Journal of Paleolimnology **10**: 17–23, 1994.

Diatom paleoecology of the Mar Chiquita lagoon delta, Argentina *

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Received November 1992; accepted May 1993

Key words: diatoms, paleoecology, multivariate analysis, coastal lagoon, Holocene, environmental changes, South America, Argentina

Abstract

A 68 cm thick outcrop of diatomaceous sediments at the head of Mar Chiquita Lagoon on the Argentine coast near Buenos Aires provides evidence of Holocene paleoenvironmental changes related to sea level changes and freshwater input to the lagoon system. Salinity tolerances of extant diatom taxa were used for the reconstruction and multivariate analytical techniques were applied to reduce subjective interpretations of the diatom percentage data.

The basal half of the record was deposited before 3000 years ago and fossil diatoms indicate generally freshwater conditions with one fluctuation in mesohalobous diatoms suggesting brackish water conditions at a depth of about 60 cm. Polyhalobous (marine) diatoms characterize the record after 3000 years ago and large numbers of epiphytic diatoms indicate salt marsh environments with episodic seawater fluctuations to supratidal levels. Freshwater diatoms returned at the top of the outcrop, presumably as a result of the restriction of the historic marine inlet to the lagoon and the effects of freshwater inflow to the basin.

Introduction

The Holocene development of Mar Chiquita lagoon, the only coastal lagoon in Argentina, has been studied using morphological and stratigraphical criteria (Schnack *et al.*, 1982). The estuarine environment was developed after the 5000 years B.P. maximum in sea level, during the regressive phase. Radiocarbon dates of mollusk shells, preserved in the living position at 0.40 m below the profile surface, suggest a silting evolution trend towards the south.

Paleoecological diatom research plays an important role in reconstructing Holocene coastal processes, since diatoms are known to be very sensitive to changes in environmental variables, such as salinity, tidal currents and flooding frequency (Vos & de Wolf, 1988).

In the present paper, diatom assemblages were used to interpret the environmental development, and especially salinity changes, of the delta at the head of the lagoon.

This paper will be part of the doctoral thesis where the author will suggest a development scheme for the southeastern coast of Buenos Aires during the Holocene.

Description of the study site

Mar Chiquita coastal lagoon is situated on the Atlantic coast of Buenos Aires province at 37°40′S and 57°25′W (Fig. 1). The Chico o de las Gallinas Creek discharges into a delta, which preserved a Holocene sequence of clayey silts and silty clays (Fig. 2). On top of the sequence, a soil profile (A Horizon) was developed on lacustrine sediments. 200 m downstream, *Tagelus plebeius* remains, which were preserved at a sediment depth of 0.35–0.40 m, yielded a radiocarbon age of 3110 ±80 years B.P. (Ac-0064, Schnack *et al.*, 1982).

* This is the second 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.

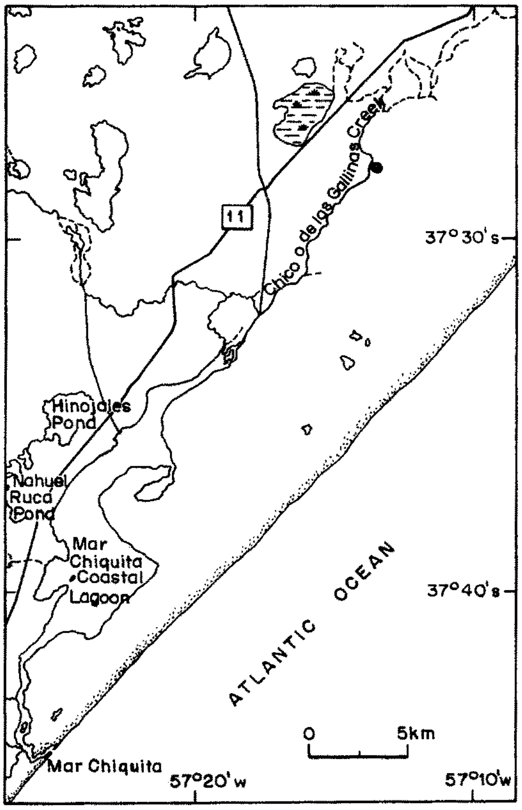


Fig. 1. Location map of Mar Chiquita lagoon. Black dot indicates the sediment section on the Chico o de las Gallinas Creek.

Material and methods

The profile that was sampled was a fluvial terrace of 0.68 m height. Eight samples were collected. The samples were chosen to reflect the lithological changes in the profile.

At the laboratory, each sediment sample was treated with hydrochloric acid to remove carbonates, and then oxidized with hydrogen peroxide to remove organic matter. After numerous washing with distilled water, the samples were mounted in Canada Balsam and counted under a magnification of 1000×. 500 to 600 diatom frustules were counted from each sample.

Species percentages were plotted, and grouped with respect to their salinity tolerances, following guidelines developed by Kolbe (1927) and modified by Hustedt (1957). The four main groups are:

- *Polyhalobous taxa*: marine taxa with an optimum range of 30 ‰ salinity or more.
- *Mesohalobous taxa*: brackish water taxa with their optimum and lower tolerance limit within the range 30–0.2 ‰ salinity.
- *Oligohalobous taxa*: taxa living in both brackish and freshwater

  halophilous taxa: optimum in slightly brackish water

  indifferent taxa: optimum in freshwater.
- *Halophobous taxa*: exclusively freshwater taxa, strongly averse to chloride ions.

Two diagrams have been constructed for the sequence. The first diagram shows the percentage of the diatom flora for each salinity group (Fig. 3), while the second shows percentages for each taxon in detail (Fig. 4). The taxa (those higher than 1%) are grouped alphabetically within each salinity group.

The obtained data were processed by multivariate methods, *i.e.* cluster analysis (Fig. 5) and principal component analysis (Fig. 6), using the program SYSTAT (Wilkinson, 1986). Only species who accounted for greater than 1% of the assemblage were used in the analysis (25 species).

Cluster analysis (Q Mode) was performed using the percentages of different taxa. Pearson correlation coefficients and the average linkage method were used.

The principal component analysis was based on the correlation matrix between samples. The first two components explained a very high percent of the variance. Samples plotted to scores of the first and second eigenvectors explained 91.37% of the variance (Fig. 6).

Results

Fifty-one diatom species were identified in the eight stratigraphic samples (Table 1).

From the base of the sequence (sample M8) to 0.40–0.35 m (sample M4), an oligohalobous indifferent taxon dominated: *Fragilaria pinnata*. Other diatoms that formed an important proportion of the flora were *Navicula pygmaea* and *Campylodiscus clypeus* (both mesohalobous) and *Fragilaria construens* var. *venter* (oligohalobous indifferent). This assemblage indicates mixing waters with low salinity (see Fig. 4).

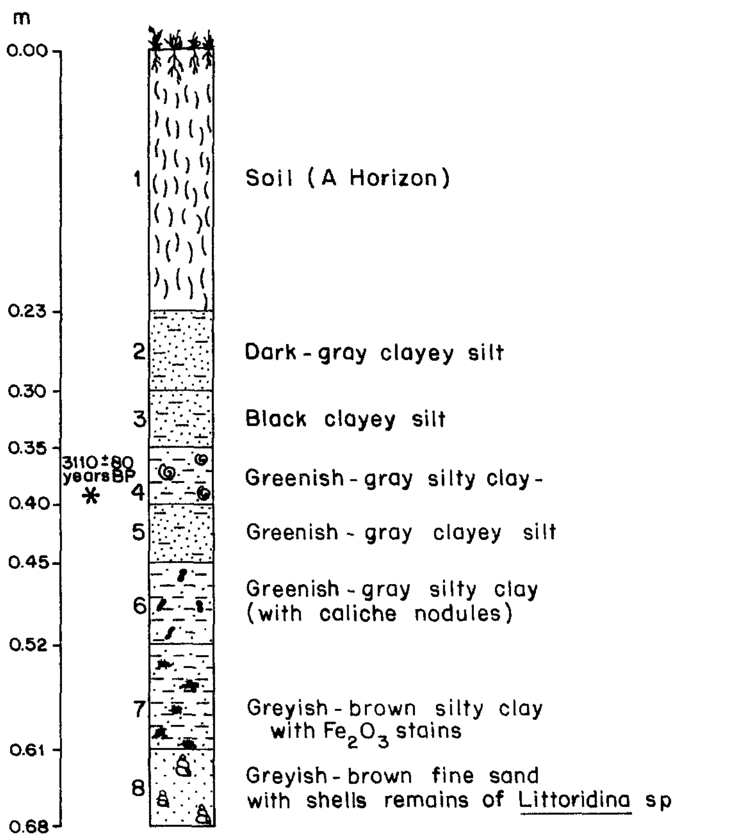
Between 0.35 to 0.23 m (samples M3 and M2), a very important change in the diatom assemblage is observed. The polyhalobous diatom, *Actinoptychus splendens*, dominates, accompanied by *Rhopalodia musculus* (mesohalobous) and *R. gibberula* (oligohalobous halophilous). *Surirella striatula*

Table 1.

List of species	M1	M2	M3	M4	M5	M6	M7	M8
Achnantes brevipes Ag.	x	x	x		x			x
A. hauckiana Grun.								x
Actinoptychus splendens (Shadb.) Ralfs		x	x					
A. undulatus (Bail.) Ralfs		x	x	x				
Amphora proteus Greg.		x	x	x		x	x	x
A. salina W.SM.						x		
Aulacoseira granulata (Ehr.) Simonsen	x			x				
Caloneis bivittata var. *lata* Heid.	x		x	x	x	x	x	x
Campylodiscus clypeus (Ehr.) Ehr.	x		x	x	x	x	x	x
Cocconeis diminuta Pant.		x		x		x	x	
C. placentula Ehr.						x	x	x
C. scutellum Ehr.			x					
Cyclotella meneghiniana Kutz.	x		x	x				
C. striata (Kutz.) Grun.			x	x				
C. stylorum Brightw.			x	x				
Cymbella affinis Kutz.							x	
C. cymbiformis Ag.					x			
Denticula elegans Kutz.						x		
Diploneis smithii (Breb.) Cl.	x	x	x	x	x	x	x	x
Epithemia argus Kutz.	x		x	x	x	x	x	x
Eunotia sp.	x							
Fragilaria construens var. *subsalina* Hust.	x	x	x	x	x	x	x	x
F. construens var. *venter* (Ehr.) Grun.	x	x	x	x	x	x	x	x
F. pinnata Ehr.	x	x	x	x	x	x	x	x
Gomphonema acuminatum Ehr.							x	x
G. longiceps Ehr.							x	
G. olivaceum (Lyngb.) Kutz.			x		x			
Gyrosigma sp.							x	x
Hyalodisus scoticus (Kutz.) Grun.			x	x	x		x	x
Navicula pupula Kutz.					x	x		
N. pygmaea Kutz.			x	x			x	x
N. serena Freng.					x			x
N. Zosteretii Grun.		x						
Nitzchia frustulum (Kutz.) Grun.			x	x				
N. hungarica Grun.	x							
N. ignorata Kras.			x					x
N. obtusa W.SM.				x				
N. punctata (W.SM.) Grun.		x						
N. vitrea Norman	x	x	x		x	x		x
Opephora martyi Herib.				x				
Paralia sulcata (Ehr.) Cl.		x	x		x			x
Podosira stelligera (Bailey) A. Mann	x				x		x	

Table 1 cont..

List of species	M1	M2	M3	M4	M5	M6	M7	M8
Rhopalodia gibberula (Ehr.) O. Mull.	x	x	x	x	x	x	x	x
R. musculus (Kutz.) O. Mull.	x	x	x	x	x	x	x	x
Stauroneis phoenicenteron (Nitzsch) Ehr.							x	
Surirella ovalis Breb.	x							
S. striatula Turpin	x	x	x	x	x	x	x	x
Synedra acus Kutz.				x				
S. platensis Freng.	x	x	x	x	x	x	x	x
S. ulna (Nitzsch) Ehr.	x		x	x	x	x	x	x
Triceraium favus Ehr.		x						



* Radiocarbon dates obtained from Tagelus plebeius 0.35 - 0.40 m below the top of Horizon A, (at the same bank, 200 m downstream)

Fig. 2. Lithologic description of the profile.

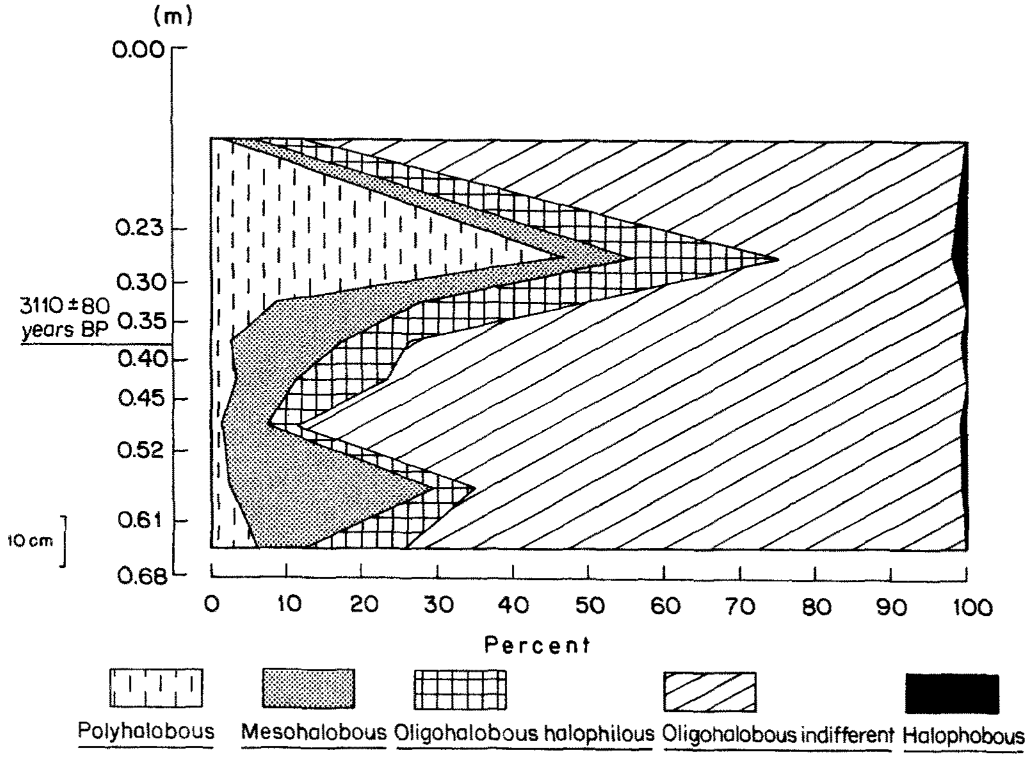


Fig. 3. Changes in the diatom salinity groups.

(mesohalobous) and *Synedra platensis* (oligohalobous halophilous) were always present from the base of the sequence to this level. However, they too showed important peaks in these two levels. This assemblage would indicate an important marine influence, suggesting a brackish environment with relatively high salinity content. Furthermore, the abundance of epiphytic diatoms, such as *Rhopalodia gibberula* and *R. musculus*, suggests the development of dense aquatic vegetation (Fontes *et al.*, 1985).

The upper 0.23 m (sample M1) of the sequence was a soil profile (A Horizon), where *Fragilaria pinnata* had the highest percentage (75%), accompanied by *Aulacoseira granulata* (oligohalobous indifferent) and *Fragilaria construens* var. *venter* (oligahalobous indifferent) indicating freshwater conditions. In other words, the top of the sequence is composed of fine grained overbank sediments representing episodic floods.

Multivariate analysis

Cluster and principal component analysis were used to further explore the observed changes in diatom species composition.

Cluster analysis showed that at a very high similarity level (0.938), the samples M1, M4, M5, M6, M7 and M8 (group I) clustered, while samples M2 and M3 (group II) were remarkably distant (Fig. 5). The group I samples contained high percentages of oligohalobous indifferent diatoms, while polyhalobous and mesohalobous diatoms dominated in group II.

The principal component analysis showed that the two first components explained 91.37% of the variance (Fig. 6). In component I (78.04% of the variance), *Fragilaria pinnata* had the highest score in the factor. All samples had positive values in component I, but samples M2 and M3 were distant from the others. Samples M1, M4, M5, M6, M7 and M8 had very high and similar values. Component I, therefore, characterizes the less saline environment.

Component II (13.33% of the variance) had *Actinoptychus splendens*, *Rhopalodia gibberula* and *Synedra platensis* with the highest scores. Samples M2 and M3 had negative component loadings, while the others (samples M1, M4, M5, M6, M7 and M8) had positive values. Component II characterizes the highest salinity conditions.

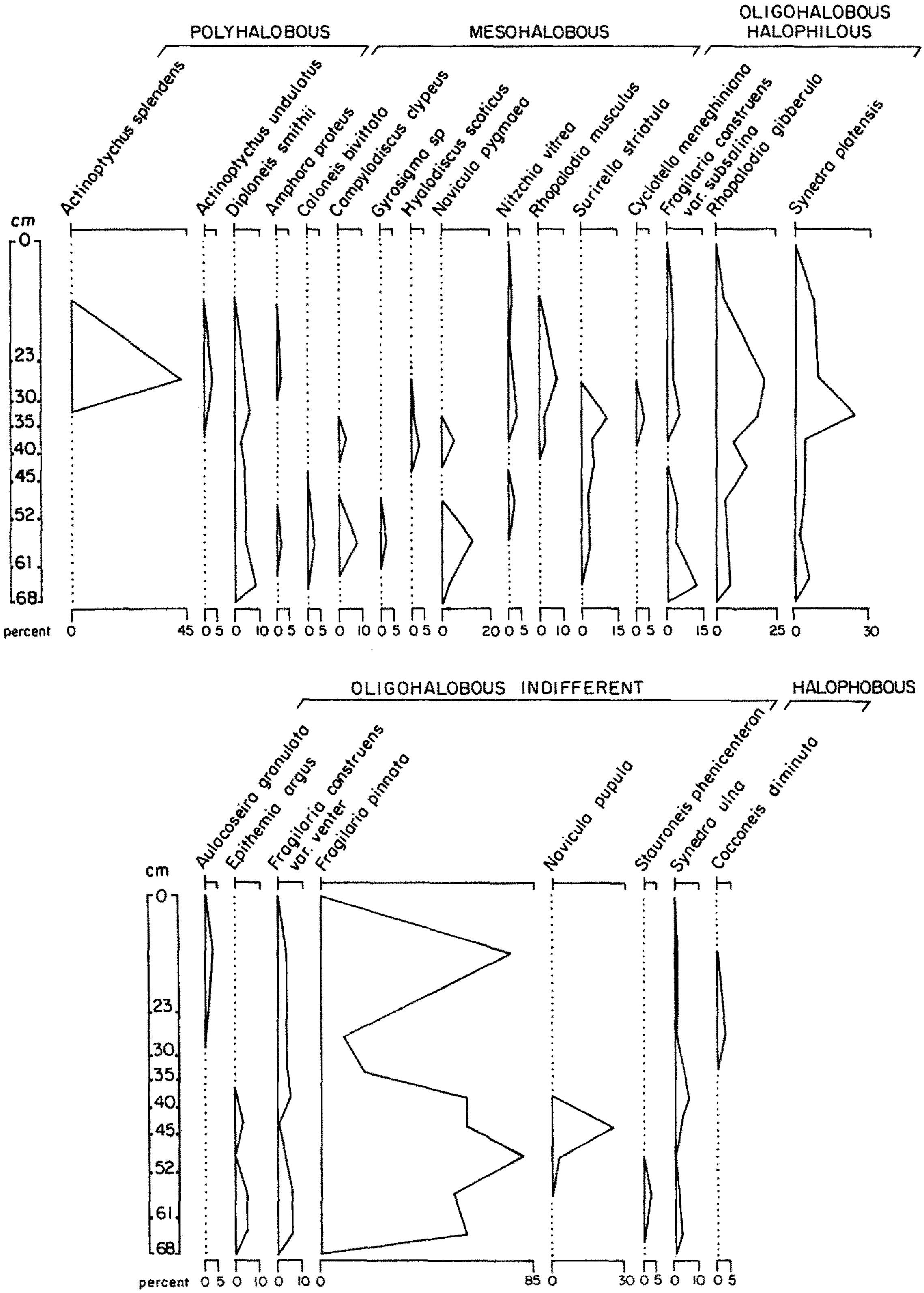


Fig. 4. Cluster analysis of samples (Q-Mode).

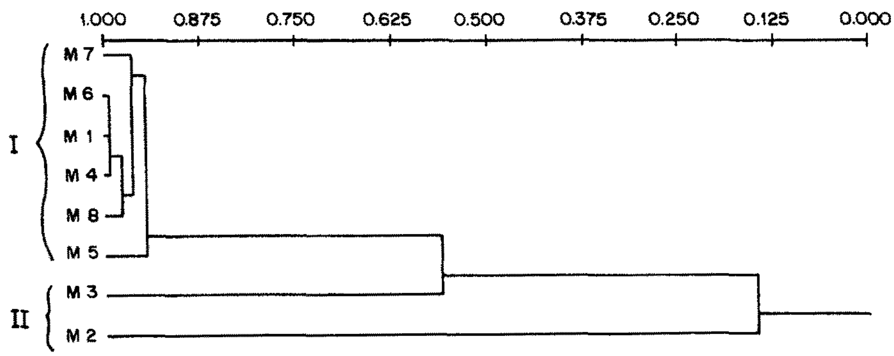


Fig. 5. Relative frequency diagram of diatom species composition.

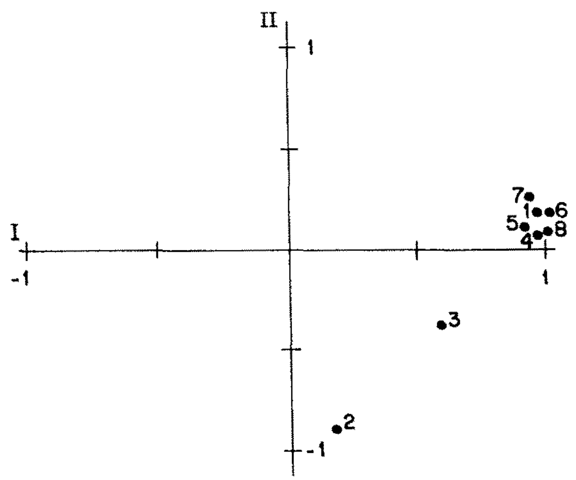


Fig. 6. Principal component analysis of the sediment samples.

Cluster and principal component analysis corroborated the relationships between samples and the corresponding environmental development of the area.

Conclusions

From the base of the sequence to 0.40 m (3110±80 years BP), silty clays were deposited and the diatoms indicate low salinity brackish conditions, representing tidal channel conditions.

The overlying clayey silts (0.35–0.23 m) preserved a very different diatom assemblage, indicating a marine influence. This portion represents a salt marsh, with episodic inputs of sea water.

The top of the sequence represents modern episodic events (floods). The historic inlet restriction prevents intrusion of marine water at the headlands of the lagoon.

This study once again demonstrates the value of fossil diatom analysis to indicate environmental conditions of a coastal lagoon.

Acknowledgements

The author wishes to acknowledge Federico Isla for his assistance with the field work and comments on the manuscript. Jorge Fasano helped with the lithological description. Susana Serra treated the samples. Virginia Bernasconi, Mónica Tomás and Marcelo Farenga did the drafting.

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