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Late Cretaceous palaeoenvironments expressed by the clay mineralogy of Cenomanian–Campanian chalks from the east of the Paris Basin

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Abstract

The clay fraction of Cenomanian–Campanian chalks cored at Poigny and Sainte-Colombe, close to Provins (east-south-east of Paris), includes variable proportions of smectitic minerals, illite and kaolinite. The smectitic sediments (which constitute the background of low-terrigenous supply throughout the stratigraphic interval) resulted mainly from the warm, humid climate and high sea level that prevailed during Late Cretaceous in this area. During the Late Turonian, the smectitic sedimentation was interrupted by significant detrital inputs of illite and kaolinite. This reflected tectonic rejuvenation of landmasses coeval with an explosive volcanism expressed by the occurrence of bentonite layers. Comparison with clay assemblages occurring at equivalent stratigraphic intervals in the western part of the Paris Basin reveals great variation in clay mineralogy reflecting either local detrital input or complex basin morphology. Bentonites identified in the Poigny and Sainte-Colombe boreholes include the Southerham, Caburn, Bridgewick and Lewes marls. Cropping out from England to Germany, these clay-rich beds usually show a smectitic clay fraction originating from the submarine weathering of volcanic glass shards. Surprisingly, at Poigny and Sainte-Colombe, the occurrence of authigenic kaolinite characterizes these bentonite layers. Authigenesis of kaolinite in volcanic layers deposited in marine environments is unusual. The formation of kaolinite, which requires a low pH, usually occurs in organic matter-rich continental settings. At Poigny and Sainte-Colombe, kaolinite probably formed shortly after burial in reducing microenvironments. The systematic Cr, V, U and organic carbon enrichment of kaolinite-rich bentonites by comparison with smectite-rich bentonites suggests deposition in oxygen-depleted environments in the deepest part of the Paris Basin.

Keywords: Bentonites; Chalk; Clay minerals; Late Cretaceous, Paris Basin

1. Introduction

The variable clay fraction of chalks in the Anglo-Paris Basin was controlled either by environmental conditions prevailing during the Late Cretaceous or by authigenic and diagenetic processes (Deconinck and

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Chamley, 1995). In France, the clay fraction of the Late Cretaceous successions has been studied mainly in the Boulonnais and Normandy (north-west Paris Basin) where the chalk is particularly well exposed along coastal cliffs (Deconinck et al., 1989, 1991b) but few data have been published dealing with the chalk deposited in the eastern part of the Paris Basin. Recently, the chalk was continuously cored at Poigny and Sainte-Colombe, close to Provins (east-south-east of Paris; Fig. 1), as part of the so-called "Craie 700" scientific program. The objectives of "Craie 700" were to identify the origin of variations in the velocity of seismic waves in the chalks (Hanot and Renoux, 1991; Hanot and Thiry, 1999). The study of the chalk recovered has shown that velocity variations originated in diagenetic features including the occurrence of a dolomitized interval of Campanian age (Robaszynski et al., 2005). The 650-m-thick chalk succession encompasses the Cenomanian to Campanian stages with a recovery reaching 98%. The Poigny and Sainte-Colombe boreholes therefore provide an opportunity for detailed continuous clay mineralogical investigations (Pomerol, 2000; Robaszynski, 2000) and biostratigraphic studies of foraminifers (Robaszynski and Bellier, 2000), nannofossils (Janin, 2000), ostracods (Robaszynski et al., 2000), dinoflagellates (Masure, 2000) and other fossils.

The main objectives of this paper are to: (1) reconstruct the environmental conditions that prevailed during the deposition of the Late Cretaceous chalk, including climates, terrigenous influences, tectonic events and volcanism; (2) compare our data on the clays with those from the western part of the Paris Basin; and (3) characterize the bentonite layers previously identified from England to Germany in middle and late Turonian chalks (Ernst et al., 1983; Zimmerle, 1989; Deconinck et al., 1991a; Wray, 1999).

2. Material and methods

After a visual core description, wherever possible a sampling interval of 3 m or less throughout the whole succession of the Poigny borehole was used. At Sainte-Colombe, as the same mineralogical trends were expected, sampling was restricted to the Cenomanian–Coniacian interval. More than 300 samples from chalk and clay-rich beds were studied. Clay mineral associations were examined using X-ray diffraction on orientated mounts. Defloculation of clays was achieved by successive washing with distilled water after removal of carbonates from the crushed rock with 0.2 N HCl. The clay fraction (<2 μm) was separated by sedimentation and centrifugation (Brown and Brindley, 1980). X-ray diffractograms were obtained using a Philips PW 1730 diffractometer with CuK_{α} radiation and Ni filter. A tube voltage of 40 kV and a tube current of 25 mA were used.

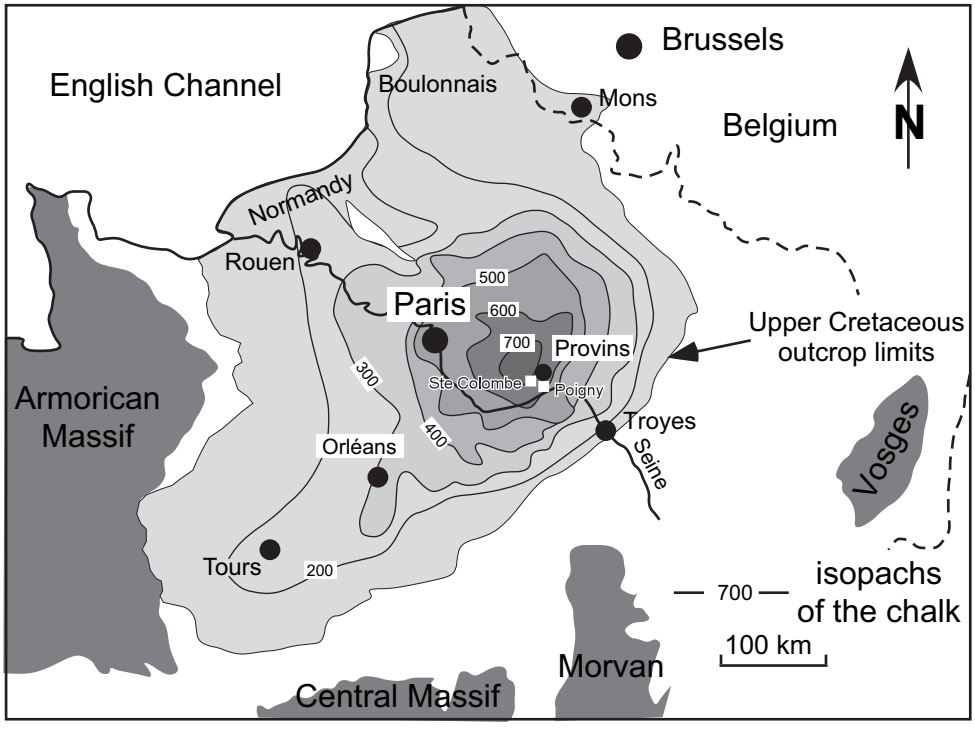

Fig. 1. Location map with chalk isopachs. The distance between boreholes 701 and 702 respectively at Poigny and Sainte-Colombe is only 2 km.