santiago del Estero Province that would, correlated with that sea, whilst Stappenbeck (1926) suggested the same for sediments in Catamarca Province, where it may have been represented by brackish facies. The palaeogeographic reconstruction of Windhausen (1931) shows the "Paranense" Sea streched from the southernmost tip of South America northwards to Paraguay. Since then, few changes have been made to its areal extent except for the addition of some minor incursions of the sea into Mendoza and San Juan provinces (Groeber, 1949; Yrigoyen, 1993; Pérez and Ramos, 1996). Units exposed in northwest and western Argentina are the continental Anta, Del Buey, Chinches and San José formations, and the carbonate beds intercalated in them were thought to have had a marine origin related to the presence of the "Paranense" Sea, or to an hipersaline lagoon permanently or sporadically connected with that sea (Russo and Serraioto, 1978; Cione et al., 1995; Quatrocchio et al., 2003; Davila and Astini, 2002; Ottone et al., 1998; Hernandez et al., 2005). The age of those units are undoubtly middle Miocene (Reynolds et al., 2000; Davila, 2005; Jordan et al., 1996; Gavriloff and Bossi, 1992) and the analysis of Ruskin et al. (2011), bring to an end the idea of the presence of any marine influence in west and northwestern Argentina. Among other aspects, and due to the ratio of carbon and oxygen stable isotopes, those authors demonstrated that the carbonate strata are of lacustrine origin, concluding that the "Paranense" marine incursion would have never reached those regions of Argentina, rejecting any marine intra-continental connection between the Caribbean Sea and the South Atlantic Ocean.

The San José Formation, exposed in the Santa María Valley (Tucumán and Catamarca provinces) was not considered by Ruskin et al. (*op.cit.*) in their analysis. The diagenetic aspects of the ostracod *Cyprideis herbsti,* and the foraminifers *Streblus parkinsoniana* and *Streblus compactus* found at the base of the San José Formation, led Bertels and Zabert (1980) to infer the presence of a high salinity lagoon with high salinities directly connected with the "Paranense" Sea, an idea later followed by Bossi and Palma (1982). Gavriloff and Bossi (1992) also claimed an obvious relationship between this microfauna and the "Paranense" transgression, but they concluded that the San José Formation "would not represent a typical marine sequence or if so, it would have soon stopped being one" (p.28). Later, Gavriloff (1999) and Bossi et al. (1999) proposed for this unit a paralic environment related to the "Paranense" Sea.

Chaia (in Vergani et al., 1991), Leiva and Morton (2001) and Espíndola (2004) increased the number of foraminifer and ostracod

species of the San José Formation. According to the nomenclature used in those papers, the foraminifers are: *Ammomia beccari parkinsoniana* (= *Streblus parkinsoniana*), *Rotalia beccari*, *Bucella frigida*, *Nonion demens*, *Protelphidium tuberculatum*, *Trochammina* sp., *Streblus compactus*, and the ostracods are: *Cyprideis herbsti*, *Cyprideis* cf. *torosa*, *Cyprideis salebrosa*, *Darwinula* sp., *Perissocytheridea* sp., *Limnocythere* sp., *Cyprinotus cingalensis*, and *Cyamocytheridea ovalis*. Chaia (*op.cit.*) considered the microfauna to be a late Miocene assemblage of Atlantic origin, and distinguished three marine transgressive episodes at the base of the formation.

Except for those provided by Bertels and Zabert (1980), there are no illustrations of the microfossils mentioned above, rendering any assessment difficult. Some taxa are extinct, others are not useful as paleoenvironmental indicators. This is the case of *P. tuberculatum* that is tolerant to brackish waters (Malumián, 1978) or to open marine environments, as it is demonstrated by its presence in the Puerto Madryn Formation (Marengo, 2015) where it is associated to a molluscan assemblage of normal salinity (del Río, 1992, 1994). The species *Nonion demens* can be restricted to brackish environments (Boltovskoy, 1991). Among extant species, *Buccella frigida* is tolerant to low salinities (Boltovskoy and Wright, 1976), and *A. beccari parkinsoniana* can either inhabits freshwater environments with intermittent influence of brackish waters, as it happens in the Río de la Plata estuary, in lagoons with influx of fresh waters (Boltovskoy and Boltovskoy, 1968; Boltovskoy and Lena, 1971; Boltovskoy and Wright, *op.cit.*) or present in the Puerto Madryn Formation (Marengo, *op.cit.*). In reference to the ostracods, *Cyprideis herbsti* is an endemic taxon, *C. salebrosa* is a limnic to oligohaline species (up to 5 psμ; Keyser, 1977), and *C. cingalensis* is a freshwater inhabitant (Eagar, 2000; Karanovic, 2008). In some cases, the microfauna is associated with freshwater gastropods, carophytes and bones remains (Herbst et al., 2000). Moreover, there is a strong abundance and diversity decrease of the microfaunas towards the northwestern region, being dominated by only two species typical of stressful environments (*P. tuberculatum* and *A. parkinsoniana*) (Marengo, 2000). Regarding molluscs, there is no evidence of open marine species in the San José Formation as those recorded in easternmost exposures (*i.e.* Paraná and Puerto Madryn formations, and "Entrerriense Beds" of the Salado Basin), but instead, microfaunas are associated with freshwater molluscs (Herbst et al., 2000; Morton and Herbst, 2003).

In consequence, the idea of any marine incursion in Tucumán and Catamarca provinces cannot be supported. Even if the base of the San José Formation would have been deposited in brackish marine environments, the presence of a sea close to the area should be expected (*i.e.* Santiago del Estero Province). Yet, until now, no unequivocal evidence of open marine conditions has been found in the Santiago Province, although a low diversity and scarce microfauna has been recorded (Zabert, 1978; Herbst and Zabert, 1987; Marengo, 2015). Last, but not least, even in the unlikely case that an unequivocally marine microfauna in the middle Miocene San José Formation is eventually found, the inference of a sea close to the area should not be related any longer to a late Miocene sea, but instead to an older transgression of middle Miocene age. Thus, the westernmost limit of the "Paranense" Sea would have reached the Santa Fé Province such as demonstrated by the still moderate high diversity of foraminifers in this region.

5.3. Late Miocene bioprovinces and long-term living species

Martínez and del Río (2002) defined the late Miocene Molluscan Valdesian and the Paranaian bioprovinces. According to the numerical Sr-ages presented herein, the Valdesian province existed between about 11.9 and 6.5Ma while the Paranaian one between 8.85 and 6 Ma, having little overlap in time (2.35Ma). Compared with the duration of other late Paleogene-Neogene bioprovinces such as those defined by Petuch (1988, 2014) for the Western Atlantic and Eastern Pacific, the Valdesian and Paranaian provinces have lasted for a considerable shorter time.

Our analysis also contributes to assess the duration of species that were restricted to the *Aequipecten paranensis* Zone as *A. paranensis* itself, *Anomalocardia entrerriana, Anadara bomplandeana, Epitonium borcherti, Calliostoma bravardi* and *Trophon leanzai*. These taxa are widely distributed in each one of the studied regions, and lived at least during 5.9 Ma, which agrees with the duration of molluscan species proposed by Crampton et al. (2010). The time-life elapsed for the mentioned late Miocene species is even shorter when compared with the associated long-living taxa, such as *Ameghinomya argentina, A. meridionalis, Dosinia meridionalis, Crassatella kokeni, Macoma perplana, Tellina jeguaensis* and *Panopea regularis*, which are present in the region since the early Miocene. The time range of the late Miocene species is also shorter in comparison with those taxa that survived from the late Miocene into modern times in the region: *Leionucula puelcha, Felaniella vilardeboana Caryocorbula pulchella* and *Cyrtopleura lanceolata*. Moreover, the flooding interval of the "Paranense" Sea, was long enough for the evolution of closely related species such as *Chionopsis australis, Amusium paris, Leopecten piramidesensis* and *Dosinia cuspidata* (that lived at the beginning of the transgression) and the later taxa *Chionopsis muensterii, Amussium darwinianum, Leopecten oblongus* and *Dosinia entrerriana*.

6. Conclusions

1 Numerical dating by Sr-isotope stratigraphy shows that flooding time of the "Paranense" Sea ran from 11.9 to 6.00 Ma (latest Serravalian-Messinian), with sediments analyzed herein showing a general trend to be younger northwards. These dates are the first to be published for the "Entrerriense Beds" located in the Salado Basin, for the Facies Balneario La Lobería of the Río Negro Formation and the Puerto Madryn Formation exposed at Cuevas Los Leones.

2 Numerical ages fall into five intervals: 1) 11.9–10.4 Ma; 2) 10.2–9.82 Ma; 3) 9.40–9.05 Ma; 4) 8.85–7.95 Ma; and 5) 7.50–6.00 Ma.

3 The first three intervals, stratigraphically coherent, allow discriminating the time of deposition of the entire Puerto Madryn Formation at its type locality (Península Valdés and surroundings of the city of Puerto Madryn). The dates of 11.9–10.4 Ma (Serravalian) for the lowest beds of the transgressive phase permit their correlation with the basal horizons of the unit exposed at Cueva de Los Leones. The dates of 10.2–9.82 Ma and 9.40–9.05 Ma constrain the entire highstand and the regressive phases to the Tortonian. The ages of 9.40 to 9.05 Ma are close to those of Zinsmeister et al. (1981) obtained by the $^{4}K/^{40}Ar$ from the beds we sampled at Bahía Cracker; they are herein correlated with the uppermost strata of the Barranca Final Formation exposed at the base of the section in its type locality.

4 The interval 8.85–7.95 Ma corresponds to the upper horizons of the "Entrerriense Beds" deposited in the Salado Basin, and so are younger than the previously proposed ages based on nannoplancton biostratigraphy. Our new ages suggest that the "Entrerriense Beds" in the Salado Basin correlate with the "Cape Fairweather Beds" and are slightly younger than the uppermost strata of the Puerto Madryn Formation.

5 The youngest units clustered in the interval 7.50–6.00 Ma, correspond to the Facies Balneario La Lobería, and the Paraná and Camacho formations. The ages we derive of 6.60–7.08 Ma for the Facies Balneario la Lobería (6.60–7.08 Ma) prove that sediments of this unit were deposited by the "Paranense" Sea, which is also corroborated by the presence of the *Aequipecten paranensis* Zone. It also correlates with the uppermost strata of the Barranca Final Formation exposed at the middle part of the section at its type locality, where the *Aequipecten paranensis* Zone has been recognized in this paper

6 The upper part of the Paraná Formation exposed in Paraná and Diamante is 6.67–7.50 Ma (Messinian), and so is much younger than thought previously.

7 Ages obtained for the Camacho Formation are younger than those estimated by Sprechmann et al. (2010), and their similarity with those obtained for the Paraná Formation supports the proposal of Martínez (1989) that, in the frame of a global similitude, the Paraná and Camacho Formations are more related between them than to the Puerto Madryn Formation.

8 Neither the early Miocene -earliest middle Miocene marine strata recorded in the Chenque Formation, nor the middle Miocene carbonate beds intercalated in the continental units of western and northwestern Argentina should be related with the latest Serravalian-Messinian "Paranense" Sea.

9 The maximum westward extension of the "Paranense" Sea would have reached Santa Fe Province and so precludes any western intracontinental connection with the Caribbean Sea during the late Miocene.

10 In reference to the southern extension of the sea, the studied rocks show continuous exposures of late Miocene deposits from the northern coast of the San Matías Gulf southwards to around the city of Trelew as proposed by Scasso and del Río (1987), and are recognized again in the "Cape Fairweather Beds", which represent the southernmost incursion of the "Paranense" Sea in Patagonia.

11 The duration of the *Aequipecten paranensis* Zone was 5.9 Ma and the Paranaian and Valdesian Molluscan Bioprovince were coeval for the last 2.35 Ma of that interval.

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