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Sedimentological and Taphonomical Differentiation of Quaternary Marine Deposits, Bahía Blanca, Argentina

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ABSTRACT

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The last two Quaternary transgressive-regressive events (Late Pleistocene and Holocene) left abundant marine deposits along coastal areas in various regions of the world, including the Bahía Blanca Estuary in Argentina. In this work, the sedimentation paleoenvironmental conditions prevailing during the marine transgressions are established, on the basis of sedimentological and taphonomic characteristics. Analysis of the two deposits, which are located well inland of the current littoral zone and are separated by an unconformity, shows that Pleistocene materials are distinguished by a higher degree of cementation, specially in the uppermost part of deposit. Sedimentological and taphonomic features reflect differences in the dominant sedimentation regime. The Pleistocene deposit, with sediment finer grained and less well sorted, were formed under lower energy conditions with an important role of stream flows carrying lithic material coming from coastal formations. The Holocene transgressive maximum is proposed to have given rise to a coastal geography more exposed to the action of storm waves (concentrated fossils in beach ridges), with sediments mobilized by coastal drift. The diversity difference of the marine fauna (Pleistocene:17 species, Holocene: 106 species) suggest a Pleistocene ecosystem poor for the development of organisms. The disappearance of species between the two transgressive events would be indicative of a fall in the sea water temperature.

ADDITIONAL INDEX WORDS: *Coastal paleoenvironment, Pleistocene, Holocene, grain size evaluation, mineralogy, molluscan fauna.*

INTRODUCTION

Marine deposits associated with Quaternary transgressive-regressive processes are abundant along many coastal regions of the world. There are several studies in the literature on the morphological, sedimentological and paleontological aspects of marine facies along the Argentine coast. Fossiliferous horizons, ridges, tidal lagoons and tidal plains are all geological features whose characteristics were established by coastal paleoenvironmental conditions.

The Bahía Blanca Estuary is located in the south of Buenos Aires province in Argentina (Figure 1). Its coast is of clay-silt sediment formed during the Holocene regressive event (ALIOTTA and FARINATI, 1990), and the entire petrochemical complex and port facilities of the area (Galván, White, Belgrano) rest on these materials. A dense network of channels, separated by islands, wide low marshes and tidal flats, is the characteristic morphological feature. The Principal Channel has a length of 60 km and an average width of 10 m. The system is mesotidal (mean range: 3m) and circulation is governed by reversal currents. The predominance of the ebb over the flood causes net sediment transport toward the continental shelf (ALIOTTA and PERILLO, 1987).

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Most of the marine Quaternary research on the Bahía Blanca area focuses on stratigraphic studies which coincide in establishing the last two transgressive processes in the late Pleistocene (GONZÁLEZ, 1984; CHAAR *et al.*, 1992) and in the middle Holocene (FARINATI, 1985a; GONZÁLEZ, 1989; ALIOTTA and FARINATI, 1990; FARINATI *et al.*, 1992). Between the two transgressive periods there is a hiatus, which also reported by CODIGNOTTO (1987) along the patagonian coast. Before the last marine transgression, the sea was below its current level, as evidenced by the rocky terraces submerged at the mouth of Bahía Blanca Estuary, whose formation corresponds to an old marine level located 12–18 m below the present one (ALIOTTA and PERILLO, 1990).

In the inner area of the Bahía Blanca Estuary, marine sediments belonging to the last two Quaternary transgressive events are overlaped and well defined. The aim of the present paper is to establish the paleoenvironment conditions that characterized both marine events and to define the type of sedimentation that prevailed in the internal sector of Bahía Blanca Estuary.

METHODOLOGY

In the interests of greater precision of analysis a study area was chosen in which the deposits of the two marine events are superimposed. In six sites short corers were drilled to

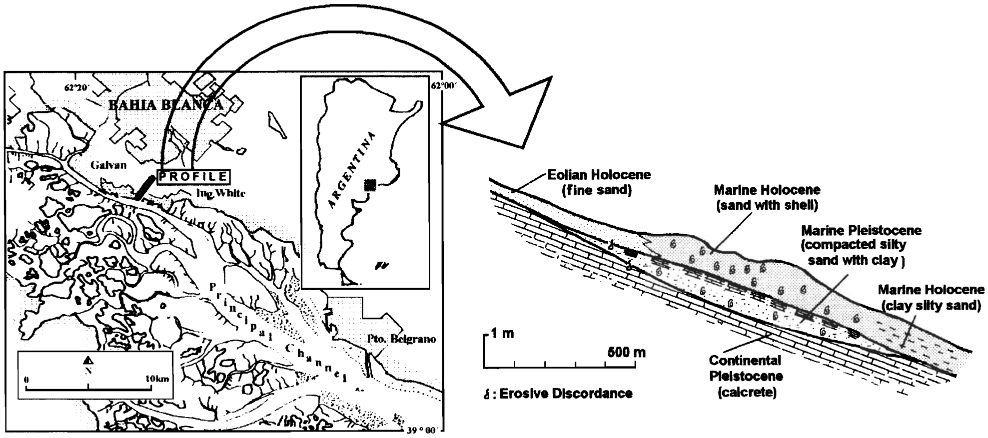

Figure 1. Study area and stratigraphic cross section of the Quaternary deposits.

research sedimentological and paleontological sampling and the stratigraphic scheme of the deposits. The textural analysis of the samples (39 of Holocene sediment and 41 of Pleistocene sediment) was followed to FOLK (1974) and the statistical parameters according to FOLK and WARD (1957). An 0.5 phi (ϕ) interval was used during sieving. The samples with more than 10 % silt-clay were pipetted to 8 ϕ. In the cemented material, the percentage of calcium carbonate was determined with 5 % HCl (CARVER, 1971). Identification and counting of the mineralogical species in the fine sand fraction (retained in a 125 μm sieve) was carried out in accordance with the technique used by PARFENOFF *et al.* (1970).

The taphonomic analysis carried out on valves of molluscs of Pleistocene (25 samples) and Holocene (30 samples) included the following parameters: disarticulation, fragmentation, abrasion, bioerosion and dissolution. The semi-quantitative and qualitative evaluations of the valves were carried out on the basis of the absence or presence of these parameters and on the qualifying parameters already used by other authors (PARSONS and BRETT, 1991; RUSSELL CALLENDER and POWELL, 1992; MELDAHL, 1994). Therefore, were measured a scale of "high", "medium", "low" and "none" (PARSONS and BRETT,1991), refer to the relative quantity of the taphonomical attributes.

MARINE QUATERNARY STRATIGRAPHY

The Quaternary stratigraphic sequence was established along a perpendicular geological profile to coast (Figure 1).

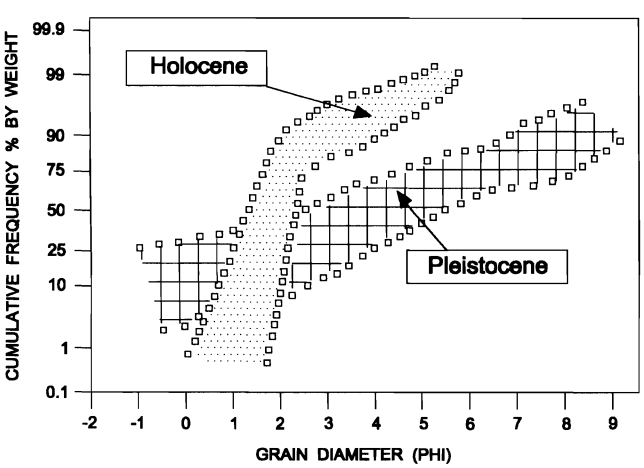

Figure 2. Cumulative grain size package curves Holocene and Pleistocene sediments.

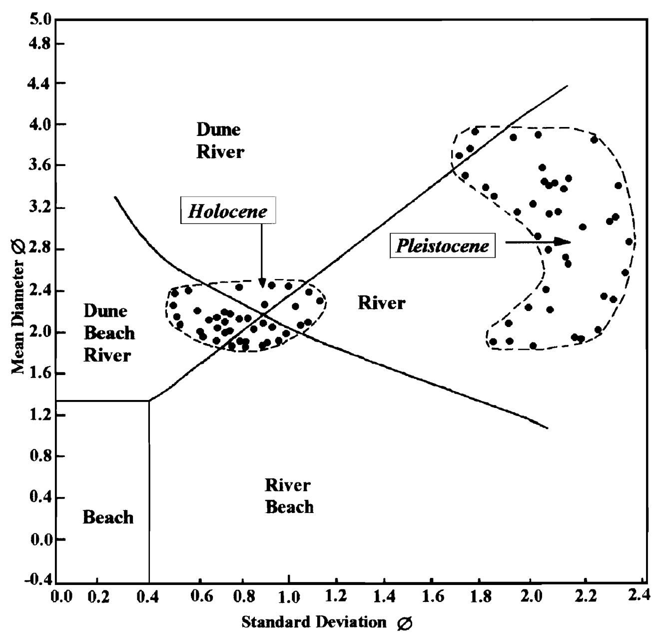

Figure 3. Sediment environmental distribution based upon statistical coefficients after Mazzoni (1978). The dashed line generates a graphic envelope which separates the fields corresponding to Holocene and Pleistocene samples.

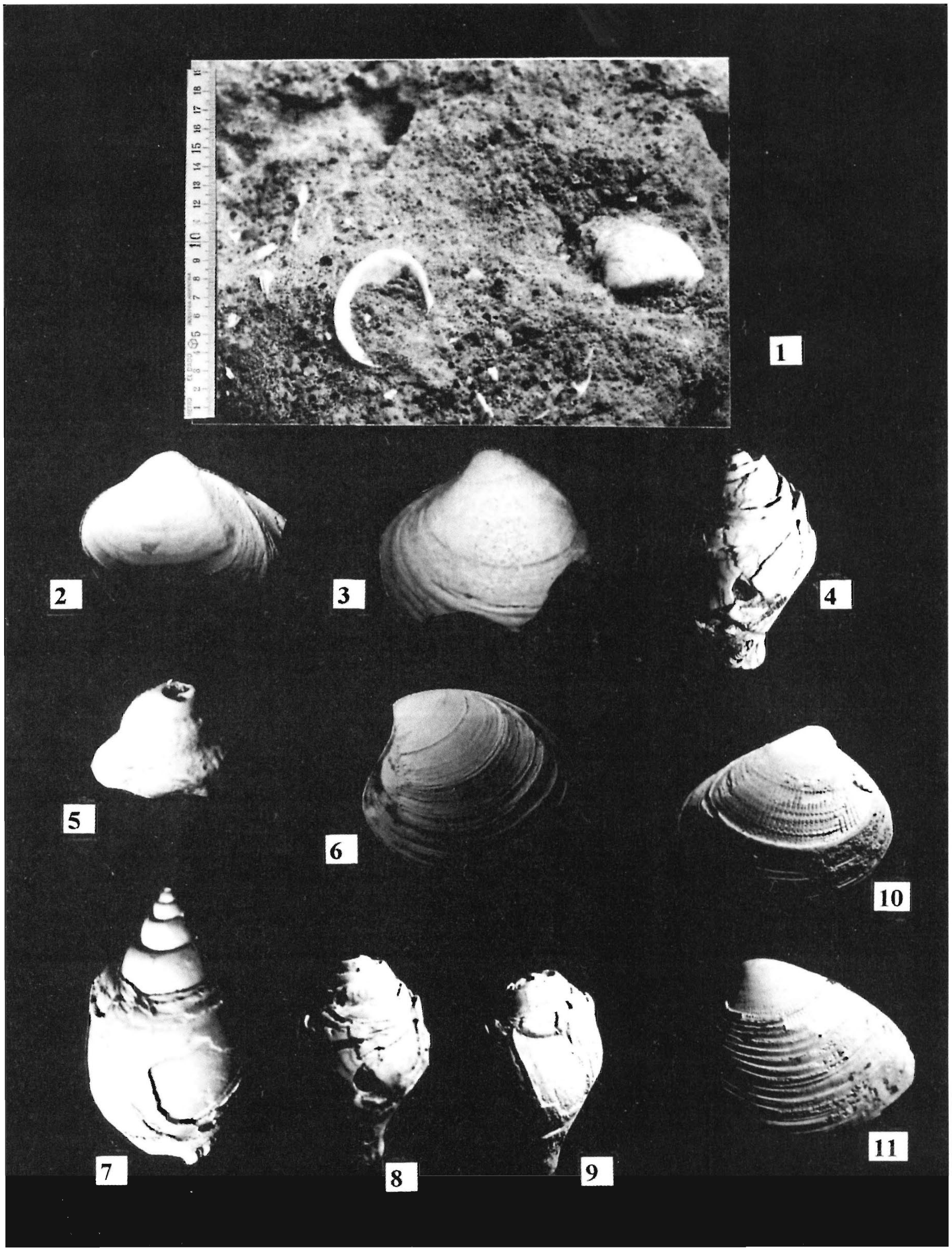

Plate 1. Characteristic of the Pleistocene deposit and related taphonomic features.
1. Pleistocene deposit showing matrix-supported biofabric. The scale is in cm.
2. Original sheen lost through dissolution in the umbonal area of *Pitar rostratus.*
3. Minor pitting due to dissolution in the central area of *Pitar rostratus.*
4. *Buccinanops deformis* showing a shallow hole in the surface of the shell.
5. Surface sculpture completely erased by dissolution of *Buccinanops sp.*

The marine deposits analyzed are superimposed and represent the transgressive maximum of the two studied events. Silty sand or sandy silt forms the basement on which the marine sediments rest. This yellowish-reddish-chestnut substratum is compacted and its upper part is cemented with calcium carbonate (calcrete-type paleosol). In some places, abundant carbonized remains of roots attest to their continental origin (Pampiano Formation, FARINATI, 1985a).

The sequence continues upwards with a fine-medium, partially silty and weakly compacted sand of a chestnut slightly yellowish colour. At the base of this stratum and a few centimeters from the erosive discordance (Figure 1), small well-lithified quartz and siltstone pebbles of up to 2.5 cm in diameter were observed. The mollusc remains (Plate 1–1) are concentrated in a few beds. Numerous radiocarbon datings made on the shells indicate ages between 35,000 and 25,000 years B.P. (GONZÁLEZ, 1984; CHAAR and FARINATI, 1988; CHAAR *et al.*, 1992). These values are in agree with ^{14}C ages obtained by several authors along the whole Argentine coast (CORTELEZZI and LERMAN, 1971; CORTELEZZI, 1977; BAYARSKY and CODIGNOTTO, 1982; CODIGNOTTO, 1983, 1987; GONZÁLEZ *et al.*, 1986, 1988a, 1988b; ISLA *et al.*, 1986; WEILER *et al.*, 1988; WEILER and GONZÁLEZ, 1988; ISLA, 1989; RABASSA and CLAPPERTON, 1990). Because these results indicate ages significantly lower than those of the last Pleistocene transgression, worldwide accepted to be approximately 125,000 years B.P. (interglacial Sangamon), the hypothesis arises of an Mid Wisconsin interestadial period, with a sea level above present values. In addition, palaeoecological analyses based on mollusks and microfossiles (AGIRRE and WHATLEY, 1995), together with magnetoestratigraphic evaluations (GONZÁLEZ and GUIDA, 1990) can, to a certain extent, be considered as endorsing the existence of that interestadial period. On the other hand, it is beyond doubt that the extant ^{14}C data are very near the upper limit of the method, which entails a loss of accuracy, underestimating their real value (CLAPPERTON, 1993a). Likewise, the processes of calcium carbonate cementation that most of the studies mention as a lithological feature of the Pleistocene deposits, can produce ages lower than the true ones. On the basis of these concepts, some authors therefore propose that ^{14}C ages would only indicate the minimum age of the last Pleistocene transgressive event (WEILER and GONZÁLEZ, 1988; CLAPPERTON, 1993b; AGUIRRE and WHATLEY, 1995; PASTORINO, 2000).

The application of more modern geochronological techniques (RUTTER *et al.*,1989,1990; SHELLMANN and RATDKE,1997; SCHELLMANN, 1998) on marine deposits exclusively of the Patagonian coast (South of the study area) produce ages considerably higher than those obtained with ^{14}C, and highly correlationable with the world Sangamon transgression. Within this degree of knowledge of the Argentine coasts, and in view of the great uncertainties of 14C datings of the oldest deposit considered in this work, we can only claim its connection with the last Pleistocene transgressive period, but without asserting its absolute age, something which, on the other hand, falls outside the aim of this research.

ALIOTTA *et al.* (1996b) established that the deposit formed by Pleistocene marine sediments is discontinuous along the coastal area. Studies carried out toward the outer estuary (ALIOTTA and FARINATI, 1990; FARINATI *et al.*, 1992) for instance and analysis of drill cores extracted in subtidal areas (ALIOTTA *et al.*, 1991; 1992; 1996a,b) demonstrate the absence of these sediments. They corresponds to relict deposits of the transgressive Holocene processes. The profile defined in Figure 1 highlight the Pleistocene stratum forming a wedge toward the coast.

Sandy ridges with a high shell concentration along the coastal sector defined up to 6–7 m AMSL (GONZÁLEZ, 1989; ALIOTTA and FARINATI, 1990) represent the Holocene transgressive maximum. A large number of ^{14}C ages (FARINATI, 1985a; GONZÁLEZ, 1989; ALIOTTA and FARINATI, 1990; FARINATI *et al.*, 1992) indicate that the last transgressive episode affected the Bahía Blanca area during middle-late Holocene occurred between 4,600 and 6,700 years B P.

In our profile in particular, Holocene marine sediments of the transgressive ridge formation erosionally cross-cut cemented marine Pleistocene material (Figure 1). The ridges are composed of medium-fine sand, with a high percentage of shells. The last regressive event (combination between progradation and fall in sea level) is evidenced by the old Holocene tidal plain, made up of clay-silt sediment, which is the main morphological feature characterizing the coast of the estuary.

SEDIMENTOLOGICAL CHARACTERIZATION

Although the marine sediments of Pleistocene age are generally massive, some levels have thin shell rich layers. Biogenic remains in these sediments amount to 20 % of the total weight. Another characteristic is the presence of quartz pebbles of various dimensions at the base of the Pleistocene stratum, although in general they do not exceed 2 cm in diameter. This feature is fairly constant along the whole of the studied profile.

The degree of compaction or lithification of this deposit is related to the presence of calcium carbonate as a cementing agent. At the base of the stratum the amount of calcium carbonate varies between 10 % and 15 %. In general, the degree of lithification increases towards the top of the deposit, developing an incipient sheeting with a significant increase in calcium carbonate cementation. The values determined in this upper part of the deposit varies between 25 % and 40 % in weight.

The grain size analyses show that the marine sediments of Pleistocene age are made up for the most part of silty-sand.

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6. Enhanced surface sculpture of *Pitar rostratus*.
7–8–9. *Buccinanops sp.* showing extensive dissolution and surface layer completely erased.
10–11. Preferrential dissolution in the umbonal zone of *Anomalocardia brasiliana*.

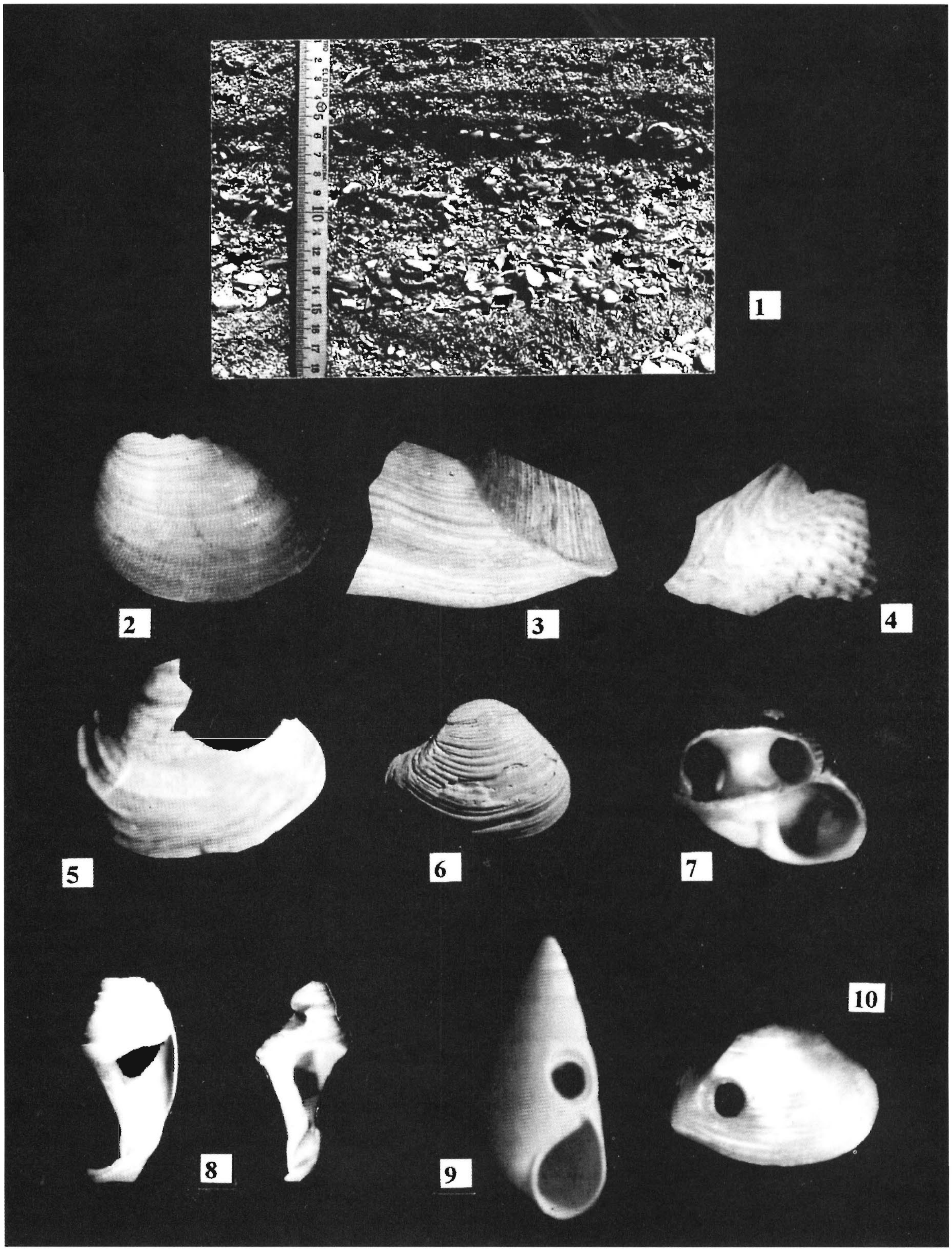

Plate 2. Characteristic of the Holocene deposit and related taphonomic features.
1. Holocene deposit. Biofabric bioclast-supported. The scale is in cm.
Major fragments of bivalves: 2. *Brachidontes rodriguezi*. 3. *Corbula lyoni*. 4. *Cyrtopleura lanceolata*.
5. Loss of surface ornamentation in *Petricola lapicida* by abrasion.
6. Abraded shell of *Corbula patagonica*.
7. Effects of abrasion in *Tegula patagonica*.

An average representative sample of paleoenvironmental sedimentological conditions is thus composed of 62 % sand, 25 % silt and 6 % clay. The remaining component comprises gravel-sized biogenic remains. The amount of this fraction present in the sediment can vary enormously, being almost absent at some sedimentary levels and reaching values of 30 % in weight at others, with a mean of 7 %. The sand fraction, is mostly fine to very fine. Figure 2 presents the zone comprising the cumulative frequency curves that characterize the marine Pleistocene sediments. From the general evaluation of the statistical parameters it is clear that the mean grain size is between 1.85 ϕ and 4.46 ϕ with an average value of 3.14 ϕ. The degree of granulometric uniformity of the sediments is on the whole very low, with an very poor average sorting value of 2.36 ϕ.

The Holocene deposits are made up of loose sandy material. Their tabular bedding is caused by the high percentage of mollusc valves and their fragments, representing over 50 % of the weight of most strata. There is an overall decrease in the size of biogenic remains from the base to the top of the stratum. The sediment is composed mainly of medium to fine sand. The silty-clay fraction is less than 10 %. Although shell content is variable, the sediment is quite homogeneous, as evidenced by the tight banding of the cumulative frequency curves of the samples analyzed (Figure 2). The statistical parameters also show such similarity. Thus, mean grain size varies between 2.0 ϕ and 2.7 ϕ (average 2.4 ϕ), and the sorting of the sediments is moderate (average 0.85 ϕ).

The mineralogical concentration of Pleistocene and Holocene marine sediments are illustrated in Table 1. Among the light minerals, the volcanic glass, whose refraction index is lower than 1.54 comes from acid magmas (MILNER, 1962). There are three types of volcanic glass in the Pleistocene sediments: 1) limpid and colorless, 2) limpid and dark-brown, 3) devitrified and coated in clay; whereas there is only one type in the Holocene sediments (limpid and colorless type). We consider as "altered minerals" those that have a strong alteration degree so that it is impossible to recognize them by microscopical examination. The zoned plagioclase type are abundant in the pleistocene sediments. Among the heavy minerals, piroxenes, amphiboles and opaque minerals are the most abundant and olivine, epidote and garnet apears as traces in both deposits. The Pleistocene deposit is characterized by hyperstene with serrated edges and presence of titaniferous augite and biotite.

QUATERNARY MALACOFAUNA

The quantitative analyses of fossil malacofauna revealed a low diversity of both gastropods and bivalves during the late Pleistocene. Whereas 106 taxa of molluscs (58 species of gastropods and 48 species of bivalves) have been recorded for the Holocene, only 17 (8 gastropods and 9 bivalves) have been recorded for the Pleistocene. Except for two bivalve species (*Anomalocardia brasiliana* and *Crassostrea rhizophorae*) which are absent in the Holocene, all the taxa of gastropods and bivalves have living representatives along the adjoining littoral zone that forms part of the Argentine Malacological Province extending from Santa Catharina (28° S) to San Matías Gulf (43° S) (WOODWARD, 1856).

Table 1. *Minerals percentage of the Pleistocene and Holocene marine sediments.*

Mineral Type	Pleistocene Sand (%)	Holocene Sand (%)
Volcanic fragments	12	5
Volcanic glass	19	5
Altered minerals	19	29
Plagioclase	29	25
Alkali feldspar	3	5
Quartz	11	11
Heavy minerals	7	11
Shell remains	0	9

Most of the Pleistocene bivalves (80%) are shallow infaunal, suspension feeders of soft substrates, while the Pleistocene gastropods are epifaunal, free-living, carnivores of hard substrates. All these characteristics bear similarity to those of Holocene molluscs. The Holocene molluscan fauna differs quantitatively and exhibits more diversity that from the Pleistocene (Table 2).

From the taphonomic point of view and according to KIDWELL *et al.* (1986), the skeletal accumulations of Pleistocene and Holocene deposits are parautochthonous, though there are obviously differences in the biofabric. The Pleistocene sediments are matrix-supported (Plate 1–1), while the Holocene are bioclast-supported (Plate 2,-1). According to a chart showing the relative abundance of shells (SCHÄFER, 1969), the shell-sediment radio is 1:3 and 3:1 in the Pleistocene and Holocene respectively.

In the Pleistocene deposit, no articulated bivalve shells were observed and the fragmentation index is medium to low. Mollusc valves, particularly bivalves, tend to break along the weakness lines of growth or ornamentation; while gastropods valves are fragmented at the aperture or spire. In gastropods the spires are generally destroyed, and in bivalves the valves are smoothened and the ornamentation weakened for abrasion. No evidence of boring or incrusting organisms was observed on shells in the Pleistocene deposits, indicating low degree of biological interaction.

Dissolution is one of the primary processes responsible for modification of valves of Pleistocene molluscs. According to DAVIES *et al.*, (1990) such dissolution manifests first itself as chalkiness on the surface of the valves through loss of the original sheen (Plate 1–2), pitting (Plate 1–3), small holes on the external surface (Plate 1–4) or the complete disappearance of the surface sculpture (Plate 1–5). Another sign of dissolution is seen in the enhanced surface sculpture of *Pitar rostratus* (Plate 1–6). *Buccinanops deformis* shells show how

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8. Progressive destruction of spire of *Olivella tehuelcha* by abrasion.
Sings of bioerosion: 9. *Littoridina australis* with drill-hole probably made by a naticid gastropods. 10. Borings of naticid gastropods in *Erodona mactroides.*

Table 2. *Summary of the taphonomic features of Pleistocene and Holocene marine deposits.*

Taphonomic Characteristics	Pleistocene	Holocene
Disarticulation	High	High
Fragmentation	Low-Medium	High-Medium
Abrasion	Medium	High
Bioerosion	None	Medium
Dissolution	High	None
Species diversity	Low (17 ssp)	High (106 ssp)
Shell Concentrations	Parautochthonous	Parautochthonous
Bioclastic fabrics	Matrix-Supported	Bioclast-Supported
Shell/Sediment ratio	1:3	3:1

valvar dissolution exposes the inner layers of the shells (Plate 1–7,8,9). In bivalves, dissolution most frequently affected (75 %) the umbonal zone of *Anomalocardia brasiliana.* (Plate 1–10,11).

In the Holocene the degree of disarticulation of sells is very high. The fragmentation varies at different levels of the same ridge. All identified fragments were considered major fragments. (Plate 2–2, 3, 4). There are strong signs of abrasion on the outer surface of the shells: rounding of edges, loss of surface ornamentation (Plate 2–5, 6) and progressive destruction of the spire in gastropods (Plate 2–7, 8). Mollusc shells have been heavily modified by the action of boring organisms such as Naticidae and Muricidae (Plate 2–9, 10). A comparative summary of the taphonomic characteristics of molluscs from studied deposits is given in Table 2.

DISCUSSION

Sedimentology

The sediment-stratigraphic characteristics of the Late Pleistocene and Holocene deposits indicate qualitative differences in the modes of the last two transgressions affecting the Bahía Blanca region. The primary difference is that the degree of carbonate cementation in the oldest sediments is up to 10 times higher than that of the Holocene facies. Although in other coastal regions of the world a similar change has been attributed to changes in sea water temperature (SEMENIUK, 1997), in case of the Bahía Blanca coast the lithologic environment in which the Pleistocene ingression occurred should also be taken into account. Strongly carbonatized material of the Pampiano Formation forms a large abrasion platform (ALIOTTA and FARINATI, 1990) underlying the marine sediments. The presence of highly alkaline groundwater with carbonates, coming from the Pampiano Formation and of the partial dissolution of the shells, and a long period of subaerial exposure has resulted in the creation of a calcrete (hardpan) in the top of the Pleistocene marine deposit.

Distinctive sedimentation conditions become clear from overlapping the cumulative frequency distribution curves for the two groups of samples considered (Figure 2). The granulometric subpopulations present in a sediment type (particularly notable in the Pleistocene material analyzed in our work), manifest dynamic conditions and / or specific sedimentary sources (MCMANUS, 1988). To begin with, the high content (up to 40%) of fine grain size (silt-clay) in Pleistocene sediments denotes a marine environment with scarce wave energy, where the marine sedimentation conditions are governed by tidal currents. The presence of coarse clasts (quartz pebbles and limolite fragments), which may seem contrary to a low energy environment, is associated with materials coming from fluvial contribution.

There are numerous studies demonstrating that granulometric characteristics of sediment can provide a good diagnostic tool for determining the depositional paleoenvironment. Various models of paleoenvironmental differentiation in terms of both the dominant dynamic conditions and source of sedimentary contribution were therefore taken into consideration and an evaluation of the statistical-textural parameters of Pleistocene and Holocene sediments was carried out. Though the results arising from the different bivariate scattergrams models (FOLK and WARD, 1957; STEWART, 1958; FRIEDMAN, 1967; BULLER and MC MANUS,1972) showed overall congruence, within the local context we prefer to analyze our data in terms of a scheme based on the textural qualities of sediments of different environments in regions bordering on the Bahía Blanca Estuary (MAZZONI, 1978). Thus, the oldest samples were found to be clustered toward the field of fluvial processes (Figure 3). The Holocene samples, on the other hand, are associated with a mixture sedimentary environment, with high marine influence. In this respect, the stratigraphic configuration of the Holocene materials corroborates wave activity as an important variable in the depositional mechanism. The very well-defined discontinuities between strata and the high concentrations of biogenic remains in their make-up indicate episodic energy conditions.

The mineralogical analysis throws light on certain peculiarities of Quaternary sedimentation. The compositional results are valuable parameters for determining not only the transport mechanism energy (ITO and MASUDA, 1986) but also the source of lithic clasts and sediment origin (KOMAR, 1976; SPALLETTI, 1980). Glass traces indicate that large amounts of volcanic material were deposited during the Pleistocene. The presence of three different glass types is an outstanding characteristic both of the Pampiano Formation sediments (TERUGGI, 1955) and of the Río Negro Formation (ANDREIS, 1966), both of continental origin and located to the north and south of the Bahía Blanca Estuary, respectively. This underlines the importance of the continental contribution to Pleistocene marine sediments. According to the observations of TERUGGI *et al.* (1964) on the other hand, Holocene sediments with only one type of volcanic glass are associated with present-day beach sands and with sands in the southern tide channels of the estuary, (GELÓS and SPAGNUOLO, 1989). The augite, hypersthene and plagioclase characteristics and the presence of biotite in the Pleistocene sediments are all in agreement with the above-mentioned sedimentary sources. Thus, the abundance of hypersthene with typical intrastratal dissolution manifested by serrated edges, the presence of biotite and zoned plagioclases are all indicative of a Río Negro Formation origin. The absence of titaniferous augite, euhedral hypersthene, for the most part limpid plagioclase and absence of biotite are linked with characteristic beach sediments toward the west of Bahía Blanca and outside the estuary (TERUGGI *et al.*, 1959; GELOS and SPAGNUOLO, 1989).

Based on the vertical sequence of sedimentary lithofacies in the Principal Channel, ALIOTTA *et al.* (1996) defined the Holocene estuary as an inverse filled basin. That is to say, in agreement with the results of the present paper, the sedimentation of the last transgressive period is produced fundamentally by materials that enter the system from the sea. At maximum sea level the coastal paleogeography would have been characterized by a wide shallow bay fed by sand drifting in from the south and east. The strong south-southeast winds had sufficient fetch to generate the waves responsible for the formation of the sand shell ridges distributed along the north coast of the estuary.

Taphonomy

In recent years the assessment of the taphonomic characteristics of mollusc valves has become an established tool for paleoenvironmental reconstruction and for the determination of sedimentation conditions. Such studies have been conducted in environments as diverse as reefs (PARSONS, 1989), intertidal to shallow shelves (MELDAHL and FLESSA, 1990) and inner continental shelves (STAFF and POWELL, 1990). Disarticulation and fragmentation, the first stages of the taphonomic pathway, are clear indicators of the level of energy regulating the sedimentary environment. The degree of fragmentation is a helpful parameter for differentiating regressive-transgressive deposits of the same epoch but with different wave surf conditions (MELDAHL, 1995).

In this study, observations carried out on Holocene bioclasts suggest higher energy levels than during the Pleistocene. The former are associated with a deposition generated by the combined action of waves and currents. Thus, the Holocene deposit shows beds with alternating moderate to very high fragmentation. According to BRETT (1990), this characteristic suggests intervention of depositional events in which wave energy is sufficient to play an important role in the sediment transportation mechanism.

The erosion or smooth of shells as a consequence of their differential movement with respect to sediments is an indicator of the degree of abrasion (DRISCOLL and WELTIN, 1973; DRISCOLL, 1967). Though the degree of abrasion may be similar in the two deposits, there are major differences in bioerosion as a result of the action of boring organisms. The absence of bioerosion in the Pleistocene material is associated with more rapid burial, which reduced the time of exposure to grazing and boring organisms. The bioeroded valves of littoral-sublittoral sectors of calm waters are captured and transported to the supratidal zone by storm events.

We also studied the effects of dissolution on bioclasts. Significant differences were observed between the two deposits. Particulary for the Pleistocene shells the postdepositional diagenesis through interactions with groundwater pH is the main factor that regulated their solubility. On the other hand, considering the species population of both deposits is possible to carry out some paleoenvironmental evaluations about salinity and temperature. Based on the presence of the species we can not establish a lighted difference between salinity conditions of Pleistocene and Holocene, since species of brackish water found in the Pleistocene (*Littoridina australis, Mactra sp., Brachidontes rodriguezi, Erodona mactroides, Ostrea sp.*) they also constitute, with similar relative percentages, the Holocene malacofauna. However, the remarkable disparity in species number leads us to think that the drop diversity of the Pleistocene fauna is related to an ecosystem with faulty salinity conditions for the development of a high organisms diversity. In such a sense, it is rejected that the postdepositional dissolution process of the Pleistocene bioclast it has been of such magnitude to cause the total disappearance of species. With regard to the great quantitative difference of shells among the deposits, we consider it as the product of differential sedimentation conditions, where a bigger wave action during the Holocene was the concentration mechanism of the shell remains. Also, through the comparison of species we stand out that *Anomalocardia brasiliana* and *Crassostrea rhizophorae* are the only two species not present in the coastal Holocene paleoenvironment of Bahía Blanca area (38° S). These species are present in beach ridges as far south as latitude 36° S in the mid Holocene (CODIGNOTTO and AGUIRRE, 1993). The current distribution of these molluscs is slightly further north, with the southern limit at 34° S. The change in range of the species evidences a significant drop in sea water temperature throughout the argentinian littoral region.

CONCLUSIONS

The last two Quaternary incursions identified along the Argentinian coast achieved a higher relative sea level than the present day. In the Bahía Blanca Estuary, deposits of the late Pleistocene and middle Holocene possess sedimentological and taphonomic characteristics that enable us to distinguish between different dominant paleoenvironmental sedimentations.

The Pleistocene deposit were formed under lower energy environmental conditions with limited fetch for the wave formation, where the sediment transport derived fundamentally from tidal currents. Several mineralogical features point out that stream flows carrying lithic material coming from contiguous formations played an important role in the deposition environment. Both the sediments and the taphonomy reflect a noticeable increase in wave energy during the Holocene event. It is hypothesized that the transgressive maximum gave rise to a coastal geography more exposed to marine action and wave formation, making way far materials mobilized by coastal drift to enter the sedimentation system.

The low diversity of the Pleistocene fauna is associated to an poor ecosystem (reduced salinity or oxygenation) for the development of organisms. The disappearance of species between the two transgressive events would be indicative of a fall in temperature in the paleoclimatic condition. Lastly, the differentiation among deposits is accentuated by a postburial diagenesis. The greater dissolution of bioclasts is therefore a distinguishing feature of sedimentary accumulations of the Pleistocene age.

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☐ RESUMEN ☐

Los dos últimos eventos transgresivos-regresivos cuaternarios (Pleistoceno tardío y Holoceno) han originado abundantes depósitos a lo largo de diversas zonas costeras del mundo. El estuario de Bahía Blanca no resulta una excepción. En la presente investigación se definen, en base al análisis sedimentológico y tafonómico, las condiciones paleoambientales de sedimentación que caracterizaron los procesos marinos. Los dos depósitos estudiados, alejados del litoral actual, se hallan sobrepuestos y separados por una marcada discontinuidad. Los sedimentos del Pleistoceno se distinguen por su mayor grado de cementación, especialmente en el techo del depósito. Las características sedimentológicas y tafonómicas evidencian diferencias en el régimen dominante de sedimentación. Los sedimentos pleistocenos, de menor granulometría y selección, fueron depositados en condiciones de menor energía, con un aporte importante de material lítico de formaciones costeras, transportado por aguas continentales. El máximo transgresivo holoceno se asocia a una geografía costera más expuesta a la acción de olas de tormenta y al transporte de sedimento por deriva costera.. Durante este período se generan cordones arenosos con elevada concentración de restos biógenos. La diferencia en la diversidad de la paleofauna marina (Pleistoceno: 17 especies, Holoceno: 106 especies) sugiere un ecosistema pleistoceno pobre para el desarrollo de organismos. En tanto que la desaparición de especies entre los dos eventos transgresivos puede ser indicativo de una disminución en la temperatura del agua de mar.