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Changes in the pelagic fine fraction carbonate sedimentation during the Cretaceous–Paleocene transition: contribution of the separation technique to the study of Bidart section

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Abstract

The Bidart section (southwestern France) displays an almost complete Late Maastrichtian–Early Danian transition. As the Cretaceous–Paleocene (K/P) crisis mainly affects carbonate producers, the aim of this study is to precisely evaluate the evolution of pelagic sediments composition across the boundary. A new protocol for separation of fine carbonates into discrete size fractions was used (1) to precisely evaluate (in weight of carbonate and not only number of particles per gram of rock) the contribution of each carbonate component type (foraminifera, calcareous nannofossils and "nonbiogenic" carbonates, calcite microparticles, and calcareous macrocrystals), and (2) to measure their isotopic signature and thus constrain the origin of these carbonate particles.

The Maastrichtian pelagic carbonates are mostly biogenic (70% of the bulk carbonate) but also contain "nonbiogenic" carbonates: calcite microparticles (<4 μm) and calcareous macrocrystals (>4 μm). Due to their isotopic signature, calcite microparticles cannot result from fragmentation and partial dissolution of biogenic remains, and the most likely origin appears to be early diagenetic processes and/or export from shallow-water platforms. The calcareous macrocrystals derive from an early diagenetic process.

The lowermost Danian sediments are dominated by "nonbiogenic" carbonates (between 50% and 80% of the bulk carbonate). Nevertheless, two kinds of biogenic components are present: *Thoracosphaera operculata* and Maastrichtian-like calcareous nannofossils. *Thoracosphaera operculata* is an opportunistic calcareous dinoflagellate, which frequently occurs at high abundances in basal Danian sediments and is certainly in situ, this is confirmed by it showing a Danian isotopic signature. The Maastrichtian-like calcareous nannofossils are nannofossils of taxa that indisputably occur in the Maastrichtian, but which do not occur consistently in later Danian strata, they show a Maastrichtian-type isotopic signature, which strongly supports the inference that they are mainly reworked from the Maastrichtian.

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This study shows that "nonbiogenic" carbonates are important components of the pelagic carbonate even during periods of normal sedimentation. In the "crisis interval", the biogenic carbonate production drops sharply, while calcite microparticles and carbonate macrocrystals remain almost unaffected and represent the major part of the carbonate in the earliest Danian sediments. Finally, the sediments return to a composition similar to that of the Maastrichtian in *M. pseudobulloides* foraminifera zone.

Keywords: Pelagic sediments; Carbonate production; Calcareous nannofossils; K/T crisis; Reworking; Micarb

1. Introduction

The Cretaceous–Paleocene (K/P) transition is one of the best-studied periods of Earth history because of the well-known biological crisis (including dinosaur extinction), which ranks among the major biological crises of the Phanerozoic (Raup, 1986; Raup and Sepkoski, 1986). Following the work of Alvarez et al. (1980), numerous studies argued for a "cosmic" hypothesis (impact of a large asteroid) or a "volcanic" hypothesis (involving the Deccan Traps), see Glen (1994), Courtillot (1995), Frankel (1996), and Keller (1996), and references therein.

This crisis strongly affects the pelagic carbonate producers. The calcareous plankton (planktonic foraminifera and calcareous nannofossils) underwent a major turnover, which was not preceded by any clear forewarning (Perch-Nielsen et al., 1982; Gartner, 1996; Smit, 1990). The Early Danian nannofossil assemblages are restricted to successive blooms of disaster species, such as the calcareous dinoflagellates *Thoracosphaera operculata*, which occupied the ecologic niches vacated by the nannoplankton (Eshet et al., 1992), and opportunistic survivors sensu Harries et al. (1996), such as nannoliths of *Braarudosphaera bigelowii*. In addition to these forms, the Lower Danian sediments contain Maastrichtian-like nannofossils, i.e., the same taxa as in Maastrichtian samples. Some workers consider that these forms are reworked from the Maastrichtian (Thierstein, 1981; Pospichal, 1994, MacLeod et al., 1997; Gardin and Monechi, 1998; Gardin, 2002), while others have hypothesised that at least a substantial part was produced by surviving taxa (Perch-Nielsen et al., 1982; Keller, 1996). In that case, the turnover would occur over a much longer time interval than has been suggested in many cosmic scenarios. Noncalcareous pelagic groups seem less affected by the crisis; organic dinoflagellates (Elliot et al., 1994) and radiolaria (Hollis, 1996) passed across the K/P transition without any major diversity change. Furthermore, few benthic groups experienced a significant extinction. Bignot (1984) showed that, in northwestern Europe, 67% of Danian benthic foraminifera were already present in the Upper Maastrichtian. Conversely, 80% of the Maastrichtian assemblage persisted in the Danian.

From the geochemical point of view, the Cretaceous–Paleocene boundary is marked by an important negative shift in the carbon isotopic ratios of carbonates recorded by both bulk carbonate and foraminifera (Létolle and Renard, 1980; Boersma, 1981; Boersma and Shackleton, 1981; Romein and Smit, 1981; Renard et al., 1982; 1983; Renard and Rocchia, 1984; Shackleton and Hall, 1984; Shackleton et al., 1984; Renard, 1985; Zachos et al., 1985; Stott and Kennett, 1990a; 1990b). Routinely, isotopic analyses are carried out on bulk carbonates. With this approach, the potential diagenetic overprint cannot be detected. Furthermore, the important change in the carbonate producers at the Cretaceous–Paleocene transition could in part be responsible for the negative isotopic shift. As a result, the actual significance of this shift has remained in doubt. We have recently developed a technique to separate fine carbonate particles into discrete size fractions (homogeneous nannofractions). This technique has been applied to the K/P section of Bidart (S. France) to allow (i) characterisation of the geochemical signatures of the various carbonate producers through the Cretaceous–Paleocene transition; and (ii) quantification of the consequences of the crisis on these components.