ACTA GEOLOGICA HISPANICA, v. 37 (2002), nº 1, p. 37-42

Root traces in fossil bones from the Huayquerian (Late Miocene) faunal assemblage of Telén, La Pampa, Argentina

C. I. MONTALVO (1)

(1) Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Uruguay 151, 6300 Santa Rosa, La Pampa, Argentina.
E-mail: cmontalvo@exactas.unlpam.edu.ar

ABSTRACT

One of the exposures of the Cerro Azul Formation in northern La Pampa (Argentina) has yielded a Huayquerian (Upper Miocene) faunal assemblage. The degree of bioerosion caused by roots on mandibles of *Paedotherium minor* (Mammalia, Notoungulata, Hegetotheriidae) was analyzed, in an attempt to throw light upon the events that affected the remains after deposition. According to the features observed on the specimens, two types of traces were identified. These were referred to the ethological categories Sphenoichnia and Corrosichnia. The first type is interpreted as the marks produced by rootlets growing on the skeletal element/sediment boundary after burial. These traces would indicate the development of a herbaceous cover on the soil where the remains were deposited and later buried and may be another feature helpful in the identification of these paleosols. The second type implies a surface dissolution of the hard substrate, which in this case is the fossil itself. The characteristics of the remains that show this kind of trace may suggest that root growth has affected them only in recent stages.

Keywords: Bioerosion. Paleosols. Root traces. Upper Miocene. La Pampa. Argentina.

RESUMEN

Uno de los afloramientos de la Formación Cerro Azul, ubicado en Telén, al norte de la provincia de La Pampa (Argentina), ha aportado fauna de vertebrados de edad Huayqueriense (Mioceno superior). Con la finalidad de conocer los acontecimientos que afectaron a los restos recuperados de esta asociación faunística después de su depósito, se analizó el grado de bioerosión producido por raíces. Se eligieron para este análisis los fragmentos mandibulares de *Paedotherium minor* (Mammalia, Notoungulata, Hegetotheriidae). Las características observadas en los materiales permitieron identificar dos tipos de trazas, que se atribuyeron a las categorías etológicas Sphenoichnia y Corrosichnia. El primer tipo de traza se interpreta como marcas de raicillas desarrolladas en la interfase elemento esquelético-sedimento después del enterramiento. Su presencia indicaría el desarrollo de una cobertura herbácea sobre el suelo mientras los restos fueron depositados. Constituye, además, otra evidencia que facilita la identificación de los paleosuelos presentes en este aflo-

ramiento. El segundo tipo de trazas está representado por marcas de mayor tamaño que las anteriores, con disolución superficial del sustrato que en este caso son los restos fósiles. Las características de los especímenes que presentan esta traza sugerirían que el desarrollo de raíces ha afectado los restos en etapas más recientes.

Palabras clave: Bioerosión. Paleosuelos.Trazas de raíces. Mioceno superior. La Pampa. Argentina.

INTRODUCTION

Telén is located in the northern part of La Pampa, Argentina (36º15'13"S; 65º30'41"W) (Fig. 1). Here, one of the outcrops of the Cerro Azul Formation (Linares et al., 1980) has yielded a Huayquerian (Upper Miocene) fauna. The faunal assemblage recovered from Telén is diverse and abundant, and the frequency of mammal remains smaller than 10 kg is very high. This assemblage includes mammals typical of open environments, such as grassland plain, though there are some taxa (e.g., Echimyidae rodents) that show anatomical features indicative of arid or semiarid climates (Montalvo et al., 1998).

The extent of the bioerosion on the remains of the assemblage from Telén was analyzed from taphonomical and paleoecological points of view, in an attempt to uncover the events that affected the remains once these had been buried. This paper deals with the analysis of the bioerosion caused by roots on mandibles of the most abundant mammal of this faunal assemblage, *Paedotherium minor* CABRERA, 1937 (Mammalia, Notoungulata, Hegetotheriidae).

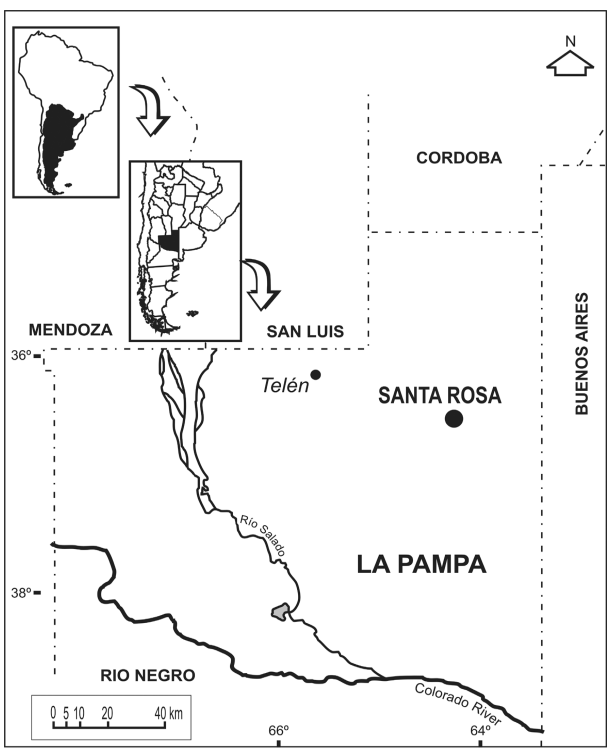

Figure 1. Geographic location of Telén, La Pampa, Argentina.

MATERIALS AND METHODS

The material dealt with in this paper comes from the two paleosol beds described in the section (Fig. 2) and is housed in the Vertebrate Paleontology Collection of the Facultad de Ciencias Exactas y Naturales, Universidad Nacional de La Pampa, Argentina. Representatives of the mammalian families present in this faunal assemblage were classified according to the body-size categories proposed by Vizcaíno and Fariña (1999), to facilitate the interpretation of the way in which different agents acted in the biostratinomic phase and in the early phases of fossil diagenesis. Degree of weathering was categorized following Alcalá Martínez (1994). Color of specimens was determined according to Goddard et al. (1948). Microphotographs of the specimens were made using a SEM Jeol 35CF and dispersive microanalysis with a EDAX ultra-fine window system.

STRATIGRAPHY

The vertebrate fossil assemblage is included in the Cerro Azul Formation (Linares et al., 1980), well represented in central-northern La Pampa. The sedimentological analysis performed by Melchor et al. (2000) suggested a typical continental environment, formed by loessic sediments, composed of clayed siltstones and fine sandstones, in which two successive levels of paleosols were distinguished and described as calcic vertisols. Pedogenetic changes are diffuse in the profile and are represented by pedogenetic slickensides, clastic dikes with random orientation and pervasive (although not uniform) carbonatic cementation, evidenced by concretions and small nodules. Fossils occur throughout the section at Telén, both in the siltstone and the calcareous concretions (Fig. 2). Semi-arid conditions and seasonal climate during the soil formation were inferred.

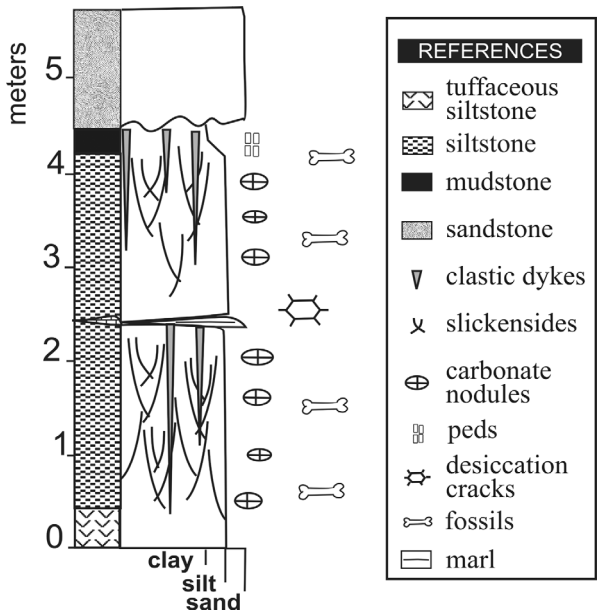

Figure 2. Stratigraphic section of the Cerro Azul Formation, Telén.

RESULTS

A total of 8,492 specimens were recovered from the outcrops of the Cerro Azul Formation at Telén. In the fossil assemblage recovered, most skeletal elements were disarticulated, dispersed, randomly orientated and some are fragmentary and unidentifiable (51.94%). From their size and characteristics, it may be inferred that many of them resulted from intense weathering on skeletons of large body-size specimens. Because of preservation, only 38.39% of the total number of specimens was used in the drawing of the taxonomic list. Fourteen mammal families typical from the South American Upper Miocene were identified: Didelphidae, Sparassocynidae (Marsupialia), Dasypodidae, Glyptodontidae (Xenarthra), Abrocomidae, Echimyidae, Octodontidae, Chinchillidae, Caviidae, Dinomyidae (Rodentia), Procyonidae (Carnivora), Macraucheniidae (Litopterna), Mesotheriidae and Hegetotheriidae (Notoungulata). Finally, 9.67% of the remains could only be identified anatomically; they belong mostly to micromammal postcranials (Fig. 3).

The analysis of the taphonomic features of the specimens allowed for the distinction of different types of preservation that were related to the body size estimated for each taxon (Vizcaíno and Fariña, 1999). Those elements belonging to large sized individuals (category 3, between 10 and 100 kg, and 4, more than 100 kg) generally show high weathering with superficial flaking, longitudinal grooves, fractures and crackling. Most of them may be considered as corresponding to weathering stage 2 (Alcalá Martínez, 1994). This character suggests a long time of exposure to atmospheric agents (Behrensmeyer, 1978). On the other hand, the elements from small to middle sized mammals (less than 10 kg), that show a better preservation state, would have had brief exposure time and fast burial (Montalvo, 1999). In this last group we include the elements assigned to *Paedotherium minor*, whose estimated body mass is less than 10 kg (Vizcaíno and Fariña, 1999). Four hundred and ninety (490) specimens have been referred to this taxon, 262 of them are mandibles on which the degree of bioerosion was analyzed. Mandibles were selected because they are very abundant in this locality and have a relatively large exposure surface (Fig. 4), facilitating the identification of the traces. Similar features have been observed in different skeletal elements of this and other taxa of the faunal assemblage of Telén.

The color of these fossils, according the color table of Goddard et al. (1948), ranges from light brown (5 YR 6/4) or white (N9) to middle (N5) and very dark gray (N3). This gradation is related to gradual dendritical impregnation of manganese sesquioxides. Impregnation may affect one or both mandibular faces and is considered a diagenetic character. Oxides would have moved by micromigrations in small amounts from the soil, staining and progressively impregnating the buried bones.

Many mandibles show bioerosive signals attributed to rootlets on the surface. According to the features observed on the specimens, the activity of the roots on the mandibles resulted in two different ways, related to the moment of the action.

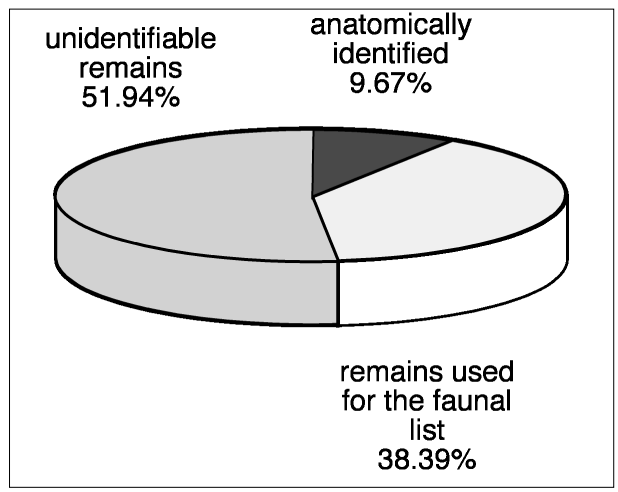

Figure 3. Percentage frequencies of major groups of specimens.

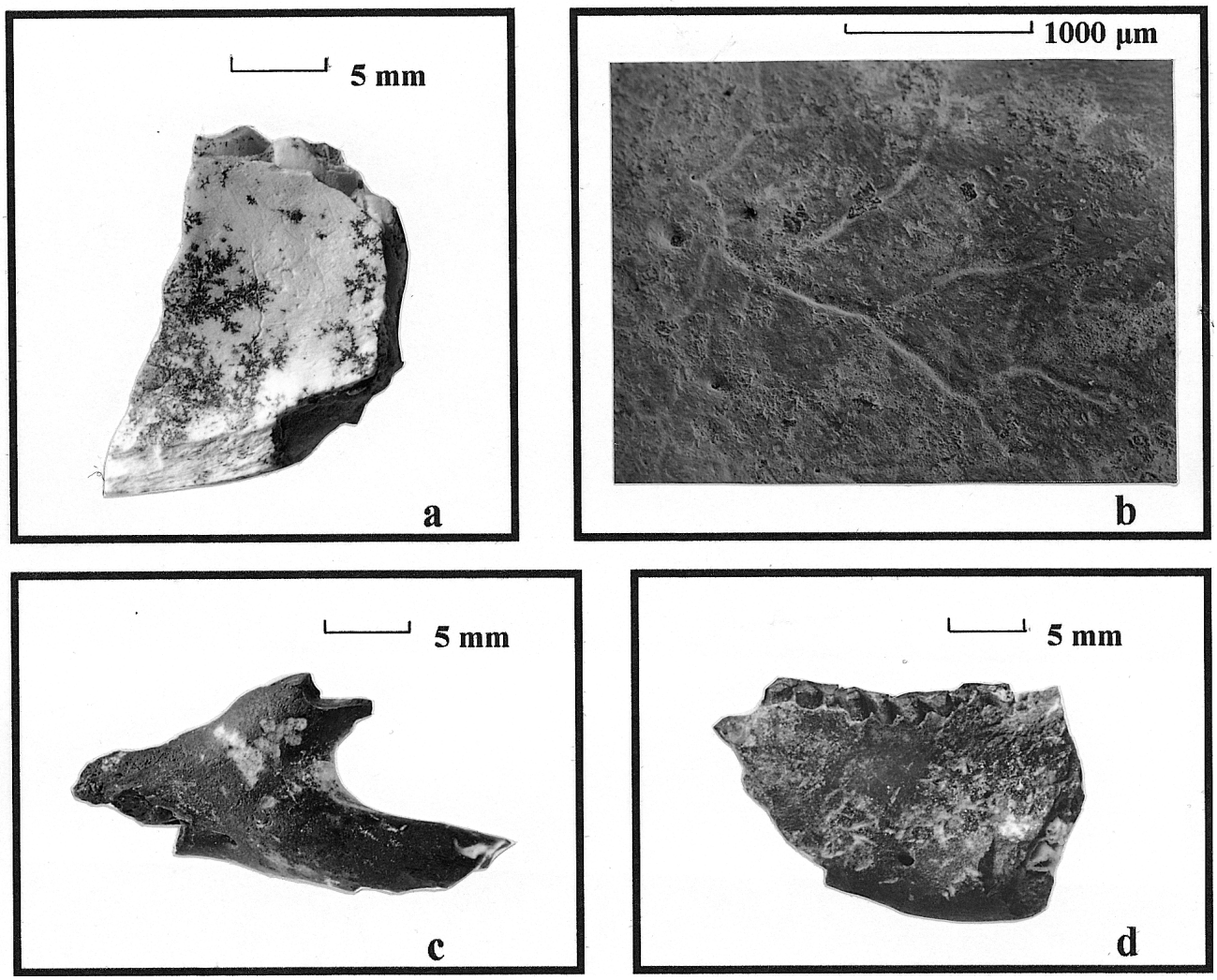

Figure 4. (a) Mandible of *Paedotherium minor* with Sphenoichnia category root trace; (b) SEM micrograph showing Sphenoichnia category root trace; (c,d) Mandibles of *Paedotherium minor* with Corrosichnia category root trace with later impregnation of manganese sesquioxides.

A first type of bioerosive trace belongs to small, superficial, irregular dendrite marks, forming "U" shaped channels with neat margins on the surface, with main and bifurcated branches, usually 0,15 to 1 mm wide (Fig. 4 a, b). These marks are generally similar to those described as produced by roots on modern and fossil skeletal remains (Andrews, 1990; Lyman, 1994). Mikulás (1999 a) classified the biogenic structures generated by plants in ethological categories. According to these categories, the described type of trace would belong to Sphenoichnia. In this case, traces are interpreted as the marks produced on the fossil by rootlets developing on the skeletal element/sediment boundary after burial. These traces are seen in remains not very impregnated with manganese sesquioxides as well as in those darker ones. Traces belonging to Sphenoichnia are observed in remains recovered from different levels of the sequence of the Cerro Azul Formation in Telén.

The second type of trace is also observed on dark remains, more impregnated with manganese sesquioxides as well as on those lighter, less impregnated ones. These traces are generally larger than those described previously, more than 1.5 mm wide, almost without bifurcation, with very irregular surface and contours, showing a high corrosion degree (Fig. 4 c, d). In many specimens, these traces are associated with other small and subcircular ones. In the case of the more impregnated remains, the corroded external surface may be affected by a change of color, being white in many sectors, and "U" shaped only

in some areas. The comparison of the percentage in weight of manganese obtained with x-ray analysis (SEM-EDAX) indicated very low values of manganese in the most corroded area respect to the values in areas not affected by the trace, which would suggest a posterior loss of this element. This type of trace is regarded within the ethological category of Corrosichnia, as it implies a surface dissolution of the hard substrate, which in this case is the fossil remain. On a few specimens this kind of traces is overimposed to the Sphenoichnia. Fossils with this type of traces were also found along the whole section.

DISCUSSION AND CONCLUSIONS

Bioerosion degree may render information about the microenvironment in which the specimen was deposited, but the presence of several specimens with similar features supply information about the conditions of the burial and also of the first fossil diagenetic alterations. In this case, the analysis of the traces attributed to Sphenoichnia category on fossil bones shows that small rootlet marks on them are abundant and may have been produced during the soil formation period. This would indicate the development of a herbaceous cover on the soil where the remains were deposited and later buried. These data agree with those supplied by the analysis of the mammals of the faunal assemblage, since the taxa adapted to grasslands environments are abundant (i.e., species with high hipsodonty degree). The record of well preserved remains bearing Sphenoichnia traces suggests, on the other hand, that those from small and middle-sized mammals were buried more quickly than those from mammals of more than 10 kg. In the outcrop at Telén, sedimentological data suggest that the action of pedogenetical processes and the presence of this kind of trace may be another feature to identify these paleosols.

The second type of traces, belonging in the Corrosichnia category, is interpreted as resulting from root activity in recent times, perhaps even after the impregnation of specimens with manganese sesquioxide. These traces are similar to those described by Retallack (1983, 1990, 1997) and Mikulás (1999 b) as drab haloed root traces. The possible mechanism to explain the origin of these traces was, among other hypotheses (Retallack, 1983, 1990), the activity of anaerobic bacteria around roots that would build a microenvironment causing chemical dissolution of the substrate, in this case, fossil bones. This activity in the materials from Telén is even more evident in those remains more affected by the gradual impregnation by sesquioxides. As this impregnation is considered a taphonomical feature resulting from more recent weathering, the corrosion produced in these fossils may be a good indicator that they have been produced during recent times. Besides, as pointed out by Mikulás (1999 b), the formation age of traces of this kind is directly related to the position of the bearing levels respect of the present-day terrane surface. At the outcrop at Telén, these levels are parallel to the present-day topography and do not reach deeper than 5 m, a fact that would also support their recent formation.

ACKNOWLEDGEMENTS

We thank S. Casadío, R. Melchor, and G. Visconti for the critical review of the manuscript and C. Deschamps and M. Griffin for the translation. We also thank anonymous reviewers. This paper was partially supported by Facultad de Ciencias Exactas y Naturales (UNLPam).

REFERENCES

Alcalá Martínez, L., 1994. Macromamíferos neógenos de la fosa de Alfambra-Teruel. Madrid, Museo Nacional de Ciencias Naturales, 554 pp.

Andrews, P., 1990. Owls, caves and fossils. Predation, preservation, and accumulation of small Mammal bones in caves, with the analysis of the Pleistocene cave faunas from Westbury-sub-Mendip, Somerset, UK. The University of Chicago Press, 231 pp.

Behrensmeyer, A., 1978. Taphonomic and ecological information from bone weathering. Paleobiology, 4, 150-162.

Goddard, E.N., Trask, P.D., De Ford, R.K., Rove, O.N., Singewald, J.T. , Overbeck, R.M., 1948. Rock Color Chart. Geological Society of America.

Linares, E., Llambías, E., Latorre, C., 1980. Geología de la provincia de La Pampa, República Argentina y geocronología de sus rocas metamórficas y eruptivas. Revista Asociación Geológica Argentina, 35(1), 87-146.

Lyman, R.L., 1994. Vertebrate Taphonomy. Cambridge Manuals in Archaeology. Cambridge University Press, 524 pp.

Melchor, R., Visconti, G., Montalvo, C.I., 2000. Late Miocene calcic vertisols from central La Pampa, Argentina. II Congreso Latinoamericano de Sedimentología y VIII Reunión Argentina de Sedimentología, 119-120.

Mikulás, R., 1999 a. Notes to the concept of plant trace fossils related to plant-generated sedimentary structures. Bulletin of the Czech Geological Survey, 74 (1), 39-42.

Mikulás, R., 1999 b. Fossil corrosive root traces on rock surfaces and bioclasts (Bohemian Cretaceous Basin, Czech Republic). Bulletin of the Czech Geological Survey, 74 (3), 289-292

Montalvo, C.I., 1999. Identicación de dos grupos tafonómicos en

la asociación faunística del Mioceno superior en Telén, La Pampa, Argentina. VII Jornadas Pampeanas de Ciencias Naturales, 51.

Montalvo, C.I., Verzi, D.H., Vucetich, M.G., Visconti, G., 1998. Nuevos Eumysopinae (Rodentia, Echimyidae) de la Formación Cerro Azul (Mioceno tardío) de La Pampa, Argentina. Quintas Jornadas Geológicas y Geofísicas Bonaerenses, I, 57-64.

Retallack, G. J., 1983. Late Eocene and Oligocene paleosols from Badlands National Park, south Dakota. Geological Society of America. Special Paper 193, 82 pp.

Retallack, G. J., 1990. Soils of the past. An introduction to paleopedology. Unwin Hyman, Boston, 520 pp.

Retallack, G. J., 1997. A colour guide to paleosols. J. Wyley & Sons, 175 p.

Vizcaíno, S.F., Fariña, R.A., 1999. On the flight capabilities and distribution of the giant Miocene bird *Argentavis magnificens* (Teratornithidae). Lethaia, 32, 271-278.