UNDER THE CITY: MIOCENE RODENTS FROM CORE SAMPLES OF THE SUBSOIL OF BARCELONA

BAJO LA CIUDAD: ROEDORES MIOCENOS DE MUESTRAS DE SONDEOS DEL SUBSUELO DE BARCELONA

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ABSTRACT

Ongoing civil engineering works in the city of Barcelona have allowed getting new data on the stratigraphy of the Pla de Barcelona minor graben. The tectonic evolution of this small basin is divided in a Palaeogene compression phase and a Neogene extensional one. Even though sedimentation already occurred during the compression stage, the bulk of sediments was deposited during the extensional one. The study of several geological cores has shown that the earliest layers deposited during this extensional phase correspond to alluvial fan sediments that were provisionally referred to the early Miocene (Mi-1a unit). The study of the rodent remains recovered from these samples allows refining the dating and assign an age of 17 to 14.5 Ma to this lithostratigraphic unit.

Keywords: Rodentia, Gliridae, Cricetodontidae, micromammals, biostratigraphy, early Miocene, Aragonian, Pla de Barcelona minor graben.

RESUMEN

Las obras de ingeniería civil actualmente en curso en la ciudad de Barcelona han permitido obtener nuevos datos referentes a la estratigrafía del graben menor del Pla de Barcelona. La evolución tectónica de esta pequeña cuenca se divide en una fase de compresión paleógena y una de extensión neógena. Aunque la sedimentación ya se inició durante la etapa compresiva, el grueso de los sedimentos fue depositado durante la etapa extensiva. El estudio de numerosos sondeos geológicos ha mostrado que las capas más antiguas depositadas durante esta fase extensional corresponden a sedimentos de abanico aluvial que fueron datados de manera provisional como Mioceno Inferior (unidad Mi-1a). El estudio de los restos de roedores recuperados en dichas muestras permite precisar esta datación y asignar una edad de 17 a 14.5 Ma a esta unidad litoestratigráfica.

Palabras clave: Rodentia, Gliridae, Cricetodontidae, micromamíferos, biostratigrafía, Mioceno inferior, Aragoniense, graben menor del Pla de Barcelona.

1. INTRODUCTION

The Neogene rift in the Catalan Coastal Ranges, located in the NE of the Iberian Peninsula, corresponds to a system of grabens along the north-western margin of the Valencia Trough (Roca *et al.,* 1999). These grabens are defined by longitudinal, near vertical basement faults which are parallel to the coastline. The evolution of the Catalan Coastal Ranges during the Cenozoic is divided into two phases: a Palaeogene compression stage and a Neogene extension (Fontboté *et al.,* 1990; Roca, 1996; Roca *et al.,* 1999; Cabrera *et al.,* 2004). During the Palaeogene compressive stresses related to the Alpine orogeny resulted in the inversion of the main faults that bounded the former Mesozoic basins (including the Vallès-Penedès and Barcelona faults) (Gaspar Escribano *et al.,* 2004). The

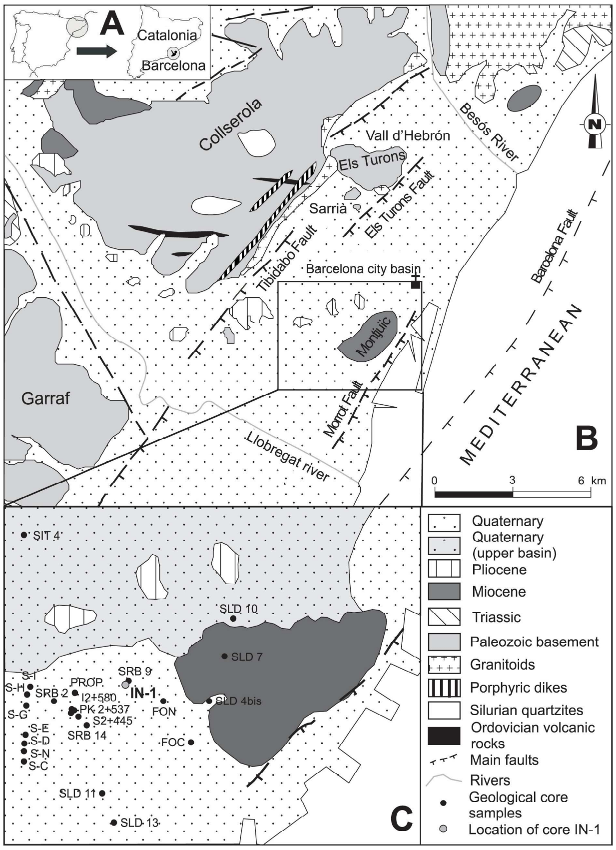

Figure 1. Geographical and geological context of the study area. A) Situation of the Barcelona Plain minor graben. B) Geological map showing the main geological units and tectonic structures of the basin. C) Location of the geological core samples. Core sample IN-1 has provided the rodent sample studied in this work.

extensional phase began during the Oligocene and was related to the opening of the Valencia Trough. Whereas large parts of the Catalan Coastal Ranges were uplifted, the extensional activation of the Barcelona and Vallès-Penedès faults resulted in the development of subsiding half-grabens in the Catalan margin which were filled by Oligocene and Neogene sediments (Roca *et al.,* 1999; Cabrera *et al.,* 2004).

The Barcelona half-graben is up to 60 km long and 16 km wide and its NW margin is defined by a major listric fault, the Barcelona fault. The trace of the Barcelona fault follows the coastline but is situated a few kilometres offshore, so this half-graben is entirely covered by the sea. The Plain of Barcelona minor graben is a transition zone between the Barcelona half-graben (to the SE) and the Garraf-Montnegre horst (to the NW; see Fig. 1B). This minor graben is affected by different faults that delimit minor basins (Sarrià, Vall d'Hebrón, Barcelona city) and highs (Els Turons, Montjuïc) (Llopis, 1942; Gómez-Gras *et al.,* 2001, Parcerisa *et al.,* 2008). The Barcelona city depression is the largest of these basins and is filled by sedimentary successions up to 300 m thick (Gómez-Gras *et al.,* 2001). Unfortunately, the city of Barcelona covers great part of this depression and the few outcrops are defined by Quaternary sediments related to the evolution of the Llobregat Delta. Accordingly, major civil engineering works provide a unique opportunity to study the geology and stratigraphy of this unit. Thanks to such works several geological cores have been extracted and studied, providing details on the stratigraphy of the Barcelona Plain minor graben (Parcerisa *et al.,* 2008).

The basement of the basin is defined by Palaeozoic and Mesozoic (Triassic, Buntsandstein) rocks which are overlain by red or ochre breccias, sands and mudstones (units Mi-1a for the red lithologies and Mi-1b for the ochre ones; after Parcerisa *et al.,* 2008). These deposits are interpreted as alluvial fan facies and, even though fossils were not found they are provisionally assigned to the Early Miocene by comparison with similar facies from the Vallès-Penedès Basin. Brown to ochre and whitish sands and silts which have delivered some fossil foraminifera lay conformably over this unit (unit Mi-2 of Parcerisa *et al.,* 2008). According to the fossil content this unit can be correlated to the Middle Miocene, Langhian (zones N9-N10 of Blow, 1969). Disconformably above the Miocene units we find Middle Pliocene marine sediments. Finally continental Quaternary sediments separated from the other units by an erosive contact, cover all the succession (Parcerisa *et al.,* 2008).

A few cores including some mudstones that belong to the Mi-1a unit (SRB-1, IN-1, FON) were washed in order to recover some fossil micromammals that may refine the dating of these layers (see Fig. 1C). The results were mostly negative, but one core (IN-1) provided a very scarce sample of rodent teeth including three complete cheek teeth, two molar fragments and one fragment of a rodent incisor. The rodent sample comes from three different layers: PAR1, PAR2 and PAR3. Here we describe this material and we also provide further data on the age of this unit.

2. MATERIAL AND METHODS

The material described in this paper is housed at the Institut Català de Paleontologia in Sabadell, Barcelona (abbreviated with the acronym IPS preceding the collection number). The classification of rodents follows McKenna and Bell (1997) as modified in Casanovas-Vilar (2007). Dental nomenclature and measurements follow Daams (1981) for the Gliridae and Mein and Freudenthal (1971) and Daams and Freudenthal, (1988) for the Cricetodontidae. Estimated measurements (due to minor damage or distortion) are given within parentheses. The measurements were taken using a 'Leica MZ16' stereomicroscope with a 'Leica IC 3D' digital camera. Specimens were drawn using a light camera mounted on a 'Leica MZ6' stereomicroscope.

3. SYSTEMATIC PALAEONTOLOGY

Order Rodentia Bowdich 1821

Rodentia indet.

Material: one fragment of left lower incisor from PAR2.

Description: The fragment corresponds to the tip of the incisor. The wear facet is very short and straight. The

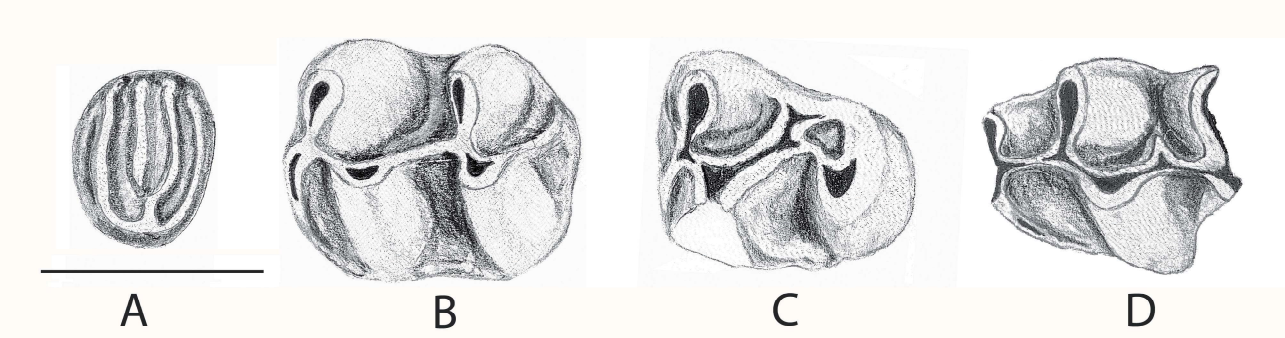

Figure 2. Rodents recovered in the geological core IN-1. All teeth are figured as if they were left ones. A). *Muscardinus* sp., left P4 from PAR1. PAR1-1. B) *Democricetodon* sp., right m2 from PAR3 (reversed). PAR3-2 C) *Democricetodon* sp., right m3 from PAR1 (reversed). PAR1-2. Note the broken lingual wall of the protoconid. D) *Megacricetodon* sp., right m1 from PAR3 (reversed). PAR3-1. Scale bar = 1 mm.

enamel of the anterior side of the incisor does not show any kind of ornamentation or grooves.

Family Gliridae Muirhead 1819

Genus *Muscardinus* Kaup 1829

Muscardinus sp.

Material: one left P4 from PAR1 (Fig. 2A).

Measurements (length x breadth): 0.60 x 0.73 mm

Description: The tooth is rounded, slightly wider than long. The crown is low and the wear surface completely flat. There are four transverse ridges (anteroloph, protoloph, metaloph and posteroloph) perpendicular to the antero-posterior axis of the tooth that merge into a short endoloph. All these ridges end in a tiny cusp in their labial side. The prolotoph and the metaloph join into a short ridge before merging the endoloph. There is a small platform in the anterior edge of the tooth, just in front of the anteroloph.

Remarks: The low crown, flat wear surface and the orientation of the main ridges clearly allow ascribing the material to *Muscardinus*. The specimen fits within the size and morphological range of *M. thaleri*, *M. sansaniensis* and *M. hispanicus*. The oldest record of this dormouse genus in the Iberian Peninsula is MN4 in the Vallès-Penedès Basin (Els Cassots; Agustí and Llenas, 1993) and MN5 in the Calatayud-Daroca Basin (Daams, 1985).

Family Cricetodontidae Schaub 1925

Genus *Democricetodon* Fahlbusch 1964

Democricetodon sp.

Material: one right m2 from PAR3 (Fig. 2B) and one right m3 from PAR1 (Fig. 2C).

Measurements (length x breadth): m2: 1.30 x 1.02 mm; m3: 1.07 x (0.90) mm

Description: The m2 does not have an anterosinusid though a vestigial lingual anterolophid is present. The protosinusid is closed by the labial anterolophid which is quite low but joins the base of the protoconid. The metaconid joins the anterolophid by means of a very short metalophulid. The sinusid is wide, transverse and closed by a low cingulid. The mesolophid is lacking. The mesosinusid is open. The entoconid joins the longitudinal ridge just in front of the hypoconid. The posterolophid is long and becomes progressively lower until reaching the posterior wall of the entoconid thus closing the posterosinusid.

The m3 is triangular. Part of the wall of the protoconid is broken. The anterior valleys are highly reduced and are closed by the two arms of the anterolophid. The metaconid joins the anterolophulid by means of a very short metalophulid. The sinusid is transverse. This valley is wide and so large that it forces the longitudinal ridge to bend. The sinusid is closed by a low cingulid. The entoconid is highly reduced and becomes part of a continuous ridge that departs from the hypocone and joins the posterior wall of the metaconid, thus closing all the lingual valleys. The hypolophulid is long and placed very anteriorly.

Remarks: The m2 and m3 show a similar morphology and width. This would indicate that both elements belong to the same species. On the basis of its size and morphology we assign the material to *Democricetodon*. The wider valleys, different shape of the m3 and slightly larger size clearly preclude the ascription of these molars to the other cricetodontid genus present in the samples: *Megacricetodon*. The molars fit within the size range of several small-sized *Democricetodon* species, including *D. franconicus* and *D. hispanicus* (see Freudenthal and Daams, 1988; Van der Meulen *et al.,* 2003). These species almost invariably have mesolophids which tend to be long. On the contrary, this ridge is missing in our material. The genus *Democricetodon* first occurs in Western Europe by the latest Early Miocene (MN4; Agustí *et al.,* 2001).

Genus *Megacricetodon* Fahlbusch, 1964

Megacricetodon sp.

Material: one fragment of a right m1 from PAR3 (Fig. 2D).

Measurements (length x breadth): - x (0.92) mm

Description: The posterior end of the molar is broken and the anteroconid is also damaged. The preserved part of the anteroconid shows that this cusp is subdivided into two lobes. The anterolophulid joins the anteroconid in its middle part. Two long though low anterolophids depart from each cusp of the anteroconid and close the anterior valleys. The sinusid is transverse and closed by a low cingulid. There is a short mesolophid that is placed quite anteriorly. The end of this ridge bends lingually and joins the base of the metaconid. The mesosinusid is open.

Remarks: The m1 is clearly more elongated than the same molar in *Democricetodon*. Furthermore the central valleys are narrower than in that genus allowing the ascription of the material to *Megacricetodon*. Because of its size this molar must belong to a small-sized *Megacricetodon* species, such as *M. minor* (see Daams and Freudenthal, 1988). The genus *Megacricetodon* first appears in Western Europe at the same time as *Democricetodon* (MN4, Early Miocene; Agustí *et al.,* 2003).

Cricetodontidae indet.

Material: fragment of a left M1 or M2 from PAR2.

Measurements (length x breadth): - x (1.31) mm

Description: Only the posterior part of the molar can be described. The posteroloph is long and joins the base of the metacone thus closing the posterosinus.

Remarks: According to its width this molar does not seem to fit with the cricetodontid material from PAR1 and PAR3 and would indicate the presence of a third cricetodontid species in PAR2.

4. BIOSTRATIGRAPHICAL IMPLICATIONS

The rodent fauna recovered from the core IN-1 does not provide many details on the age of the Mi-1a unit. The cricetodontid genera *Democricetodon* and *Megacricetodon* first appear in Western Europe by the latest Early Miocene (MN4; see Kälin, 1997, Daams *et al.,* 1999 or Agustí *et al.,* 2003) and by the same time the dormice of the genus *Muscardinus* are also recorded for the first time. Accordingly we can rule out ages older than MN4. Nevertheless, all these genera have very long stratigraphical ranges, *Megacricetodon* and *Democricetodon* going extinct by the Late Vallesian (Agustí and Moyà-Solà, 1990) and *Muscardinus* being represented nowadays by the hazel dormouse *M. avellanarius*.

Nevertheless, it is possible to constrain the age of Mi-1a when the age of the following unit (Mi-2) is taken into account. The foraminifera recovered from the whitish sands and silts of Mi-2 indicate an N9-N10 age (Parcerisa *et al.,* 2008) according to the zones of Blow (1969). These zones were formerly included within the Serravallian, but recent reviews (see Ogg *et al.,* 2008) place them within the Langhian. The lower boundary of the N9 zone is close to 14.5 Ma (after Ogg *et al.,* 2008). Taking this into account and considering that the base of MN4 in Western Europe is said to be around 17-16.6 Ma (according to Agustí *et al.,* 2001) the age of the studied materials must range from 17 to 14.5 Ma, that is Late Burdigalian.

5. CONCLUSIONS

On the basis of the limited rodent sample from core IN-1 and the constraint provided by the Langhian (N9-N10 zones) age of the silts of the Mi-2 unit is possible to constrain the age of the Mi-1a unit between 17 to 14.5 Ma, that is Early Miocene as previously hypothesized by Parcerisa et al. (2008). The sedimentary infilling of the Barcelona city depression within the Barcelona Plain minor graben therefore started during the Early Miocene (Burdigalian). The sedimentation is known to have started earlier, by the Chattian (Late Oligocene), in other areas of the Barcelona Plain minor graben located close to the NE margin (Turó de Montgat; Parcerisa *et al.,* 2004). The sedimentation in that part of the basin occurred during the compressive phase, while the layers from the Mi-1a unit were deposited during the extensive phase. All the available evidence places the transition from a compressive to an extensional regime took place during the Chattian-Early Aquitanian (Parcerisa *et al.,* 2004) but for the moment the oldest layers deposited within the extensional phase in the Barcelona Plain minor graben are dated as Late Burdigalian.

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