GEOLOGICAL AND ENVIRONMENTAL EVOLUTION OF LAGOON SYSTEM III IN THE SOUTHERNMOST COASTAL PLAIN OF RIO GRANDE DO SUL STATE

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Here is presented a preliminary report of an ongoing research on the deposits of the Lagoon System III found in the Santa Vitória do Palmar county, in southernmost Rio Grande do Sul state. This contribution includes new paleoenvironmental and paleontological data that provide further information regarding the evolution of this unit. The southernmost portion of the Brazilian coast comprises the Coastal Plain of Rio Grande do Sul State (RSCP). This 620 km-long geomorphological unit had its morphology influenced by glacioeustatic oscillations during the Neogene and Quaternary. Between late Pleistocene and Holocene, sea-level transgressions originated four major barrier-lagoon depositional systems parallell to the coastline. The transgressive event of 123 ka AP formed the Barrier-Lagoon System III, which is well represented along the entire RSCP (Tomazelli & Dillenburg, 2007). In the southern sector of RSCP, the Lagoon System III, located between Barrier III and the older Barrier II, is well preserved, and the facies associated to this system are exposed along the banks of Chuí Creek (Fig. 1A). The creek flows in a NE-SW direction, parallel to the coastline, but near the town of Chuí its course changes to NW-SE before discharging into the Atlantic Ocean.

Chuí Creek was originally a shallow creek flowing through the plain between Pleistocene barriers II and III. During the late 1960s, it was further excavated for agriculture purposes and during the excavations the underlying sedimentary facies were exposed, revealing marine sediments and continental sediments containing fossils of Pleistocene mammals (Figure 1B). The first stratigraphic study on Chuí Creek was made by Soliani Jr. (1973), who correlated the marine deposits at the base of the stratigraphic sequence to the "Chuí Formation" of Delaney (1965), and the overlying fossiliferous layer to a new lithostratigraphic unit that he named "Santa Vitória Formation". During the 1980s the lithostratigraphic scheme of the RSCP was abandoned in favour of the concept of depositional systems, replacing the lithostratigraphic units by chronocorrelated stratigraphic units. Under this new scheme, both the marine and continental deposits are now correlated to the Lagoon System III.

Marine facies

Today the banks of Chuí Creek measure some 4,5 meters in height above the creek bed (Figure 1C). The lowermost 2 meters of the sequence is the marine facies correlated to the "Chuí Formation". The total thickness of this layer is still unknown, but manual drillings revealed that it is more than 4 meters. Ichnofossils *Ophiomorpha nodosa* are common throughout this facies (Figure 1D); the sediment is a fine yellow sand, exhibiting parallel and low-angle cross stratifications (Figure 2A). Recently, an accumulation of marine mollusks was identified at the base of the exposed portion of this facies, with abundant remains of sandy bottom dwellers such as *Amiantis purpurata*, *Pitar rostrata* and *Mactra isabelleana* (Lopes, 2010). It is noteworthy that above this accumulation *Ophiomorpha* galleries are found but no shells have been observed yet.

Fluvial facies

The transition between the marine facies and the overlying layer is gradual (Figure 2B). The latter is the fossiliferous unit that Soliani Jr. named "Santa Vitória Formation" and interpreted as deposited in a lagoon environment. However, the taphonomic features of the vertebrate fossils, mostly unidentified fragments but also including articulated remains, and the presence of dark sand lenses interpreted as oxbow lakes, indicate a meandering fluvial environment. These lenses are massive and measure between 20 and 30 centimeters in thickness and 3 to 7 meters in length (Figure 2C); the top and bottom exhibit iron oxide crusts. The lenses protrude into the marine facies below and may contain small fragments of vertebrate fossils. Adjacent to these lenses paleosols with abundant root traces can be observed (Figure 2D).

Until now, vertebrate fossils were found only on the lower portion of the fluvial facies, in a ~1m-thick level. ESR datings on fossil teeth found in this layer revealed ages between 42 and 33 thousand years (Lopes *et al*., 2010). No sedimentary structures have been observed in this facies. Above the fossiliferous layer only root traces have been recorded, but at some points along the banks a carbonate layer can be found, which was named "Caliche Cordão" by Delaney (1965) (Figure 2E). It measures some 40 cm in thickness, and although its distribution is not homogeneous, its longest continuous exposition is 461 meters in length. The carbonate forms irregular nodules and rhizocretions.

The sediment that constitutes the fluvial facies is composed mainly by fine sand, but there is an upwards increase in silt-sized particles. Although no vertebrate fossils have been recovered so far from the upper portions of this facies, some structures that suggest burrows made by micromammals were recently found (Figure 2F). The uppermost portion of the sequence is formed by a ~70 cm-thick layer of organic matter-rich fine clayey sand, which contains archaeological artifacts and vertebrate remains indicative of a Holocene wetland environment.

DISCUSSION

The sedimentary sequence exposed along the banks of Chuí Creek shows the transition between a shallow marine environment to a continental one. Although detailed regional stratigraphic data are not available yet, the present data suggest that the marine facies may be correlated to the Barrier System II, formed by the marine transgression estimated to have occurred around 325 ka AP, by correlation with the Marine Isotope Stage (MIS) 9 by Villwock & Tomazelli (1995), but it may also represent the transgression of 200 ka BP, correlated to MIS 7. One tooth of an extinct mammal found in the same level of the marine facies and dated on 226 ka BP (Lopes *et al*., 2010), suggests that the transgression may have occurred at 200 ka BP and reworked older continental deposits. Until datings for the sediments and large-scale, detailed stratigraphic surveys are available, the exact age of this depositional system is still debatable. Anyway, the stratigraphic sequence indicates that after the marine transgression that formed the Barrier II, sea-level retreated and continental sediments started to accumulate on top of the marine facies. During the interval before the marine transgression of 123 ka BP, that formed the Barrier System III seawards of Barrier II, all drainage presumably would flow eastwards to the ocean. Seismic surveys on the continental shelf have shown the existence of several fluvial paleochannels with an E-W orientation that were correlated to fluvial systems that existed during sea-level lowstands. Thus, during the interval between 325 or 200 ka AP and 123 ka BP, Chuí Creek on its present NE-SW orientation wasn't established yet. After the 123 ka BP transgression, drainage coming from the surrounding higher areas of Barriers II and III would have flown to Lagoon System III, increasing the sedimentation. Although Soliani Jr. (1973) and other authors considered the sediments above the marine facies were deposited in lagoon environment, no evidence of such lagoon have been found yet. The dark, organic matter-rich sand lenses contain palynomorphs that suggest the existence of shallow lentic environments, such as the margins of a lake or lagoon or oxbow lakes. Because this dark sand layer is not continuous along the banks, the correlation with oxbow lakes, formed by abandoned channels in a meandering fluvial system, seems more plausible. The presence of mostly fragmented remains of fossil mammals, with clear indication of post-fossilization reworking, reinforces the existence of a fluvial system (Lopes, 2009).

It's not clear yet whether this fluvial system was continuously active after the formation of Barrier-Lagoon System III. The only available ages obtained so far from three fossil mammal teeth revealed ages of 42, 38 and 33 ka BP, which suggest an active fluvial system around 30 ka BP. However, additional ages should probably reveal the existence of older fossils and fluvial sediments. The ages between 42 and 33 thousand years are correlated to a more humid climatic phase that has been recorded in other parts of central-southern Brazil (Ledru, 1993) and Argentina (Prado & Alberdi, 1999), coincident with the milder climate of MIS 3. The fossil record of the aquatic rodent *Myocastor coypus* on this layer indicates the presence of a stable water body (Pereira *et al*., 2009). The vertebrate fossils are concentrated on the ~1 meter-thick basal portion of the fluvial facies, and the apparent absence of such remains on the upper portion may be related to climatic and environmental

changes, as recorded in the Luján Formation of the Pampean Region of Argentina (Tonni *et al*., 1999). The deposition of the caliche layer and the upwards increase in silt-sized sediments seem to be result of an increasingly drier climate and deposition of finer, probably loessic sediment, correlated to the climate deterioration that led to the last glacial maximum (LGM) during MIS 2. During the LGM the dry (Patagonian) climatic belt was displaced some 750 km NE of its present position, as indicated by loessic deposits in Uruguay (Iriondo, 1999) and probably southern Rio Grande do Sul. The presence in Chuí Creek of fossil mammals that indicate drier environments such as *Catagonus stenocephalus, Dolichotis* sp. and *Microcavia* sp. (Pereira *et al*., 2009) also reinforces a drier climatic phase. The Pleistocene-Holocene transition in the study area is represented by the dark clayey sand layer on top of the sequence. The increase in organic matter, plus the vertebrate remains and archaeological evidence found in this layer indicate a more humid environment that allowed the development of wetlands in the area. The excavation of Chuí Creek, in the 1960s, changed this environmental condition, favoring the drainage of the wetlands for agriculture purposes

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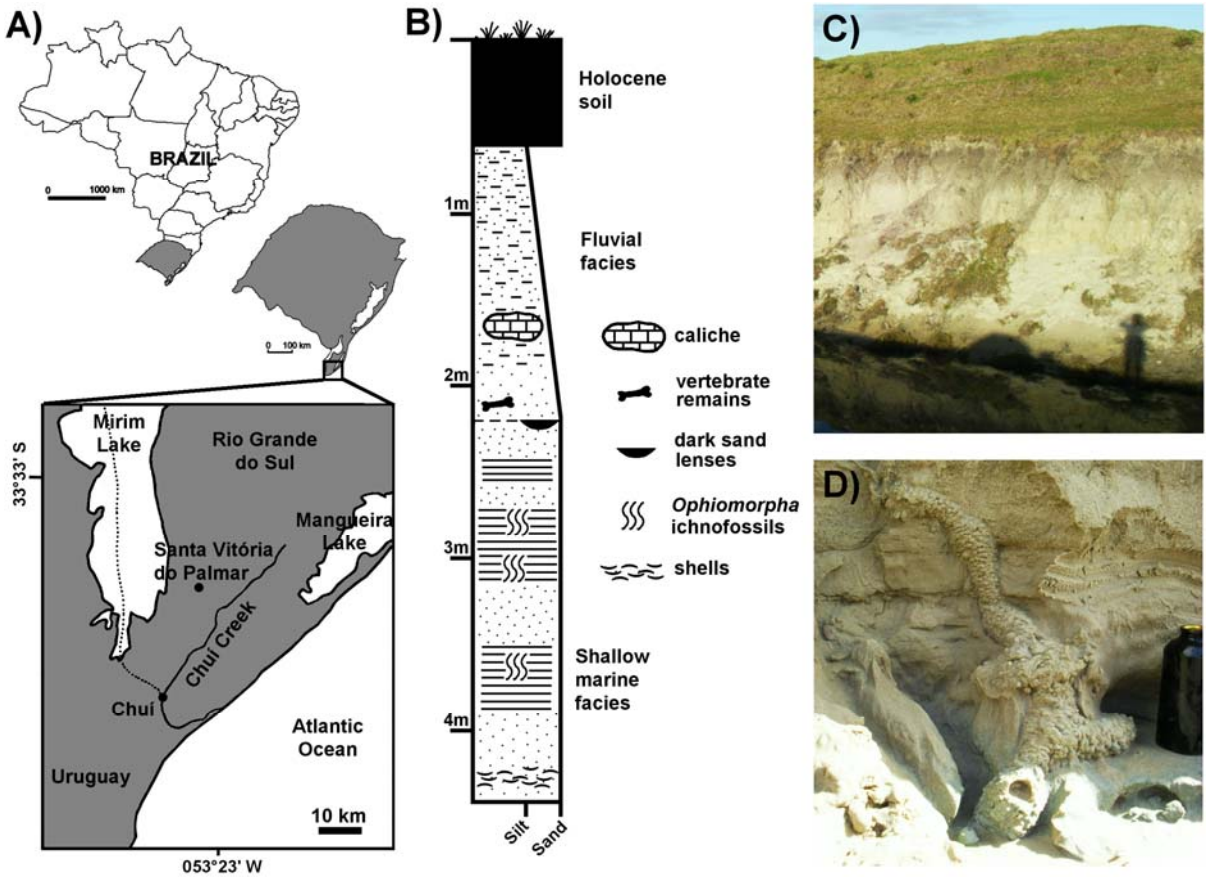

Figure 1 – A) Location of Chuí Creek; B) Stratigraphic sequence exposed along the banks; C) View of the banks; D) gallery of *Ophiomorpha nodosa*.

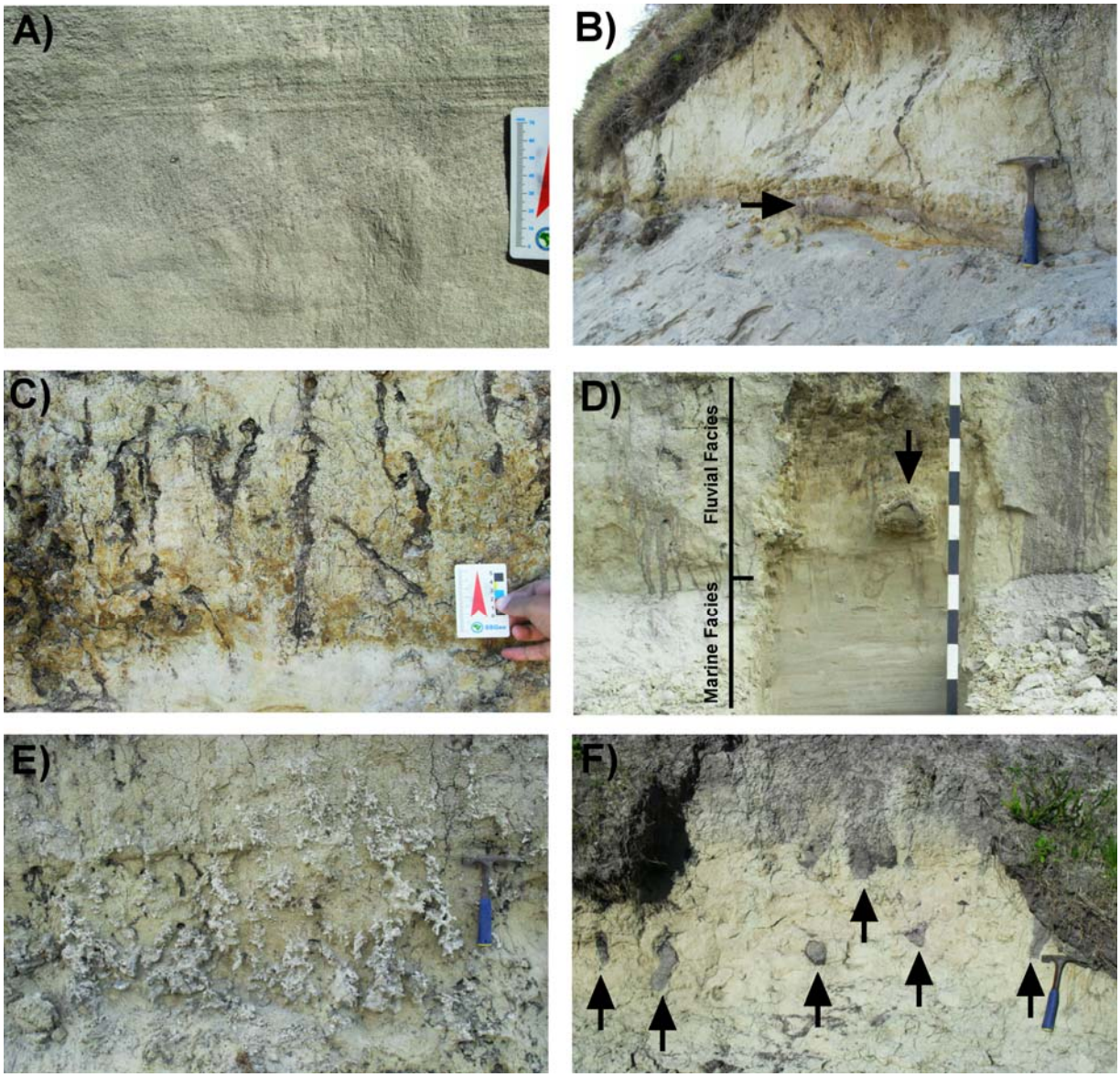

Figure 2 - A) Parallell and cross stratifications in the marine facies (scale bar = 7 cm); B) Dark sand lens (indicated by arrow); C) Detail of the paleosol on top of the marine facies (scale bar = 7 cm); D) Transition between the marine and fluvial facies, with a mammal fossil indicated by arrow (each division of the scale measures 10 cm); E) Detail of the caliche layer; F) Possible micromammal burrows (indicated by arrows).