

Quaternary ontogeny of a pampean 'laguna'

I. Sedimentological and biological characteristics of Lobos Lake sediments, Argentina *

Nauris V. Dangavs¹ & Adriana M. Blasi²

¹*Instituto de Geomorfología y Suelos, Universidad Nacional de La Plata, Argentina;*

²*Comisión de Investigaciones Científicas de la Provincia de Buenos Aires, Argentina; Present address: Instituto de Geomorfología y Suelos, UNLP. Calle 3 Nro. 584, (1900) La Plata, Argentina*

Accepted 29 December 1993

Key words: Quaternary, limnogeology, Pampean laguna, sedimentology paleoenvironments, marine sediments

Abstract

Our sedimentological study of Lobos Lake sediments has shown that, below modern deposits, there is a clastic and biological record of three different paleoenvironments: two aquatic (freshwater and mixohaline respectively) and one subaerial. This record documents the climatic and geomorphologic changes that affected the basin during its evolution up to its present water level, from the upper Pleistocene to the Holocene.

Introduction

Few sedimentological studies of modern pampean 'lagunas' have appeared in the limnological literature.

This paper, on the basis of geologic surveying in the Lobos Lake area, deals with the main sedimentary characteristics of this modern pampean 'laguna' basin, which are described in terms of vertical sedimentary sequences, textural facies and depositional environments. Furthermore, a reconstruction of the basin's development is presented, as it is useful not only for comparison with other Holocene 'lagunas', but also as an analogue to determine the origin of other Quaternary sequences.

Geological setting

Lobos Lake is an inland lake typical of the Pampean plains of Argentina. It is a permanent water body, regionally called 'laguna', corresponding to a third order

or polymictic lake, on the basis of its continuous circulation and absence of thermal stratification.

The lake, at 22.6 m above sea level, covers an area of 7.6 km². It is situated 115 km southwest of Buenos Aires City (37° 17'S and 59° 07'W) in an aeolian plain of low relief and very gentle slope (0.026%). The drainage system of Lobos Lake is 1720 km², and is a tributary of the Salado River of Buenos Aires Province (Fig. 1 and 2).

The regional climate is humid temperate, with a mean annual temperature of 15.6 °C and a regular distribution of the rainfall through out the year, with an annual mean of 902 mm. However, the hydrographic network is poorly developed, with a 71.3 km long collector, Las Garzas Creek and sixteen tributaries, which compose only twenty-two channels with a drainage density of 0.126 km km⁻². All these streams have been, to various extents, culturally modified. The lake is fed by rainfall and runoff. The seepage relationship with the groundwater regime has a double character (effluent - influent).

Water chemical characteristics show an oligohaline salinity range (2 g l⁻¹), with scarcely alkaline pH, high total hardness (420 mg l⁻¹), Mg/Ca: 4.9 and Cl/CO₃+HCO₃: 2.6. The distinctive features of its

* This is the seventh in a series of papers published in this issue on 'Paleolimnology in Southern South America'. Dr. C. A. Fernández served as guest editor for these papers.

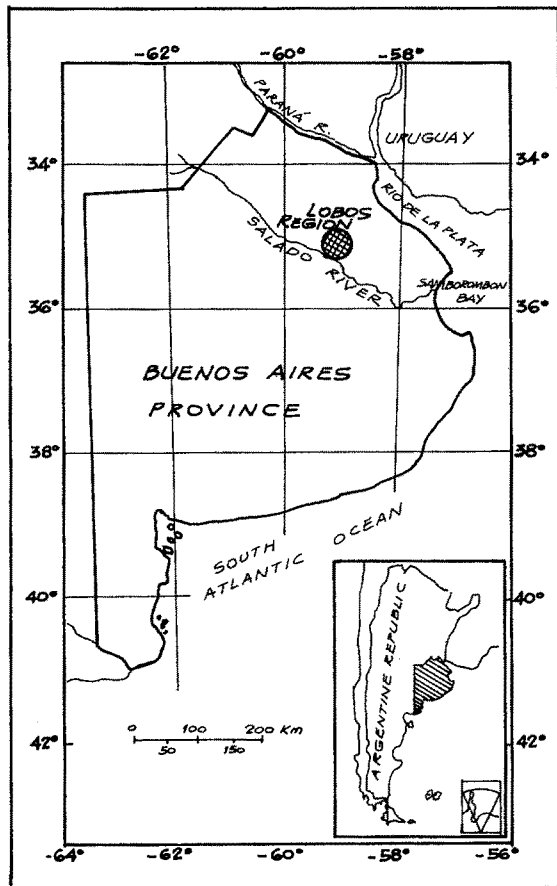


Fig. 1. Buenos Aires Province, Argentina. Lobos region location map.

chemical composition, according to Maucha's classification (Maucha, 1932) are: clorate sodic, sulfated, hemi to bicarbonated and hemi-magnesian water.

This aquatic environment is located in a basin ontologically related to hydrologic and aeolian processes with a progressive infilling of detrital and chemical materials. The initial 'wanne' shape was more than 7 m deep, but the present shallow 'pfanne' is only 2 m deep. Bluffs of variable height (0.3 to 4 m) composed of upper and late Pleistocene and Holocene sediments, are found around its coastal perimeter.

Stratigraphy

The regional landscape is developed in Quaternary terrains, whose main outcrops are found along the lake bluffs. Four lithostratigraphic units have been recognized; three making up bluffs and one along the shore

line (Fig. 4).

The oldest unit, correlated with the Ensenada Formation (Riggi *et al.*, 1986) of middle Pleistocene age, constitutes the lake bedrock. This unit, which is a slightly to strongly consolidated and carbonated, laminated or massive sandy siltstone, crops out at basal bluff section and lake beaches.

The second unit, the Buenos Aires Formation (Riggi *et al.*, *op. cit.*) of late Pleistocene age, is a loess mantle, 0.15 to 3 m thick, unconformably overlying the Ensenada Formation. It is mostly a friable sandy silt loess, containing scattered caliche nodules (Lösskindel).

The uppermost unit, the upper La Postrera Formation (Fidalgo, 1983), blankets the whole landscape. It is a Holocene vitroclastic loess mantle, up to 1 m thick, devoid of caliche nodules. Its thickness diminishes considerably below the alluvial deposits in the valleys outside the lake area. Present soils have developed on this unit.

The youngest subaereous unit in the area is the Alluvium, a discontinuous, poorly sorted, gravelly to clayey sediment found in lake beaches and fluvial channels. Besides, it occurs as the major conspicuous alluvial deposit at the lake bottom, where it is more than 1.3 m thick, (Blasi & Dangavs, 1992) (Fig. 4).

Sedimentary and biological paleoenvironmental record of the lake basin

The paleotopography of the primitive lake bed basin and the vertical sedimentary sequences were studied from cores of 40 boreholes reaching a depth of more than 6 m, which allowed us to analyze 5 m of infilling sediments, (Fig. 3).

The infilling sediments, constitute different superimposed sedimentary bodies (Fig. 4), which represent diverse paleoenvironmental depositional episodes that occurred in the basin throughout the development to the present water body. Thus, below the modern lake sediments, we have found the clastic and biological record from three different paleoenvironments: two subaqueous (freshwater and mixohaline) and one subaerial.

All sedimentary sequences have been modified by post-depositional intra-sedimentary gypsum precipitation that occurred during the maximum desiccation episodes of the basin under semi-arid conditions (Dangavs & Blasi, 1992a).

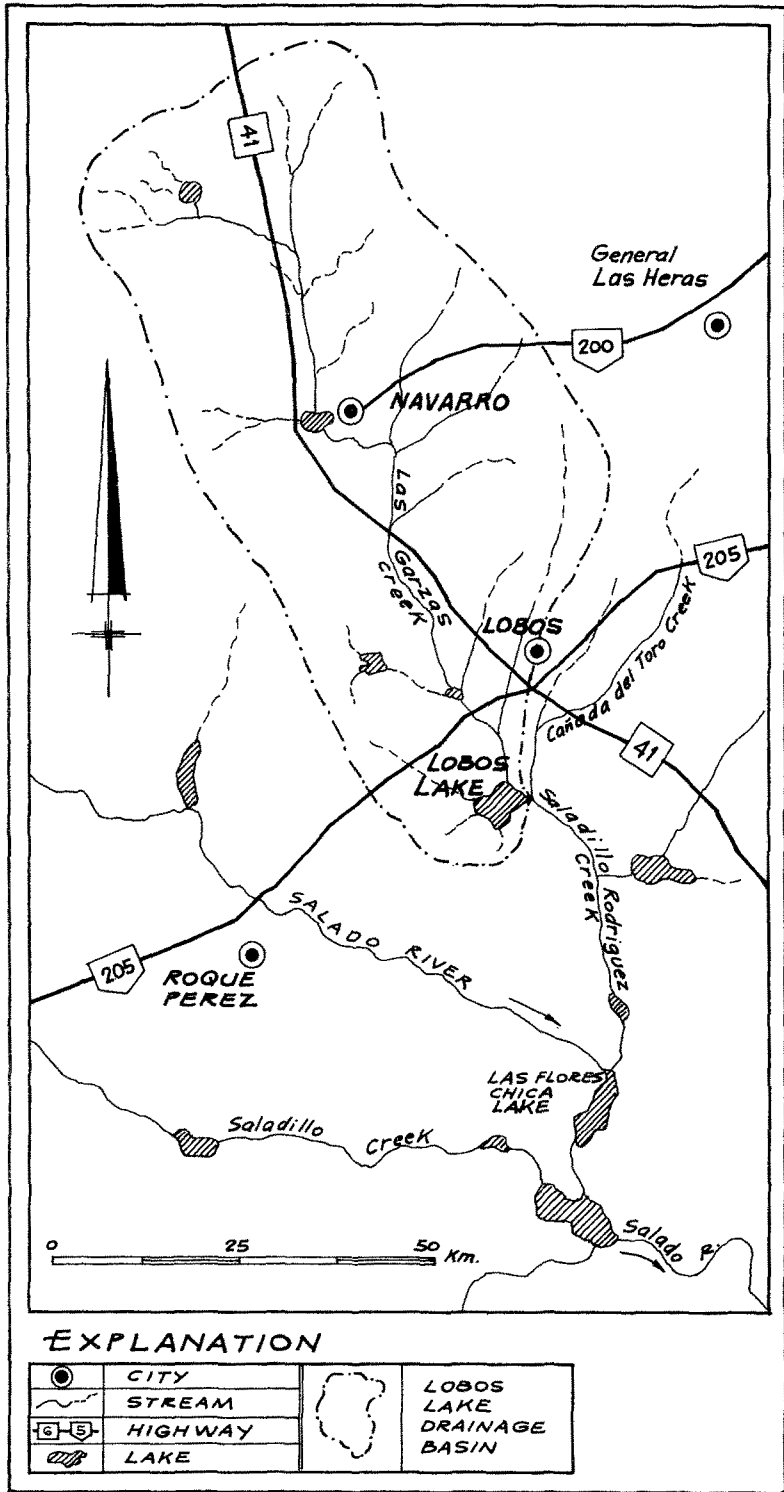


Fig. 2. Location map of Lobos Lake and its drainage basin.

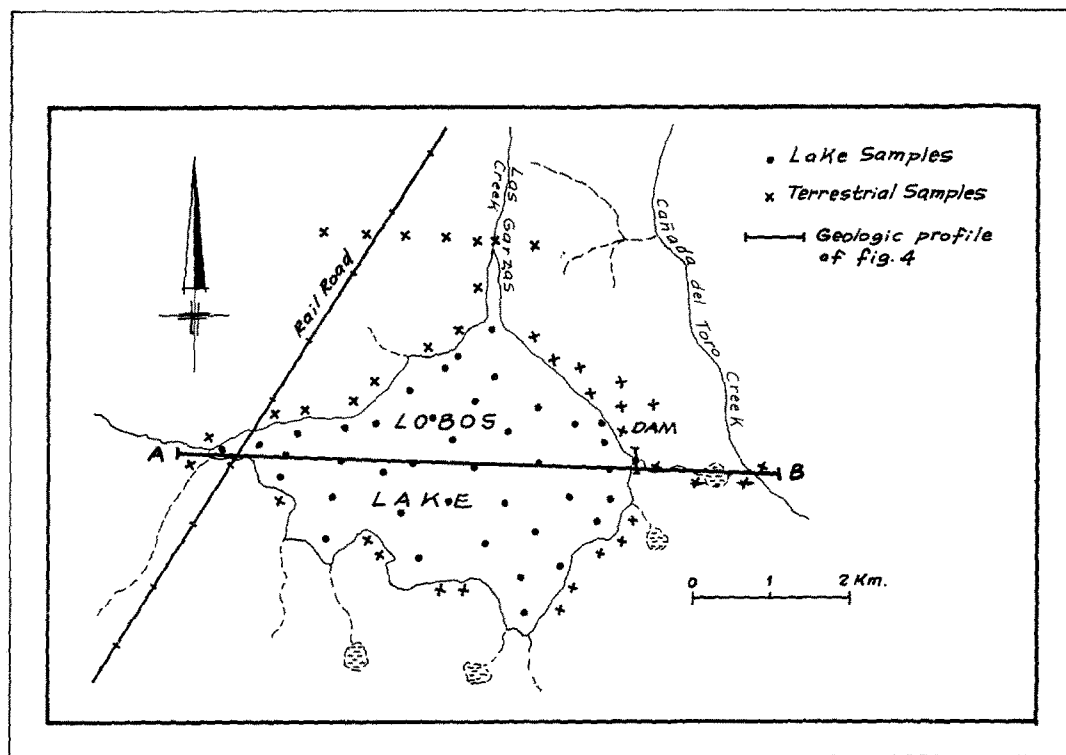


Fig. 3. Index maps of Lobos Lake Sample locations.

Sedimentary body 1 – Freshwater paleolentic deposit (mudstone facies)

Over the basal bedrock are 2.9 km² of freshwater paleolentic deposits, with a maximum thickness of 2.66 m and a volume of 3.1 hm³. These are composed of grey to light grey silicoclastic mudstones (5Y 7/1 - 5Y 6/1), slightly hard to hard, bearing freshwater organic remains and abundant post-depositional lens-shaped gypsum crystals.

The biological remains of the mudstones are:

Gastropods

Littoridina parchapei: adults and young; abundant.
Ampullaria canaliculata: valve fragments; frequent to rare.

Ostracods

The same species found in present lentic environments of Buenos Aires Province. Adults and young. Left and right valves in the same proportions. *Charophyta*. Abundant.

Oogonia, calcified tubes and plates of the same origin; common.

Diatoms

Related to high vitroclastic ash contents. Rare in the sand fraction but abundant in the silt fraction.

Deposition of these sediments is related to subaqueous and partially subaerial processes during dessication periods, indicating waning water inputs and/or seasonally changing climates. Biological remains are similar to present lake organisms (i.e. oligohaline and alkaline indicators), but in lower numbers and much more broken. This evidence suggests that a marshy environment developed during the late Pleistocene.

Sedimentary body 2 - Subaerial paleoenvironment (dessiccation surface and clay - pellets facies)

The more conspicuous deposits appears in the east sector, as an elongate eolian accumulation 1.7 m thick, which runs parallel to the present eastern coastline.

This dune is made up of sand-size, pellet-shaped clay-aggregates, light brown and light green, by break down of the lake's floor dry crust into sand-sized particles, and eolian accumulation due to the action of steady on-shore winds in the warm seasons with strong insolation.

This depositional feature is associated with clear signs of weathering (such as strong bioturbation, iron-oxide precipitation, abundant broken bioclasts and isolated clay pellets) in the upper 0.4 m of the surrounding paleoleptic deposit.

Sedimentary body 3 - Mixohaline paleoleptic deposits (siltstone and mudstone facies)

This deposit covers an area of 6.25 km² with a maximum thickness of about 2 m and 9.7 hm³ of total volume overlaying the Ensenada Formation, Sedimentary Body 2 (weathering crust and clay dune), and Sedimentary Body 1 (paleoleptic freshwater deposit).

Sedimentites are friable to hard sandy siltstones and sandy mudstones, pale-colored: yellowish-white to slightly green and gray, all in hue 10YR, 5Y and 2.5Y.

The mudstone facies were affected by post-depositional intra-sedimentary gypsum precipitation in the form of sand size crystals with discoidal or lens-shape grains or even as microrrosetes.

Epigenetic gypsum constitutes 34 to 56% of the mudstone facies, which cover an area of 3.22 km². In the sandy siltstone facies, the gypsum content is very low due to the dissolution of crystals (Dangavs & Blasi, 1992a).

Biological remains of this unit are:

Fish teeth, spines and vertebrae

Gastropods

A large amount of shells of diverse species, such as: *Littoridina parchappei* (d'Orbigny), abundant to frequent. *Littoridina australis* Pilsbry, common to frequent, that is dominant over *L. parchappei* near the present mouth. *Littoridina conexa* Gaillard, frequent to rare, only in ten samples. *Littoridina australis crassa* Gaillard is rare. *Biomphalaria peregrina* is frequent. *Ampullaria* sp. is frequent to rare. *Succinea meridionalis* is rare.

Ostracods

Abundant adults and young with both open and closed valves. Both valves in the same proportions. Typically freshwater forms, common in modern Buenos Aires Province inland waters. The major genera are *Cypridopsis*, *Limnocythere* and *Elpidium*. In smaller numbers there are closed valves with sculpture and

valvular vaulting. In some samples, the ostracods replace Foraminifera and constitute an ostracod-mud.

Foraminifera

Abundant to rare. Present in all samples, but with low species diversity. They are generally large forms (0.33 mm). Foraminifera taphanocoenosis is dominant in some sites and absolute in others. It is associated with marine organisms such as *Littoridina australis*, *L. australis crassa* and *L. conexa*. The taxonomic determinations made by *nomenclatura aperta* identify these species: *Rotalia beccari parkinsoniana* (d'Orbigny) abundant; *Elphidium discoidale* (d'Orbigny) frequent; *Elphidium galvestonense* Kornfeld rare; *Bucella ex gr. frigida* (Cushman) rare; *Discorbis nitidus (f. praegeri)* (Heron-Allen et Earland)? rare; *Cornuspira planorbis* Schultze very rare.

Generally the dominant genus is *Rotalia*, except in some samples where it is replaced by *E. discoidale*. *Rotalia* - *E. discoidale* - *Bucella* - and other species relationships are 92:6:1:1.

Diatoms

Frustules appear discontinuously in the sand fraction; finer sizes were not studied. Their presence is usually related to the vitric ashfall layers. We only identified some of the large forms: *Surirella striatula* Turpin, *Campylodiscus clypeus* Ehrenberg, *Navicula* sp., *Caloneis* sp., *Coscinodiscus* sp. and *Anomoeoneis* sp.

Charophyta

Oogonia are always present in samples, and especially common in sand-size samples. We could recognize three different types. Also, the gyrogonites were associated with calcium carbonate plates, tubes, branches and stems related to the calcified thalli of these algae.

Regarding the origin and salinity tolerance of these organisms, we have found freshwater and mixohaline-euryhaline (Segerstrale *et al.*, 1959) species together. The Gasteropoda of marine lineage, like *Littoridina australis* (Pilsbury, 1911), live presently in the Rio de la Plata near Montevideo in an euryhaline habitat. *Littoridina conexa* is a typically estuary-lagoon form (Gaillard, 1974), and *Littoridina australis crassa* perhaps could be an ecological variety of *L. australis*. Among the Ostracoda, we have found freshwater and mixohaline species together, and perhaps calcareous and siliceous algae also.

Elsewhere, Foraminifera populations (*Rotalia bec-*

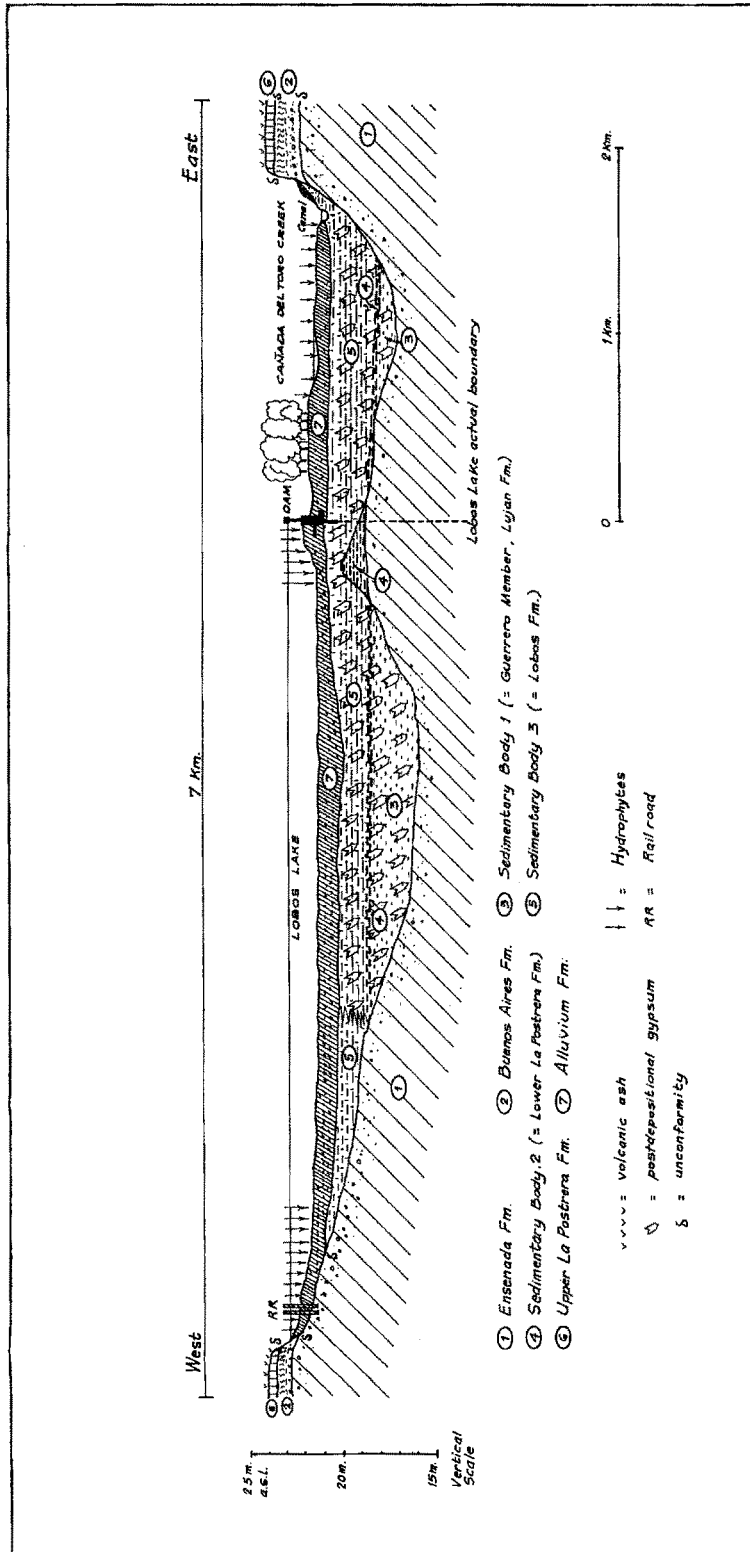


Fig. 4. Lobos Lake west-east geologic profile showing stratigraphic features.

cari parkinsoniana, *Elphidium discoidale*) suggest a mixohaline environment, such as a tidal marsh or what Urien (1967) called a 'fluvio-marine zone' in the Río de la Plata ([named later '*Rotalia beccari parkinsoniana* biofacies zone' by Boltovskoy & Lena (1974)]).

Hence, the freshwater and mixohaline species mixture in Sedimentary Body 3 reveals the same habitat characteristics that occur in coastal lagoons, with salinity variations from oligo to mesohaline ranges. These may be related to a broader estuary of the Río de la Plata that developed toward the south, when the Holocene marine transgression reached the ancient Lobos Lake.

Cann & DeDecker (1981), however, state for Australia the athalassic origin of this type of population, introduced by sea bird displacements into an environment where saline lakes made possible their survival and reproduction. Likewise, DeDecker (1988) considers that the low species diversity of Foraminifera is typical of non-marine saline lakes. All these possibilities are not denied by our study, but in our opinion, based furthermore on considerable Pampean plain research, the arguments for direct marine influences are more likely. For example:

1. Modern lentic environment samples (fresh or brackish saline waters) never contain Foraminifera tests.
2. The existence of a fluvio-lacustrine watershed that formerly interconnected with the Río de la Plata estuary.
3. The regionally broad distribution of the mixohaline environment sediments.
4. The presence of surficial and related groundwater, whose ionic composition relationships (Cl/HCO₃; Mg/Ca) suggest sea water influence.
5. The inland geographic location of these sediments is similar to those assigned by various authors to the Holocene Querendinense ingression.
6. The position above sea level (18.4 to 21.5 masl) is not compatible with a Holocene ingression, unless they are considered neotectonic events.
7. The presence of similar mixohaline sediments along the Salado River course up to the Las Flores Chica Lake latitude.
8. The low species diversity of the paleolake Foraminifera benthos thaphanocoenosis is similar to the present assemblage in the Samborombón Bay coastal plain and Ajó River.

Stratigraphic correlation

Lithological and environmental characteristics allow us to place the Sedimentary Body 1 in a stratigraphic position near the Pleistocene-Holocene boundary, and correlate it with the Guerrero Member of the Luján Formation (Fidalgo, 1983). The overlying clay dune deposits of Body 2 belong to the lower La Postrera Formation (Fidalgo, *op. cit.*).

The overlying mixohaline deposits of Body 3 belong to the Lobos Formation (Dangavs & Blasi, 1992b), and was deposited in the Holocene, with a probable age between 6000 to 7000 years B.P. It can be correlated with the Querandinense Transgression (Frenguelli, 1957). Both the Lobos Formation and Querandinense are lithostratigraphic records of estuarine channel deposits in the region along the Salado River up to +15 m bench mark, *i.e.* 120 km west of the present Samborombón Bay coastline.

Conclusions

All the infilling sediments of Lobos Lake and the stratigraphic sequences of the surrounding terrain represent more than 0.1 million years between the upper Pleistocene and the Holocene.

Our sedimentologic study of Lobos Lake allows us to recognize a development of different environments during the Quaternary in response to climatic and geomorphologic changes, and the existence of an important stratigraphic *hiatus* between the Sedimentary Body 3 and the modern lake sediments, of about 5000 B.P. This *hiatus* imposes a great limitation on our paleoenvironment interpretations.

More research on the geological history of the surrounding sedimentary sequences is needed, which should include paleopedologic, paleohydrologic and paleoenvironmental data for elucidating the environmental history of Lobos Lake.

Acknowledgements

Our thanks to Comisión de Investigaciones Científicas of Buenos Aires Province, Argentina for their support of this project. We also offer our thanks to Drs John P. Smol and Mario E. Terrugi for their suggestions in reviewing this manuscript.

References

- Blasi, A. & N. Dangavs, 1992. Sedimentos actuales de la laguna Lobos, Buenos Aires, Argentina. 4^a Reunión Argentina Sedimentología Actas II: 167-174. La Plata.
- Boltovskoy, E. & H. Lena, 1974. Foraminíferos del Río de La Plata. Publicación H 661 Servicio Hidrografía Naval, 22 pp. Buenos Aires.
- Cann, J. & P. DeDecker, 1981. Fossil Quaternary and living Foraminifera from athalassic saline lakes, South Australia. *J. Paleontol.* 55: 660-670.
- Dangavs, N. & A. Blasi, 1992a. Presencia de yeso en Lobos, Buenos Aires, Argentina. *Revista Museo La Plata, secc. Geol. X* (in press).
- DeDecker, P., 1988. Biological and sedimentary facies of Australian salt lakes. *Palaeogeogr., Palaeoclimatol., Palaeoecol.* 62: 237-270.
- Fidalgo, F., 1983. Algunas características de los sedimentos superficiales en la cuenca del río Salado y en La Pampa Ondulada. *Coloquio Internacional Hidrología Grandes Llanuras, Olavarría. UNESCO. Actas II: 1043-1067.* Buenos Aires.
- Frenguelli, J., 1957. Neozoico. In: *Geografía República Argentina GAEA. 2: 1-113.* Buenos Aires.
- Gaillard, M. C., 1974. Sobre nuevas *Littoridina* de la República Argentina. *Neotrópica* 20: 141-143.
- Maucha, R., 1932. Hydrochemische Methoden in der Limnologie. *Die Binnengewässer* 12: 1-173. Stuttgart.
- Pilsbry, H., 1911. Non marine Mollusca of Patagonia. *Rep. Princeton University Expedition Patagonia, Zoology* 5: 513-653.
- Riggi, J., F. Fidalgo, O. Martínez & N. Porro, 1986. Geología de los 'Sedimentos Pampeanos' en el Partido de La Plata. *Asociación Geológica Argentina Revista* 41: 316-333. Buenos Aires.
- Segestrale, S. *et al.*, 1959. Simposio sulla classificazione della acque salmastre. Venezia 1958. *Archivio Oceanografia e Limnologia XI, suppl.* 243 pp. Italia.
- Urien, C., 1967. Los sedimentos modernos del río de La Plata exterior. *Boletín Servicio Hidrografía Naval* 4: 113-213. Buenos Aires.