THE PURBECKIAN SITE OF CHERVES-DE-COGNAC (BERRIASIAN, EARLY CRETACEOUS, SOUTHWEST FRANCE): A CONTINENTAL ECOSYSTEM ACCUMULATED IN AN EVAPORITIC LITTORAL DEPOSITIONAL ENVIRONMENT

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INTRODUCTION

ALTHOUGH REPORTED as early as the middle of the 19th Century (Coquand 1858), and noted on the basis of occasional later discoveries (Buffetaut *et al.* 1989; Hervat and Hervat 1993; Le Loeuff *et al.* 1996), the fossiliferous Purbeckian site of Cherves-de-Cognac was not exploited scientifically prior to 2001, at which time we began preliminary prospecting work. Our team undertook its first excavation in 2002, and this has been followed by extensive annual fieldwork that is planned to continue until 2008. More than thirty European specialists collaborate in this study. Its aim is to reconstruct the evolution of what appears to be a continental ecosystem that evolved through time in response to variable environmental conditions.

Institutional abbreviation: CHE – Cherves-de-Cognac Collection, Musée d'Angoulême.

GEOLOGICAL SETTING

The area of Cognac is located on the northern margin of the Aquitanian Basin (southwest France) (Figure 1A), where the Late Tithonian regression led to the development of margino-littoral and lagoonal environments that are classically referred to as Purbeckian facies. To the north of Cognac, these evaporitic and marly levels are not naturally exposed and constitute the substratum of the so-called "Bas Pays Charentais". These levels are only exposed in a huge gypsum quarry located at Champblanc, near the village of Cherves-de-Cognac. A series of 81 successive levels is exposed, with alternating evaporite, clay, marl and limestone layers (Figure 1A, B, C). Dating on the basis of ostracods, charophytes and dinoflagellates gives a lower to middle Berriasian age, making Cherves equivalent to part of the English Purbeck Limestone Group (Colin *et al.* 2004; El Albani *et al.* 2004).

MATERIAL AND METHODS

Each of the 81 levels has been sampled in order to look for microfossils and microremains. Sediment samples collected for the study of microremains have been weighed in order to provide a quantitative study of the biodiversity (see Pouech *et al.* this volume). Excavations have also been carried out in the fossiliferous layers.

RESULTS

The first sedimentological studies demonstrate a progression from a hypersaline lagoon at the bottom of the series to continental freshwater lacustrine environments in the uppermost levels (Figure 1B). The bottom of the series (Unit 1) corresponds to the evaporitic stage, with deposition of intercalated gypsum and clay levels. The upper part of the series (Unit 2) consists of intercalated clays and marls, and the top of the sequence is capped by a lacustrine limestone, reflecting the progressive increase in freshwater influence (El Albani *et al.* 2004). Several layers of Unit 2 show emersion features, such as mud cracks and root bioturbation.

Faunal distribution in the series reflects this general pattern. Ostracods occur in numerous layers and their distribution confirms the succession of saline, brackish and freshwater environments along the series (Colin *et al.* 2004). Taken globally, the invertebrate assemblages (ostracods, gastropods and

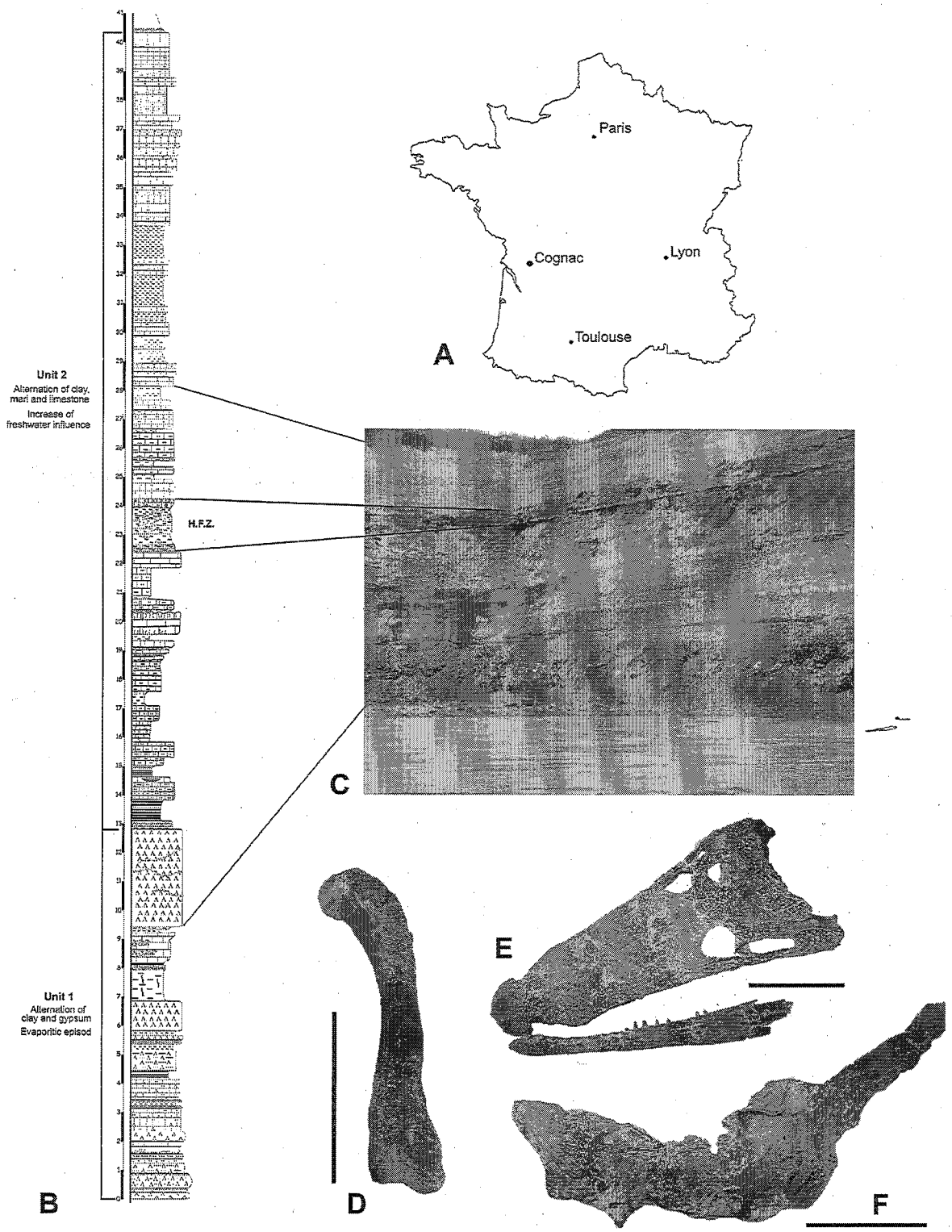

Figure 1. Cherves-de-Cognac, Berriasian, France. A, location of Cognac. B, stratigraphical log of the quarry of Champblanc. C, part of the studied series in the quarry. D, CHE 03.102, isolated femur of *Goniopholis* sp. E, CHE 04.321, skull and incomplete toothed mandible of *Goniopholis* sp. F, CHE 03.058, nearly complete articulated skeleton of *Theriosuchus* sp. D, E and F represent the three stages of preservation: frequent isolated bones (scattered specimens), partially disarticulated specimens and complete toothed skulls, and rare complete articulated specimens. Scales: 10 cm.

bivalves) also indicate brackish conditions in the lagoon, with increasing freshwater influence towards the top of the series (Colin *et al.* 2004; El Albany *et al.* 2004).

Most of the levels are fossiliferous in terms of vertebrate microremains: more than 15,000 specimens have been collected during the course of this study. All of these taxa indicate a parautochthonous or an allochthonous assemblage, reflecting the continental habitat that lay adjacent to the lagoon into which they were transported (see Pouech *et al.* this volume). All of the specimens are very well preserved and lack indications of energetic transport.

Concerning the vertebrate macroremains, more than 1,000 specimens have been extracted from a four-level complex named the "Highly Fossiliferous Zone" (HFZ) (Figure 1B, C). Their taphonomical signature seems heterogeneous and corresponds to three taphofacies, as suggested by El Albani *et al.* (2004). For example, in level C36 (the richest horizon), fossils are found as isolated, but well preserved, bones (totally disarticulated specimens), sub-complete skeletons (partially disarticulated specimens or complete toothed skulls), or exceptionally well preserved complete skeletons (e.g. complete skeletons of small crocodilians). No bones exhibit abrasion or marks indicative of transport. Furthermore, specimens are randomly oriented and sorted. In the HFZ, vertebrate micro- and macroremains are gathered in the same deposit.

All vertebrate classes are present, as shown in the following familial list:

Chondrichthyes Huxley 1880
- Lonchidiidae Herman 1977

Osteichthyes Huxley 1880
- Semionotidae Woodward 1890 (in Woodward and Sherborn 1890)
- Pycnodontidae Agassiz 1833-1844
- Ichthyodectidae Crook 1892
- Caturidae Owen 1860

Lissamphibia Haeckel 1866
- Albanerpetontidae Fox and Naylor 1982

Chelonii Bongniart 1800
- Pleurosternidae Cope 1868

Lepidosauria Haeckel 1866
- Squamata Oppel 1811 (Fam. indet.)
- Sphenodontidae Cope 1870

Crocodylia Gmelin 1788
- Bernissartiidae Dollo 1883
- Atoposauridae Gervais 1871
- Pholidosauridae Eastman 1902 (in Zittel and Eastman 1902)
- Goniopholididae Cope 1875

Dinosauria Owen 1842
- Dromaeosauridae Matthew and Brown 1922
- Theropoda Marsh 1881 (Fam. indet., non-Dromaeosauridae)
- Camarasauridae Cope 1877
- Iguanodontia Dollo, 1882 (Fam. indet.)
- Heterodontosauridae Romer 1966
- Stegosauridae Marsh 1880

Avialae Gauthier 1986
- Archaeopterygidae Huxley 1871

Pterosauria Kaup 1834
- Pterodactyloidea Plieninger 1901 (Fam. indet.)

Mammalia Linnaeus 1758
- Triconodontidae Marsh 1887
- Spalacotheriidae Marsh 1887
- Dryolestidae Marsh 1879
- Multituberculata Cope 1884 (Fam. indet.)

DISCUSSION

All of the vertebrate fossils were transported from the adjacent continental area into the lagoon. Although successive microvertebrate assemblages through the series reflect increasing freshwater influence (see Pouech *et al.* this volume), the macroremains are found only in four consecutive layers, corresponding to a paroxysm of deposition. In this HFZ, the good preservation of fossils that are clearly reworked, together with the occurrence of typically terrestrial taxa (dinosaurs, mammals) in association with amphibious (crocodilians, amphibians) and aquatic taxa (fish, sharks), and the presence of sedimentological structures, such as hummocky cross-stratification (HCS), argues for exceptional deposition events. Storms and floods are suggested as an explanation for these exceptional accumulations and the concentration of a continental biocoenosis.

CONCLUSIONS

The site of Cherves-de-Cognac provides a double opportunity. First, it is possible to follow the composition of the microvertebrate assemblages through the series and to study their responses to changing environmental conditions. Second, the exceptional accumulation in the HFZ allows reconstruction of the adjacent continental community.

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