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Coastal Environmental Change During Sea-Level Highstands: A Global Synthesis with implications for management of future coastal change

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Molluscs, Palaeoenvironments and Palaeoclimates during late Pleistocene and Mid-Holocene highstands along Bahia Vera-Camarones (Patagonia)

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Abstract

The Quaternary sea level history along the Patagonian coastal area has been explained by several factors (i.e., eustasy, sediment supply, wave action, current energy). Sea level changes allowed the preservation of a complex of fossiliferous coastal deposits known in the local literature as Feruglio's Marine Terraces (MT, III to VI). Especially well preserved are those along the southern Chubut Province, between Bahía Vera and Camarones (44.2° S-45° S) in response to global sea-level highstands and minor neotectonic events. They were documented early in the literature (d'Orbigny, 1834-1847; Darwin, 1846; Feruglio, 1933-1950) and by subsequent authors (Codignotto et al., 1992; Rostami et al., 2000). Their rich biogenic composition consists mainly of molluscs and associated macrofauna (balanids, terebratulid brachiopods, polychaetes, bryozoans). In marine sedimentary deposits originally described as MT III (+ 44m, Camarones), IV (+ 22-29m, Punta Pescadero and Camarones) and V (+ 16-18m, Bahía Vera, Punta Pescadero, Camarones) of Late Pleistocene age, and as MT VI (+ 8-14m, Punta Lobería, Punta Pescadero, Camarones) of mid-Holocene age, both the gastropod and mainly the bivalve taxa recorded have not as yet been sufficiently studied.

The molluscan assemblages integrate parautochthonous shell concentrations which can provide palaeoenvironmental signals complementary of detailed sedimentary and modern geochronological work performed in the area (Schellman and Radtke, 2000).

They are appropriate for new analysis, especially in terms of palaeobiogeographical and palaeoclimate changes to present. An attempt to establish the typical molluscan fauna and, on this basis, to characterize the nearshore conditions during marine episodes since at least the long warm highstand acknowledged for MOIS11 (MTIII) can help objective comparisons with pre-Quaternary terraces in Patagonia (MTI-II and Salamanca Fm.).

Preliminary results for selected samples (10 fossiliferous localities and 4 modern collecting sites along the adjacent nearshore) indicate that molluscs (42 taxa; 25 gastropods and 17 bivalves) represent 91% of the total faunal content.

The molluscan assemblages show variations in composition, distribution, diversity patterns and morphology of individual taxa (such as differences in size and intraspecific morphological variations), both latitudinally and chronologically, likely linked to environmental controls. Faunal differences, geographically and between the Late Pleistocene (MTIII, IV, V), mid-Holocene (MTVI) and present (Magellanean Province), suggest that changes of substrate nature, water energy, salinity and especially SST, are the main controlling factors.

The most characteristic taxa recorded are *Patinigera* deaurata, *Fissurella* spp., *Crepidula protea*, *C. aculeata*, *C.* cf. *unguiformis.*, *N. isabelleana*, *Trochita pileus*, *Buccinanops* spp., *Pareuthria plumbea* (Philippi), *Acanthina monodon* (Pallas) and *Trophon* spp. (Gastropoda); *Brachidontes purpuratus*, *Protothaca antiqua*, *Clausinella gayi*, *Mactra* aff. *patagonica*, *Ostrea* cf. *tehuelcha*. New records for the Late Pleistocene (MTIV and V, MOIS7/9 - 5) are *C. aculeata*, *N.isabelleana*, *B. purpuratus*, *A. tehuelchus* (Bivalvia).

Apart from qualitative compositional differences, an outstanding observation relates to the dominance and greatest size of *Tegula atra* and *P. antiqua* in the Pleistocene (especially within MTIV) and of *Trophon* spp., *A. atra, B. purpuratus* in the Holocene (MTVI) or modern nearshore.



Figure 1. Area of study in central Patagonia (Argentina). General location of study area along the coastal area of southern Chubut Province between Bahía Vera and Camarones (SW Atlantic). Modern boundary for the Argentinian and Magellanean modern Zoogeographical provinces. Mid-Holocene (H) vs. modern (M) relative abundance of species groups according to their preferences for shallow water masses, along the area of study and in adjacent coastal areas (within the Bonaerensian area black stands for the remaining elements). M5: Puerto Quequén (SE Buenos Aires Province), M6: G.S.Matías (Río Negro Province), M7: P.Pirámides (Chubut Province), M8: Chubut and Santa Cruz provinces. H5: Bahía Blanca (Buenos Aires Province), H6 S.A.Oeste (Río Negro Province), H7: P.Pirámides (Chubut), H7': Camarones (Chubut), H8E: B.Bustamante (Chubut); H8n: B.Solano (Chubut); H8: C.Rivadavia (Chubut); H9: Tierra del Fuego.

Exclusive for the MTIII (MOIS11?; ca. 350-400 ka BP) are *Pectinidae*, *Ostrea* cf. *tehuelcha* and *Mactra* cf. *patagonica* which together with other taxa recorded by GI2S Coast, Research Publication, 4, 2003 Feruglio (i.e., *Corbula patagonica, Diplodonta vilardeboana*) suggest warmer SST than at present.

Typical of MTIV (MOIS7?, ca. 225 ka BP) are *T. atra*, big *P.antiqua*, and Veneroida indet. The assemblage from MTV (MOIS5?, 125ka BP) (*T. atra, T. patagonica, C. dilatata, M. edulis, B. purpuratus, P. antiqua, P. rostratus*) is not indicative of a climatic optimum like the Last Interglacial maximum highstand (MOIS5e) (Muhs et al., 2002; Kukla et al., 2002). MTVI (ca. 6.7 ka BP) is characterized by *B. cf. purpuratus, N. (Patinigera) magellanica, N.(P.) deaurata, Trophon geversianus, Brachidontes purpuratus, A. atra.* Exclusive for the modern littoral are *Chlamys* sp., *Panopea abbreviata, Lyonsia* sp. and *N. delicatissima*.

At present all molluscs live in the adjacent nearshore, mainly in cool-temperate and typically cold water masses (Argentinian and Magellanean Zoogeographic Provinces), except for T. patagonica, N. isabelleana and B. rodriguezi which show a northwards migration along the SW Atlantic (Argentinian Province) and T. atra representing a faunal extinction, both situations as biotic responses to climate change. Overall the molluscan associations are indicative of hard substrates, shallow waters and truly marine conditions, smilar to the modern littoral of central Patagonia (Magellanean Province). Apart from qualitative, quantitative, morphological and distributional variations, a comparison with the modern associations (Carcelles, 1950; Bastida et al., 1992; Castellanos and Landoni, 1988-1993) on a temperature basis suggest slightly higher than present SST during the Mid-Holocene (MTVI, MOIS1, Hypsithermal), slightly colder for MTV (MOIS5c ?, 5a?), similar for MTIV (MOIS5e, 7?) and warmer for MTIII (MOIS11?). It is outstanding that the MTIII at Camarones contains a very rich assemblage made of enormous Ostrea tehuelcha d'Orbigny, extinct in the adjacent littoral, and as a whole very similar to the molluscan assemblage of the Belgranense (Late Pleitocene) deposits preserved very restrictively northwards in the NE Bonaerensian littoral. traditionally interpreted as a Last Interglacial highstand but recently documented as a pre-Last Interglacial highstand on magnetostratigraphic evidence (Nabel, 2002) in accordance with the faunal content and taphonomic attributes. Our present data can be integrated with the whole molluscan records and bibliographic data gathered for a more extensive Patagonian coastal area, along Chubut and Santa Cruz provinces (Bahía Vera-Golfo San Jorge). A Two-way table of Q Mode vs. R-Mode cluster analysis (41 samples and 53 species recorded) allow to recognize 4 biofacies (with 6 sub-biofacies) and 8 molluscan associations. They agree with the geographical location of the samples, from north to south, arround Camarones, Bahía Bustamente and Golfo San Jorge coastal areas.

For the mid-Holocene terrace (MTVI, ca. 9-6 ka BP) a southwards latitudinal decrease in the abundance of temperate taxa and increase of cold water elements is most likely consequence of a greater influence and southwards shift of the Brazil Current during a climatic optimum (not fully coincident with Pastorino, 2000).

The palaeobiogeographic response to sea-level and climatic changes is, however, less evident than at lower latitudes (Río Negro and Bonaerensian littoral areas).

MTIII at Camarones is the only terrace clearly showing extralimital faunal elements (mainly *Ostrea* cf. *tehuelcha* d'Orb., *Mactra cf. isabelleana* d'Orb.) typical of warmer waters than at present, in agreement with previous correlation with MOIS11 highstand (Schellmann and Radtke, 2000) and palaeoenvironmental conclusions by Feruglio (1950). The remaining terraces do not show typical warmer water elements or characteristic of climatic optima.

Further studies are urgently needed in Argentina to establish the number, timing, duration and climates of Late Quaternary sea-level highstands preserved. From a palaeontological point of view, it is fundamental to establish molluscan variations (all aspects) linked to shifts in oceanic and atmospheric circulation patterns during former sea-level highstands.

Along central Patagonia, it is especially relevant to perform detailed comparisons of stable isotope analyses on well dated and selected taxa in terms of their palaeoecologic value (*Protothaca, Clausinella, Brachidontes; Nacella, Tegula*), panbiogeographic approaches focused on the Last Interglacial vs. Mid-Holocene highstands, and to study the biotic histories of ancestral molluscan biotas along this important part of the SW Atlantic margin.

Unfortunately, the economic situation in Argentina has not allowed to carry out such a multidisciplinary project as needed.

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