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Multidisciplinary studies at Cerro Tapera Vázquez site, Pre-Delta National Park, Argentina: The archaeological, sedimentological and paleobotanical evidence

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ABSTRACT

The initial results of archaeological, sedimentological and paleoethnobotanical studies of Cerro Tapera Vázquez (CTV) archaeological site were analyzed. This research aims to characterize the ceramic, lithic and bone materials recorded at CTV, to establish the chronology of the site and to define the paleo-environmental context during human occupation of the site. The site is located on the wide alluvial floodplain of the Paraná River. In 2008, 16 m^2 were excavated at CTV, and abundant smooth, incised and modeled pottery and numerous bone remains (especially of coypu) were recorded. Radiocarbon dates put past human occupation at between 650 and 520 BP. The paleobotanical evidence establishes that for this period the climatic conditions were colder than at present, while the anthracological record allowed the selection criteria used by the occupants in search of vegetal fuel to be determined. The results reached in this study lead to the conclusion that the pre-Hispanic populations that occupied CTV by the end of the Late Holocene were riverine canoe peoples, with complex ceramic technology and subsistence based on hunting, fishing and probably small-scale horticulture.

1. Introduction

The Paraná River is the second longest fluvial system in South America. It forms a vast delta that is unique because it does not empty directly into the ocean. The Paraná Delta is a key area for the discussion of supra-regional issues that have great relevance for the archaeology of the South American Lowlands. These issues are: a) the origin and southern dispersal of agriculture in the lowlands (Lothrop, 1932; Lathrap, 1977; Piperno and Pearsall, 1998; Denevan, 2001); b) the role of anthropic agency in modeling the landscape, especially in the construction of artificial earthen mounds (Roosevelt, 1991; López Mazz, 2001; Bracco, 2006; Erickson, 2006; Iriarte, 2006); c) the expansion of Guaraní populations into the Southern Cone (Brochado, 1984; Soares, 2004; Noelli, 2008; Prous and Andrade Lima, 2008); and d) the development of ranked societies and social hierarchies (Hornborg, 1988; Carneiro, 1993; Chapman, 2003).

Despite its importance, the Upper Paraná Delta is an area understudied by archaeologists (for exceptions see Ambrosetti, 1893; Gaspary, 1950 and Nóbile, 2002), which means that systematic fieldwork at stratigraphic sites is necessary. In this paper the initial results of multidisciplinary studies at Cerro Tapera Vázquez (CTV) stratigraphic site are presented. The site is inside the Pre-Delta National Park, located on the left margin of the Paraná River (Fig. 1). The technological study of pottery and lithic tool and the zooarchaeological study of bone assemblages were undertaken. Archaeological charcoal was radiocarbon dated and identified to genus level. Phytolith samples were processed and analyzed to characterize plant communities. In order to retrieve evidence of anthropic modifications in the occupational levels, sedimentological samples from the inner site profile and a profile from an area outside the site (and hence uninfluenced by humans) were compared.

This research aims to characterize the ceramic, lithic and bone materials recovered, to establish the chronology of the human occupation, to define the geological context of the site, to identify the original plant paleocommunities and to interpret the anthropic use of plants. The present study is encompassed within a major project (Bonomo et al., in press; see summary in Politis et al., in this issue), the main objective of which is to identify the basic adaptive patterns in the Upper Paraná Delta during the Late Holocene (ca. 3000 to 400 BP) with special attention given to horticultural practices and management of non-domesticated plants.

Paleobotanical remains preserved in archaeological sites, such as phytoliths and charcoals, provide different types of information on

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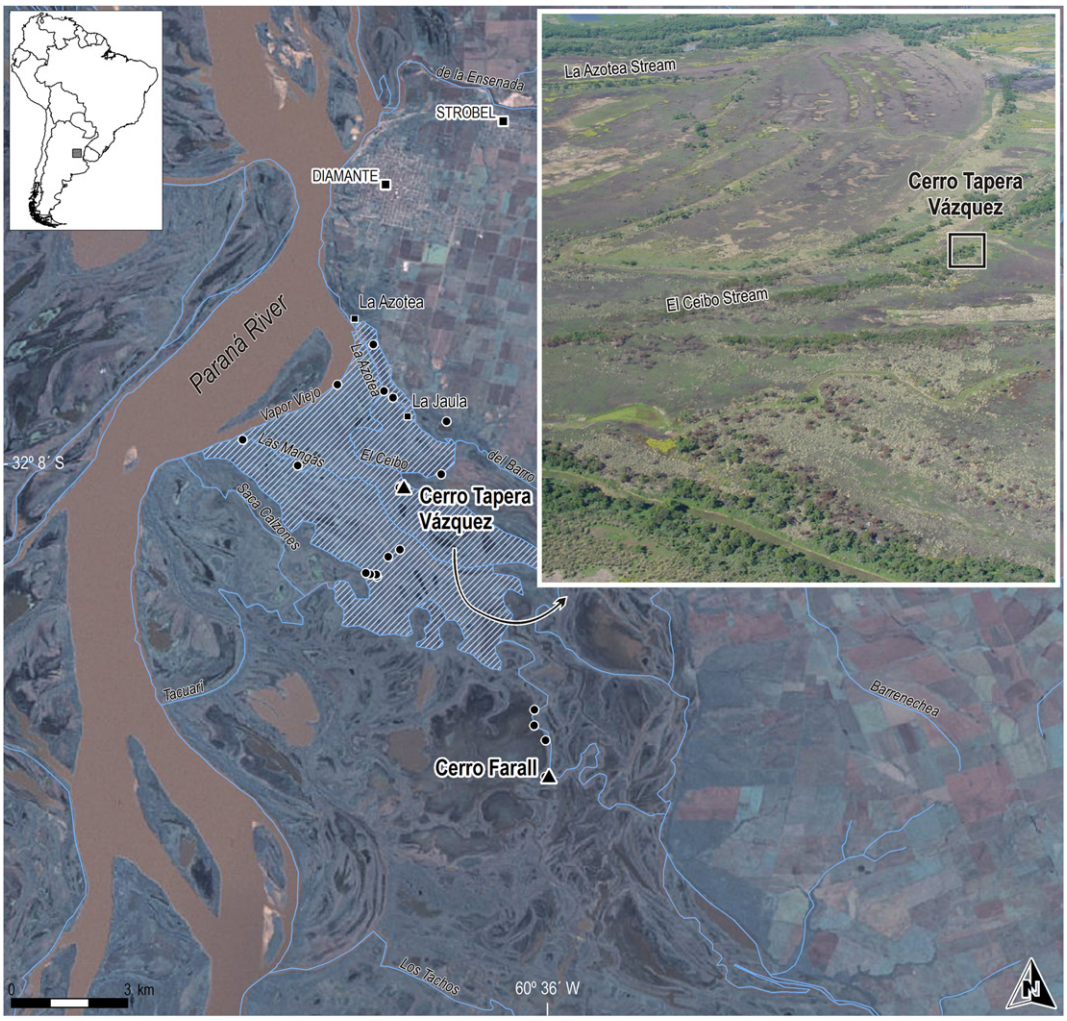

Fig. 1. Study area with the location of Cerro Tapera Vázquez archaeological site.

the transformation of vegetal landscapes and the interaction among plants and humans (Piperno and Pearsall, 1998; Piqué i Huerta, 1999; Fiorentino and Magri, 2008). Phytoliths afford a strong possibility of establishing the composition of plants communities when other vegetal remains are not well preserved. Carbonization prevents the biological decomposition of wood and preserves intact its original anatomical features (Alden, 2009). Archaeological charcoal can be employed to identify trees or shrubs found in the area around human settlements. Charcoal macro-residues are sometimes found accumulated as burned hut posts, or in hearths, but most frequently are widely disseminated throughout the archaeological deposit (Gariboti, 1998; Rodríguez, 2000; Solari, 2007; Alden, 2009). Concentrated charcoal is usually a sign of human selection and use of forest resources (Figueiral, 2005 and references therein).

2. Environmental and archeological framework

The Pre-Delta National Park is located 4 km south of Diamante City, western Entre Ríos Province (Fig. 1). This aquatic ecosystem with high biodiversity is mainly the product of periodic flooding events. It consists of a multiple-channel system that surrounds riverine islands, which have high levees along the banks of the mayor streams and central low zones occupied by pools and swamps. Vascular flora and vertebrate fauna from this National Park have been the subjects of several recent studies (e.g. Aceñolaza et al., 2004; Rodríguez, 2007; Almirón et al., 2008; Alonso, 2008).

Due to the great latitudinal extension of the Paraná River, it acts as a biological corridor merging subtropical flora and fauna in a temperate zone, including Amazonic, Chacoan and Pampean species (Aceñolaza et al., 2004). In phytogeographic terms, the vegetation corresponds mainly to the Paranaense Province of the Amazonic Domain, as well as elements from the Chacoan Domain (Cabrera, 1976). The fauna is characteristic of the Mesopotamia District of the Subtropical Domain (Ringuelet, 1961), with a minor influence from Pampasic elements. The main economic activity in the Paraná islands is raising cattle, without any systematic or intensive agriculture.

This research follows a sequence of archaeological studies in the Paraná Delta, concentrated in the Lower Delta, which began at the end of the nineteenth century and continues to the present (e.g. Ambrosetti, 1893; Torres, 1911; Lothrop, 1932; Lafón, 1971; Caggiano, 1984; Loponte, 2008; Bonomo et al., 2009a, in press). These contributions revealed some of the major trends in the pre-Hispanic archaeological record of the Paraná Delta. Archaeological sites are from the Late Holocene (between 2700 and 300 BP), with no data on earlier human occupations. Sites are situated in high non-flood zones (on mounds, dunes and levees) and were utilized as residential and/or burial areas. The sites include abundant and diverse pottery and bone tools (especially antler points), lithic tools

(grinding tools, hammerstones, spheroids, axes, and flake tools) and shell and copper ornaments. Subsistence was based on hunting local mammals (mainly freshwater otter and swamp deer), fishing, and gathering molluscs, palm and algarrobo fruits.

3. Materials and methods

The archaeological excavation of 16 grids of 1 m^2 at CTV was conducted on the top of a mound (Fig. 2). The mound is located at the high end of a levee of the El Ceibo Creek, in a sector partially dissected by the drainage channel of adjacent swamps. Sedimentological analyses and morphologic descriptions of three soil profiles (grid 5, grid 13 and non-site) were carried out in accordance with the norms established by USDA Soil Survey Staff (1993). The granulometric analysis was carried out using the pipette method (Gee and Bauder, 1986) for size fractions lower than 62 m, and by dry sieving for the larger fractions. The grain size frequency distribution was described in accordance with the Wentworth scale (Wentworth, 1932, 1935), expressed as values of Φ (phi) (Krumbein, 1936). Having established the relative percentages of material in every size class, the principle statistical parameters (such as median, mean, standard deviation, skewness and kurtosis) were calculated following the moments method (Friedman, 1962).

In relation to the archaeological material, the pottery recovered in grids 1 and 2 was studied by integrating techno-morphologic and refitting analyses (Rice, 1987; Clive et al., 1997). Macroscopically, the shapes, surface treatments, firing characteristics, and decoration of sherds, were examined. The lithic material was described following Babot (2004). Bone and tooth remains recovered in all grids were classified according to anatomical and taxonomic categories for identifying the utilization of faunal resources. Standard zooarchaeological quantitative analyses (NISP, MNI, MNE, %MAU) (Binford, 1981; Lyman, 1994) were applied to these bone assemblages.

Charcoals were identified by examining freshly fractured surfaces (cross, radial and tangential sections) using reflected light. Each sample was identified using a standard microscopical wood key, wood atlases and descriptions by Metcalfe and Chalk (1950), Tortorelli (1956), Tuset (1963), Richter and Dallwitz (2000), Garibotti (1998), Rúgolo de Agrasar and Rodríguez (2003), as well as the InsideWood database (2004-onwards). The terminology for the wood features follows the IAWA Lists of Features Suitable for Hardwood Identification wherever possible (IAWA Committee, 1989). These charcoal fragments were also compared to extant species, particularly present-day Pre-Delta woody species. The charcoals were deposited at the Laboratorio 3 of Departamento

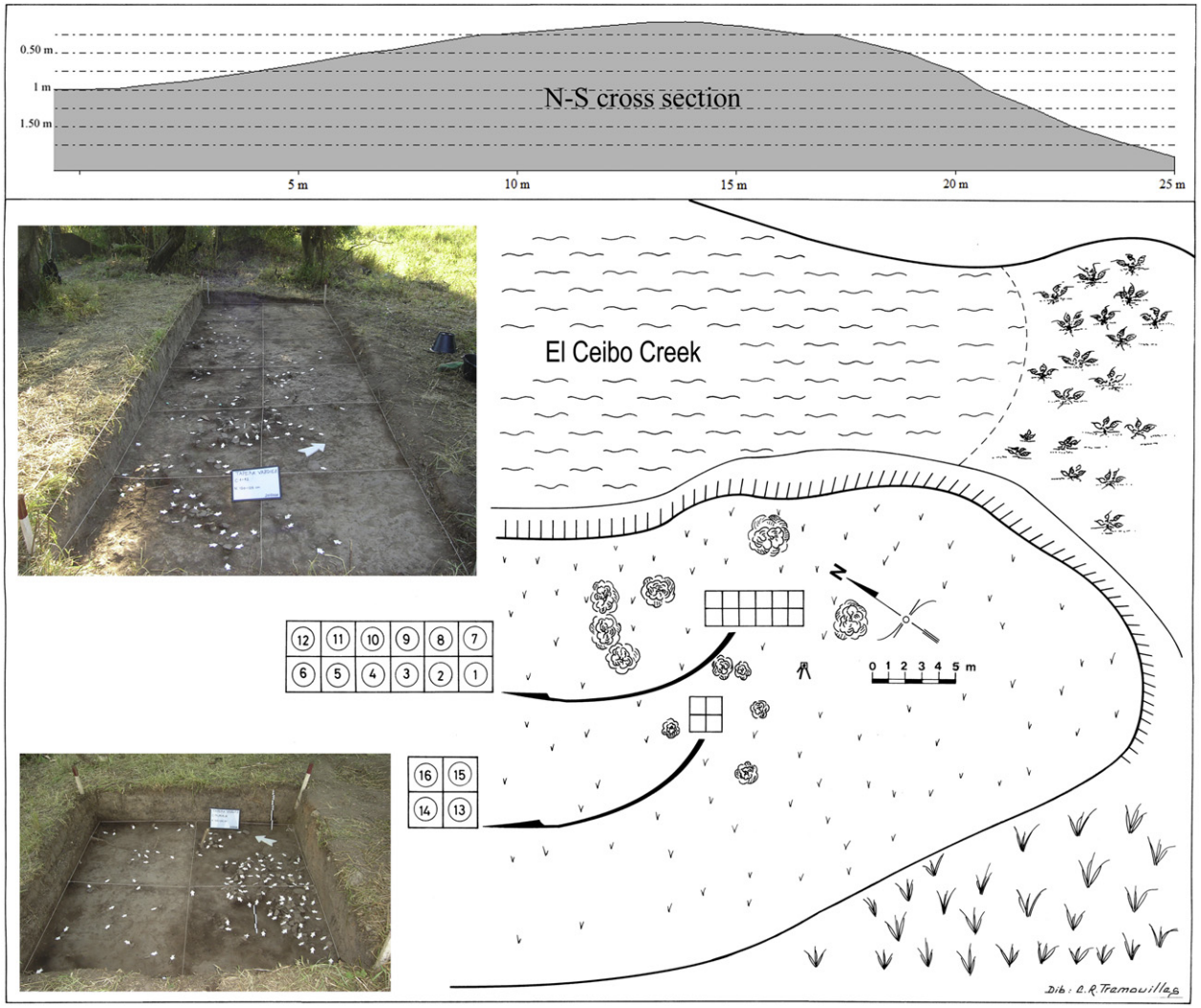

Fig. 2. Excavation at Cerro Tapera Vázquez.

Científico de Arqueología at Museo de La Plata under the acronym C-CTV.

The profile of grid 5 of the CTV excavation (G5P) and the non-site profile (NSP) (taken from an area of the levee with no evidence of human occupation) were selected to obtain sedimentary samples from which to analyze phytoliths. For the siliceous microfossil concentration, 17 samples were obtained from two profiles. The clastic samples were subjected to preliminary treatment according to the methodological rules described in Bonomo et al., (2009b). The steps followed were: elimination of soluble salts, carbonates and organic matter and desegregation of the sample with sodium hexametaphosphate (0.1 N). Granulometric separation was established in three fractions: fine (<5 μm), medium (5–250 μm) and thick (>250 μm). The medium fraction (5–250 μm) was used for densimetric separation with sodium polytungstate solution (2.3 g/cm^3). The material resulting from this separation was mounted for microscopic observation both in a liquid medium for three-dimensional observation of bodies and on a permanent slide in Canada balsam. The counting was done in populations of 400 phytoliths per sample; each phytolith was assigned to a particular morphotype based on the classification and descriptors developed by Bertoldi de Pomar (1971), Twiss (1992), Kondo et al., (1994), Zucol (1996) and ICPNWG (2005).

4. Results

Work in 2007 included an intensive survey and twelve test pits in elevated features of the Pre-Delta National Park and surroundings. During fieldwork in this wetland area, two archaeological sites, Cerro Farall and Cerro Tapera Vázquez, were detected (Fig. 1). CTV, the subject of the present study, was inhabited by local people who had installed a temporary rural post ("puesto"), which was occupied until the middle of the twentieth century. The only vestiges of this little post are some material remains buried near the surface (mainly in the area of grids 13 to 16). CTV is located inside a unit called "meander plain" (sensu Iriondo, 1972, 2007), characterized by a succession of meander scars, crescentic ponds, and levees produced by the lateral migration of El Ceibo Creek. This creek is a small tributary of the Paraná River, has a temporary regime, and is isolated from the active channels. It presents an important levee on its right bank, which reveals the past influence of a fluvial course with high activity and transport energy.

4.1. Pedological and sedimentological analysis

The stability of the area where CTV is located is made evident by incipient pedological development associated with abundant woody trees that produce a "gallery forest", which contrasts with the tall-grass vegetation that dominates the low adjacent zones. An immature soil has developed on the levee, related to the Udifluvent group (Passeggi, 2000). This soil constitutes a superficial horizon, is lightly humic, friable, and with a silty clay loam texture and granular to crumb structure, which indicates a typically incipient edaphization of the top of the alluvial deposit (in this case restricted to the first 15 cm; Fig. 3).

Sedimentological analysis of the non-site profile reveals a succession of clearly distinguishable strata by means of their morphologic and granulomeric characteristics. The NSP, located in the same levee of CTV, 94 m to the NW of the excavation, was analyzed to establish the natural sedimentary features of the levee. The profile reflects an heterogeneous and grain-increasing pattern to 1 m depth. In the surficial, layers particle size data reveals a mean grain size close to 7.6 Φ (5.2 μm; very fine silt) and 6.2 Φ (13.5 μm; fine to medium silt) in the profile base and below (Fig. 4C). In all these cases, the standard deviation is close to 3 Φ (very poorly sorted); the grain size frequency distribution is asymmetrically lightly positive and platikurtic (Table 1).

These characteristics correspond perfectly with those found in sedimentological studies in similar environments in the Middle Paraná River floodplain (Passeggi, 2000), and are a consequence of a decrease in flow competence and efficacy of sorting of the sediment load by the transport agent. Consequently, the long flood events that periodically affect the fluvial system give rise to a particular sedimentological dynamic in which sand, silt and clay are transported and deposited inside the floodplain creating a poorly sorted matrix.

The grain size frequency distribution in the lower stratum (layers IV and V) is strongly unimodal with approximately 30% pure mode in 3.5 Φ (93.75 μm; very fine sand), which disappears progressively towards the surface because of the increasing appearance of secondary modes in size grades in the range of 8 Φ (4 μm; very fine silt) to 11 Φ (0.5 μm; clay).

This pattern is typical of materials that have been sorted in an environment of moderate energy and have been transported and deposited in a levee as bed sediment load (lateral accretion deposit). From the isolation and progressive deactivation of the creek channel, the new sedimentary environment drastically lost its effective sorting energy in relation to the primary context, so that the materials that initially constituted the deposit, and that show a distribution with a principal mode in medium sizes, begin to receive only the contributions of the finest sediments from the overflow produced only during the extraordinary flooding of the system (the vertical accretion deposit). Thus, a mixture of populations of grain sizes is produced that is reflected clearly in the polymodality of the top stratum. The incipient edaphization of the profile contributes to the progressive eluviation of the finest materials (silts and clays) which migrate to depth and are accumulated (iluviation) in the sub-superficial horizons.

With respect to the archaeological excavation, the granulometric analysis was centered on the profile of grid 13 (G13P), which presents a greater sedimentary record than G5P because the latter was partially decapitated by erosion as a consequence of its topographic position on the levee slope (Fig. 4C). The sedimentary pattern of G13P (Fig. 4B) from Layer VI in the profile base to Layer IV is correlated with that of the NSP. At 40 cm depth from the surface, an important discontinuity in the deposit is detected, characterized by sediments with mean grain size in the range of 7.8–8.4 Φ (3–4.6 μm; very fine silt) in a very poorly sorted matrix and symmetrical, platykurtic to mesokurtic distribution (Table 1). However, the sediments of these superficial strata (Layer I to III) show significant polymodality, which is intrinsic to the deposit formation. In this case it is probable that the stratum reflects anthropic modification (sediment accretion), caused by recent human occupations of the post. This could explain the elevation of the mound. The sedimentological features of Layer IV of G13P (Fig. 4B) and Layer IV′ of G5P (Fig. 4C) do not provide evidence of anthropic movement of sediments in the past as the patterns are perfectly correlated with those of the middle stratum of the NSP (Layer III; Fig. 4A) and have granulometrical continuity with the underlying stratum.

4.2. Archaeological materials

Planimetric mapping allowed reconstruction of the elliptical shape (ca. 34 × 22 m) and the cross section of the mound that rises 1 m above the levee (Fig. 2). Through the survey profiles of the gully and eight test pits along the levee and the low adjacent plain, it was determined that distribution of the archaeological material extended for 102 m. However, the remains outside the mound are absent on the plain and are less dense on the levee. This spatial

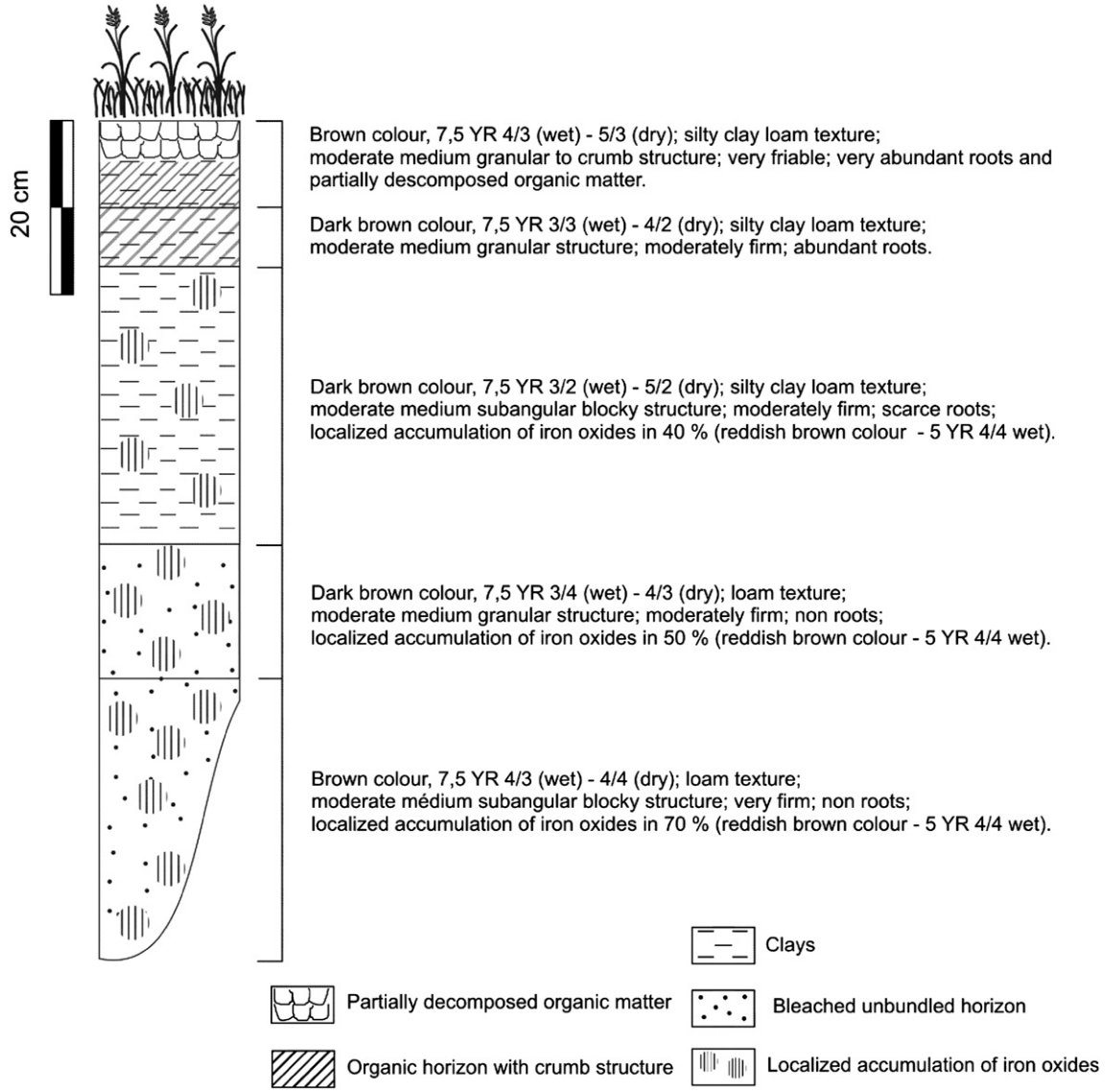

Fig. 3. Soil profile from Cerro Tapera Vázquez archaeological site (key based on Catt, 1990).

variation shows that the site is not exclusively restricted to the limits of the mound. Part of the archaeological material recovered during the 2008 excavation is currently being analyzed; therefore only the initial results of their study are presented here.

Vertical distribution of the archaeological material demonstrates that in the first 15–41 cm of the sequence in grid 13 numerous remains of the rural post, such as bricks, metal objects, glass fragments and sawn bones of European introduced fauna, were found (layers II and III; Fig. 4). Scarce pre-Hispanic sherds were mixed with these modern items. Similar associations have been observed in the earthen floors of modern rural, fisher and hunter posts and shelters ("puestos" and "ranchadas") of the Paraná Delta, which are frequently located on the top of archaeological mounds, where modern materials are deposited and pre-Hispanic objects arise on the surface by erosion, animal trampling and human activity. The last 45 cm of the sequence (mainly layers IV, V and VI; Fig. 4) is made up of a significant volume of pre-Hispanic materials, which contributed to the elevation of the mound. Such materials included scarce metal and glass objects of small size in some levels. This vertical migration was favored, essentially, by the mechanical action of the roots of the gallery forest trees that developed on the stable landscape of the levee. It is an interesting fact that the site had a recent occupation, and the migration of modern materials serves as a control for the degree of disturbance of the pre-Hispanic component.

In relation to the materials generated during the pre-Hispanic occupation ($n = 3314$ with three axis record), pottery ($n = 2958$) predominates over the faunal ($n = 352$) and lithic ($n = 4$) materials. In regard to the scarce lithic artifacts, the only tool is a hand stone made from a block of sandstone. It has knapped and polished edges for a handle and traces of use on two of its faces. Starch grain analysis carried out on this artifact showed the dominance of oval (74.2%) followed by kidney-shaped (13.3%) grains, the measurement and qualitative characteristics of which enabled them to be assigned to the genus *Phaseolus* spp., probably *Phaseolus vulgaris* (common bean) (Bonomo et al., in press).

The totality of the faunal remains recovered during the excavation ($n = 1595$, including those with three axis records and those from the sediment screening) was quantified by Lic. Juan Castro. A percentage of 47.7% of the remains were assigned to a taxonomic

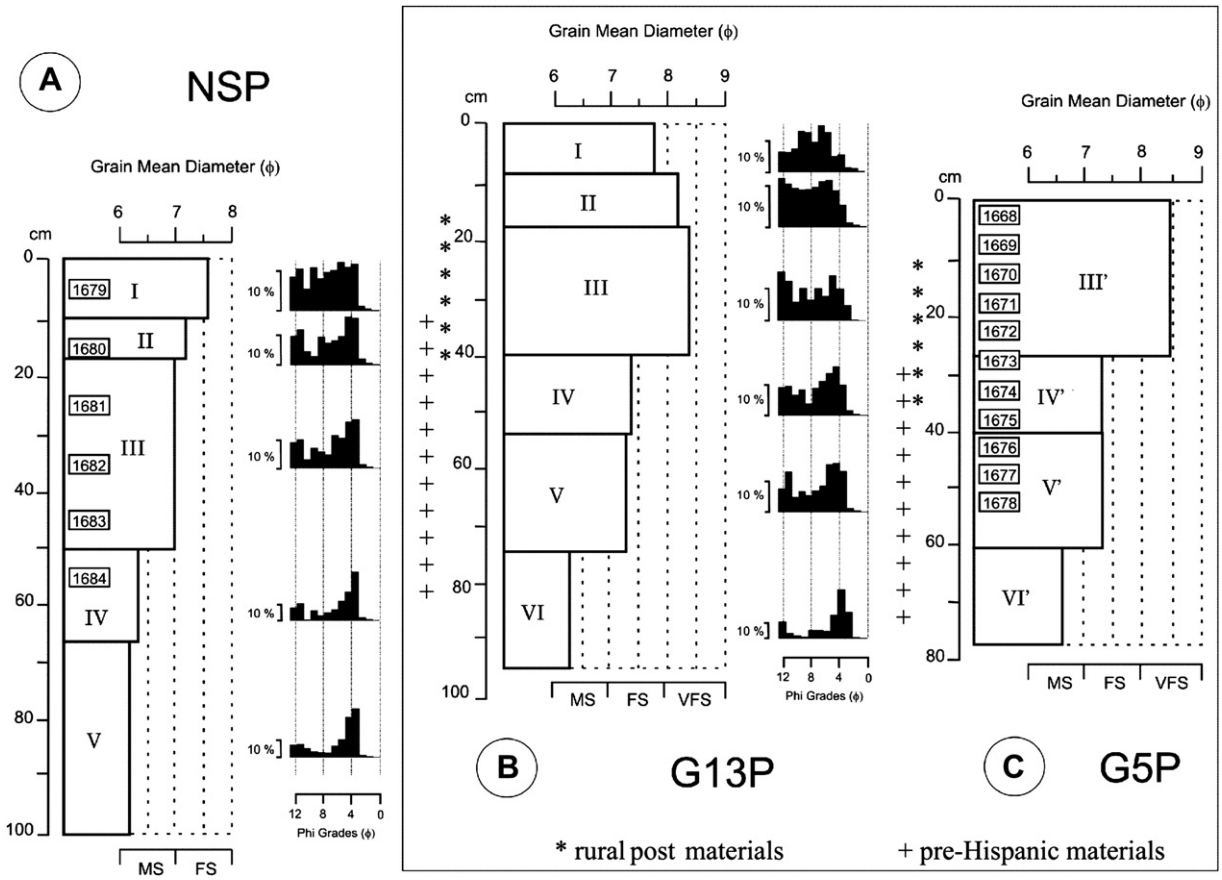

Fig. 4. Schematic comparative diagram showing the sedimentary sequences of the profiles studied at Cerro Tapera Vázquez archaeological site and location of the phytolith analysis samples and the archaeological material distribution. A = NSP (Non-Site Profile); B = G13P (Grid 13 Profile); C = G5P (Grid 5 Profile); MS = Medium Silt; FS = Fine Silt; VFS = Very Fine Silt.

level (from class to species) while the others were classified as indeterminate because of their high grade of fragmentation (92.2% are under 2 cm in size). As shown in Table 2, the majority of specimens correspond to mammals, especially rodents (*Myocastor coypus*, *Hydrochaeris hydrochaeris* and *Cavia aperea*) and cervids (*Blastocerus dichotomus* and *Ozotoceros bezoarticus*). In decreasing order of frequency are fish (*Pimelodus* sp. and Doradidae), birds (*Podiceps major*) and freshwater molluscs. Included within the faunal remains are bone specimens of *Homo sapiens*, pertaining to the skull (right parietal) and jaw (right ascending ramus).

The most abundant species is the coypu or freshwater otter (*Myocastor coypus*; NISP = 443; MNE = 233), represented by 24 individuals calculated from the mandible (MNE = 48), the most

Table 1
Principal statistics granulometric parameters of the profiles studied in the archaeological site Cerro Tapera Vázquez. NSP = Non-Site Profile; G13P = Grid 13 Profile; G5P = Grid 5 Profile; D_{50} = Decil 50 (Median); $\bar{x}$ = mean; σ = standard deviation (sorting); *Sk* = skewness (asymmetry); *K* = kurtosis.

Profile/level		Mode 1 (μm)	Mode 2 (μm)	D_{50} (μm)	$\bar{x}$ (μm)	σ	*Sk*	*K*
Non-Site (NSP)	I	23.4	93.8	6.2	5.2	2.98	0.13	1.83
	II	48.9	0.4	10.2	6.7	3.22	0.32	1.74
	III	93.8	11.7	13.2	7.5	3.15	0.45	1.83
	IV	93.8	0.4	30.6	12.4	3.17	0.82	2.22
	V	93.8	0.4	35.0	13.5	3.12	0.90	2.34
GRID 13 (G13P)	I	11.7	1.5	4.7	4.6	2.66	−0.07	2.39
	II	0.2	23.4	3.6	3.4	2.90	−0.07	1.88
	III	0.2	23.4	3.3	3.0	2.96	−0.02	1.66
	IV	46.9	0.4	9.4	6.0	3.02	0.31	1.82
	V	46.9	0.4	11.5	6.5	3.08	0.35	1.74
	VI	46.9	0.2	32.0	13.3	2.96	1.13	2.96
GRID 5 (G5P)	III′	11.5	4.5	8.6	8.4	3.06	−0.20	1.75
	IV′	5.5	12.5	6.5	7.3	3.15	0.36	1.77
	V′	5.5	3.5	6.6	7.3	3.12	0.33	1.76
	VI′	4.5	12.5	5.3	6.6	3.05	0.81	2.32

Table 2
Taxa represented in CTV according to minimum number of specimens and individuals (NISP and MNI respectively).

TAXA	NISP	%NISP	NMI
MOLLUSCA	1	0.12	1
TELEOSTOMI	57	7.29	–
CHARACIFORMES	1	0.12	1
Doradidae	3	0.38	3
Pimelodus sp.	4	0.51	4
AVES	15	1.91	1
Podiceps major	3	0.38	1
MAMMALIA	205	26.21	–
Cervidae	7	0.89	1
Blastocerus dichotomus	7	0.89	1
Ozotoceros bezoarticus	2	0.25	1
Canidae	1	0.12	1
Dusicyon gimnocercus	1	0.12	1
Felidae	1	0.12	1
Oncifelis geoffroyi	2	0.25	1
Hydrochaeris hydrochaeris	16	2.04	2
Myocastor coypus	443	56.65	24
Cavia aperea	5	0.64	2
Homo sapiens	8	1.02	1

frequent element, followed by the femur (MNE = 32). Incisor fragments are also very abundant (NISP = 110). Although the anatomical units of the axial skeleton (mainly cranial) are proportionally better represented than the appendicular skeleton (forelimbs and hindlimbs), the different skeletal parts are all present (Fig. 5). According to volume density (VD) assays for leporid means (Pavao and Stahl, 1999), mammals with similar corporal size to coypu, the highest density bones are the most represented in CTV (correlation between $VD_{LD/BT}$ and %MAU: $R = 0.6$; $P < 0.05$). As such, the representation of coypu skeletal parts could be related to the different density of the bone elements. In addition, along with the high fragmentation of the bones, weathering stages 2 and 3 (sensu Behrensmeyer, 1978) are the most represented (87.7%) in the assemblage. Therefore, the coypu bone representation was affected by destructive processes that caused their differential preservation.

Five species of mammals (*M. coypus*, *B. dichotomus*, *O. bezoarticus*, *H. hydrochaeris* and *O. geoffroyi*), fish vertebrae and pectoral thorns and bird long bones, show evidence of anthropic modification, such as fresh fractures with signs of impact ($n = 20$), cut marks ($n = 42$) and burning ($n = 47$). This evidence is more frequent in the coypu, which were more intensively exploited. This taxa had cut marks on 11.6% of the elements, mainly in the diaphysis and epiphysis of the long bones (8 humeri, 7 femurs, 5 tibiae, 3 ulnae, 1 radius) and jaws ($n = 3$). In addition, deer tibia and metapodial bones were recorded, with cut and saw marks that could be debris from tool manufacture processes.

In the case of pottery, there are numerous assemblages of large sherds, although these are highly fragmented (Fig. 6A), that have so far produced 233 refittings from 630 sherds, that is 21% of the fragments recorded in the grids according to the three axes. Refitting has enabled us to begin to reconstruct the decorative designs, the shapes of the open vessels (bowls and plates) and the soot distribution pattern that indicates direct exposure to fire. In addition, they show that a great many of the fractures occurred in situ.

A sample of 526 ceramic fragments recovered from grids 1 and 2 was analyzed. Ninety-six percent of the fragments are sherds, of which 16% are edges of containers made by coiling. The remaining 4% are masses of fired and unfired clay, which indicate that pottery was locally manufactured at the site. The most frequent surface treatment observable on the sherds is smoothing (82%). With respect to firing, incomplete oxidation is most abundant (93%), followed by reducing and oxidizing atmospheres. This tendency is similar to other sites analyzed in the area and indicates: a) brief exposure to fire or lower firing temperatures (below to 500 °C) and b) a high percentage of organic matter in the raw material (Rice, 1987; García Rosselló and Calvo Trias, 2006).

Decoration is present in only 5% of the pottery assemblage. The decorative technique was mainly incising (Fig. 6B), although modeling, red painting and trimmed edge silhouettes have also been recorded. Widely spaced parallel and zigzag lines with points in between ("*surco rítmico*"; Caggiano, 1985) are the most frequent designs. In addition, a small oval-shaped fragmented vessel with a lateral tubular spout attached at a right angle (Fig. 6C) was found adjacent to a hearth. A possible zoomorphic pendant and a massive modeled zoomorphic appendage that might depict a tapir's head were also recovered (Fig. 6D).

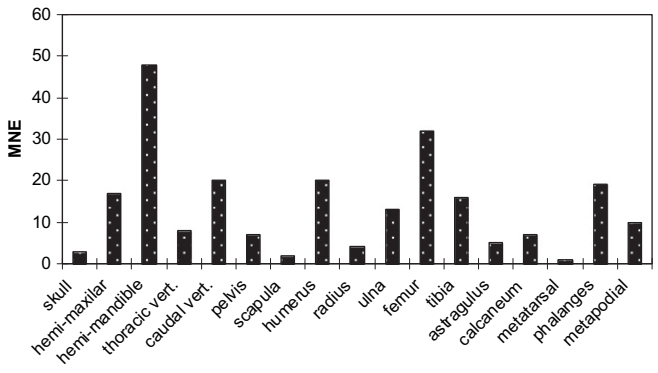

Fig. 5. Representation of *Myocastor coypus* skeletal parts in minimal number of elements (MNE).

Two radiocarbon dates were obtained from CTV using charcoal samples from grid 2. The samples dated to 650 ± 60 BP (artificial levels 5 and 6: 40–50 cm from the surface) and 520 ± 60 BP (artificial levels 10 and 11: 65–75 cm from the surface). Although there is a slight inversion in the dates according to their depth (15–35 cm separation), they are statistically equivalent. These similar ages from separate levels, along with the homogeneous characteristics of the archaeological materials, indicate that the archaeological assemblage forms a single component.

4.3. Charcoal analysis

The analyses of 18 samples of archaeological charcoal enabled the following genera to be identified: *Nectandra* Rottb. (Lauraceae), *Myrsine* L. (Myrsinaceae), *Inga* Mill. (Fabaceae-Mimosoideae), *Prosopis* L. (Fabaceae-Mimosoideae) and *Guadua* Kunth. (Poaceae-Bambusoideae).

Anatomical characteristics of *Nectandra* (C-CTV 6) are diffuse porous wood with small vessels in radial multiples of 5–7 (2–9) and in clusters (Fig. 7B). Rays are narrow and abundant, heterocellular(?), composed of procumbent and square(?) cells, both uniseriate and biseriate and <16 cells high. Apotracheal axial parenchyma is scarce and diffuse-in-aggregates, and fibers are distributed in radial series. Extant *Nectandra* is present as a woody component of marginal river communities in the study area (Tortorelli, 1956).

Myrsine (C-CTV 7, 9, 16) is recognized by semi-ring porous to diffuse porous vessels that are paired tangential, clustered, although predominantly solitary, and occur in radial multiples of 2–4 (Fig. 7E). The vessels are small sized and short, lack contents, and are very numerous with oblique or straight end walls. Intervessel pits are bordered, subopposite and compressed. Vasicentric tracheids(?) are present. Wide and very abundant, multiseriate rays are present, <8 cells wide; rays are homocellular, composed exclusively of procumbent cells. Apotracheal axial parenchyma is diffuse-in-aggregates and paratracheal axial parenchyma is vasicentric, occasionally banded and with very abundant, large and thick-walled fibers. These anatomical characters suggest a close affinity to the Myrsinaceae family; the charcoal is similar to *Myrsine laetevirens* (Mez.) Arechav (common name: "canelón"). This species inhabits the gallery forests of the Paraná River floodplain (Aceñolaza et al., 2004).

Anatomical features such as vasicentric and banded paratracheal axial parenchyma associated with wide rays and homocellular composition allow the charcoals to be assigned to *Inga* (C-CTV 1, 2, 15, 17). The wood charcoals show distinctive growth rings that are diffuse porous with semi-ring porous tendency; vessels are mainly solitary, in radial and tangential multiples of 2–3 and rarely in clusters (Fig. 7A and F). Vessels are moderately numerous and large sized, frequently lack contents although dark and brown gums or resins are rarely observed. Intervessel pits are bordered, alternate and compressed; paratracheal axial parenchyma is vasicentric and banded, and axial parenchyma is very abundant (Fig. 7A). Rays are wide and multiseriate, <5 cells wide, 15–20 cells high, homocellular, composed of procumbent cells and fibers are abundant. These anatomical characters suggest a close

Fig. 6. Pottery recovered from Cerro Tapera Vázquez. A: assemblages of large sherds; B: incised decorated sherds; C: spouted vessel, and D: zoomorphic appendage and pendant.

affinity to *Inga uruguensis* Hook. Et Arn ("ingá"). These trees live on old and wide levees in the Pre-Delta region (Aceñolaza et al., 2004).

Prosopis (C-CTV 10–12, 14) has predominantly solitary vessels in radial multiples of 2–3 and in clusters (Fig. 7 D). Rays are heterocellular, composed of procumbent cells with mostly 2–3 rows of square cells, 2–5 (8–9) seriate and uniseriate(?), and are <30 cells high. Cells present a vasicentric, confluent and banded axial parenchyma paratracheal arrangement (Fig. 7D); fibers are abundant and distributed in radial series. The species within the genus *Prosopis* ("algarrobo") inhabited open and dry forest located in upland areas and patches within a grassland matrix (Kandus et al., 2006). At present, in the topographically higher areas in the Pre-Delta National Park, the landscape is dominated by open forest where *Prosopis nigra* (Griseb.) and *Prosopis affinis* Speng. are frequent (Rodríguez, 2007). *Prosopis alba* Griseb. and *Prosopis kuntzei* Harms ex Kuntze are also present in others drier areas of Entre Ríos Province (Rodríguez, personal communication).

Well preserved carbonized culm provides the basis for the description of a charcoal fragment closely related to *Guadua* (C-CTV 4). The cross section of the aerial axis internode is visible, and here described from the outside. The epidermis and subepidermis are not preserved. The cross section of the charcoal culm shows clear zonation. Sclerenchyma is continuous, surrounding the first cycle of peripheral vascular bundles. The transitional and central vascular bundles are surrounded by four sclerenchyma sheets (Fig. 7C). The sclerenchyma tissue is more abundant in the peripheral zone. Parenchymatic tissue is abundant among the vascular bundles. Finally, the central zone surrounding the hollow central cavity can be seen. The charcoal was compared with bambusoid taxa, especially the American woody bamboos (sensu Judziewicz et al., 1999). These anatomical characters suggest a close affinity with *Guadua trinii* (Nees) Nees ex Rupr. (Rúgulo de Agrasar and Rodríguez, 2003). This species lives in marshes, particularly those closer to permanent bodies of water in the study region.

These results indicate that *Inga*, *Prosopis* and *Myrsine* were used as fuel at the CTV site, with *Inga* and *Prospis* being the most abundant. The fragments are recurrently concentrated and charcoals of *Inga* were also found inside a hearth and within the spouted vessel, while *Myrsine* was also found adjacent to fired clay. On the one hand, *Prosopis* and *Myrsine* are hardwoods and therefore have high caloric values and long combustion durations. They produce small flames, and the stems are used for firewood (Tortorelli, 1956). Because of their good combustion qualities, they are an excellent source of heat and were probably used for cooking food or firing pottery. On the other hand, *Inga* produces a great deal of smoke when burnt, and splinter burns to partial white to grey ash and not coals (Richter and Dallwitz, 2000). It is not, therefore, used as firewood.

4.4. Phytolith analysis

Numerous siliceous micro-remains were recorded throughout the sedimentary sequence of grid 5 of CTV (G5P) and the non-site profile (NSP). In general, non-articulated phytoliths were more abundant in the various samples than articulated ones (Fig. 8Q), which have a low frequency. In addition to phytoliths, the sequence showed the regular presence of spicules of sponges, a lower representation of diatoms, and scarce chrysophycean stomatocysts (Fig. 8M).

Grass phytoliths with non-diagnostic elements, such as prismatic and parallepipedal morphotypes, were recorded in both profiles. Bilobates and truncated cone phytoliths were the most abundant diagnostic elements (Fig. 8C–G and J–L). Point-shaped, fan-shaped, cross (Fig. 8A and B) and saddle types were in lower abundance, linked to non-graminoid phytoliths such as globular (Fig. 8N and Ñ) and fusiform (Fig. 8O–P) morphotypes.

Variations were observed in the upper section of G5P samples (1668–1673) compared to the same section of the NSP (1681–1683, Layer III). The phytolith assemblage analysis from NSP showed an increase in pooid affinity elements related to the higher abundance of cross and panicoid bilobate in G5P marked by the pre-Hispanic-modern transition in the archaeological record (Fig. 4). Variations were also seen in the sedimentology analysis of G13P at Layer IV that marks anthropic disturbances with respect to the natural NSP. The upper section of G5P (from 1674 up) also showed a decrease in fusiform elements not manifested in the NSP where these morphotypes were homogeneously distributed throughout the sequence (Fig. 9).

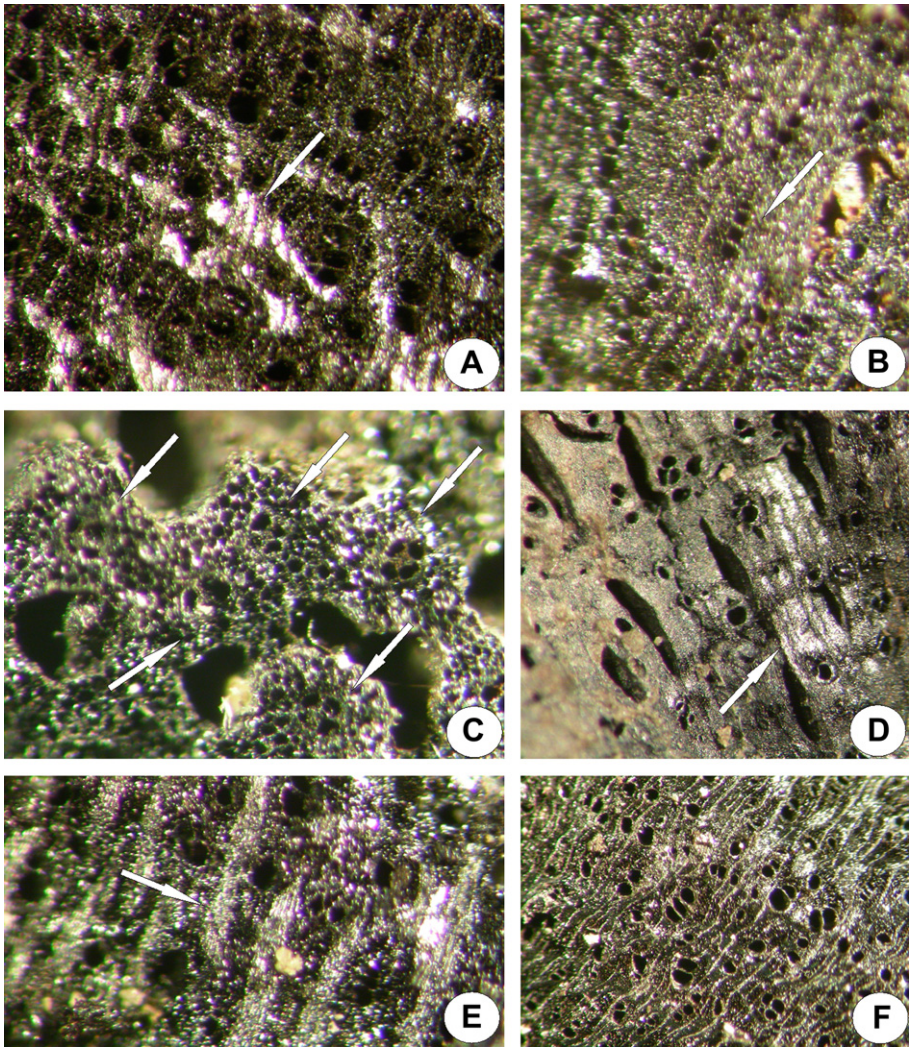

Fig. 7. Charcoal assemblages from Cerro Tapera Vázquez. A. *Inga* sp. cross section; general view showing vasicentric (arrow) and banded vessel distribution, and fibers (60×). B. *Nectandra* sp. cross section, showing diffuse porosity, vessels in radial multiples (arrow) and diffuse-in-aggregates and scarce apotracheal axial parenchyma (80×). C. *Guadua* sp. cross section, showing vascular bundles (arrows) surrounded by four sclerenchyma sheets (60×). D. *Prosopis* sp. cross section; general view showing vessel distribution, vasicentric, confluent (arrow), and banded parenchyma paratracheal, and abundant fibers (30×). E. *Myrsine* sp. cross section, showing vessel distribution and wide and very abundant rays (arrow) (60×). F. *Inga* sp. cross section; detail showing mainly solitary vessels in radial and tangential multiples of 2–3 and rarely in clusters (40×).

Bilobate stipa-type and chloridoid elements increased gradually towards the top of both profiles (Fig. 9), which indicates less water availability. Panicoid elements related to danthonioid ones were present along whole sections of both profiles, with an increase in abundance in the middle to top samples (1673 to top of G5P, Layer II and 1682 to top of NSP, Layer III), indicating warmer climatic conditions towards the top of the sequence analyzed. Festucoid and pooid phytoliths were observed relatively homogeneously in the NSP, while they have a larger relative abundance which increases in lower levels of G5P and appear associated with panicoid elements. This increase in panicoid elements associated with the reduction of festucoid and pooid elements (Figs. 4 and 9; G5P, samples 1674 to top, Layer III) could be related to human action or warmer climatic conditions in the area that altered the microenvironment.

Among the panicoid elements, the presence of cross phytoliths (Fig. 8A and B) related in some of their types to *Zea mays* (sensu Bertoldi de Pomar, 1971; Pearsall, 2000; Piperno, 2006) in G5P (samples 1672, 1673 and 1674), and their coincidence with decreasing festucoid and pooid elements, shows a clear difference with respect to the NSP. Although cross morphotypes were present in various types of panicoid plants, the lower abundance of panicoid elements (the absence of crosses in sample 1681 is notable) and a constant presence of festucoid and pooid morphotypes in the NSP suggests some kind of plant resource management at the site. The increase in Panicoideae at G5P combined with the lower abundance of Festucoideae and Pooideae subfamilies could be related to the introduction of corn crops into the settlement, both by pre-Hispanic or post-Hispanic populations.

5. Discussion

Cerro Tapera Vázquez is a mound where past populations took advantage of the preexisting natural elevation of the levee. Its height is probably partly the product of accretional growth generated by domestic materials discarded by people at different moments over a period of six hundred years, as has been proposed for other archaeological sites of the Paraná floodplain (e.g. Lothrop, 1932; Lafón, 1971; Cornero et al., 2007; Bonomo et al., in press). In this case, the upper layers of the site stratigraphy indicate that the elevation seems to be more related to the modern human settlement (that lasted until the middle of the twentieth century). The pre-

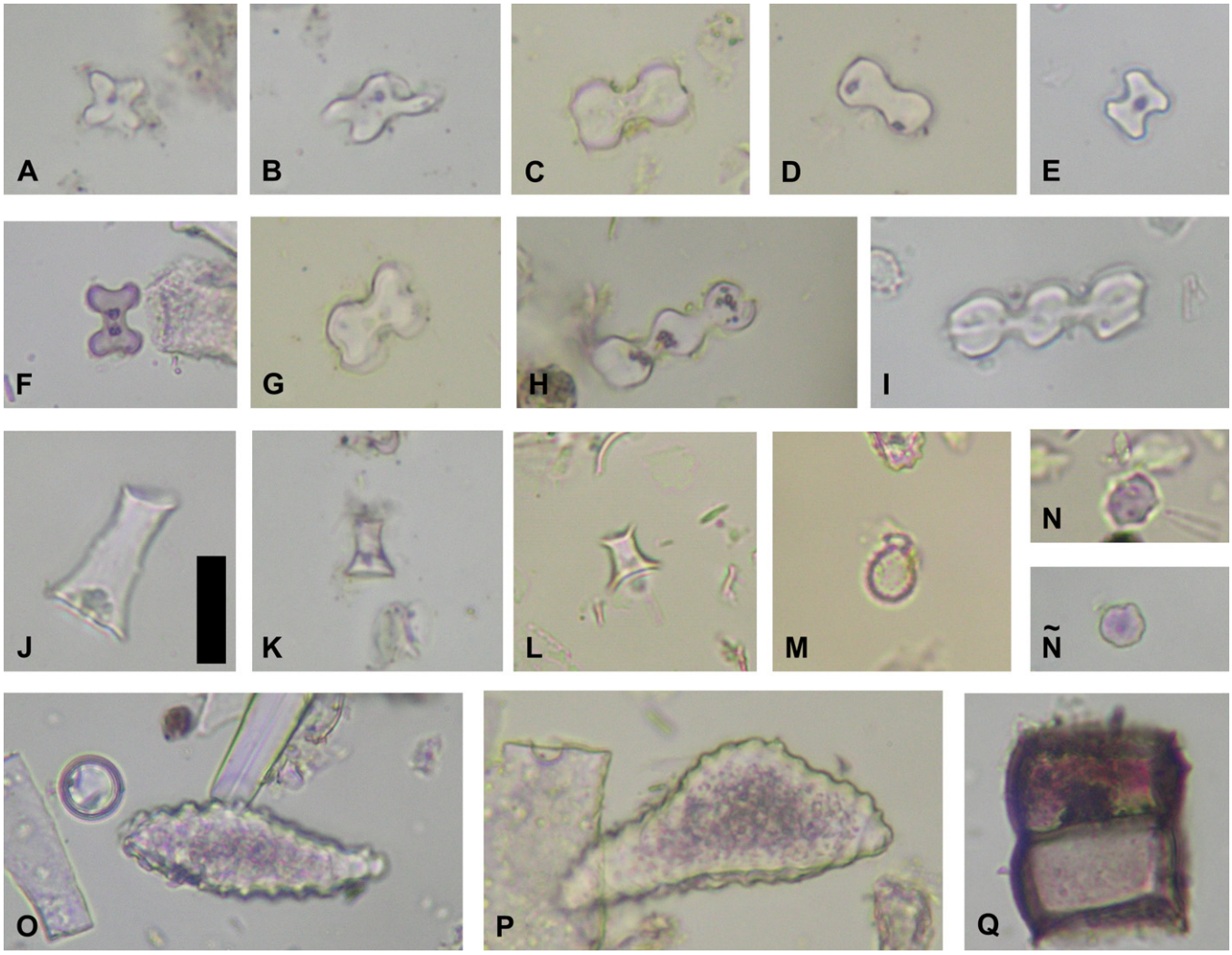

Fig. 8. Various phytoliths and stomatocysts observed in the profile samples studied. A–B: Crosses. C–G: Bilobates. H–I: Polilobates. J–L: Truncated cones. M: Chrysophycean stomatocysts. N–Ñ: Globular. O–P: Fusiform. Q: Articulated phytolith. Scale bar in J: 20 μm.

Hispanic occupation of CTV extended for some distance along the levee. The greater density of archaeological remains in the mound with respect to the rest of the levee could indicate a spatial differentiation of domestic activities inside the site, as has also been detected in Los Tres Cerros Locality (Politis et al., in this issue).

Although riverine islands could be seen as disadvantageous places to live because of the recurrent floods (see Brown, 2003), the pedological development of CTV's profile and its association with the gallery forest present a highly stable landscape, removed from the influence of regular flooding events. The dimensions of the levee and its gradual isolation from the direct influence of the principal channel of the Paraná turned the place into a highly stable area for settled residential camps within an alluvial environment dominated by a changeable fluvial dynamic. In addition, the decrease in Podostemaceae, Festucoideae and Pooideae phytoliths in the upper part of the site sequence may indicate less influence of water in the area used by humans in relation to what is observed in a non-site profile from a natural area (Fig. 9).

Analyses of the archaeological materials show the use of pottery vessels and the in situ manufacture of pottery containers fired in an incomplete oxidizing atmosphere in bonfires. The clay zoomorphic appendage, spouted vessel and incised decorative designs ("*surco rítmico*") found in Cerro Tapera Vázquez's pottery is noteworthy. This kind of pottery, with plastic representations and incised designs, is characteristic of the archaeological entity denominated Goya-Malabrigo within the regional cultural scheme proposed by Ceruti (2003). This entity was attributed to canoe hunter-gatherer's that inhabited the islands and lower coasts of the Middle and Lower Paraná River from 2000 BP to the European conquest.

The case of the spouted vessel warrants a more detailed discussion. Such vessels have a low frequency in the archaeological record of the Paraná alluvial plain. They have been called "spoons" and their tubes related to the passage of liquid (as possible spouts for skin bags, known as "odres" in Spanish) (Serrano, 1950). Similar but not identical small vessels with a tubular spout on one extreme have been reported from Marajó Island at the mouth of the Amazon (Meggers and Clifford, 1957, plate 81; Roosvelt, 1991, fig. 1.23B) and from Costa Rica (Wassén, 1965, fig. 2). Much has been conjectured in relation to their possible use. Varied functions have been attributed to them, ranging from their use as spoons with stick handles inserted in the tubes (Meggers and Clifford, 1957), to lamps or drinking vessels ("medicinal cups") (Farabee, 1921, pp. 146) or, the most common interpretation, as snuffers for inhaling powder with narcotic effects (Wassén, 1965; Schultes, 1976; Roosvelt, 1991). However, their function remains unknown, as neither archaeobotanic nor ethnographic evidence has been produced to support their use.

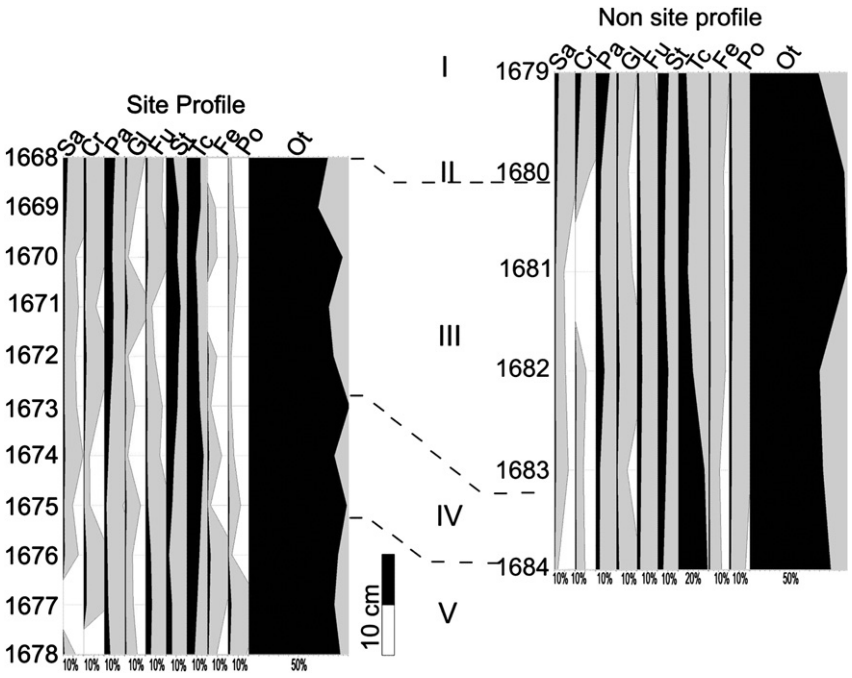

Fig. 9. Phytolith diagram, showing distribution of the principal non-articulated phytolith morphotype groups. Sa: Saddles. Cr: Crosses. Pa: Bilobate panicoid types. Gl: Globulars. Fu: Fusiforms. St: Bilobate stypa types. Tc: Truncated cones. Fe: Pooid festucoid types. Po: Pooids (ovate, rondel, reniform). Ot: Others (Prismatic, Point-shaped and Bulliform phytolith, principally).

Regarding the fauna, mammals (coypu, capybara and cervids), fish and birds were exploited for subsistence purposes. The coypu is the predominant resource and diverse anatomical units of its skeleton are present, showing that these herbivorous rodents were transported whole to the site. The differences in the frequencies of the representation of coypu skeletal parts may be explained by the different volume densities of the anatomical units. The disarticulation of coypu skeletons and the removal of the flesh were carried out, as numerous cut marks in the diaphyses and epiphyses show. There is also evidence of fresh fractures and direct exposition to fire (roasting). The presence of cut marks on the mandibles – an anatomical unit with little flesh – and the high percentage of fragmented incisors could be related to hide processing (see Escosteguy and Vigna, 2010 for experimental work).

This intensive exploitation of the meat, leather, bones and teeth of coypu has been recorded archaeologically from the Salado River depression in the Pampean Region, through the Paraná Delta, to the north of the confluence of the Paraná and Paraguay rivers in the Humid Chaco (Cione and Tonni, 1978; Salemme, 1987; Santiago, 2001; Acosta, 2005; Ceruti and González, 2007; Santini, 2009). This evidence supports ethnohistoric observations among the indigenous groups of Paraná (Schmidl, 2009 [1567]) and the Chacoan Abipones (Dobrizhoffer, 1967 [1784]) that otters were a resource exploited for their flesh and, mainly, their skins, which were used to make cloaks and clothes.

In addition, it is important to note the presence of *Homo sapiens* bones alongside faunal remains and discarded sherds of utilitarian vessels at CTV. At a regional level, mortuary practices in the Paraná Delta include primary and secondary burials, cremation and internment in large Guaraní pottery vessels (Torres, 1911; Lothrop, 1932; Gaspary, 1950, among others). In place of this careful manipulation and preparation of bodies, at CTV a human cranium were simply abandoned along with domestic materials discarded during the site occupation. At the moment with the current evidence, it is not possible to determine if these human bones are related to a mortuary or anthropophagic practice.

The study of concentrated charcoal of *Prosopis*, *Myrsine* and *Inga* might indicate selection of resources by human groups. The carbonized wood was used mainly for fuel. *Prosopis* and *Myrsine* were selected for their high caloric value and may have been destined for heating, firing pottery and cooking food (roasted or boiled in pots). The wood of other species (*Inga*) was burnt for purposes such as smoking food. Smoking various types of fish and other previously dried meat may have been used to preserve food throughout the year (especially for the winter), a practice mentioned in relation to the Paraná River islands in the sixteenth century [1526–1530] by the first European accounts (Santa Cruz in Wieser, 1908:57).

Phytolith assemblages are characterized by abundant panicoid and danthonioid phytoliths, among the graminoids, associated with arecoid and podostemoid phytoliths, according to the level. In relation to paleoenvironmental conditions, elements of the danthonioid subfamily (observed as short and long truncated cone phytoliths) together with panicoid type bilobates in both profiles indicate warm temperate climatic conditions. Cooler conditions and higher hydric levels for pre-Hispanic occupations than at present can be inferred from the increase in pooid and fusiform morphotypes towards the base of the sedimentary site profile. These frequency changes also may be related to the anthropic influence.

Sedimentary and phytolith samples (from 1674 up) associated with modern and upper levels of pre-Hispanic human occupation are more variable. This could be interpreted as anthropic modification as a consequence of species introduced to the residential area or due to the disturbance by a non-anthropic factor such as bioturbation. Globular echinate phytolith morphotypes, related to palm tree forms, are homogeneously distributed across the two profiles analyzed. The southernmost geographic distribution of palms east of Entre Ríos Province is recorded at the latitude of Victoria city (Báez, 1937), which includes the study area. Palm fruits (*Butia yatay* and *Syagrus romanzoffiana*) have also been recorded at

archaeological sites in the region (Torres, 1911; Caggiano, 1984; Loponte, 2008; Bonomo et al., 2009a). Therefore, the presence of these morphotypes at the site could be the result of both natural and anthropic agents.

The presence of cross phytoliths assignable to *Zea mays* (maize) in the sediments and starch grains of *Phaseolus* spp (beans), on a hand stone is significant. The first could indicate in situ horticulture. This could be related to riverine island settings, where exceptional flows give these areas high agricultural potential. The cultivars recorded are complementary, as beans fix ground nitrogen while maize demands it. For that reason they are generally sown alternately in the same land to aid recovery of the soil nutrients and fertility, or intercropped in the same parcel to protect the soil and take advantage of its different nutrients (Denevan, 2001).

This evidence is in accordance with the first Hispanic accounts (Ramirez [1528] in Madero, 1902; Santa Cruz [1526–1530] in Wieser, 1908; Villalta [1556] in Schmidl, 2009; Schmidl, 2009 [1567]), which reported that some local ethnic groups (Chaná-Timbú, Caracarais, Timbú, Mbeguá and Guaraní) used domesticated plants: maize, squash, beans and probably cotton. Starch grains of maize and beans have been found adhering to the interior surface of pots in other non-Guaraní sites (Bonomo et al., in press). However, it is not clear if all groups practiced horticulture, or whether they obtained their crops through exchange with Guaraní populations (Ceruti and González, 2007).

6. Conclusions

Paleobotanical analysis based on the identification of charcoal and phytolith composition is a new approach to the study of plants in archaeological contexts in the Pre-Delta area. The results presented above constitute evidence that increases knowledge of plant resource use by indigenous populations in aquatic ecosystems of the Late Holocene. Charcoal fragments were identified as *Guadua*, *Nectandra*, *Myrsine*, *Inga* and *Prosopis*. All the taxa described would form a riparian landscape with gallery forests, dry forests, marshes, grasslands and swamp communities. This information is linked with evidence from phytoliths, where elements from grass communities such as Panicoideae and Danthonioideae, principally, together with fusiform elements, sponges and diatoms present in very wet areas were identified. Fusiform elements indicated hydric conditions, and analysis of their variations indicates that the levels with modern human occupations are less flooded than the pre-Hispanic levels.

The main results detailed in this article can be summarized as follow:

- Phytolith studies enabled identification of a plant assemblage dominated by grasses, indicating temperate-cold conditions with adequate moisture availability during pre-Hispanic times, and a change to dry and temperate-warm conditions later. Variations between site and non-site profiles may indicate the incorporation or selection of certain resources, evidenced by the greater abundance of panicoids.
- Most of the charcoals identified correspond to intercropped arboreal taxa, and the presence of scarce shrubs or sub-shrubs could indicate resource selection. Charcoals of *Prosopis*, *Myrsine* and *Inga* might have been used for firing pottery and roasting and smoking food.
- The human occupation was mainly oriented to the capture, primary processing, intensive consumption and hide processing of coypu, complemented by other continental and aquatic resources (swamp deer, capybara, fish and birds).
- The identification of beans and maize demonstrates direct archaeological evidence of the use and processing of cultivated plants. Therefore, the Paraná Delta marks the southernmost limit of domesticated plants in the South American Lowlands.
- The characteristics of the pottery found at Cerro Tapera Vázquez, the radiocarbon age of 520–650 BP, the geographic location and the insular environment of the site are in accordance with the chronological and spatial range of Ceruti's (2003) Goya-Malabrigo archaeological entity.
- In summary, the pre-Hispanic populations that occupied the site at the end of the Late Holocene would have been canoe peoples, with a complex ceramic technology, and whose subsistence was composed of hunting, gathering, fishing, and probably small-scale horticulture.

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