



Rivers as repositories for fossil vertebrates: a case study from the Upper Cretaceous of southern France



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ABSTRACT

An accumulation of vertebrate remains in Late Cretaceous continental deposits at Cruzy (Hérault, south-western France) is studied, using sedimentological (clay mineralogy, granulometry, cathodoluminescence) and taphonomic approaches, in order to reconstruct the depositional environment under which it was formed. The fossil-bearing conglomerates, sands and clays were apparently deposited during brief flood episodes affecting a braided river system, under a “tropical” type of climate with alternating dry and wet seasons. This type of depositional environment shows close similarities with those reconstructed for Late Cretaceous vertebrate sites in Romania.

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1. Introduction

With a few exceptions (e.g. aeolian deposits), most accumulations of fossil terrestrial vertebrates occur in water-lain sediments. Although remains of land vertebrates not uncommonly occur in marine rocks (Buffetaut, 1994), they are mainly found in lacustrine or fluvial deposits. The type of preservation of the fossils can be very different depending on the taphonomic processes the animal remains have undergone during and after burial (Weigelt, 1927). While *Lagerstätten* with exceptional preservation tend to attract considerable attention and to be the subject of complete studies aiming at detailed reconstructions of fossilisation processes (e.g. Selden and Nudds, 2004 and references therein), more usual kinds of fossil localities, where specimens may be very abundant but do not show exceptional types of preservation, receive less attention. The way they are formed is not often investigated in any detail. In the present paper, we investigate the formation of a Late Cretaceous vertebrate locality in a river environment in southern France, using sedimentological and taphonomic approaches.

2. Geographical and geological setting

The Masecaps fossil locality, discovered in 1996, is located in an abandoned vineyard about 1 km NE of the village of Cruzy, in the Hérault department, about 30 km W of the city of Béziers in SW France (Fig. 1). It has been excavated over a period of more than ten years by the “Association Culturelle, Archéologique et Paléontologique de l'Ouest Biterrois (ACAP)” and the “Centre National de la Recherche Scientifique”. As a result, more than 5000 specimens of fossil vertebrates, mostly consisting of isolated bones, have been discovered in the non-marine sediments of the site.

Localities with a faunal content similar to that of Masecaps have been known in the western part of Hérault since the end of the 19th century (Buffetaut, 2005 and references therein). Although the Campanian-Maastrichtian age of the continental succession in that part of southern France is not in doubt (see Freydet, 1971, for a review of these formations), the exact geological age of the vertebrate-bearing rocks is not easy to establish: no marine intercalations are present, there are few stratigraphically useful fossils and no opportunities for radiometric dating. According to the explanations of the 1/50 000 geological map of the area (Map 1039 N Béziers, Berger et al., 1982), the Late Cretaceous vertebrate-bearing fluvial series near Cruzy can be referred to the Campanian. On the basis of fossil eggshells, Garcia and Valentin (2001–2002) referred it to the early Maastrichtian.

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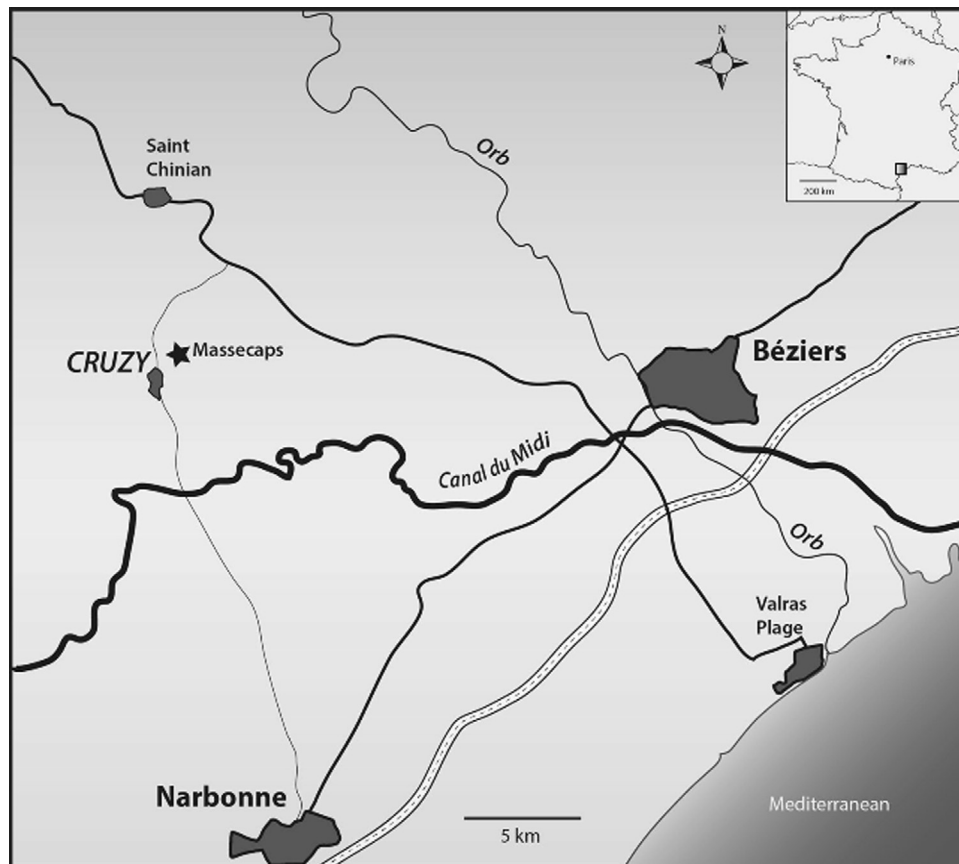


Fig. 1. Location map showing the position of the Masecaps locality, near the village of Cruzy (after Martin et al., 2014).

The general composition of the vertebrate assemblage, where the dinosaur *Rhabdodon* is abundant and hadrosaurs are not present, indicates a faunal complex that, in southern France, corresponds to the late Campanian – early Maastrichtian interval (Buffetaut et al., 1997).

3. Material and methods

The stratigraphic section at Masecaps was studied during excavation campaigns, which provided easy access to fresh exposures. To complement the observations made at the locality, additional sections were studied at outcrops a relatively short distance from Masecaps (Fontanche, Plo (or Plat) de Saint-Pons).

Besides facies analysis in the field, the techniques employed in the study of the Masecaps sediments and fossils include:

- Clay mineralogy, using the analytical methods described by Holtzapffel (1985) and Moore and Reynolds (1997). Clay mineral assemblages were identified by X-ray diffraction (XRD) on oriented mounts of non-calcareous clay sized particles ($<2 \mu\text{m}$). Diffractograms were obtained using a Bruker D4 Endeavor diffractometer with $\text{CuK}\alpha$ radiations. LynxEye detector and Ni filter, under 40 kV voltage and 25 mA intensity. Three preparations were analysed, the first was performed after air-drying, the second after ethylene-glycol solvation and the third after heating at 490 °C for 2 h. The goniometer scanned from 2.5° to 28.5° for each run. Clay minerals were identified by the position of their main diffraction peaks on the three XRD runs, while semi-quantitative estimates were produced in relation to their area (Moore and Reynolds, 1997).
- Grain-size analyses (by sieving).

- Optical microscopy and cathodoluminescence, mainly on thin sections of fossil bones, as well as microconglomerates and sandstones. Cathodoluminescence observations were completed using a 8200MKII Technosyn (20 kV–600 mA) coupled with an Olympus microscope and a digital MRC5 camera in order to reconstruct cement stratigraphy within the rock and fossil bones. This has been applied to thin sections in fossil bones.

4. Sedimentary facies and stratigraphy

Three main facies are observed in the Masecaps section (Fig. 2).

- *Microconglomerates*. These are composed of millimetric, grain-supported lime nodules, cemented by sparite. Iron-rich nodules also occur with numerous vertebrate remains. The microconglomerates have a blackish colour and form lenses which can be several tens of centimetres in thickness.
- *Variogated clays*. These correspond to silty and micaceous clays. Lime nodules are present throughout the thickness of the clays. Bioturbation also occurs in the form of vertical cylindrical clay-filled burrows. Coal fragments are present, too, as well as a few fossils of bivalves (Unionidae?), but the most abundant fossils in the clays are vertebrate remains.
- *Sandy layer*. This is a homogenous brownish level consisting of silts and fine sands. Its thickness is about 1 m. It contains a few vertebrate remains, but they are far less abundant than in the clayey layers.

Clays directly overlie the microconglomeratic level at the base of the section. The sandy layer overlies the clays and fills a depression within them. Blocks of red sandstone, about 70 cm in

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