Journal of South American Earth Sciences 37 (2012) 41–59

Contents lists available at SciVerse ScienceDirect

Journal of South American Earth Sciences

journal homepage: www.elsevier.com/locate/jsames

Late Pleistocene and Holocene environmental and climatic conditions in the eastern Andean piedmont of Mendoza (33°–34°S, Argentina)

A.E. Mehl*, M.A. Zárate

Instituto de Ciencias de la Tierra y Ambientales de La Pampa (INCITAP, CONICET), Universidad Nacional de La Pampa, Av. Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina

ARTICLE INFO

Article history:
Received 26 May 2011
Accepted 21 January 2012

Keywords:
Late Quaternary
Andean piedmont
Alluvial sequences
Paleoenvironments
Geochronology

ABSTRACT

The main goal of this paper is to analyze the late Quaternary alluvial record of the Andean piedmont between 33° and 34°S (Mendoza, Argentina) reconstructing the prevailing paleoenvironmental conditions and discussing their regional significance. The analysis was carried out along the outcrops of Arroyo La Estacada and its tributary Arroyo Anchayuyo, complementary sections were described at Arroyo Grande and Arroyo Yaucha. The sedimentological, stratigraphical and geochronological (radiocarbon and OSL dating) results as well as the paleoenvironmental interpretation are presented and discussed on the basis of the geomorphological units identified at the piedmont fluvial systems.

Late Quaternary deposits of Arroyo La Estacada compose three main geomorphological units consisting of an extensive aggradational plain, a fill terrace and the present floodplain -which is not analyzed in this contribution-. At the aggradational plain a distal alluvial fan lithofacial association was determined, mainly related to overbank sheet fluid overflows and probably temporary inactive channels of sandy-like braided streams between ~50 ka BP and the early Holocene. The mid-late Holocene fining upward alluvial sequence of the fill terrace corresponds to a sinuous fluvial system lithofacial association. The mid-to late Holocene alluvial sequence exposed at Arroyo Grande banks shows a fining upward sequence probably related to a sinuous fluvial system lithofacial association. Finally, in the Arroyo Yaucha the upper and lower terraces analyzed in this study record a Late Glacial and Holocene fining upward alluvial sequence of a sinuous fluvial system lithofacial association.

The late Pleistocene – early Holocene dynamic of the Andean piedmont documents an interval of alluvial aggradation characterized by the occurrence of sandy systems similar to braided rivers in the distal fan environments. The mid-late Holocene is marked by aggradation in sinuous fluvial systems and by two major episodes of degradation registered across the fluvial systems of the study area. This paleoenvironmental reconstruction allowed us to propose an evolutionary scheme and chronology of the major fluvial landscape landforms contributing to the general understanding of the sedimentological and geomorphological dynamic during the late Quaternary.

1. Introduction

The Andean piedmont of Mendoza, Argentina, is located at the latitude of 33°–34°S in a transitional tectonic zone between the Nazca plate flat segment (north of 33°S) and the normal subduction segment (south of 33°45′S) (Giambiagi and Ramos, 2002). As a result the piedmont is characterized by a complex geological and structural setting consisting of tectonic basins, blocks and a thrust and fold belt (Polanski, 1963; Ramos, 1999; Perucca et al., 2011). Consequently the piedmont landscape is heterogeneous, comprising several different environments dominated by both aeolian and fluvial processes. The area is located within the domain of the South American Arid Diagonal (Bruniard, 1982) and the source area of the late Pleistocene–Holocene aeolian deposits of central Argentina (Iriondo, 1997; Zárate, 2007). In this region several papers have been published on the Quaternary glacial dynamic of the upper mountain valleys of the Atuel River (Gosse, 1994) and the Grande River (Espizua, 2004, 2005). Recently some other contributions focused on the geomorphology and geochronology of Quaternary fluvial landforms at the upper Atuel River (Messager, 2010), the Diamante River (Baker et al., 2009) and the mountain and proximal piedmont reach of Las Tunas River (Pepin, 2010) have been published. Instead, few efforts were devoted to the understanding of the prevailing sedimentary piedmont

* Corresponding author. Tel.: +54 2954 430157; fax: +54 2954 432535.
E-mail addresses: adrianamehl@conicet.gov.ar, adrianamehl@gmail.com (A.E. Mehl), mzarate@exactas.unlpam.edu.ar (M.A. Zárate).

0895-9811/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jsames.2012.01.003

environments and their paleoclimatic significance. As a result, alluvial and aeolian records of this key environmental setting have been the focus of attention as potential archives of past conditions. Preliminary results have already been reported on the alluvial (Zárate and Mehl, 2008; Mehl, 2010, 2011) and the aeolian stratigraphy (Tripaldi et al., 2011), the chronology of tephra layers (Toms et al., 2004), mollusks paleoecology (De Francesco et al., 2007) and the fossil pollen analysis of some alluvial sections (Páez et al., 2010; Rojo et al., in press). However, a general interpretation of the alluvial sedimentological environments and the piedmont evolution during the late Quaternary still remain opened. Accordingly the main goal of this paper is to analyze the alluvial record of the Andean piedmont between 33° and 34°S combining the information obtained from stratigraphy, sedimentology, and geochronology of alluvial successions. As a result the late Quaternary paleoenvironmental and paleoclimatic conditions are reconstructed discussing their regional significance.

2. Geological and environmental setting

The study area is situated at the piedmont of Frontal Cordillera (Fig. 1), an Andean faulted block consisting at this latitude of three main ranges; from north to south, *Cordón del Plata*, *Cordón del Portillo* and *Cordón del Carrizalito* (Fig. 1a). These ranges are composed of Precambrian metamorphic rocks together with Permian-Triassic volcanic and plutonic suites (Giambiagi et al., 2003 and references therein). A tectonic basin developed at the northern and the central part of the piedmont (*Tunuyán* depression, Perucca et al., 2009) bounded northwards and eastwards by folded and thrusted Neogene sedimentary outcrops, Cerrilladas Pedemontanas and Meseta del Guadal respectively, (Fig. 1a); the basin is limited by a fracture southwards (Polanski, 1963; Yrigoyen, 1993). The tectonic depression is filled with nearly 2000 m of deposits dating back to the Miocene; the uppermost 600 m consist of sandy to silty sediments including some gravel deposits of mid and late Quaternary age (Polanski, 1963). The topmost 30 m, exposed along the banks of the piedmont fluvial systems, are grouped under the name of El Zampal Formation recording approximately the last 50 ka (Zárate and Mehl, 2008). At Arroyo La Estacada (Fig. 1), the deposits of El Zampal Formation encompass an aggradational plain, a fill terrace and a recent floodplain (Zárate and Mehl, 2008) (Fig. 2a and b). This area is known as *Valle de Uco*, a densely populated environment, highly modified by intensive land use causing the disturbance of the uppermost meter of the sedimentary cover and surface soils.

The southern part of the study area, known as *Valle Extenso del Campo Bajo* (Polanski, 1963) and featured by NW–SE strike faults generated under a Quaternary transtensive tectonic regime (Casa et al., 2011; Perucca et al., 2011), is mostly covered by pyroclastic deposits of the *Asociación Piroclástica Pumícea* -APP- (Polanski, 1963) (Fig. 1b). They were originated by the caldera formation of the Maipo volcano; the age of this event is controversial with dates obtained by different methods ranging from *ca.* 2,3 Ma to *ca.* 150 ka (Lara et al., 2008).

The climate is arid with a mean annual precipitation of around 200 mm, mainly resulting from summer rains produced by the Atlantic anticyclonic centre; humid Pacific winds do not reach the eastern Andean piedmont and lowlands due to the rainshadow effect exerted by the Andes Cordillera (Prohaska, 1961, 1976). Accordingly, the vegetation of the Andean piedmont is composed of semiarid xeric associations (Roig and Martínez Carretero, 1998), including hydrophytic communities at sites with local water availability of (Fig. 2b–e) (Rojo et al., in press).

The studied piedmont is drained by the Tunuyán River and its tributaries including among others, Arroyo La Estacada and Arroyo Grande crossing the *Tunuyán* depression, and further south Arroyo Yaucha in the domain of *Valle Extenso del Campo Bajo* (Fig. 1). These piedmont streams are alluvial type channels (Charlton, 2008), incised in a sedimentary bedrock corresponding to alluvial deposits such as El Zampal Formation (Arroyo La Estacada and Arroyo Grande) and the APP ash deposits, Las Tunas and La Invernada Formations (Arroyo Yaucha). Instead, the upper reaches of arroyos Yaucha and Grande are bedrock type channels (Charlton, 2008) deeply incised in the Precambrian to Mesozoic bedrock of Frontal Cordillera.

The Tunuyán River along with Arroyo Grande and Arroyo Yaucha are streams of perennial discharge that varies along the year and depends on the snowfalls generated by the Pacific humid air masses at their Andean headwaters. Arroyo La Estacada, also of perennial discharge, is fed by springs located along a piedmont fault line and by its tributary Arroyo Anchayuyo draining water from other springs and minor streams up in the NW sector of the piedmont (Fig. 1). The present channel pattern of the streams is variable, Arroyo La Estacada and the lower reach of its tributary Arroyo Anchayuyo are meandering (sinuosity index -SI- higher than 1.7). Instead, the upper reach of Arroyo Anchayuyo exhibits low sinuosity (SI: ~1.16); Arroyo Grande shows an alternating braided – sinuous pattern along the upper reach grading downward to moderate sinuosity (SI: ~1.25). Arroyo Yaucha sinuosity is moderate (SI: ~1.25) decreasing (SI: ~1.08) when the stream traverses a fault line (Mehl, 2011) corresponding to Los Alamitos fault zone (Casa et al., 2011) (Fig. 1a).

3. Methods

A general geomorphological survey was performed at the piedmont fluvial systems in order to identify the main landforms. The present floodplain environments are not analyzed in this contribution. At *Valle de Uco*, the sedimentary analysis of the alluvial record was carried out along the banks of Arroyo La Estacada (La Escala site), and its tributary Arroyo Anchayuyo (Puente El Zampal site) (Fig. 1), where sections exhibit a lateral continuity of several kilometers with an average exposed thickness of 20 m; an additional section is described at Arroyo Grande (La Riojita site, Fig. 1). In the southern part of the study area (*Valle Extenso del Campo Bajo*) the sedimentary analysis was based on exposures situated along the middle reach of Arroyo Yaucha (Los Alamitos 1 and Los Alamitos 2 sites, Fig. 1).

Lithological analysis and sampling were carried out at representative sections of the geomorphological units identified in each of these arroyos. Descriptions included textural composition, thickness, limits according to Catt (1990), color (Munsell Color X-Rite, 2000) and sedimentary structures of the deposits (Tucker, 2003). Sedimentary paleoenvironments were inferred based on a facial analysis conducted by Mehl (2010) according to Miall (1977, 2006) approach (Table 1); paleosols identification was based upon the main criteria pointed out by Catt (1990).

Grain size analysis was made using a Malvern Mastersize Hydro 2000 μm laser diffractometer -detection range between 2000 μm and 0.010 μm-; samples were classified according to Folk (1954). The organic matter content was determined by wet oxidation followed by titration with ferrous ammonium sulfate considering the Van Bemmelen factor (1.72) that assumes a 58% of total organic carbon in soil organic matter. A digital calcimeter was used to determine calcium carbonate content.

The chronological calibration of the alluvial deposits was based on both radiocarbon and OSL datings already published (Zárate, 2002; Zárate and Páez, 2002; De Francesco et al., 2007; Toms et al., 2004; Zárate and Mehl, 2008) along with a new radiocarbon date reported in this paper (Table 2). OSL ages reported by Toms et al. (2004) were carried out on quartz grains of sandy sediments above and below tephra layers. Radiocarbon dates, both by beta-counting and accelerator mass spectrometry approaches, were mainly performed on organic matter in sediment, two on