STRATIGRAPHY, TECTONIC AND PALEOGEOGRAPHY OF THE LOBERIA COASTLINE, SOUTHEASTERN BUENOS AIRES

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ABSTRACT

The Lobería coastline is dominated by cliffs cut by the inlets of creeks and rivers. These cliffs are the best place to study the relationships between the Cenozoic stratigraphic units that compose the Pampean Plain. Within the inlets, the fluvial deposits are integrated with the remains of the Quaternary sea-level variations. The present erosion of the cliffs is constantly providing fossils that made this area one of the most important sections for the Quaternary period in South America. Present contribution is an updated description considering the present knowledge about ages, a reinterpretation of the paleo-environments based on diatom assemblages, and the tectonic significance of these sequences in relation to other areas.

Keywords: *Stratigraphic units, Paleogeography, Lobería.*

RESUMEN: *Estratigrafía, tectónica y paleogeografía de la línea de costa de Lobería, sudeste de Buenos Aires.* La costa de Lobería está dominada por acantilados cortados por las desembocaduras de arroyos y ríos. Estos acantilados son los sitios ideales para el estudio de la relaciones entre las unidades estratigráficas depositadas durante el Cenozoico en la planicie pampeana. Dentro de estas desembocaduras, los depósitos fluviales están interdigitados con los remanentes de las variaciones cuaternarias del nivel del mar. La erosión de los acantilados provee constantemente restos fosilíferos que hicieron de esta área una de las secciones más importantes del Cuaternario de América del Sur. La presente contribución es una descripción actualizada del conocimiento de la edad de estos depósitos, la reinterpretación de los paleoambientes basada en las asociaciones de diatomeas, y el significado tectónico de estas secuencias en relación a otras áreas.

Palabras clave: *Unidades estratigráficas, Paleogeografía, Lobería.*

INTRODUCTION

The southern coast of Buenos Aires Province between Mar del Plata and Necochea, formerly named the Lobería coastline (Fig. 1), comprises the outcrops of scattered pampean sediments composing erosive cliffs, difficult to correlate but very important for their content in mega and micromammals. These cliffs are located (from east to west) at: Chocorí inlet, Bellamar and Centinela del Mar, in General Alvarado County, and Moromar and El Moro, in the Lobería County. Frenguelli (1928) already described some of these cliffs (Miramar, Chocorí, Bellamar, Centinela del Mar), which have been continuously providing fossil remains; therefore it became necessary for us to redefine some limits between the stratigraphic units, analyzing more precisely ages and facies.

The aim of this paper is to report specific descriptions, thicknesses, and grain-size data from the different stratigraphic units. Also, paleoenvironments defined by Frenguelli (1928) are reinterpreted based on their diatom-assemblages content. As Frenguelli (1928) already proposed a tectonic uplift for the coastline between Mar del Plata and Miramar, while no uplift seemed evident from Miramar to Necochea, another purpose was to use the leveling of the different Plio-Pleistocene units in order to obtain evidence to analyze the tectonic behavior of this coastline during the Quaternary.

STRATIGRAPHIC REFERENCES

The stratigraphy of this portion of the Buenos Aires coastline has been a matter of controversy due to several factors:

Preconceptions of some authors

Several authors arrived to the area with stratigraphic models conceived previously from other regions, or other continents. Frenguelli (1928) constructed a stratigraphic framework for this southern coast of Buenos Aires; later he changed significantly his scheme proposing a model based on pluvial and inter-pluvial intervals (Frenguelli 1950).

Kraglievich (1952) constructed a stratigraphic column for the Chapadmalal-Miramar cliffs, without considering the Upper Pleistocene transgression although he mentioned it as present in the region (Table 1). Later, he incorporated evidences from the northern coast of Mar del Plata, and finally he reinterpreted these units *when he came* to know the Centinela del Mar sequence bearing the evidences of the Upper Pleistocene transgression (1959).

Ancient paleontologists used to collect mammal bones from the cliffs without a careful stratigraphic or taphonomic control. Unfortunately, some concepts based on fossils should be reviewed as some

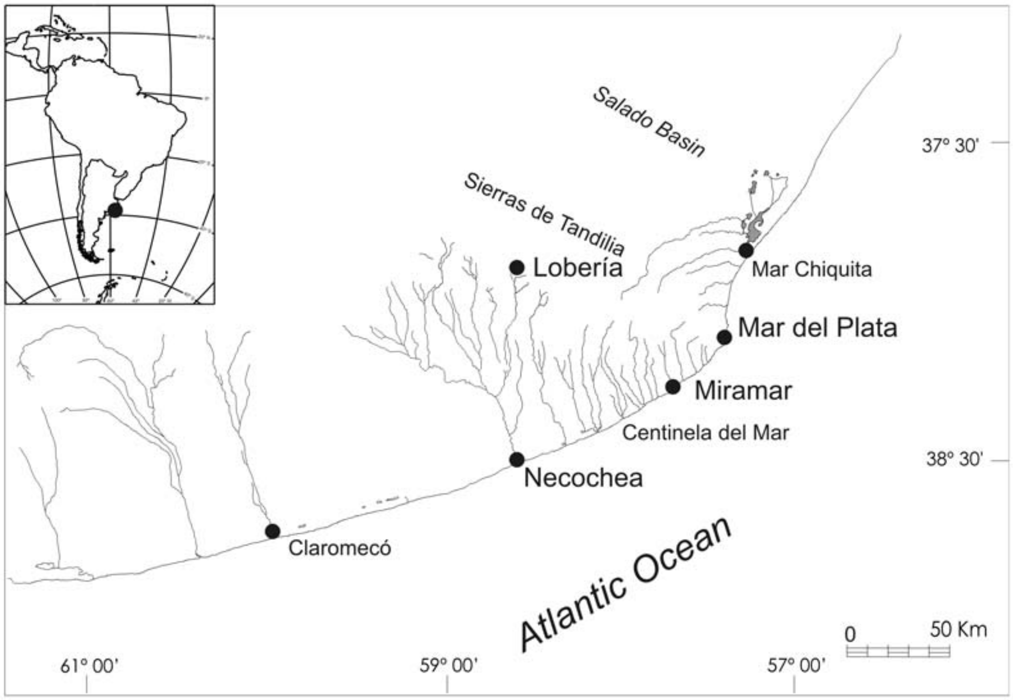

Figure 1: Location map.

bones could have been transported, e.g. the fluvial facies from the Lobería or Miramar formations. Some mammal groups (milodontids, *Paedotherium*, rodents) used to construct caves and therefore their bones could be stratigraphically transgressive, in other words younger bones in older host sediments. For example, the xenarthra bones found within the littoral eolianite corresponding to the oxygen isotopic stage (OIS) 5e (Sangamonian, Belgranense) of Centinela del Mar belong to specimens that once lived when the sandstone was already consolidated.

TABLE 1: Stratigraphic scheme, dominant facies and maximum thickness for the coastal cliffs extending from Mar del Plata to Necochea*

Age	Lithostratigraphic units	Chronostratigraphic units	Dominant facies	Thickness (m)
Upper Pleistocene	Lobería	Lujanense	floodplain	5
Upper Pleistocene	Arroyo Seco	Bonaerense	subaerial	8
Upper Pleistocene	Santa Isabel (Malacara)	Belgranense	coastal barrier	6
Middle Pleistocene	Miramar	Ensenadense (E) cuspidal	floodplain	3
Lower Pleistocene	San Andrés	E (Sanandresense)	floodplain	6
Lower Pleistocene	Vorohue	E (Vorohuense)	fluvial	5
Upper Pliocene	Chapadmalal	Chapadmalense	subaerial	25

*) Modified from Frenguelli 1928, Kraglievich 1952, 1959, and Zárate and Fasano 1989).

Confusion about some units

Informal "Mammal-stage units" (Pascual *et al.* 1965) have been usefully introduced to identify some units bearing macrofossils, but these units initiated a controversy between paleontologists and geologists as similar names have been assigned to chronostratigraphic units (Ameghino 1889, Frenguelli, 1928, Tonni *et al.* 1996, between others) A circular reasoning was originated: fossil remains led to the age of unit, but later the age of the unit conditioned new fossil discoveries.

In the last years, both units (chronostratigraphic and litostratigraphic) have been changing in different directions in relation to new evidences and/or new datings. Biostratigraphic criteria characterized by fossil assemblages were introduced (Cione and Tonni 1995), and they are subject to change when new datings could be assigned.

Overestimation of useful criteria

Several authors attempted to discern the Pampean stratigraphy introducing some useful criteria. For Kraglievich (1952, 1959), colors and grain sizes were the main tools to apply. An improvement was the concept of lateral facies that could repeat in the sequence (Frenguelli 1928); for example, similar greenish sediments could have been confused between the Lobería Formation (also the Camet Norte facies in the sense of Fasano *et al.* 1984), the *pre-Belgranense* deposits (Frenguelli 1928), or the San Andrés formation (Kraglievich 1959). Different types of caliche concretions permit to discern some litostratigraphic units at the Chapadmalal-Miramar coast (Teruggi *et al.* 1974, Tonni and Fidalgo 1982). The regional character of some paleosoil levels has been also used satisfactorily (Fidalgo *et al.* 1972, Zárate and Fasano 1989).

SETTING

The *Pampa Interserrana* ("plain between ranges") extends between the ranges of Tandilia and Ventania (Fig. 1). Recently, the 9 km thick Claromecó Basin has been defined between both ranges, considering a certain potential for oil production (Lesta and Sylwan, 2005), and related to the Karroo Basin, Southern Africa (Ramos and Kostadinoff, 2005). As the cliffs of this undulated plain discontinuously appear along the coast, they were assumed to record the tectonic component of the region during the Quaternary. Close to the coast, the undulations are caused by the differential erosion of the more important fluvial valleys (Chocorí, Pescado, Nutria Mansa, Malacara, El Moro). Some of these old streams converge in the Quequén Grande valley of assymetric development (Teruggi *et al.* 2005) caused by a fluvial capture during the end of the Pleistocene (Cortizo and Isla 2000).

METHODS

Topographic surveys (teodolite and rule) were conducted to precise some stratigraphic limits (Centinela del Mar, Punta Hermengo). Cliff outcrops were positioned by GPS. Detailed digital photography helped to compare some units between distant outcrops. Sediments were sampled at the *pre-Belgranense* and *Belgranense* units. Diatom data from Frenguelli (1926) were updated using synonyms reported by Stoermer *et al.* (1999). Their ecological affinities were related to salinity tolerances, and habitats were analyzed from several references (De Wolf 1982, Denys 1991 and 1992, Vos and De Wolf 1993).

RESULTS

Stratigraphic units

Schematic profiles from the cliffs were described in order to understand the behavior of the pampean sedimentation along this coastline (Fig. 2).

Chocorí estuary (38°23'38"S; 58°05'39 "W)

East of the Chocorí estuary, the base of the cliffs is composed of 2.4 m of compact green silts bearing bone remains and calcrete-filled cracks. Upwards, a layer (0.8 m thick) of silt clasts of similar composition of the matrix, bearing calcrete levels ends in a paleosoil. On top, the sequence continues with 2.4 m of a brownish diamicton with pedogenized levels on top. 1.5 m of a greenish diamicton with caliche nodules continues (OIS 5e). These deposits were similar to those outcropping at Punta Hermengo (Fidalgo and Tonni 1983). The top of the Pampean sequence ends with calcrete levels where rounded sand grains denote the *Belgranense* transgression.

Estancia Bellamar (38°24 04" S; 58° 06' 47"W)

These cliffs initiate with 4 m of sandy silts with caliche clasts at the base, and a calcrete level on top. A 0.5 m thick level of a calcrete and large clasts continue. Towards the top, there is 1.1 m of greenish silty sands (*pre-Belgranense*). The top of the sequence is composed of a sandstone 0.3 m thick containing shell remains (*Belgranense* in the sense of Isla *et al.* 2000). A poor-selected (1.16) medium sand (1.83 phi units) was sampled; 60% was composed of calcium carbonate. *Gliptodon* remains *were recognized within* the sands (Fig. 3).

Centinela del Mar (38°26'51"S; 58°14' 42"W)

Centinela del Mar is well known among paleontologists (Tonni *et al.* 1987, Scanferla *et al.* 2005, De los Reyes *et al.* 2006, Cenizo and De los Reyes, 2008, Báez *et al.* 2008), archaeologists (Cione *et al.* 2003), and geologists (Parodi and Parodi Bustos 1952, Isla *et al.* 2000, Schultz *et al.* 2004). In the year 2008 the site was declared of geologic and paleontologic interest by the General Alvarado authorities. Its importance obeys to the presence of coastal dunes of Upper Pleistocene age; stratigraphicly pointing to the OIS 5e, and therefore indicating a worldwide known event. Six profiles were surveyed at this locality (Fig. 4).

Compact brownish siltstones initiate the base of the cliffs, bearing calcrete levels and clasts of that carbonatic composition, with a conspicuous and extended level of a breccia, also composed of caliche. Within the profiles of the east (4 to

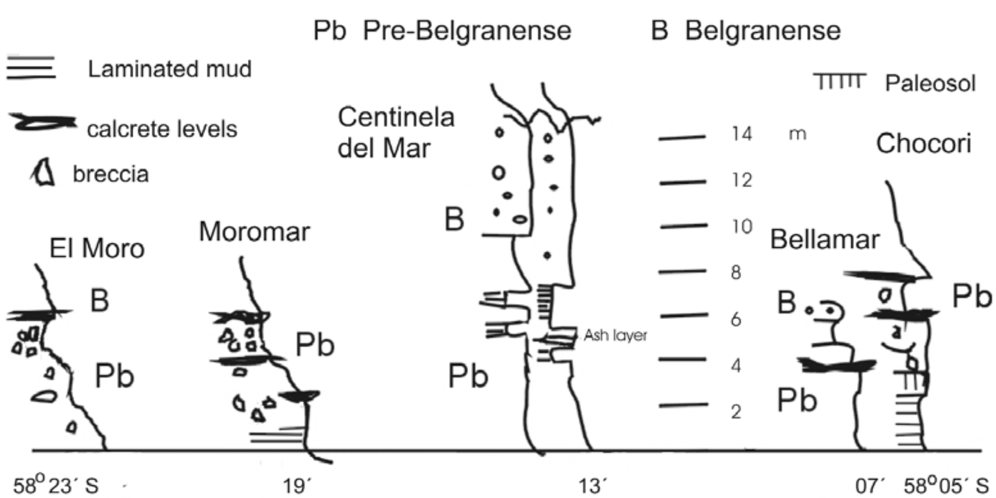

Figure 2: Schematic profiles of the Buenos Aires coastal cliffs between 58°05' and 58°23'W.

Figure 3: Inverted carapache of glipto-dontid in the *Belgranense* sandstone at Bellamar

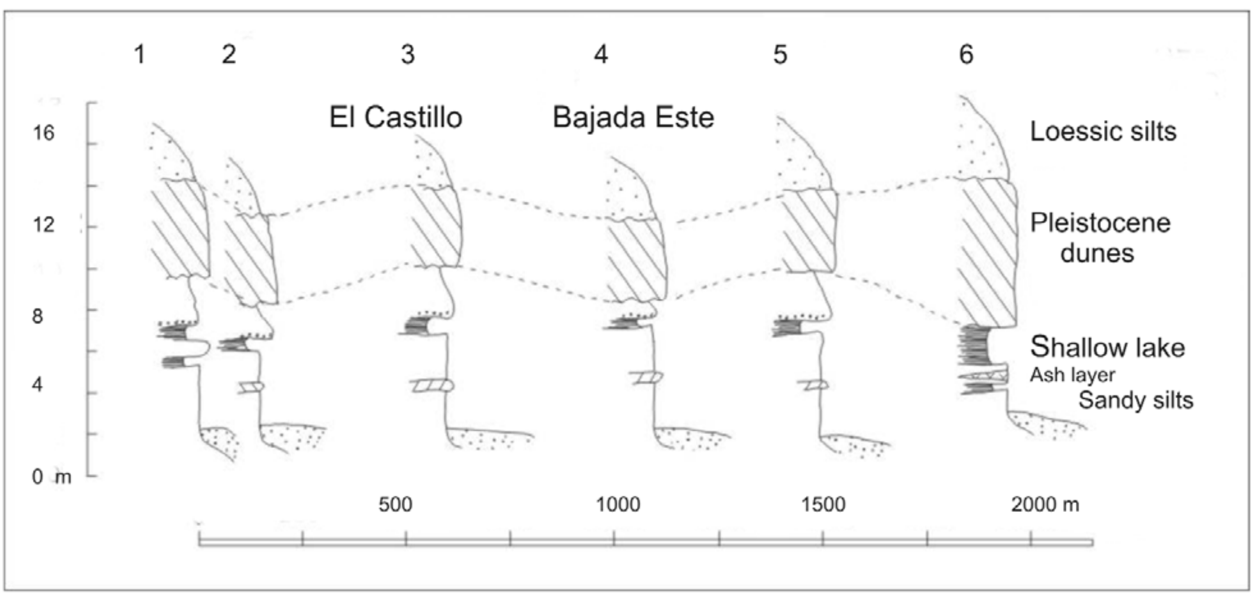

Figure 4: Schematic profiles of the Centinela del Mar cliffs (modified after Isla *et al.* 2000).

6), there is an ash layer that reaches a maximum thickness of 0.5 m. Volcanic sand grains, to the top of this package, are suggesting the *pre-Belgranense* levels defined by Frenguelli (1928); in other words, they are demonstrating the presence of an eolian supply of rounded grains related to the OIS 5e coastline.

The second major unit is recognized by laminated greenish silts, containing a diamicton on top. The greenish silts were interpreted as deposited into a shallow-water body. To the west of these outcrops, the greeninsh silts are also covering the diamicton.

The tirth unit is the characteristic and continuous layer of tabular crossbedding composed of sand grains with pieces of shells. These eolianites constitute a coastal sand barrier, composed of poor-selected (1.23-1.36) fine to medium sand (1.5-2.13 phi units) with a 50% content of calcium carbonate. Coastal dunes have migrated from west to east. Foresets have

recorded dips to the east in profiles 3 (N 90º- 110º) and 6 (N 110º-120º), but also to the northwest in profiles 1 (N 295º-350º) and profile 4 (N 350º- 40º). Maximum slopes of the foresets have been recognized at the center of the cliff, becoming more gentle to the east (Fig. 5 a).
Gliptodontid caves from Upper Pleistocene times are excavated within this coastal barrier sandstone (Fig. 5 b). Some of them are very good preserved because it was dug in sand that previously turned into an eolianite. At this locality Frenguelli (1928) did not find the loessic facies of his Basal Ensenadense units; therefore, he assigned most of the sequence to the *pre-Belgranense* (along the Chapadmalal cliffs, he also considered all the sequence of Punta Vorohué as deposited before the OIS 5e). On the other hand, in his visit to Centinela del Mar, Kraglievich (1959) realized that his formations Vorohué and San Andrés (described in 1952) should be considered only one. He also realized that the sandstones on top of the cliffs correspond to interglacial coastal dunes (Kraglievich 1959).

Moromar (38°28'39"S; 58°19'12"W)
The sequence initiates with massive brownish silts composing the foot of the cliffs and also the abrasion platform. Large caves have been recognized there. Laterally, there is a stratified shallow pond (Fig. 6 a) with escoria (material produced by the impact of a small body in the surroundings; Schultz *et al.* 2004) and convolute bedding to the top. This pond is dipping eastwards. The top of this layer ends with calcrete levels. Upwards, a layer of about 2.5 m is composed of massive silts (laminated and burrowed at the base) with irregular clasts of caliche; laterally there are diamictons, some of them carrying escoria remains. Trough cross-beds, assymptotic to the base, are suggesting point-bar migrations (Fig. 6 b). The top of this thick package ends in a calcrete level. Over this level, the stratum is 2 m thick and consists also of a diamicton deposit with caliche pebbles. At the base, a calcrete level constitutes a paleosoil. The top of the sequence is also composed of calcrete with horizontal and vertical directions of growth.

El Moro (38°31'38"S; 58°18'26"W)
In this place, the Pampean sequence outcrops not far from the beach. About 1 m of a brownish diamicton, in a matrix of silt, has many calcrete levels. The uppermost calcrete level is an intraformational breccia containing rounded grains of volcanic composition, thus suggesting a supply from the Sangamonian aeolian barrier. These deposits are very common in the region and composed the top of many cliffs, as those cropping out further west at Punta Negra, Necochea (Frenguelli 1928).

Facies interpretations
Pre-Belgranense deposits from the Miramar cliffs were reinterpreted from the samples collected at Punta Hermengo by Frenguelli (1926; these deposits were called Miramar formation by Kraglievich 1952) Based on the presence of some marine diatoms he proposed a marsh for these facies. Freshwater and epiphitic taxa as *Epithemia adnata* were the most abundant at the three levels. Epiphitic (living over macroalgae or aquatic plants) and benthic assemblages are characteristic of low-energy environments as ponds or very shallow lakes. The marshes proposed by Frenguelli are therefore questioned in regard to sedimentological evidences and a new interpretation of his diatom assemblages. However, and considering pre-sent knowledge of the habitats and salinity tolerances of these fossil diatoms these deposits have evolved in fresh to brackish water (Table 2).

Paleogeography
120,000 years ago, when the sea level was approximately 6 m over present MSL, the coast of the Argentine Pampas was completely different. There were beaches within the Río de la Plata embayment; remains of these beaches persist at the base of Belgrano cliffs (Buenos Aires city) and Pipinas (Magdalena County). These paleobeaches of Belgrano gave the name of the *Belgranense* highstand related to the Sangamonian Interglacial or the Oxygen Isotopic Stage (OIS) 5e. The present Samborombón Bay was another wide embayment with beaches emplaced close to the present Pascua Bridge (Fidalgo *et al.*, 1972). The La Plata Bank is a submerged relict of that *Belgranense* shoreline at the inlet of the Río de la Plata (Isla and Madirolas 2009). There were also beaches close to the western coast of the present coastal lagoon of Mar Chiquita (Isla *et al.* 2000). The coast extended seawards from the present coastline protruding on top of the southern blocks of the Sierras de Tandilia (Banco Pescadores, Mar del Plata). Coastal deposits were closer to present at the southern coast of Buenos Aires: beaches were surveyed at the interior of the Quequén Grande estuary, a coastal barrier at Centinela del Mar and beaches at Claromecó. *Belgranense* eolianites, extending from Punta Mogotes to Centinela del Mar, are today interpreted as former sand barriers that became indurated (Isla *et al.* 2000). Embayments occurred at the present delta of the Colorado River and San Antonio Bay (Fig. 7 a).
21,000 years ago, the sea level was at its minimum level in coincidence with the maximun glaciation phase. Rivers of high discharge (Negro) were crossing the emerged land; other rivers collected water from the foot of the former *Belgranense* cliffs (Fig. 7 b). Channels of the Paraná System diverted within the Río de la Plata valley but were displaced to the north (Cavalotto 2002, Cavalotto and Violante, 2005). Silty dunes installed where there was plenty of mud and the low water table permitted the deflation of ponds within the plain dominated by silt (Schnack *et al.* 1982).
10,000 years ago, the sea level was rising (Fig. 7 c). An increase in precipitation promoted the incision of some valleys. Floods characterized this *Lujanense* unit (in the sense of Zárate *et al.*, 1998), and would have restricted the migration of the larger herbivorous megamammals (Isla 2002). A higher water table would

Figure 5: a) Base of dunes of OIS 5e age, migrating over a shallow pond. b) Paleocave within the *Belgranense* aeolian deposits.

have induced the development of the extended paleosoil Puesto Callejón Viejo (Fidalgo *et al*., 1972, Zárate *et al*. 1998).

6,000 years ago, the mid-Holocene highstand of the sea level was about 3 m higher than present (Isla *et al*. 1986). Beach deposits extended from Mar Chiquita to the north (Fig. 7 d), entering along the embayments of Samborombón Bay and

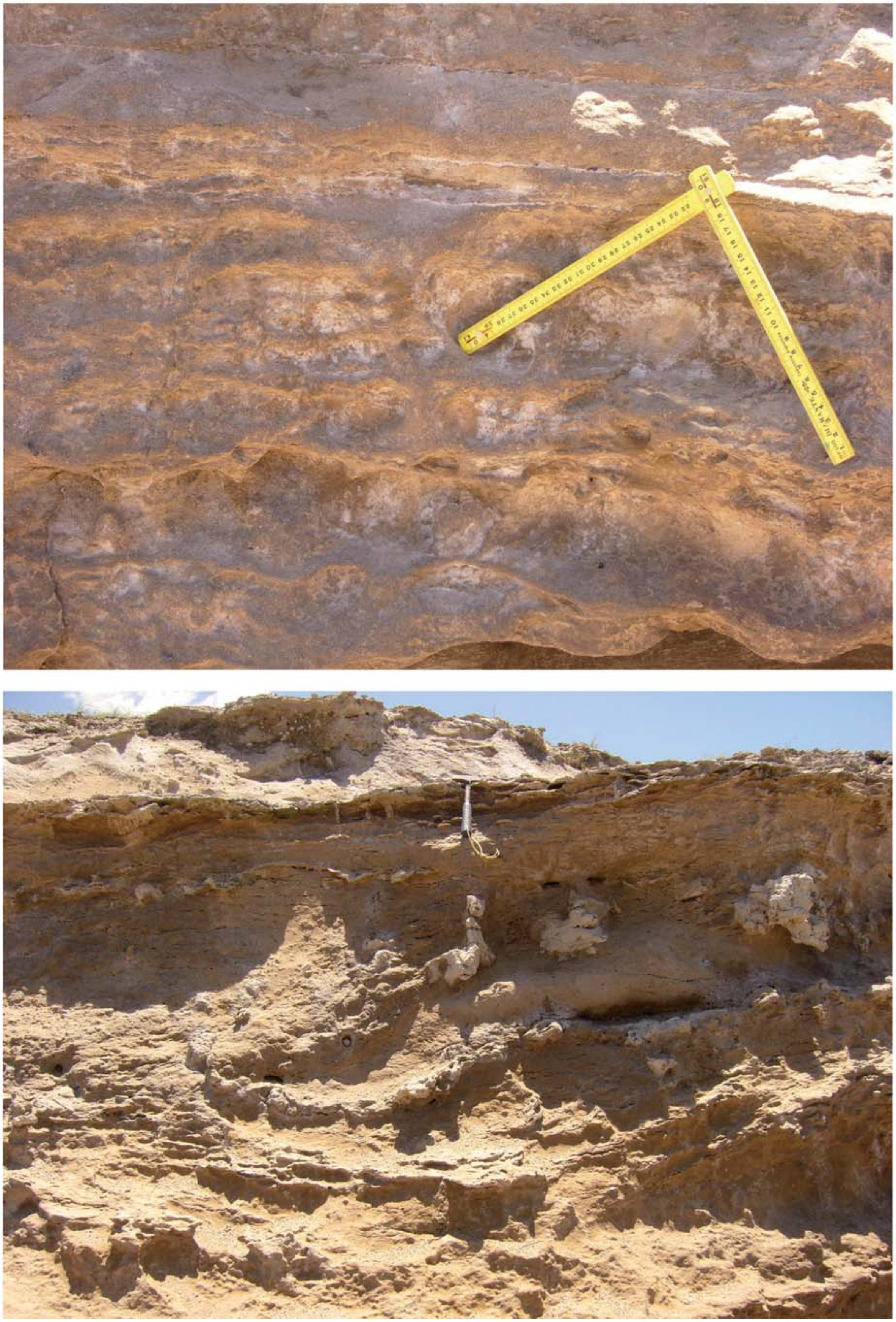

Figure 6: a) Stratified muds with convolute bedding from a shallow pond from the base of the Moromar cliff (Vorohue Formation). b) Point-bar structure at the lower Pleistocene deposit of El Moro cliff.

Río de la Plata valley (Cavalotto 2002). At the Lobería coastline, this Holocene transgression is preserved as infilled estuaries: Las Brusquitas, Punta Hermengo, La Ballenera, Quequén Grande (Isla *et al*., 1986). The Quequén Grande River had already captured the creeks Pescado Castigado, El Chancho, Diamante, Calengueyu, Calaveras, Dulce, Quequén Chico, Quelacintá, de las Mostazas, de los Huesos y Tamangueyú (Cortizo and Isla 2000, Isla *et al.* 2005).

Tectonic

Side-scan surveys performed offshore Arenas Verdes and Quequén indicated that the basal units composing the abrasion platforms continue to depths of more than 15 m. These rocks cropping out at the inner shelf are more modern than those outcropping at the inner shelf between Miramar and Mar del Plata (*Chapadmalalense*, in the sense of Parker *et al.* 2002). The level where it is possible to discern between the *pre-Belgranense* units and the base of the *Belgranense* units occur close to the altitude of 6 m. This is in accordance to worldwide accepted OIS 5e maximum sea levels (Isla *et al.* 2000), and therefore indicating tectonic stability west of Miramar city. This stability is contrasting with the uplifted rates proposed to the east. A horst was assumed between Miramar and Mar Chiquita based on the post-*Chapalmalalense* uplift (Kraglievich 1952). Submergence was suggested for the blocks extending towards the Salado Depression (Parker *et al.* 2002). Comparing the levels reached by the postglacial transgression, a tectonic uplift was considered for the sequence of Las Brusquitas creek (Isla *et al.* 1986).

TABLE 2: Diatom content from the pre-Belgranense stage of Miramar*

Taxon	M205	M219	M220	Habitat	Salinidad
Amphora copulata (Kütz.) Shoem & Arch.	f	r	r	B	OI
Cocconeis placentula var. lineata (Ehr.) Van Heurck	f	f	s	E	OI
Epithemia adnata (Kütz.) Bréb.	p	a	f	E	OI
Epithemia adnata var. porcellus (Kütz.) Patr.	r	f	f	E	OI
Epithemia adnata var. proboscidea (Kütz.) Patr.	f	s	s	E	OI
Epithemia adnata var. saxonica (Kütz.) Patr.	f	r	f	E	OI
Gomphonema subclavatum Grunow	f	r	-	E	OI
Staurosira construens var. venter (Ehr.) Ham.	f	r	r	T	OI
Fragilariforma virescens (Ralfs) Will. & Round	f	-	-	T	OI
Craticula cuspidata (Kütz.) D. Mann	r	f	f	aer	OI
Cyclotella meneghiniana Kütz.	f	r	s	T	OH
Denticula elegans Kütz.	f	f	s	B	OH
Navicula megacuspidata var. pampeana (Freng.) Luchini & Verona	f	s	s	B	OH
Navicula peregrina (Ehr.) Kütz.	f	s	s	B	M
Anomoeoneis sphaerophora var. sculpta O.Müll.	f	r	r	B	M
Nitzschia granulata Grun.	-	s	a	B	M
Nitzschia vitrea Norm.	-	f	r	aer	M
Surirella saxonica Auers.	f	r	-	B	
Achnanthes coarctata Bréb.	-	r	r	aer	OI
Amphora veneta Kütz.	r	r	-	B	OH
Campylodiscus clypeus Ehr.	e	s	r	B	M
Cocconeis placentula Ehr.	r	r	s	E	OI
Cyclotella striata var. subsalina (Grunow) Hustedt	-	r	-	T	M
Cymbella cymbiformis Ehr.	s	r	-	E	OI
Epithemia turgida (Ehr.) Kütz.	r	-	-	E	OI
Rhopalodia gibba (Ehr.) O. Müll.	r	r	-	E	OI
Rhopalodia gibba var. ventricosa (Kütz.) H. & M. Perag.	s	r	s	E	OI
Rhopalodia gibberula var. vanheurckii O. Müll.	r	r	r	E	M
Epithemia adnata var. elongata (Kütz.) Patr.	s	s	r	E	OI
Eunotia pectinalis (O. Müll) Rab.	r	-	r	E	OI
Eunotia pectinalis var. minor (Kütz.) Rab.	r	-	-	E	OI
Eunotia pectinalis var. ventricosa Grun.	e	-	-	E	OI
Staurosira construens var. binodis (Ehr.) Ham.	r	r	r	T	OI
Staurosirella pinnata (Ehr.) Will. & Round	r	-	-	T	OI
Gomphonema augur Ehr.	s	-	-	E	OI
Gomphonema dichotomun Kütz.	r	-	-	E	OI
Gomphonema grunowii Patr.	r	-	-	E	OI
Gomphonema parvulum Kütz.	s	r	r	E	OI
Hyalodiscus subtilis Bailey	-	r	r	B	M
Aulacoseira granulata (Ehr.) Simons.	r	r	r	P	OI
Paralia sulcata (Ehr.) Cleve	s	r	r	T	Po
Pinnularia abaujensis (Pant) Ross	r	-	-	aer	
Neidium affine (Ehr.) Pfitz.	r	-	-	B	OI
Craticula ambigua (Ehr.) D. Mann	-	-	e	B	

DISCUSION

The sediments outcropping below the OIS 5e Interglacial deposits are here grouped in the term *pre-Belgranense* as suggested by Frenguelli (1928), and accepted later by Kraglievich (1959) when he could not differentiate Vorohué and San Andrés formations in Centinela del Mar. Some controversy is derived from the environments where the San Andrés formation was deposited. Kraglievich defined it as "totally subaerial" without any fluvial or alluvial process and composed of fine sand (levels I and III), with calcrete levels becoming dominant at the levels II and IV (1952). However, Zárate and Fasano (1989) clearly described the San Andrés deposits as belonging to floodplain facies composed of clayey siltstones, with lenses of sandy siltstones in 3D crossbeds. Sedimentation would have taken place in shallow ponds. Vorohue formation is, on the other side, characterized by megascale asymptotic crossbeds composed of siltstones and suggesting clearly point-bar facies underlying San Andrés units (Zárate and Fasano 1989). Both facies are interfingered along the

Continues table 2

Taxon	M205	M219	M220	Habitat	Salinidad
Pinnularia borealis Ehr.	-	x	x	aer	OI
Navicula crucicula Smith Donkin	r	-	-	B	M
Neidium dilatatum (Ehr.) Cleve	r	-	-	B	OI
Pinnularia divergens var. elliptica (Grunow) Cleve	r	r	-	B	H
Caloneis westii (Smith) Hendey	-	r	-	B	M
Hippodonta lueneburgensis (Grunow) Lange-Bert., Metzeltin & Witkowski	r	-	-	B	OI
Neidium iridis Ehr.	r	-	-	B	OI
Neidium iridis var. amphigomphus (Ehrenb.) A.Mayer	r	-	-	B	OI
Pinnularia legumen (Ehr.) Ehr.	r	-	-	B	OI
Pinnularia maior (Kütz.) Rab.	s	-	-	B	OI
Anomoeoneis polygramma (Kütz.) Pfitz.	-	r	s	B	OH
Sellaphora pupula (Kütz.) Meresch	r	-	-	B	OI
Sellaphora rectangularis (Greg.) Lange-Bert. & Metzeltin	r	-	-	B	OI
Fallacia pygmaea (Kütz.) Stickle & D.G.Mann	e	-	-	B	OI
Anomoeoneis sphaerophora (Kütz.) Pfitz.	s	s	r	B	OH
Pinnularia stauroptera (Grun.) Rab.	s	-	-	aer	
Caloneis ventricosa (Ehr.) Meist.	e	r	r	B	
Pinnularia viridis (Nitz.) Ehr.	s	s	r	aer	OI
Nitzschia amphibia Grun.	r	-	-	E	OI
Hantzschia amphioxys (Ehr.) Grun.	r	-	r	aer	OI
Hantzschia amphioxys var. vivax Grun.	r	-	-	aer	OI
Nitzschia brebissonii W. Sm.	-	r	r	B	OH?
Nitzschia palea (Kütz.) W. Sm.	r	-	-	aer	OI
Nitzschia sigma var. rigida (Kütz.) Grun.	s	r	-	B	M
Hantzschia spectabilis Ehr. Hust.	s	r	r	B	M
Tryblionella tryblionella (Hantz) Proch.	s	r	-	B	OH
Nitzschia vitrea var. salinarum Grun.	e	r	-	aer	M
Stauroneis acuta W. Sm.	r	r	r	B	OI
Stauroneis anceps Ehr.	r	-	r	aer	OI
Stauroneis phoenicenteron (Nitz.) Ehr.	s	r	-	B	OI
Stauroneis phoenicenteron fo. lanceolata (Kütz.) Brun.	r	-	-	B	OI
Stephanodiscus astraea (Ehr.) Grun.	r	-	e	P	OI
Surirella biseriata Bréb.	s	-	-	B	OI
Surirella fortii Freng.	r	r	r	B	
Surirella inducta Schm	r	r	e	B	
Surirella striatula Turpin	x	r	r	B	M
Ctenophora pulchella (Ralfs ex Kütz.) D.M.Williams & Round	r	-	-	E	M
Synedra ulna var. danica (Kütz.) VanHeurck	r	r	r	E	OI
Synedra ulna var. obtusa (W.Sm.) Grunow	r	-	-	E	OI

*) Reinterpreted from Frenguelli (1926). References: p: dominant, a: abundant, f: frequent, s: scarce, r: uncommon, e: very scarce, x: accidental. B: benthic, aer: aerophilous, E: epiphytic, P: planktonic, T: tychoplanktonic, Po: polihalobous, M: mesohalobous, OH: oligohalobous hallophilous, OI: oligohalobous indifferent, H: hallophilous.

cliffs of Lobería, but the expected overlying of shallow-water pond facies on top of point-bar facies does not occur.

A marsh is a shallow depression subject to tidal effects and colonized by hallophilous plants. In Patagonia, salt lakes are colonized by salt-tolerant plants but without any tidal effect. Frenguelli (1926) defined marsh facies for the green silts composing the cliffs of Punta Hermengo at Miramar (today these deposits are mostly behind a coastal-wall defense). Although some marine diatoms were recognized, the assemblage is more biased towards brackish/fresh water (Table 2). In this sense, the Punta Hermengo deposit is not related to a marine connection, as the facies of Centinela del Mar and Claromecó.

CONCLUSIONS

Some guidelines to recognize stratigraphic units in the Lobería coastline should be avoided or taken with care (colors, textural-based facies, calcrete levels or their abundance). The use of some regional paleosoils, sea-level highstands, ash layers or impact evidences are better indicators.

The undulation of this plain was dominantly caused by fluvial differential erosion. An uplifting trend is recorded in coincidence to the Tandilia Range, where the *Chapadmalalense* units are several meters uplifted, and the Holocene estuarine facies at a higher altitude. Out of the domain of the Tandilia Range, there is no significant altitude difference in the Pampa Interserrana sequence along the coastline, indicating no major tectonic effects since the deposition of the sequence.

Although the coastal barrier corresponding to the oxygen isotopic stage 5e is recorded at Centinela del Mar -as rounded sand grains (composed of volcanic rocks) on top of the cliffs-, this Upper Pleistocene barrier is similarly related to the coastal cliffs at Chocorí inlet and Punta Negra.

The *pre-Belgranense* deposits are interpreted in terms of their diatom assemblage contents as low-energy and shallow environments, fluctuating between fresh and brackish waters, but without any connection to coastal marshes.

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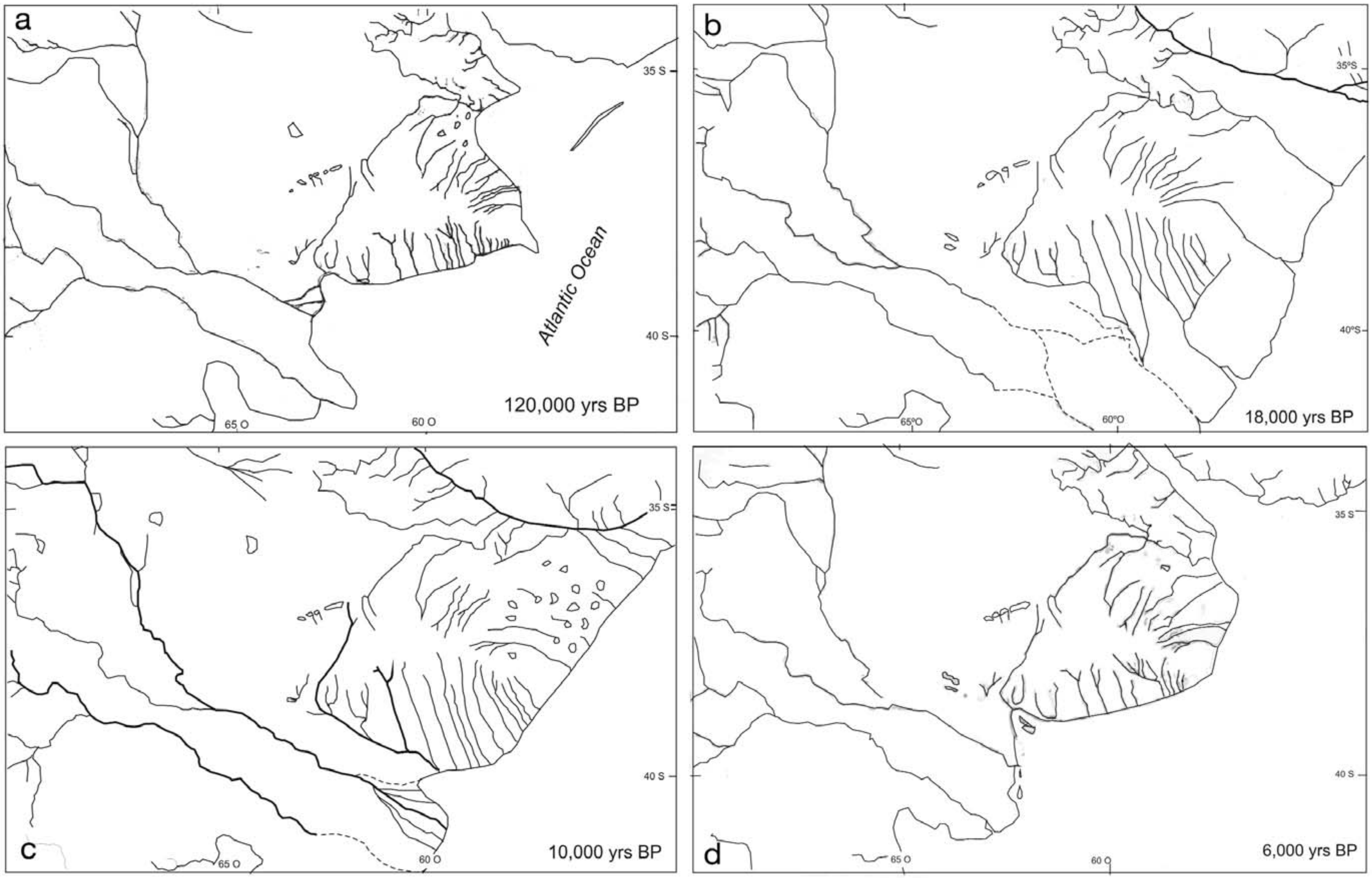

Figure 7: Paleogeographic maps of the Buenos Aires coastal plain a) 120,000 years BP; b) 21,000 years BP; c) 10,000 years BP; d) 6000 years BP (modified after Tonni *et al.* 1999).

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