Studia Quaternaria, vol. 21: 167–169.

PALEOLIMNOLOGY IN URUGUAY – A PERSONAL PERSPECTIVE

Felipe García-Rodríguez

Sección Limnología, Facultad de Ciencias, Iguá 4225, Montevideo (11400), Uruguay

Abstract

Paleolimnological research only started in Uruguay in 1999 in the frame of the German-Uruguayan Academic Cooperation Program (DAAD-UDELAR). Research focused in costal lagoons and special attention was paid to the relationship between trophic development and sea level changes. Paleolimnology was also used as tool to assess human impact on aquatic water bodies and to provide a basis for the development of a management plan. Concomitantly, diatom taxonomy was also developed as diatoms are very well established indicators of paleoenvironmental change. In this sense, about 70 diatom species have been described as new for science.

Key words: lake sediments, Uruguay, sea level changes

INTRODUCTION

In March 1998, I first wrote to Prof. Dr. Burkhard W. Scharf, because of my interest in paleolimnology, and proposed him to undertake some research in Uruguay. Burkhard Scharf accepted to co-supervise my Ph.D., and so I spent one year in Magdeburg working with him. But before that, Burkhard Scharf came to Uruguay in March 2000 with his heavy sampling equipment, and I think that was quite an adventure to us, as we had plenty unexpected problems. We spent almost two months sampling coastal lagoons, then we came back to Germany and I started my laboratory activities. In September 2002, I completed a Ph.D. with Prof. Dr. Peter Sprechmann and Prof. Dr. Burkhard Scharf as supervisors.

WHAT WE DID

The east coast of South America experienced considerable relative sea level changes during the Holocene. Particularly along the Brazilian coast (Martin, Suguio 1992, Angulo, Lessa 1997, Angulo *et al.* 1999, Lessa *et al.* 2000), a large number of surveys were undertaken to identify relative sea level variations, and a regional model was developed. Such a model postulates that: (a) present mean sea level was first overtaken approximately 7,000 yr BP; (b) by about 5,100 yr BP, sea level had risen to 4–5 m above present mean sea level; (c) between 4,000–3,900 yr BP, there was a lowering of sea level to slightly below the present one; (d) by about 3,600 yr BP, sea level rose to 3 m above present mean sea level; (e) between 2,800–2,700 yr BP, sea level fell again to slightly below the present one; and (f) at approximately 2,500 yr BP, a third high sea level occurred (2.5 m above the present one). After 2,500 yr BP, there was a constant regressive phase. Although Angulo & Lessa (1997) have criticized such a model, their sea level curves are very similar to those of Martin, Suguio (1992) (García-Rodríguez, Witkowski 2003). Isla (1998) also developed a curve of sea level changes for eastern Argentina, which is similar to that for the Brazilian coast (*i.e.*, present mean sea level was first overtaken approximately 7,000 yr BP, maximum sea level was achieved by about 5,000 yr BP, and then there was a regressive phase). However, no evidence of the two emergence/ submergence events (i.e., for 4,000–3,900 and 2,800– 2,700 yr BP) was observed in Argentina (Isla 1998, Espinosa *et al.* 2003).

Although the above mentioned studies presented detailed Holocene sea level change curves, no attention was paid to the relationship between trophic state and relative sea level. Transgressions and regressions cause runoff and erosion that may lead to the sediment record disturbance/loss in coastal water bodies such as lagoons. Thus, sea level changes may cause gaps of information in coastal deposits which would not permit continuous paleoenvironmental reconstructions. However, coastal lagoons are still appropriate systems to determine how sea level changes influence their trophic development. In southern Uruguay, there are many costal water bodies (such as Rocha Lagoon, Castillos Lagoon, and Lake Blanca) that originated after the first Holocene marine transgression. Therefore, both structure and functioning of these systems must have been strongly influenced by sea level changes. The hypothesis being tested was that Holocene sea level changes moderated the trophic state of Rocha Lagoon, Castillos Lagoon, and Lake Blanca, with the trophic state being higher during regression than transgression events. To test this hypothesis, upper Pleistocene/Holocene paleolimnological conditions of the former water bodies were tracked using physical sediment characteristics, organic matter content, nutrient concentrations, and diatoms.

THE STUDY AREA

We selected three costal water bodies in southern Uruguay: Rocha Lagoon, Castillos Lagoon, and Lake Blanca (Fig. 1).

Rocha lagoon lies at 34° 34' S, 54° 10' W, on the southern coast of Uruguay, which is a temperate/subtropical region with a mean historical annual rainfall of 1100 mm per year (García-Rodríguez *et al.* 2002a). The lagoon forms part of a series of coastal aquatic systems that originated about 7,000 yr BP, after the first large Holocene marine transgression (Martin & Suguio 1992; Angulo & Lessa 1997, Isla 1998). This transgression was a consequence of a glacioeustatic process, and there were no significant changes in tectonic/seismic activity in the eastern coast of South America during Upper Pleistocene and Holocene (Martin, Suguio 1992, Espinosa *et al.* 2003). Tidal range is about 40. The lagoon is 72 km^2, with a maximum depth of 1.4 m and a catchment area of 1312 km^2. The lagoon is separated from the Atlantic Ocean by a sand bar. Salinity values range from 0.5 to 33‰ (sometimes daily), due to the effects of wind direction and human influence (*e.g.* artificial opening of the mouth). The mouth also opens naturally to the Atlantic Ocean during heavy winter rain storms. Sediments are mainly sandy but silt and clay content increases towards the north section. The main tributary, the Rocha River (mean flow 13.4 $m^3\ s^{-1}$), receives domestic and industrial waste. Vegetation in the catchment area is dominated by extensive meadows used for raising cattle and sheep. The development of the macrophyte *Schoenoplectus californicus* (C. Meyer) Steudel was observed along the north and west coastlines of the system.

Castillos lagoon lies at 34° 21' S; 53° 52' W, on the southern coast of Uruguay. The lagoon is 81.5 km^2, maximum depth 3 m, and catchment area 1453 km^2. Salinity values range from 0 to 20‰. Recent sediments are mainly silt-clay but towards the south section, sand content increases. The system is separated from the Atlantic Ocean by a 10 km sand bar. It connects to the ocean via Valizas River, especially during the winter season because of heavy rains. The main tributary is Chafalote River on the west side. The catchment is dominated by extensive meadows used for raising cattle and sheep. Detailed ecological information on Castillos Lagoon can be found in Jorcín (1999). The lagoon forms part of a series of coastal aquatic systems that originated about 7,000 yr BP, after the first large Holocene marine transgression (Martin, Suguio 1992, Angulo, Lessa 1997, Isla 1998). This transgression was a consequence of glacioeustatic processes, and there were no significant changes in tectonic/seismic activity in the eastern coast of South America during the Holocene (Sprechmann 1978, Martin, Suguio 1992, Espinosa *et al.* 2003).

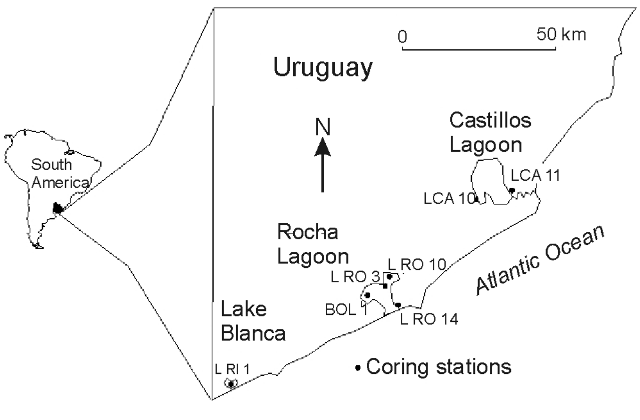

Fig. 1. Map of the study area. Black dots indicate coring stations.

Lake Blanca lies at 34° 53' S; 54° 50' W, on the southern coast of Uruguay. The lake forms part of a series of coastal aquatic systems that originated about 7,000 yr BP, after the first large Holocene marine transgression (Martin, Suguio 1992, Angulo, Lessa 1997, Isla 1998). The lake area is 0.6 km^2, maximum depth is 4 m, elevation above sea level is 3 m, and the catchment area is 7.5 km^2.The lake is freshwater and dominated by submerged plants. It is separated from the ocean by a 1.5 km-wide sand bar, on which a holiday resort was built. Recent sediments consist mainly of clay and silt. Surrounding vegetation is dominated by extensive meadows and both *Eucalyptus* sp. and *Pinus pinaster* forests. Since 1969/70 the lake has been a source of drinking water. Further information on Lake Blanca has been published elsewhere (García-Rodríguez *et al.* 2002c, Mazzeo *et al.* 2003).

METHODS

We took seven piston cores in the above mentioned aquatic systems. We measured total carbon, nitrogen and phosphorus, organic matter, carbonate, and pigments. Diatoms, chrysophyte cysts, and opal phytoliths were counted and identified. Sediment was dated by both radiocarbon and ^{210}Pb (García-Rodríguez *et al.* 2001, 2002a, b, García-Rodríguez, Witkowski 2003, Metzeltin, García-Rodríguez 2003, Metzeltin *et al.* in prep).

RESULTS AND DISCUSSION

Our data indicate that sea level change was a key-factor in the development of coastal lagoons. We identified sediment sequences that corresponded to transgressions and regressions. Transgressive sediments are characterized by sandy sediments, low nutrient, low organic matter and pigment values, and marine/brackish diatoms. In addition low relative percentages of chrysophyte cysts were observed. Regressive sediments, on the other hand, are characterized by high nutrient, high organic matter and pigment values, and increases in relative abundances of freshwater diatoms. We concluded, therefore, that transgression may lead to decreases in trophic state, while regression would cause increases in trophic state because of increased runoff and erosion process as because of sea level decreases (García-Rodríguez *et al.* 2001, 2002b, c, García-Rodríguez, Witkowski 2003).

In the case of Lake Blanca, a drinking water source, paleolimnological findings were very important to provide historical information which was ultimately used for developing a management plan. The main paleolimnological findings showed how the system reacted to lake level fluctuations, El Niño Southern Oscillations (ENSO), and how human activities led to an intensification of the eutrophication process. Paleolimnological data (García-Rodríguez *et al.* 2002a) together with parallel limnological research (Mazzeo *et al.* 2003), advised the authorities in charge of producing drinking water, on how to manage the system to avoid potential water-supply problems.

Acknowledgements

I would like to thank Burkhard Scharf, Peter Sprechmann, Ditmar Metzeltin, Horst Lange-Bertalot, and Andrzej Witkowski for the kind help and advice throughout, DAAD and PEDECIBA for financial support, UFZ-Magdeburg, J.W. Goethe-University Frankfurt, University of Szczecin, and Universidad de la República for logistical support.

REFERENCES

Angulo R.J., Giannini P.C.F., Suguio K., Pessenda L.C.R. 1999. Relative sea-level changes in the last 5500 years in southern Brazil (Laguna-Imbituba region, Santa Catarina State) based on vermetid ^{14}C ages. *Marine Geology* 159, 323–339.

Angulo R.J., Lessa G.C. 1997. The Brazilian sea-level curves: a critical review with emphasis on the curves from Paranaguá and Cananéia regions. *Marine Geology* 140, 161–166.

Espinosa M., De Francesco C. & Isla F. 2003. Paleoenvironmental reconstruction of Holocene coastal deposits from the Southeastern Buenos Aires Province, Argentina. *Journal of Paleolimnology* 29, 49–60.

García-Rodríguez F., Castińeira C., Scharf B., Sprechmann P. 2002b. The relationship between sea level variation and trophic state in the Rocha lagoon, Uruguay. *N. Jb. Geol. Paläont. Mh.* 2002, 27–47.

García-Rodríguez F., Mazzeo N, Sprechmann P., Metzeltin D., Sosa F., Treutler H.C., Renom M., Scharf B., Gaucher C. 2002a. Paleolimnological assessment of human impacts in Lake Blanca, SE Uruguay. *Journal of Paleolimnology* 28, 457–468.

García-Rodríguez F., Sprechmann P., Mazzeo N., Metzeltin D., Lange-Bertalot H., Ruppel M. 2002c. Nueva especie de diatomea bentónica del Holoceno superior del Uruguay. *Rev. Geol. Uruguaya* 1, 40–42.

García-Rodríguez F., del Puerto L., Inda H., Castińeira C., Bracco R., Sprechmann P., Scharf B. 2001. Preliminary paleolimnological study of Rocha lagoon, SE Uruguay. *Limnologica* 31, 221–228.

García Rodríguez F., Witkowski A. 2003. Inferring sea level variation from relative percentages of *Pseudopodosira kosugii* in Rocha lagoon, SE Uruguay. *Diatom Research* 18, 49–59.

Isla F. 1998. Holocene coastal evolution of Buenos Aires. *Quat. S. Am. and Ant. Pen.* 11, 297–321.

Jorcín A. 1999. Temporal and spatial variability in the macrozoobenthic community along a salinity gradient in the Castillos lagoon (Uruguay). *Archiv für Hydrobiologie* 146, 369–384.

Lessa G.C., Angulo R.J., Giannini P.C., Araújo A.D. 2000. Stratigraphy and Holocene evolution of a regressive barrier in south Brazil. *Marine Geology* 165, 87–108.

Martin L., Suguio K. 1992. Variation of coastal dynamics during the last 7000 years recorded in beachridge plains associated with river mouths: example from the Central Brazilian Coast. *Palaeogeography, Palaeoclimatology, Palaeoecology* 99, 119–140.

Mazzeo N., Rodríguez-Gallego L., Kruk C., Meerhoff M., Gorga J., Lacerot G., Quinatns F., Lourerio M., Larrea D., García-Rodríguez F. 2003. Effects of *Egeria densa* Planch. on a shallow lake without piscivorous fish. *Hydrobiologia* 506–509, 591–602.

Metzeltin D., García Rodríguez F. 2003. Las Diatomeas Uruguayas. *DIRAC Ediciones, Facultad de Ciencias, Montevideo, Uruguay*. 208 pp.

Metzeltin D., H. Lange-Bertalot, F. García-Rodríguez. *Diatoms of Uruguay*. In Lange-Bertalot H. (ed). *Iconographia Diatomologica Vol 14*. A.R. Gantner Verlag, Distributed by Koeltz Scientific Book. Koenigstein, Germany (in prep.).

Sprechmann P. 1978. The paleoecology and paleogeography of the Uruguayan coastal area during the Neogene and Quaternary. *Zitteliana* 4, 3–72.