

BURIED SOILS AT THE PLATAFORMA BASCULADA ONDULADA (UNDULATED TILTED PLATFORM) IN CENTRAL REGION OF CÓRDOBA PROVINCE, ARGENTINA

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ABSTRACT – In the central part of Córdoba Province, inside Plataforma Basculada Ondulada (Undulated Tilted Platform), and under very special circumstances present soils are buried by loessic materials. It is interesting to establish whether these soils can be considered as paleosols or not. This paper includes some examples where the second option seems to be the right one. That is the case both along drainage lines and on eastward slopes interrupted by roads or wire fences. In Corralito gully ($33^{\circ} 05' W$ - $64^{\circ} 00' S$), the modern soil, namely Serie Manfredi is covered by an alluvial sediment nearly 1 meter thick, that includes rests of recent materials such as bricks, glasses and so on. On the eastward dipping slopes, along the fences, it is very common to find present soils overlain by recent materials that were deposited alongside the obstacle by hydrological fluxes. These buried soils cannot be considered as paleosols, and are therefore not as meaningful as real paleosols are. Nevertheless, they are very good indicators of anthropogenic activities and disturbances that took place much more recently.

Keywords: Paleosols, Buried soils.

RESUMEN – *J.A. Sanabria & G.L. Argüello - Suelos enterrados en la Plataforma Basculada Ondulada (Plataforma Basculada Ondulada) en la región central de la Provincia de Córdoba, Argentina.* En la parte central de la Provincia de Córdoba, dentro de Plataforma Basculada Ondulada, y en circunstancias muy especiales, los suelos presentes son enterrados por materiales loéssicos. Es interesante determinar si estos suelos pueden ser considerados como paleosuelos o no. Este artículo incluye algunos ejemplos en los que la segunda opción parece ser la correcta. Ése es el caso, tanto a lo largo de líneas de drenaje como en las pendientes orientales interrumpidas por las carreteras o los alambrados. En la cárcava de Corralito ($33^{\circ} 05' W$ - $64^{\circ} 00' S$), el suelo moderno, nominalmente Serie Manfredi, está cubierto por un sedimento aluvial de cerca de 1 metro de espesor, que incluye restos de materiales recientes, tales como ladrillos, vidrios, etc. En las laderas que buzan hacia el este, a lo largo de las cercas, es muy común encontrar a los suelos actuales cubiertos por materiales recientes que fueron depositados junto al obstáculo por los flujos hidrológicos. Estos suelos enterrados no pueden ser considerados como paleosuelos, y por lo tanto no son tan significativos como ellos. Sin embargo, son muy buenos indicadores de las actividades antropogénicas y las perturbaciones que tuvieron lugar mucho más recientemente.

Palabras clave: paleosuelos, suelos enterrados.

INTRODUCTION

The Plataforma Basculada (Capitanelli, 1979) is located in the central region of Córdoba, between Suquía and Xanaes rivers, and is separated from Sierra Chica by the Depresión Periférica (Peripheral Depression) (Capitanelli, 1979).

Sanabria, et al. (2004) described the Plataforma Basculada (Tilted Platform) as composed by two subunits: Plataforma Basculada Ondulada (Undulated Tilted Platform) and Plataforma Basculada Plana (Flat Tilted Platform) (Figure 1). The first subunit includes undulated hills, elongated along a W-E trend. They are dissected alluvial cones, probably Plio-Pleistocene in

age, covered by a mantle of loess and loess-like materials, aging late Pleistocene- Holocene.

On this loess and loess-like materials, typical Haplustols develop at the summits, while typical Argiustols appear along the drainage lines and elongated lowlands. Both soils are excellent for agricultural purposes, and are classified as Class III c, according to the USDA Soil Classification System.

Inside this area and in certain situations, present soils are buried under the loess. The presence of elements such as bricks, glasses, etc., included in the

sediment that covers the soils is a clear evidence of a very recent burying process.

On the other hand, in Plataforma Basculada Ondulada, there are a series of gullies and barrancos, some of which exhibit a loess- paleosols sequence that depicts the paleo-environmental and paleoclimate history of the region, at least for the last 115 ka (EI5) (Kemp et al., 2003; 2005; 2006) (Figure 2).

Comparing both situations, an interesting question arises. Should all buried soils be considered as paleosols, just because they are covered by sediments? Are they necessarily indicating environmental and climatic conditions different from the present ones? In this paper, some examples are analyzed, that would involve situations where the paleosol concept should not be applied.

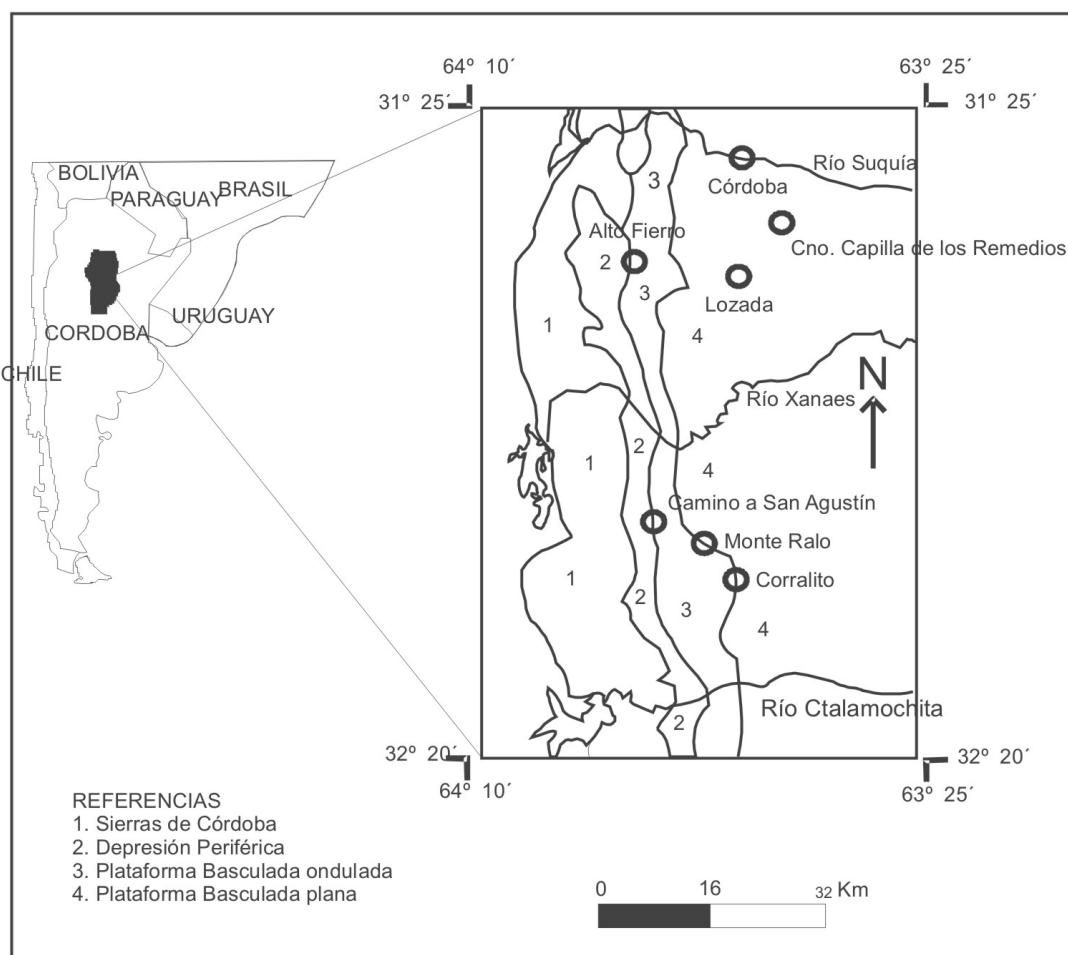


FIGURE 1. Location map of the geomorphological units and of the selected cases.



FIGURE 2. Loess paleosols sequence.

RESULTS

CORRALITO I

In the study area, buried soils are to be found in two particular situations: inside drainage lines, and on slopes facing eastwards that are intersected by wire fences. An example for the first case is the gully known as Corralito I.

Corralito gully displays two knickpoints, due to reactivations of the retrograding erosion. The knickpoints are known as Corralito I and II, being the first one, probably the best surveyed of the region. It is located about 5 km the north of Corralito City ($33^{\circ} 05' \text{S}$ - $64^{\circ} 00' \text{S}$) (Figure 3).

The beginning of the process was in September 1978 (Argüello, G. et al., 2006), and the gully evolved along the time up to its present dimensions. At Corralito II, its width is approximately 40 m; and the depth around 20 m. The full length of the gully is considered to be 25 km.

Along the profile in Corralito I, some TL and IRSL datings were established. Very fine sand mineralogy and phitolyths analysis have been performed as well. Also samples were collected in order to analyze their magnetic susceptibility (Sanabria et al., 1996; Moretti, 2002; Argüello et al., 2006; 2008; Frechen et al., 2009). The paleosols -loess sequence can be seen in Table 1.

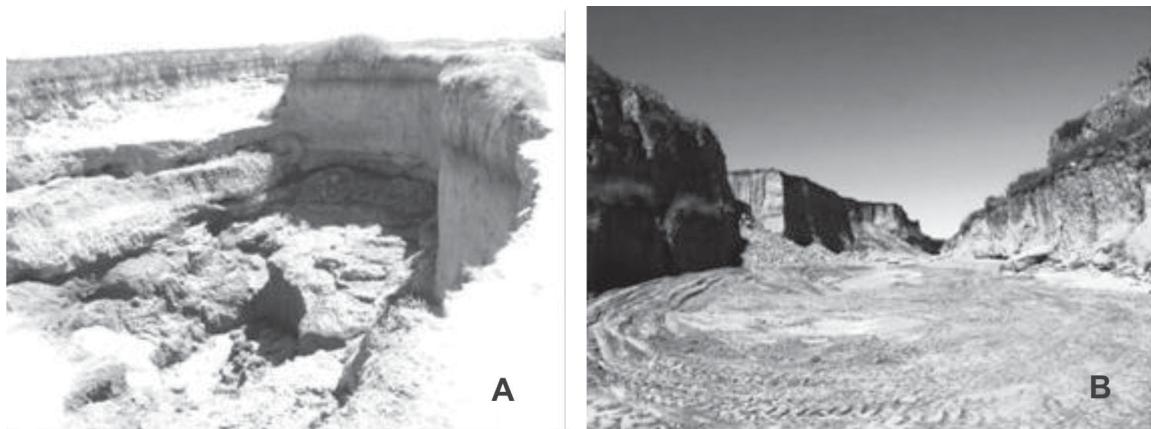


FIGURE 3. A. Corralito I. **B.** Corralito II.

TABLE 1. Profile of the loess paleosols sequence in Corralito.

Corralito Lithology	Sample	IRSL age (ka)	TL age (ka)	Geological Interpretation
0				Modern sediments sheet wash
2	Cor 0 Cor 1 Cor 2 Cor 3 Cor 4	18.8 ± 1.9 13.8 ± 2.1 15.8 ± 2.1 32.7 ± 6.7 18.9 ± 2.4	7.3 ± 1.0 11.8 ± 1.8 10.5 ± 1.4 28.7 ± 4.4 18.1 ± 2.4	Ab horizon Btb horizon Loess (number of crotovinas increases with depth)
4				2Btb1 horizon
6	Cor 5 Cor 6	32.2 ± 5.6 66.1 ± 9.4	25.7 ± 3.8 76.4 ± 9.1	2Btb2 horizon Loess, partly reworked
8				3Btb1 horizon
10	Cor 7	114 ± 17	56.2 ± 10.0	3Btb3 horizon Loess bioturbation features
12	Cor 8 Cor 9	92.1 ± 14.7 115 ± 21	94.9 ± 16.2 99.8 ± 17.5	Loess (sand content increases with depth)

In Corralito I, Manfredi Series, that is considered as the representative soil of the elongated lowlands inside the region, is covered by an alluvial sediment, that includes modern elements such as bricks, glasses, plastics, etc (Figure 4). The sediment displays a laminated structure, indicating its deposition by water, and its grain size is mostly sandy-loam, with sand intercalations that include some gravel and cement blocks. The last ones were eroded by torrential rains from the culverts and fords that were built on the provincial route that links Corralito and Monte Ralo. The average thickness of the cover is 1 m, and colours are varied.

The mantle has not been analyzed in laboratory for its classification from the point of view of Pedology and in addition it presents many lateral variations, which would give rise to complex cartographic units. Anyway, the only horizon that has been developed is A, and could very likely belong to the Mollisol Order.

In the Plataforma Basculada Plana it can be seen

that the alluvial cone of Corralito gully is producing great losses because of the agricultural soils burying.

Slopes

The second example is on the slopes. In some sectors of the Plataforma Basculada, always on the slopes dipping eastwards, and next to the wire fences of the N-S trending roads, which are perpendicular to drainage lines, there is a great accumulation of materials. They come from the water erosion in the upper river basin, and their thickness, can reach one meter in some cases. (Figure 5) This accumulation lies along narrow and long strips that in a soil map would be considered as inclusions. The buried soil belongs to Oncativo Series.

North of Córdoba City, where Depresión Periférica cannot be detected, there are buried soils as well. As a rule, they are better developed than the ones in the south (Figure 6) and so far, they have been found along drainage lines and inside fluvial terraces.

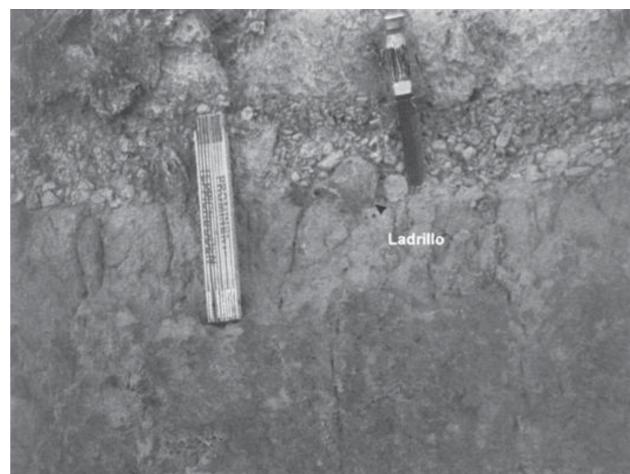


FIGURE 4. Bricks inside the sediment that is covering the exposed soil in Corralito I.



FIGURE 5. A. Wire fence almost buried; B. Topography.

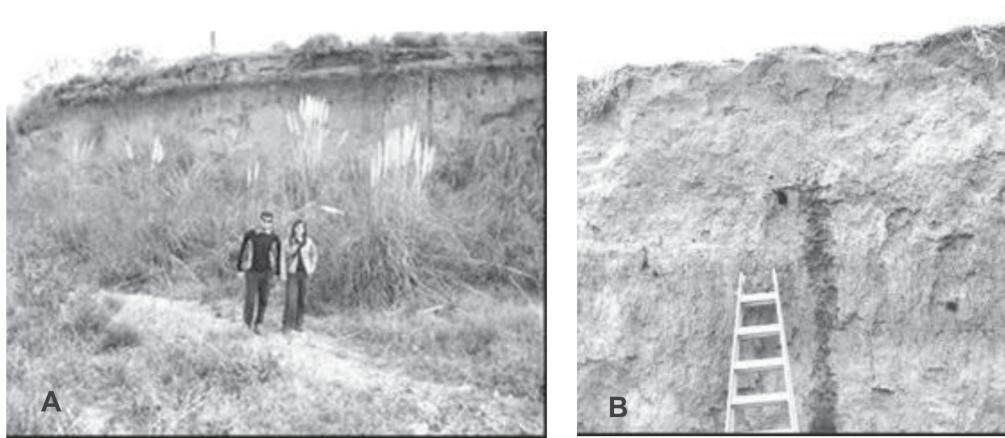


FIGURE 6. **A.** General view of Río Pinto Terrace. **B.** Details of the buried soil.

DISCUSSION

The first aspect to consider is whether these buried soils can be considered as paleosols or not.

To do that, the criteria of different authors must be analyzed: Duchaufour (1982) uses the term paleosol for soils that formed before the last cold period (Wurm) of the Pleistocene, whereas, Retallack (1990) maintains that Paleopedology is the study of ancient soils, and both he and Gerrard (1992) define paleosols as those that have developed under past conditions, regardless that they are buried within sedimentary sequences, or they persist under surface conditions that have already changed.

Catt (1990) says that there is no strict definition of paleosol likely to be universally accepted, but that anyway the term is widely used somehow informally without any problems as far as the involved soil has been completely buried before late Pleistocene. According to him, the difficulty arises when a definition including both recent soils presently at the surface and soils lying underneath young sediments is required.

This is precisely the situation to be discussed in this paper, and therefore the concepts of Catt (1986) that has questioned the use of the term paleosol become very significant. He wonders if “landscape of the past” should include all buried surfaces, even those that were buried very recently, such as those that were covered by last year slope slides material, or only surfaces that represent periods when the environmental conditions were sufficiently different as to produce detectable changes in the characteristics of the soil. If the first definition is accepted, the unburied equivalent could then be called relic paleosol, and all soils become paleosols.

Adhering to the second definition, where the distinction in age between young soils and paleosols

becomes diffuse and varies widely; and considering the evidences contributed by the presence of modern elements such as remaining bricks, glasses, concrete, etc, the soils to which we refer, were neither buried as a result of climatic changes, nor as a response to geomorphic modifications, and they should not be considered paleosols.

The second item to analyze is whether or not the buried soils that were studied here contribute the same kind of information as paleosols covered by the last loess (or Cordobense) from the late Pleistocene-Holocene do. The Corralito I profile is an example for such situation, and the answer seems to be negative, since the conditions of the buried soils formation are not different from those of exposed soils. Hence, their value as stratigraphic indicators within a profile is considerably smaller than that of stricto sensu paleosols.

Finally, it is extremely interesting to establish when the burying process took place or was started.

Considering antecedents and testimonies, two periods can be mentioned while analysing the processes of hydric erosion: the first one at the beginning of 20th century, when soils were used for agriculture and cattle breeding for the first time and both deforestation and hydric erosive processes still evolved rather slowly.

The second crisis took place in the 1970's, when soybean was introduced in the area. At the beginning, soil management consisted of preparing the soil for the sowing by the end of Spring, when the rainy season begins. Because of the tillage method that turned down the A horizon to bury the weeds, the soil was without any vegetation when the precipitations occurred and was very easily eroded. In addition to this, the regional loess is highly susceptible to the hydric erosion, because of its content in silt that can be as much as 70% in

average (Argüello et al., 1998). Geomorphology is also a factor that facilitates water runoff due to the characteristics of the slopes.

On the matter, the work of Apezteguía and Luque (1996) is illustrative, for they sequentially analyzed aerial photographies and satellite images of a sub basin belonging to Rafael García- Lozada system, and detected that the surface with pristine vegetation progressively decreased from 48% in 1962; to 32% in 1970; 27% in 1987 and finally 13% in 1994. Conversely, by 1994 agriculture occupies 87% of the study area.

Also Balbis et al. (1991) working in La Lagunilla stated that by 1962 the area without any agricultural

practices was about 78%, whereas in 1987 it had been reduced to 28%.

This situation started to change only when some conservation practices such as minimal or zero tillage were extensively applied, by the late 90's, but until then, a lot of material must have been accumulated on top of the superficial soil.

Therefore, it may be deduced that between the 1970's and the late 1990's, very intense burying processes took place, so that in profiles like that of Corralito, the sequence of paleosols, considering the term stricto sensu (s.s.) only begins at the second buried soil.

CONCLUSIONS

In the Plataforma Basculada Ondulada, the profiles that can be seen inside the gullies that developed on the drainage lines, include both paleosols s.s and buried soils that do not correspond to that definition, because they have been covered recently, when the environmental and climatic conditions were not different from the present ones.

On the slopes active soils are very commonly

buried, in places where the hydric flow is interrupted, for example next to the wire fences, and therefore the material in motion is deposited on modern surfaces.

Though these buried soils do not have the same importance as the paleosols s.s. they may be very meaningful as indicators of more recent anthropic activities and disturbances.

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*Manuscrito Recebido em: 1 de setembro de 2010
Revisado e Aceito em: 8 de outubro de 2010*