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Holocene geomorphology, tectonics, and archaeology in Barrancas, arid Central Andes piedmont (33°S)

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A B S T R A C T

Archaeology and geomorphology are closely linked in Barrancas, Argentina, where both disciplines are necessary to understand human–environment interactions during the Holocene. The geomorphology suggests that the area was located in a distal alluvial environment of the Zonda paleo-river that drained to the east. Active tectonics during the Pliocene-Early Pleistocene caused the gradual uplift of the Lunlunta Sierras to the southwest, which led to the bifurcation of the paleo-river. For most of the Holocene, the area was seasonally flooded, suggesting a lacustrine microenvironment. A long record of human occupation beginning in the Early Holocene suggests an extended period of intimate human–environment interactions. Recently, the environment has shifted dramatically. Erosion has created a badlands and significantly impacted the archaeological record. Understanding geomorphological processes is central for archaeological research in general, and especially in Barrancas. This research is an integral part of the ongoing community archaeology program in the area, and for the planned creation of an archaeological reserve.

Introduction

The history of Barrancas locality involves intimately connected geomorphological, environmental, and cultural processes. Geomorphological perspectives presented can help outline the environmental history of the area, and are necessary to clarify the effect of erosion on archaeological material. The arid Central Andes have been occupied since at least the Early Holocene (García, 2003), when hunter-gatherers adapted to arid conditions with varying degrees of mobility. Most archaeological sites have been located in high-altitude caves; this paper presents preliminary evidence that the adjacent lowlands were also occupied, specifically in Barrancas locality. While currently a badlands dominated by erosion, the area was a lagoon oasis for most of the Holocene. This environment contrasts drastically with the desert conditions prevalent since the Pliocene-Early Pleistocene (Zárate and Mehl, 2008). There is preliminary evidence that the paleo-lagoons of Barrancas locality were occupied by hunter-gatherers in the Early and Middle Holocene (Schobinger, 1971). Later, the area was used as a cemetery, and by 1500 AP, groups using Agrelo and later Viluco ceramics occupied the area in more sedentary settlements (Rusconi, 1962).

Geomorphological perspectives have also helped to clarify archaeological site formation processes. Barrancas site includes a large, dense dispersion of surface artifacts, which have attracted looters and collectors for over a century. Active erosion has deflated and displaced artifact patterns, so understanding formation processes is central to clarifying the cultural processes represented by the material record on the surface. At the same time, erosion has also exposed very deep, old contexts, as well as cemeteries. Hence, erosion can both distort and expose the archaeological record, so understanding erosional processes is crucial to future survey and excavation. The aim of this study is to understand the geomorphological evolution of Barrancas archeological site (B6) trying to connect environmental changes with cultural evolution.

Finally, this area is being incorporated into an archaeological reserve, connected to a community archaeology program whose goals include better protecting this cultural and natural resource,

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disseminating information to the public, and fostering future interdisciplinary research.

Overview of the study area

Barrancas locality is located in the department of Maipú, in the Province of Mendoza, Argentina, at the latitude 33° south (Fig. 1). This region is characterized by a dry climate with a mean annual precipitation above 200 mm. Rainfall during the South Hemisphere summer is caused by the Atlantic Anticyclone. There is marked daily thermal amplitude. Maximum temperatures can reach 42.7 °C during the summer months, but only reach 15 °C during winter months. This area has low slopes down 2°–5° to the southeast creating a large plain.

From the geomorphological point of view, the study area is situated in the Andes piedmont, bordered by the Mendoza River to the north and Tunuyán River to the south (Fig. 1) (Gonzalez Díaz and Fauqué, 1993). These Andean rivers have been fundamental for the irrigated oases of northern Mendoza. To the southwest, the Lunlunta Sierras reach 1100 m asl, 400 m above the surrounding topography. Structurally, this range is an anticline of two smaller anticline segments, 20 km long and 15 km wide, bounded by two faults on its flanks (Brooks, Sandoval & Ross, 2000). The core of the anticline contains Triassic sedimentary rocks of the Mendoza Group which contain oil reservoirs (the Barrancas Formation), making this structure a focus for the oil industry. The anticline's core is covered by Tertiary rocks, outcroppings of which are overlaid by the Pliocene Mogotes and Rio de los Pozos formations (Chiaramonte, Ramos & Araujo, 2002; Irigoyen, Buchan, Villeneuve & Brown, 2002) (Fig. 2).

The uplift of Lunlunta Sierras, corresponding structurally with the Barrancas anticline, is associated with Andean orogeny during the Pliocene (Chiaramonte et al., 2002), and is linked to the current orogenic front of the Andes at this latitude. Recent shallow seismic activity has been generated along the eastern fault of Barrancas anticline. This fault is an inverse type-fault with high dipping to northeast, extending 4 km. It preserves a 12.2 m high scarp with a mean displacement of 0.60 m. A reactivated scarp 2 km south of the Mendoza River corresponds to the surface rupture and major earthquake on March 20th, 1861, 7.2 on the Richter scale (INPRES, 1989). The eastern fault of Barrancas anticline is currently one of the most active faults in the region, and the epicenter of earthquakes in 1936, 1985, 2006, and 2012, each between 5 and 6 on the Richter scale.

In terms of paleo-climate conditions, two neoglacial advances are recognized in the Aconcagua region at the latitude of study area. The Almacenes drift is younger than sediments dated to 15 ± 2.1 ky by TL, interpreted as the Horcones–Almacenes nonglacial interval by Espizúa (1999). The travertine layer capping the lake dammed by the Horcones deposit has a U-series age of 9.7 ± 5 ky (Espizúa, 1999). The youngest confluence drift located at higher elevation does not have date available yet. Recent studies carried out along Tunuyán River reveal that distal piedmont records of fluvial aggradation, alternating with soil forming intervals during the Late Glacial and the Holocene (Mehl and Zárate, 2012).

Regional geomorphological units

Quaternary sediments are extensive in this region, however detailed studies on these deposits are lacking. Pleistocene deposits

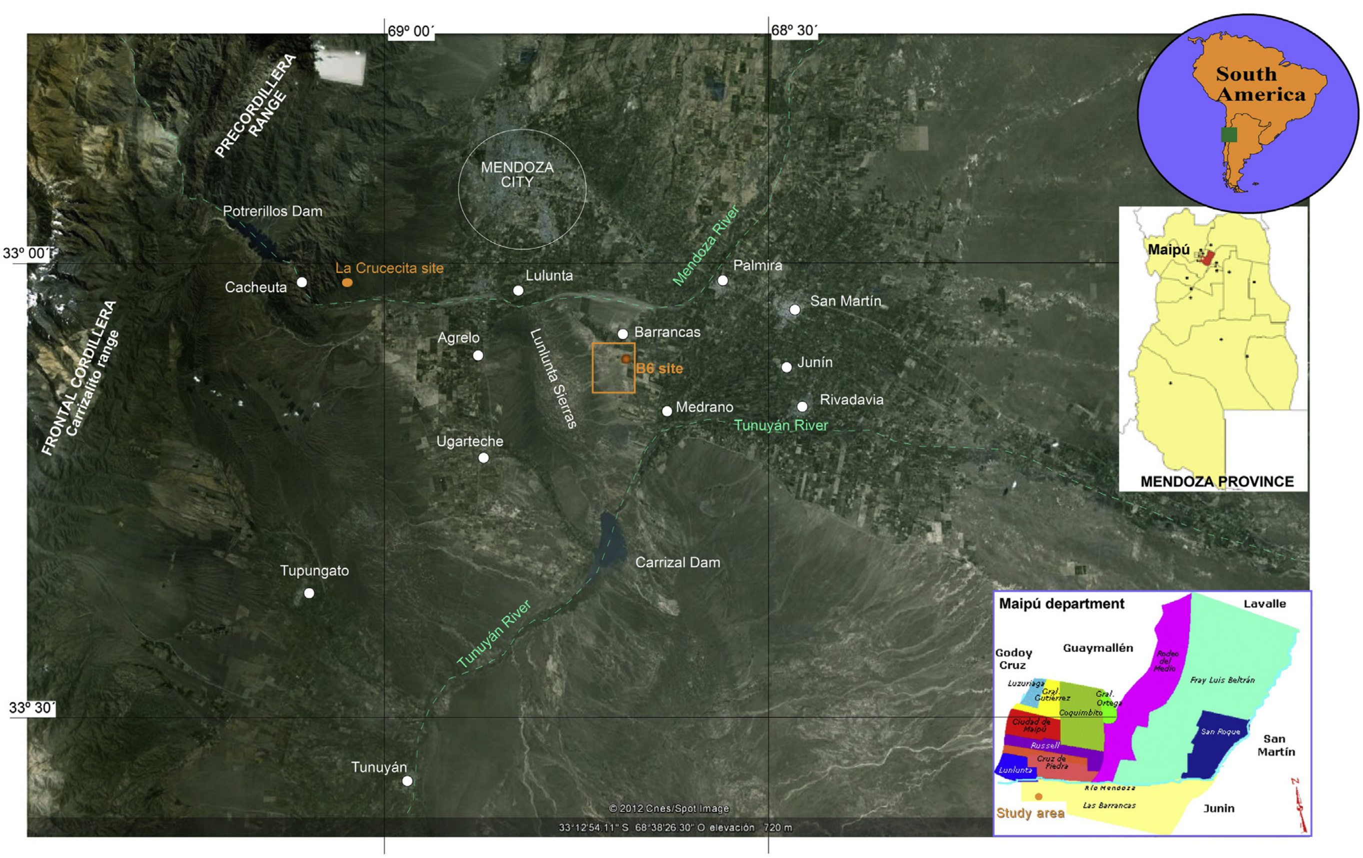

Fig. 1. Location of the study area where the B6 Archeological site is shown.

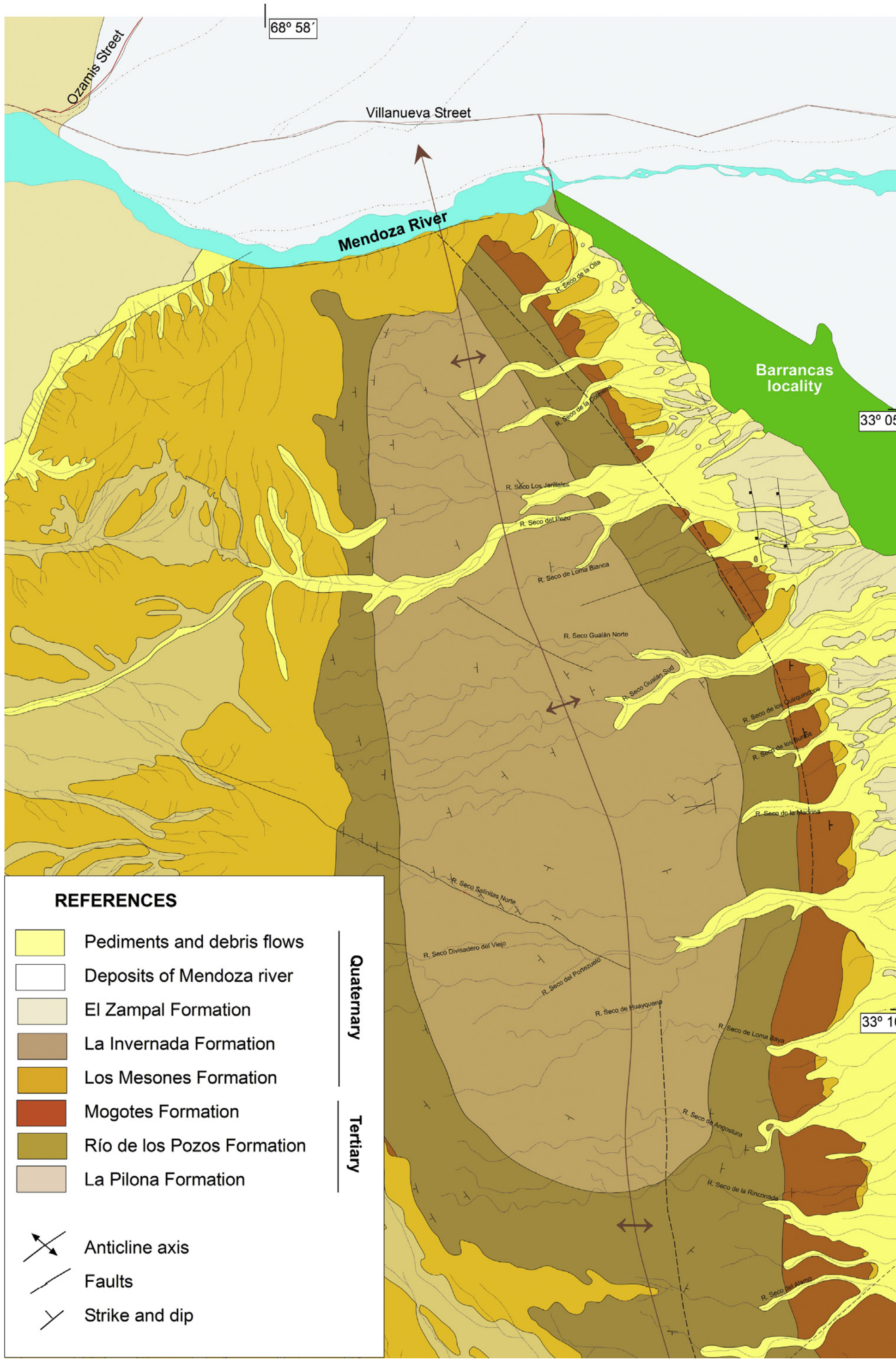

Fig. 2. Geological map of Lunlunta Sierras conforming an anticline with NNW–SSE strike that encompasses Tertiary rocks (modified from Chiaramonte et al., 2002).

were initially recognized by Polanski (1963) for the Tunuyán River. This prior research focused on finding a relationship between climate, tectonic and fluvial accumulation during the Pleistocene. Lately, these distal fluvial -playa lake deposits were correlated with deposits located in the Mendoza River (Ortiz & Zambrano, 1976, pp. 1–43; Rodríguez, 1954; Rodríguez & Barton, 1993; Zambrano, 1978).

During the Quaternary the area has been dominated by a fluvial environment forced by tectonics. Desactivation of Tulumaya River in the Late Pleistocene led to the generation of the Zonda paleo-river that drained to the north. This palaeo-river was disconnected upon the Early Holocene generating two new streams currently known as Mendoza and Tunuyán rivers (Fig. 3a). The main Quaternary deposits related to this environment are following described to understand the geomorphological context of the study area.

- *Fluvial terraces of the Zonda palaeo-river:* Terrace levels were formed by large boulders and sandstones. Lithological

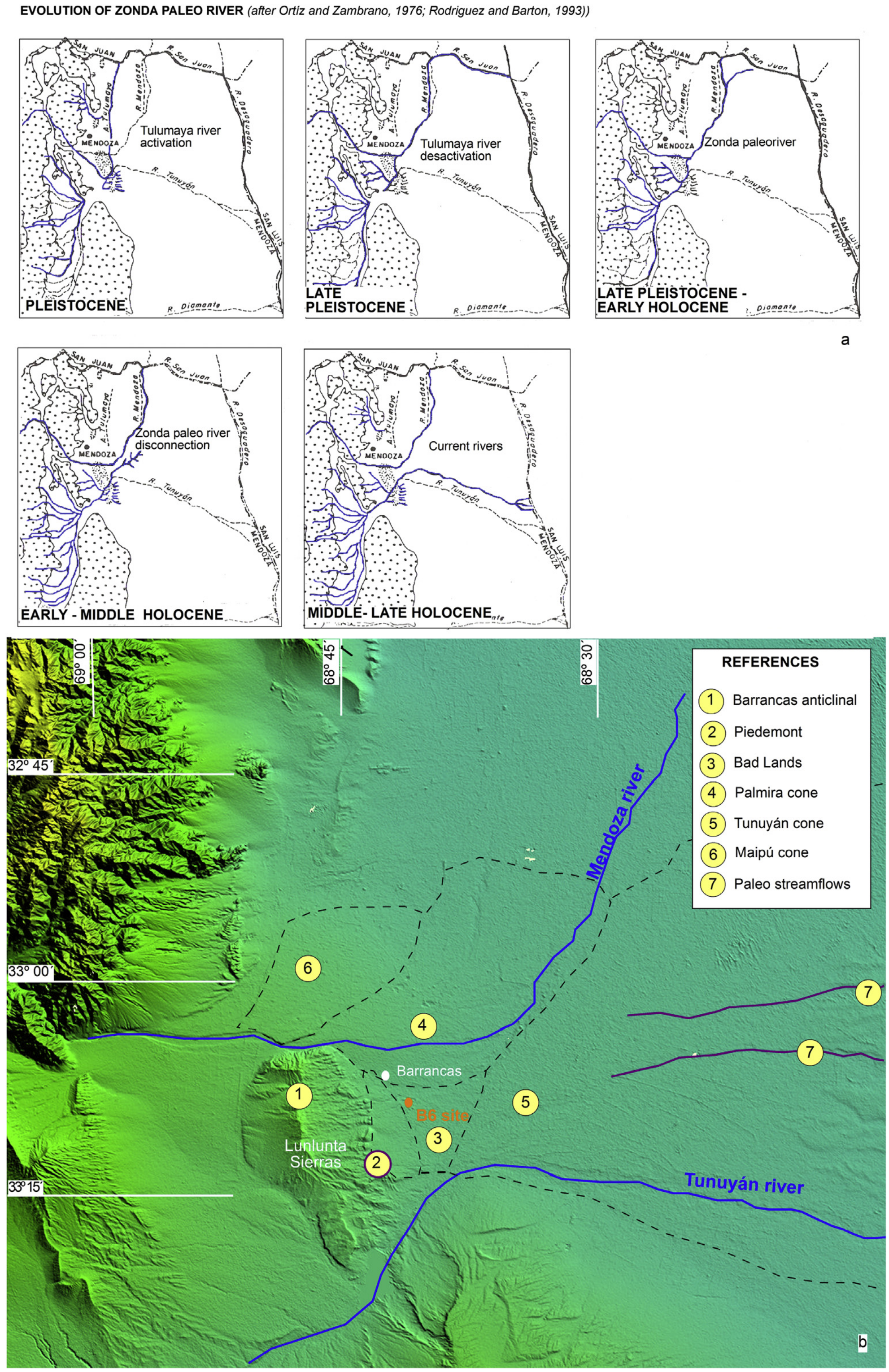

Fig. 3. a. Evolution of the palaeo-river Zonda initially proposed by Ortiz and Zambrano (1976), pp. 1–43 modified by Rodríguez and Barton (1993), and b. Geomorphological units of the study area.

composition of these blocks includes vesicular basalts, pumicites and ignimbrites, cemented by calcareous silts and volcanic ash (Rodríguez & Barton, 1993) sourced in Mendoza river basin and Tunuyán river basin. This is due to the Zonda palaeoriver was formed by the union of these current streams (Rodríguez, 1954, 1966; Rodríguez & Barton, 1993). At present these deposits are restricted to narrow belts to the east of present streamflow of the Mendoza River.

- *Mendoza River cone:* This cone is composed of conglomerates, boulders, sands, clays and silts, previously described as the Maipú and Palmira cones (Reigaraz & Barrera, 1975). Conglomerates present well rounded clasts from the Frontal

Cordillera and the Precordillera, mainly compared of granites, diorites, porphyrites, andesites, conglomerates, sandstones, schists, limestones, wackes, quarcites and phyllites. A Middle Pleistocene age is assigned to this formation, and is correlated with the Mesones and La Invernada formations (Polanski, 1963).

- *Alluvial plain of Tunuyán River:* Fluvial deposits form the distal part of alluvial plain of Tunuyán River. Near the Desaguadero River the upper sequence of this unit overlaps and is intercalated with the Holocene Arco Desaguadero Formation. This formation is characterized by fine deposits, indicating the presence of an extensive lacustrine environment during this period (Rodriguez & Barton, 1993), and is stratigraphically correlated with alluvial distal deposits of the El Zampal Formation (Polanski, 1963). Gastropods from the Arco Desaguareo Formation have been ^{14}C dated to 9280 ± 80 BP (Chielsa, Strasser & Gómez, 2010). These authors suggest that this unit represents the Pleistocene–Holocene limit. Similar dates were reported from the Salinas del Bebedero (González, 1981). In this case, the period between 11,600 ± 140 to 9070 ± 180 BP is represented by clay sediments of a deep lake that could be related to the Younger Dryas glacial advance (González, 1994).
- *Lake and playa lake deposits:* These deposits include silts, sands and clays that cover a large area. Present calcareous components include levels with continental gastropods. They comprise fine sediments from mountain rivers in a distal environment, and indicate the development of extensive lagoons during the Holocene. These deposits are correlated with Arco Desaguadero Formation (Rodríguez & Barton, 1993) and El Zampal Formation (Polanski, 1963).

Material and methods

Geomorphological processes in Barrancas were documented by sedimentological description in an exposed 15 m profile, along one of the area's principal erosional gullies (33° 7′36″S, 68°41′29″W) (Fig. 4). This profile was dated with two radiocarbon dates. The earliest (LP-2771) of which was a carbon sample from a depth of 11.05 m (Fig. 4c), while the second date (LP-2780) was taken from a

Fig. 4. a. A panoramic view of the study area, the Lunlunta Sierras range on the back and badland landscape on the front, b. the B6 archeological site where community cemetery was found, c. Sedimentological profile naturally exposed near the B6 archeological site where location of dated carbon as well as location of archeomagnetism sampling are indicated, d – exposed profile along a gully due to intense retrograde erosion of debris flows generating badland.

nearby profile, from 2.9 m below the surface, which stratigraphic level indicated in Fig. 5. Dates were estimated in OxCal 4.1 (Bronk Ramsey, 2009), using the Southern Hemisphere calibration curve (McCormac et al., 2004) and rounded by 50 years. In this paper ages are presented as the median of calibrated radiocarbon dates, followed by the 2 sigma range in parentheses.

Paleomagnetism was also employed to establish a relative chronology of the stratigraphic section (Barendrest 1984; Herz and Garrison 1998; Parkes 1986, p. 271). Then, a paleomagnetic sampling ($n = 47$) was done on a vertical way next to the hearth located ~11 m below the surface at the same depth as the earliest date (LP-2–771) (Fig. 4c). Samples were collected in using 2 cm long and 2 cm diameter plastic containers. These were carefully pushed into the sediments with the precaution that they overlapped about 50%. Their orientation was measured using a Brunton compass; they were consolidated with sodium silicate once removed and finally, numerated from the top to the bottom. At the laboratory, all samples were subjected to progressive alternating fields (AF) demagnetization in a 3-axis static degausser, attached to a 2G cryogenic magnetometer and subsequently measured with the magnetometer. Characteristic remnant magnetization (ChRM) was calculated using principal components' analysis (Kirschvink, 1980).

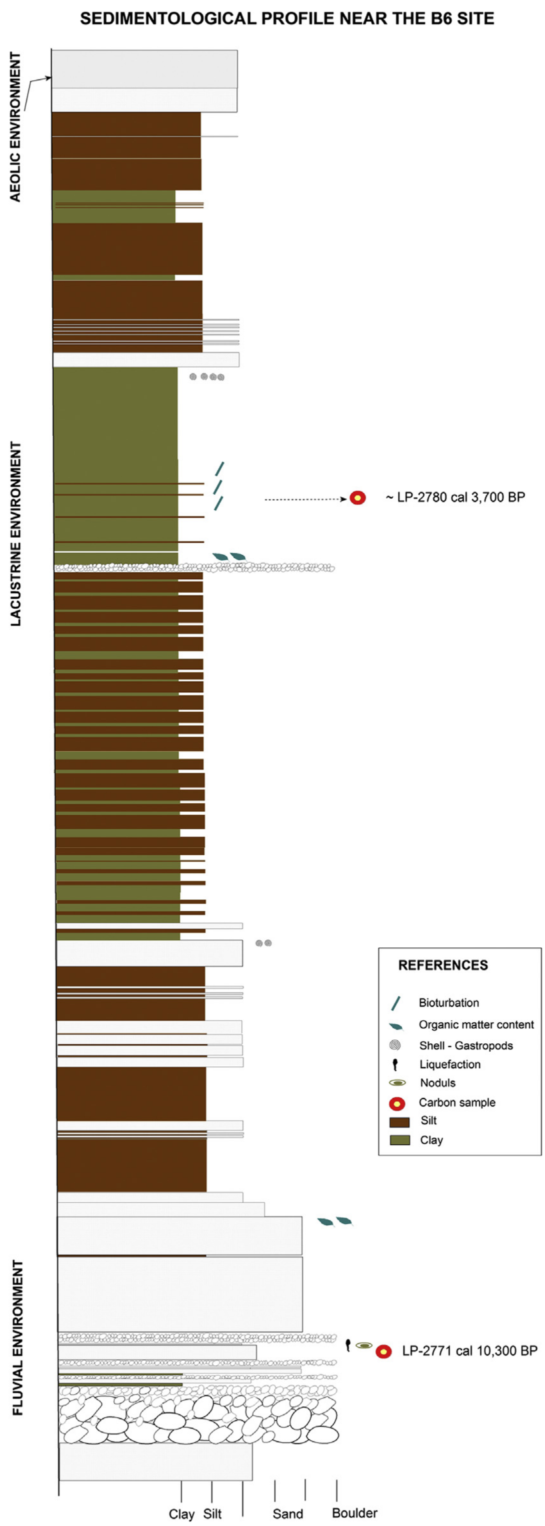

Fig. 5. Sedimentological profile described through the text.

Local stratigraphy

Sedimentological profile

The sedimentological description of the studied profile (Figs. 4c and 5) was done according to depth intervals from bottom to top. The first 0.32 m include a fine sand layer interlaid with silts and with clay nodules. Sequence follows with 0.44 m of rounded boulders, interpreted as channel lag deposits with limited lateral extension. The lithological composition of these boulders is mainly of andesites, rhyolites, granites and pumicites. The presence of the latter indicates flow from the Tunuyán River to the south. The sequence continues with intercalated boulder levels with similar lithology, as well as sands with crossed lamination, which indicate a high energy system for the first meter of deposit sedimentation. The sequence continues with a 1.7 m deposition of fine sands and silts in which coarse layers, 0.1–0.2 m thick, are interlaid. These fluvial channel deposits show an erosive base.

Successive layers of 2.63 m of fine to medium sands intercalated with silts, which ends with a carbonate concentration, appeared in the sequence. Upper, intercalation of silts and clays continues over the next 3.19 m in a very potent sequence. The top of these fine sediment sequence is eroded by a channel of coarse material 2 cm in diameter with material from the Frontal Cordillera (Choiyoi Group vulcanites) where pumicites were not identified. Over this deposit is a 0.13 m clay layer, rich in organic material, which was covered by clays and included indications of bioturbation. In this 0.76 m thick-layer, continental gastropods were recognized. A red level with oxide-clays level continues for 0.70 m, which also includes gastropods, supporting evidence for the presence of lagoons. Next, there is a clear sediment interface, marked by 0.16 m of medium gray sands. The following 2 m correspond to silt-clay alluvial deposits.

The end of the sequence is marked by 0.5 m of fine sands (Fig. 5) associated to wind borne deposits.

Radiocarbon date

The LP-2771 sample resulted 9180 ± 120, calibrated to 10,300 BP (10,650–9900) while second sample in a nearby profile (LP-2780) was dated to 3500 ± 90, calibrated to 3700 BP (4000–3450). Fig. 5 shows location of dated samples. According to obtained ages, this 15 m-exposed profile records the deposition occurred during the whole Holocene suggesting a relatively rapid, stable sedimentation in this period.

Paleomagnetic signature

Despite that paleomagnetic analysis is in progress, preliminary observations may be reported. Paleomagnetic analysis shows that all samples display a common pattern with similar reliability. In this sense, they were considered "highly reliable" with practically univectorial behavior with decay towards the origin. Most of them yielded vector projection diagrams (VPD) with one of two magnetic components. In the majority, a ChRM could be defined trending towards the origin in the Zijderveld diagrams (Fig. 6). The totality of the samples has anomalous directions with reverse magnetization directions. In this sense, the Barrancas sampling represents one of the most detailed records of the "Mylodon excursion" that was firstly observed at Mylodon cave, in southern Patagonia, where a stable record with reverse and intermediate directions at ~10 ky was observed (Nami, 1995).

Geomorphological processes

The sediment profile suggests the existence of three main stages represented by fluvial, lacustrine, and aeolian deposits (Fig. 5). During the first stage, Late Pleistocene-Early Holocene period, rapid waters flowed to Barrancas locality from the Precordillera and the Lunlunta Sierras, likely related to the Zonda paleo-river. The presence of pumice boulders, in these lag deposits, evidences their provenance from the basin of current Tunuyán River. At present, this streamflow run towards the South of the B6 site.

Second stage, involving the period compressed by obtained ages during most of the Holocene, intercalated silts and clays with gastropods content suggest a lagoon environment. During this period, Barrancas site was likely an area with a series of lagoons which formation seems to be the result of active tectonics. The area located in a distal alluvial environment of the Zonda paleo-river, which drained to the east; was affected by the gradual uplift of the western Lunlunta Sierras during the Pliocene-Early Pleistocene. The increasingly level area fostered the disconnection of the Zonda paleo-river and progressive migration streamflows in the Early Holocene. Seasonal snowmelt in the Andes was led to continual regeneration of the wetlands, fed by waters overflowing the Zonda paleo-river. The depth of sediments suggests very rapid accumulation, around 1 m per millennium. The fine alluvial sequences are intercalated by conglomerates and rounded boulders, reflecting the input ingression of river streams into the lagoons. The extension and depths of these levels are variable but document the connection with major Andean rivers.

The third stage, during the Late Holocene, is characterized by the presence of wind borne deposits that may suggest a much drier climate, probably similar to modern conditions. Or at least, these wind accumulation indicates a period of much reduced frequency and magnitude of flooding.

Finally, the current erosion has been the dominate geomorphological process, generating an area of badlands, perhaps as recently as the last few centuries. Rapid debris flows driven by summer rainstorms in the Lunlunta Sierras to the southwest have generated gulleys up to 20 m deep. This process has been especially rapid, as the base sediments are fine alluvial deposits, and because there is little soil stability, given the sparse vegetation in this arid environment. Local habitants documented that the depth of the gulley increased 6 m during 1968–2011, and by 4 m during 2003–2011, indicating the importance of erosion and badland processes (Fig. 4b).

This final period probably included the shift of the Mendoza River northward during the 18th century. Continued uplift and reduced flow toward to the end of the 17th century would have slowed flows and meandering courses, likely causes of this major change (Prieto, 2000; pp. 43–47, pp. 18–366). This was the only major climatic shift during the colonial period and had major social impacts (Prieto, 1985). While the areas east of Mendoza's capital became flooded, the area near Barrancas localities became much drier, with reduced seasonal flows. The current discharge of the Mendoza River reduced gradually over time, but there were still major flooding events throughout the 19th century (Dolcemascolo 1994; pp. 18–22).

Despite flooding the Mendoza River that affected the modern village of Barrancas, many archaeological sites were not impacted, as they are located southeast of the village, at a higher elevation

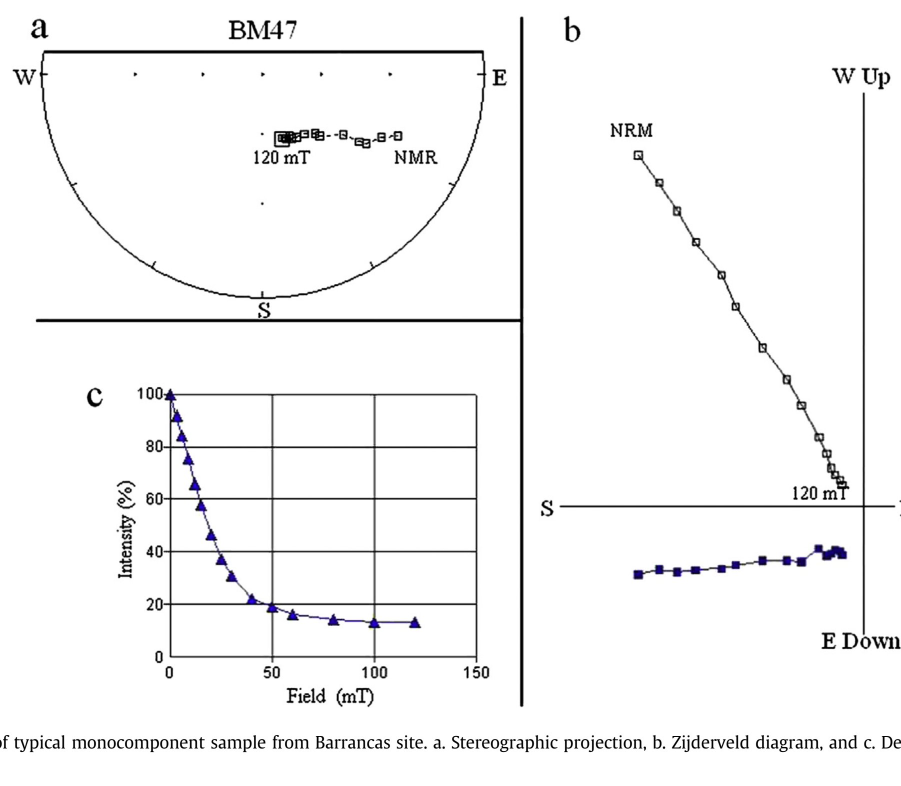

Fig. 6. Example of typical monocomponent sample from Barrancas site. a. Stereographic projection, b. Zijderveld diagram, and c. Demagnetization curve.

(Fig. 7). After thousands of years of seasonally regenerated wetlands, Barrancas site has developed into an arid badlands.

Human occupation in Barrancas

During the Terminal Pleistocene and Early Holocene, the Andes west of Barrancas locality were first occupied by human groups (García, 2003; 2005). The large majority of archaeological finds are located in high-altitude caves, but two finds suggest that this earliest hunter-gatherers' ranges of mobility also included the lowlands near Barrancas locality. The first is a fishtail projectile point found about 30 km upstream from Barrancas site. This temporally diagnostic style suggests that the region's first inhabitants also occupied the open lowlands east of the Andes (Schobinger, 1971).

The second is the earliest dated context comes from a feature resembling a hearth, identified in the sediment profile described in this article, dated to around 10,300 BP (LP-2771). This feature includes very dense concentrations of carbonized organic material and ash, while no other carbon is visible at this depth, 11 m. Its size and shape also suggest a hearth, a bowl shaped feature 70 cm wide and 10 cm deep at its center. No associated artifacts were immediately apparent in the profile, so additional studies will be necessary to confirm the working hypothesis that this early feature is associated with human occupation. A similar feature was detected in a second profile, about 80 m downstream. It is an ash lens extending 180 cm, whose central part is a 75 cm wide bowl shaped feature, with a depth of 12 cm. A carbon sample from the deepest part of the feature was dated to 3500 ± 90 (LP-2780), calibrated to 3700 BP (4000–3450, 2 sigma). Assuming these are Early and Middle Holocene hearths, they are likely evidence of mobile hunter-gatherers. These initial results suggest that the area may have been occupied during most of the Holocene.

The next material evidence is from the site B6 (Novellino, Estrella, Brachetta Aporta & Mansegosa, 2010), a cemetery including 34 individuals dated with two strongly overlapping radiocarbon dates on human bone: 2260 ± 80 (LP-2387) and 2251 ± 49 (AA-98707). Combining and calibrating these dates provides an estimate for the cemetery's age, 2250 BP (2350–2100, 2 sigma). There were impressions of unpreserved basketry were recorded near the heads of some individuals. Two individuals were found projectile points impaled in the abdomen, suggesting violent deaths. No other artifacts were found in association with this burial context. Two other cemeteries have also been reported with 12 and 22 individuals (Rusconi, 1964, 1967), indicating that Barrancas site was an area where past cultures chose to bury their dead.

A slightly more recent dated archaeological context was excavated by Michieli (1974, pp. 33–34). An ash layer 15–20 cm below the surface was associated with a hearth which included bones and grey ceramic sherds with incised chevrons. This context was dated to 1480 ± 80 BP (GaK-5560; Gambier, 1977; p. 84), calibrated to 1350 BP (1550–1150, 2 sigma). This date is one of the earliest associated with this incised ceramic style, called Agrelo or Calingasta, which was used in a large area, over what is currently the north of Mendoza and south of San Juan, perhaps as late as the arrival of the Spanish (García, 2004). Many surface finds in Barrancas site are of the same style, suggesting significant occupations during this temporal span (Rusconi, 1962). Ceramics from this area were used in original definition of the style Agrelo by Canals Frau and Semper (1956; see Bárcena, 1996). Most of the ceramics and other objects that have been collected over the past century do not have clear provenience information.

At the site B61, northwest of B6, a systematic surface collection includes ceramics in this style, in a context dominated by expedient lithic tools (Marsh et al., 2013; Sergo & Bosicovich, 2013). The presence of ground stone suggests agricultural activities. The preliminary impression is of groups with less mobility than most hunter-gatherers, with economic practices that included grinding food, making and using decorated and undecorated ceramic vessels, and possibly cultivating crops and herding camelids.

Finally, historical documents indicate the presence of local Huarpe populations upon the arrival of the Spanish in the area, during the middle of the 16th century (Michieli 1998). Archaeological material from burial contexts and surface finds have also been reported, including ceramics in the Viluco style, diagnostic of the period of contact with the Inca and Spanish empires during the 15th to 17th centuries (Bárcena, 1996; García, 2004; Michieli, 1998; Prieto & Chiavazza, 2009; Rusconi, 1964). Jesuit missionaries began arriving in Barrancas in 1610, and prior to 1807, a church was built that is still standing today (Dolcemascolo, 1994). This church is one of the oldest surviving churches in the region, and was recognized as one of Argentina's historic national monuments in 1972.

Geomorphological, environmental, and cultural processes

Throughout the Holocene, Barrancas site has experienced complex interactions between geomorphological, environmental, and cultural processes. During the Early and Middle Holocene, the area was likely visited by hunter-gatherers, attracted to the ample plant and animal resources that would have flourished in this humid oasis, contrasting starkly with the arid zones farther from the lagoons. By the Late Holocene, inhabitants used the area to bury their dead, and around 1500 BP, there were more sedentary occupations. At this time, the lagoon area may have used for some degree of plant cultivation, perhaps similar to more recent cultural uses of the other nearby lagoons (Prieto, 1985). Historically documented populations in these lagoons made use of a wide variety of resources that were probably available to the inhabitants of Barrancas locality, a potentially fruitful analogy. One of the major features of a moister climate regime is the increase in overall

Fig. 7. North – South longitudinal profile showing altitude of the study area. Relative good preservation of the B6 archeological site is due it is in higher position and far of the Mendoza river cone. Whereas the Barrancas village is proper to be affected by flood of Mendoza river as it is inside its cone.

climatic stability, perhaps a principal motivation for spending longer periods of time at occupational sites in Barrancas. In the most recent period of aridity in Barrancas, local populations dropped sharply, in part due to colonial resettlement, but also as there were severely reduced quantity and quality of plant and animal life.

For at least the most recent few centuries, erosion has been the dominant geomorphological process, which has had a major impact on the existing archaeological assemblage. Clarifying the past cultural processes requires accounting for these formation processes. The exposure of deep levels in natural gullies has been the principal means of identifying ancient cemeteries.

The large surface dispersion of artifacts is one of the factors that has attracted collectors and looters to the area for over a century. This situation is partly a result of eroding archaeological sites, that may have once been stratigraphically superimposed. Advancing erosion would have removed sediments that separated temporally distinct cultural deposits, resulting in surface assemblages of artifacts from various epochs. This makes it especially difficult to locate these assemblages in time, especially in the case of previously collected artifacts. In addition, the rapid movement of water has displaced artifacts downstream. In the surface collection of B61, artifact density and slope were closely correlated. In the gullies, there was a complete and conspicuous absence of artifacts, immediately adjacent to relatively stable surfaces with densities of up to 8.5 artifacts per m^2. These forces have local impacts, as gullies cut through previously deposited artifact concentrations, as well as more regional impacts, as eroded areas gradually increase in area and depth downstream.

Understanding these forces has implications for future survey of this large area. Upstream area may be better preserved, and stable surfaces may be well preserved in all areas. Careful survey of dynamic gullies, which change after each major storm, may reveal future evidence of the oldest occupations. The rapid deposition of alluvial sediments during the Holocene would have buried and protected archaeological sites at depths which are impractical to excavate from the surface. Patterns of surface artifacts must be overlaid on to high-resolution topographical maps, in order to understand the local impacts of debris flows from the southwest.

Finally, the modern inhabitants of Barrancas village have begun participating in the development of a public archaeology program intended to provide a valuation of this area as part of Argentina's national heritage. Sociologists Natalia and Mariano Lucero are disseminating and connecting the community to its past with the support of a national grant, and the local municipality of Maipú has collaborated with research in the area. In the near future, local politicians expect to declare Barrancas as a strategic archaeological reserve, in order to protect, educate, develop its heritage as a cultural resource.

Conclusions

Barrancas has been known to collectors for over a century as a place rich in archaeological material. Only recently have systematic investigations begun to reconstruct past geomorphological, environmental, and cultural processes, and there are very few prior investigations that have targeted any aspect at all of this dynamic area. Radiocarbon dates have helped locate all of these processes in time, as the outlines of the area's natural and cultural begin to emerge. Besides, paleomagnetic analyses confirms the Holocene age for the studied sequence representing one of the most detailed records of the "Mylodon excursion" recorded during Late Pleistocene-Early Holocene (~11–9 ky) (Nami 1995, 1999, 2012, 2013), comparable to contemporary results from other parts of the world (Creer, Anderson & Lewis, 1976; Lund et al., 2008; Nami 1995, 1999; Wiegank, Petrova & Pospelova, 1990). This anomalous behavior of the geomagnetic field has been also recorded in numerous sites across the southern cone of South America (Nami, 1999, 2012, 2013).

One of this paper's goals was to describe geology and geomorphology of Barrancas site, and its implications for reconstructing the paleo-environment. The major conclusion of this research is that for most of the Holocene, Barrancas was the site of seasonally fed lagoons, which would have also attracted plants, animals, humans. It seems this was a place visited by some of the first humans to arrive in the area. Around two thousand years ago, multiple cemeteries were maintained. In the last 1500 years, it was a site of agricultural activities, and a principal locality in the regional settlement patterns of people who used both Agrelo and Viluco ceramics, and of Huarpe populations at the time of Spanish contact. Continuing research has broader implications for modern residents and visitors, as they continue to participate in the public archaeology program. Further research will be focused on better understanding geomorphological processes in different parts of Barrancas locality, and a more detailed reconstruction of climatic variability, though additional sedimentological profiles and additional environmental proxies.

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This lively geomorphological and archaeological setting is the focus of the national heritage project *Pantano Negro*, which has been working with the local Municipality of Maipú since 2008 to create one of Argentina's first archaeological reserves. Integrating the local community is a part of this project, including creating a local museum and disseminate research through community and school talks. We are glad with two anonymous reviewers that help to improve greatly this paper.

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