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Diagenetic features of limestones from the Cretaceous/Tertiary boundary of SW Slovenia (Yugoslavia)

Roman Koch
Institut für Paläontologie, Loewenichstr. 28, D-8520,
Erlangen, BRD

Abstract

The Upper Cretaceous limestones show commonly syntaxial overgrowth on echinoid fragments, geopetal fillings with vadose silt, gravitational cements, neomorphic altered miliolids, and microsparite and pseudosparite. All features are indicative of a strong early freshwater diagenesis. In the Kozina beds minor hints for a freshwater diagenesis are present. In general a trend from freshwater influenced limestones to normal marine limestones can be observed. Birdseyes occur commonly with dedolomite. Additionally molds, vugs, and geopetal microsparitic silt is present. The Miliolid limestones generally were formed under normal marine lagoonal conditions. Only very locally hints for a weak early diagenetic freshwater influx are given. Scarce syntaxial overgrowth on echinoid fragments and some clear fine granular cements can be observed. Microcodium was commonly formed in local areas of short time emersion.

Introduction

The recent analyses were carried out on material from Delvalle (1985) and Delvalle and Buser (1990) who studied the microfacial development of limestones from the Cretaceous/Tertiary boundary in SW Slovenia in detail. They analysed three profiles near the villages of Kozina, Materija, and Slivje by microscopic and geochemical means. From their samples representative limestones of Upper Cretaceous, Early Paleocene (Kozina beds), and Late Paleocene age (Miliolid limestones) were selected. Delvalle and Buser (1990) characterise the facial development of these beds as follows:

Upper Cretaceous: Shallow subtidal, environment with local intertidal zones. The water energy was low (micrites), but locally higher (sparites). Some rudist mounds were present. Bauxitisation occurred during longer periods of emersion. Bauxitic material in the limestones indicates a proximity of land. A longer period without sedimentation followed which was ended by the deposition of the overlying Kozina beds.

Early Paleocene (Kozina beds): The Kozina beds have a polygenetic character. They comprise different facies types. Nevertheless a general trend can be observed characterising the development from a highly freshwater influenced environment to normal marine conditions in the upper part of the Kozina beds.

Late Paleocene (Miliolid limestones): Normal marine subtidal to intertidal conditions are referred to favourable conditions for marine organisms. Locally areas of emersion existed where plants grew commonly. During these periods Microcodium was formed.

Diagenetic features

The aim of the recent study is to reveal the diagenetic features of these limestones and to demonstrate their facies indication.

Upper Cretaceous limestones

The most prominent diagenetic features of limestones in the three profiles analysed are (1) syntaxial overgrowth on echinoid fragments, (2) the filling of molds with vadose silt, (3) relic textures of gravitational cements, (4) partly and nearly completely altered (neomorphosed) miliolids, and (5) commonly microsparite.

Syntaxial overgrowth on echinoid fragments (plate 1, A) occurs commonly. The rims are 20 to 250 µm thick and reveal a replacement texture. According to Walkden and Berry (1984) and Koch and Schorr (1986) they are interpreted to be of early diagenetic meteoric origin. Their formation was possible due to the dissolution of neighbouring carbonate material and a subsequent cementation of the mold by a large calcite crystal which has partly a replacing character. Syntaxial overgrowth is only developed around echinoid fragments which have no micritic envelopes.

Geopetal fillings with vadose silt (plate 1, B) consist of fragments of crystals with a size of 20 to 100 µm. They are generally floating in a micritic to microsparitic matrix. Probably this internal sediment represents a mixture of two sediment types. The crystals were formed in a supratidal environment and transported into the intertidal zone where they were deposited together with marine micrite. The micrite was recrystallized subsequently. This type of sediment is comparable to a mixture of crystal silt (supratidal and terrestrial environment) and marine micrite (subtidal) as described by Aissaoui and Purser (1983).

Gravitational cement (plate 1, B) occurs only locally on the roofs of molds. It can be recognized due to the fine crystal size and is interpreted to be the result of an aggrading neomorphism of a former meteoric vadose gravitational cement (Müller, 1971). It consists of xenotopic crystals of 20 to 70 µm size. The rest of the molds is filled by coarse-granular calcite. It is interpreted to be primarily of meteoric vadose origin and to be overprinted by meteoric phreatic conditions.

Neomorphic altered miliolids (plate 1, C and D) occur commonly. They are replaced by clear, greyish microsparite or pseudosparite partly or nearly completely. The miliolids are dark grey or brownish where no replacement had occurred. There they reveal the original texture. The brownish colour indicates the presence of a certain amount of organic material. When this material was oxidized completely, the formation of microsparite took place and the colour turned to light grey. The 'shelter-effect' of the organic material (Hall & Kennedy, 1967; Kemper & Koch, 1982) disappeared.

The intraparticle pores of the miliolids are filled by fine to mediumcrystalline calcite (20 to 120 µm size). Both features indicate an early diagenetic freshwater influx. Nearly complete alteration of the miliolids by a longer reaching freshwater diagenesis resulted in a complete transformation and recrystallization of the miliolids.

Microsparite and pseudosparite (plate 1, D) occurs where an early freshwater diagenesis altered the primary micritic matrix of the limestones completely. In these limestones all miliolids are recrystallized too.

Early Paleocene limestones (Kozina beds)

The Kozina beds show layerwise abundant "birdseyes" and locally molds and vugs which were created by enhanced freshwater influx. In some vugs geopetal fillings of microsparite silt occur.

"Birdseyes" (plate 2, A and B) according to Shinn (1968) are indicative for an intertidal environment of deposition. Additionally degassing structures can occur. Many of these "birdseyes" in the recent study are similar to molds enlarged by solution of the surrounding micrite. Now they are filled by sparry calcite. A closer view reveals angular shapes of former crystals indicating that the vugs are filled now by dedolomite (plate 2, B). The former dolomite is replaced completely by very fine grained calcite crystals of different optical orientation. This structure is described by Evamy (1967) and De Groot (1967) as the result of near surface diagenetic processes resulting in dedolomitization.

Geopetal microsparitic silt (plate 1, C and D) shows a slightly pelletoidal structure. It is composed of finely recrystallized micrite containing some coarser crystals and is therefore similar to vadose crystal silt. Due to the very fine crystal size it is considered to be another type of vadose silt and therefore indicative for supratidal conditions. The relict pore space in the vugs is completely cemented by coarse granular calcite.

Late Paleocene (Miliolid limestone)

The miliolid limestones show a normal marine fauna content with abundant benthic foraminifers. One of the most striking features is the abundance of Microcodium. This indicates soil forming processes within several periods of the Late Paleocene combined with the growth of plants. Regardless of these hints for times of emersion diagenetic indications of freshwater influences are only weak. The most prominent features are (1) the syntaxial overgrowth on echinoids, (2) clear, fine granular cements, and (3) the occurrence of Microcodium.

Syntaxial overgrowths on echinoid fragments (plate 3, A) are very thin and very scarce. Therefore they can not be taken as proof for freshwater influx in the Miliolid limestones. These thin overgrowths were probably formed by direct replacement of the surrounding micritic matrix only. Compared with the packstones (plate 1, A) where large overgrowths are developed in the recent wackestones only a very low flow rate of freshwater was possible. Therefore no stronger solution can be taken into account.

Clear, fine granular cement (plate 3, B) occurs in molds and in intraparticle pores of some foraminifers and gastropods. These cements commonly show growth forms perpendicular and subperpendicular to the substrate and can be sometimes observed in the form of granular rim cements. The single crystale have a size of 10 to 40 µm. Granular rim cements can be formed by an early freshwater diagenesis (meteoric phreatic) overprinting former marine cements (probably Mg-calcite) immediately after the formation of the first marine bladed crystals. At this time marine phreatic isopachous rim cement was not yet formed. This indicates only local and short time freshwater influxes – probably in form of freshwater lenses. Some crystals show the shape of "dog-tooth" cements which are interpreted to be of meteoric phreatic origin too.

Microcodium (plate 3, C and D) occurs enriched layerwise. A closer look to the boundaries of the Microcodium aggregates towards the micritic matrix demonstrates the growth form and the type of enlarging processes of Microcodium. The first, outer rims at the contact to the micrite consist of recrystallized micrite (plate 1, D). Whereas the micrite is composed of tiny crystals of 5 to 15 µm size, the microsparites are enlarged to crystals of 10 to 20 µm. Further crystal growth results in pseudosparite (40 to 60 µm size), and finally in the large crystals characteristic for Microcodium. These large crystals have a length of up to 300 µm and a diameter of up to 200 µm at the outer contact. This processes are probably induced by the influence of pore waters delivered from the centre of Microcodium throughout. By this process expanding forms can be created.

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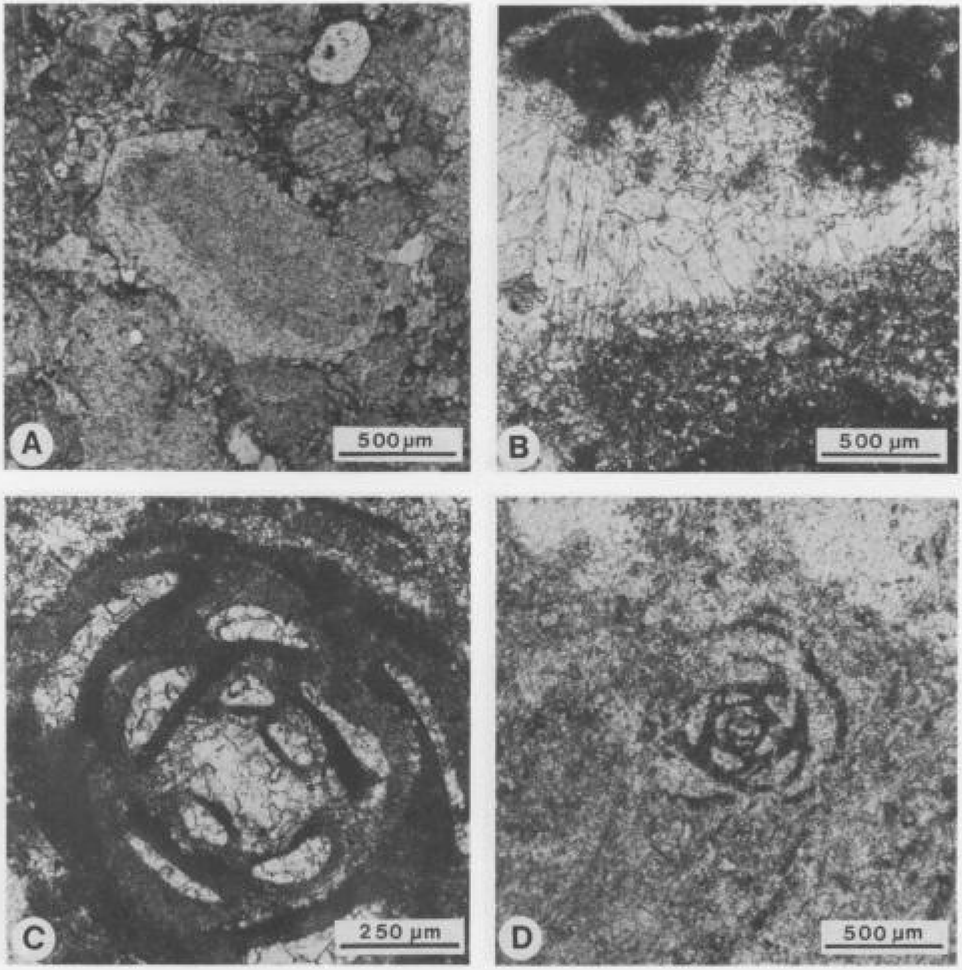

Plate 1

Diagenetic features of Upper Cretaceous limestones

(A) Syntaxial overgrowth of echinoid fragments are common and well expressed

(B) Vadose crystal silt occurs as geopetal filling in a mold. At the roof of the mold granular gravitational cements occur which are characterized by their very fine crystal size

(C) Miliolids are partly neomorphosed to microsparite. Obviously the inner part of the miliolid chamber walls are more susceptible for recrystallization

(D) Limestone completely altered to microsparite and pseudosparite. Only relics of miliolids can be observed

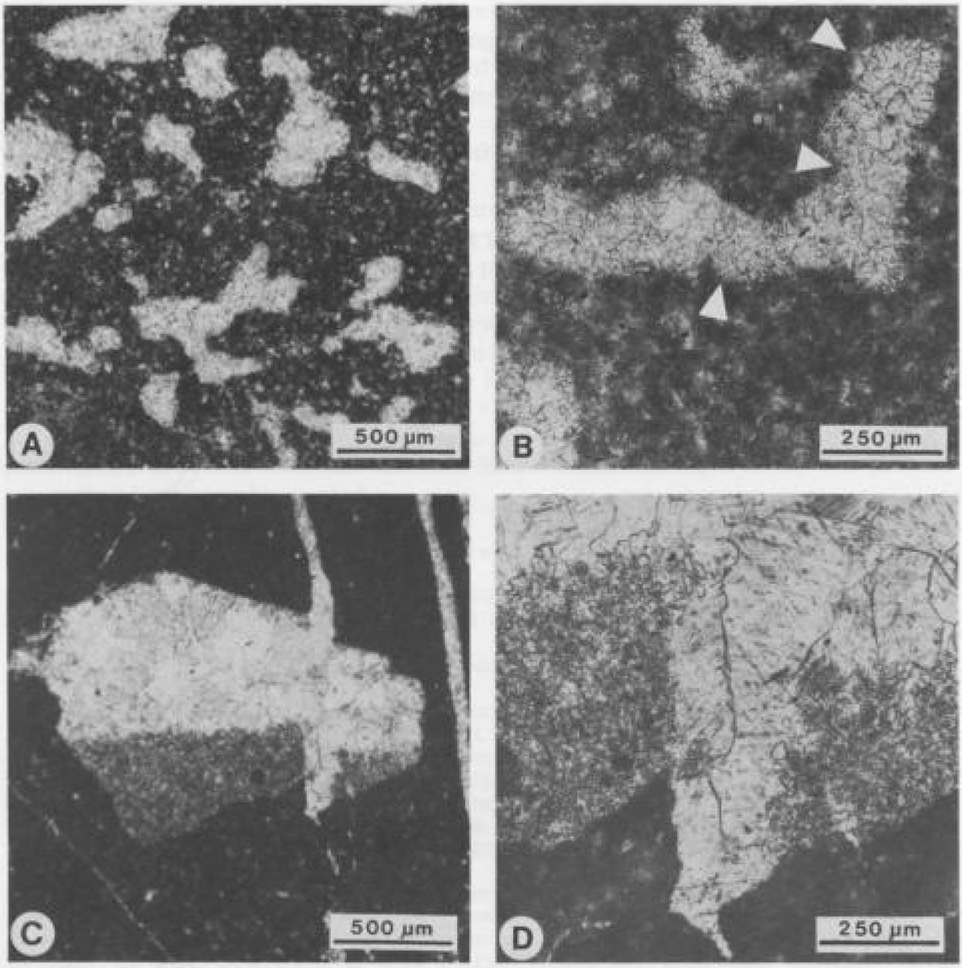

Plate 2

Diagenetic features of Early Paleocene limestones (Kozina beds)

(A) "Birdseyes" and degassing structures are common. Some of these structures are molds and vugs enlarged by solution and a dolomitization-dedolomitization process

(B) Detail of microphotograph A reveals local angular outlines of former dolomite crystals (arrows) which are now dedolomitized and consist of fine calcite crystals of different optical orientation

(C) Larger vug created by solution of a former biogenic component. The vug is filled with geopetal microsparitic silt

(D) Detail of microphotograph C shows microsparite with some coarser crystals and pelletoidal structure. Large, blocky calcite crystals occur in fractures cutting through the vug and sparry calcite

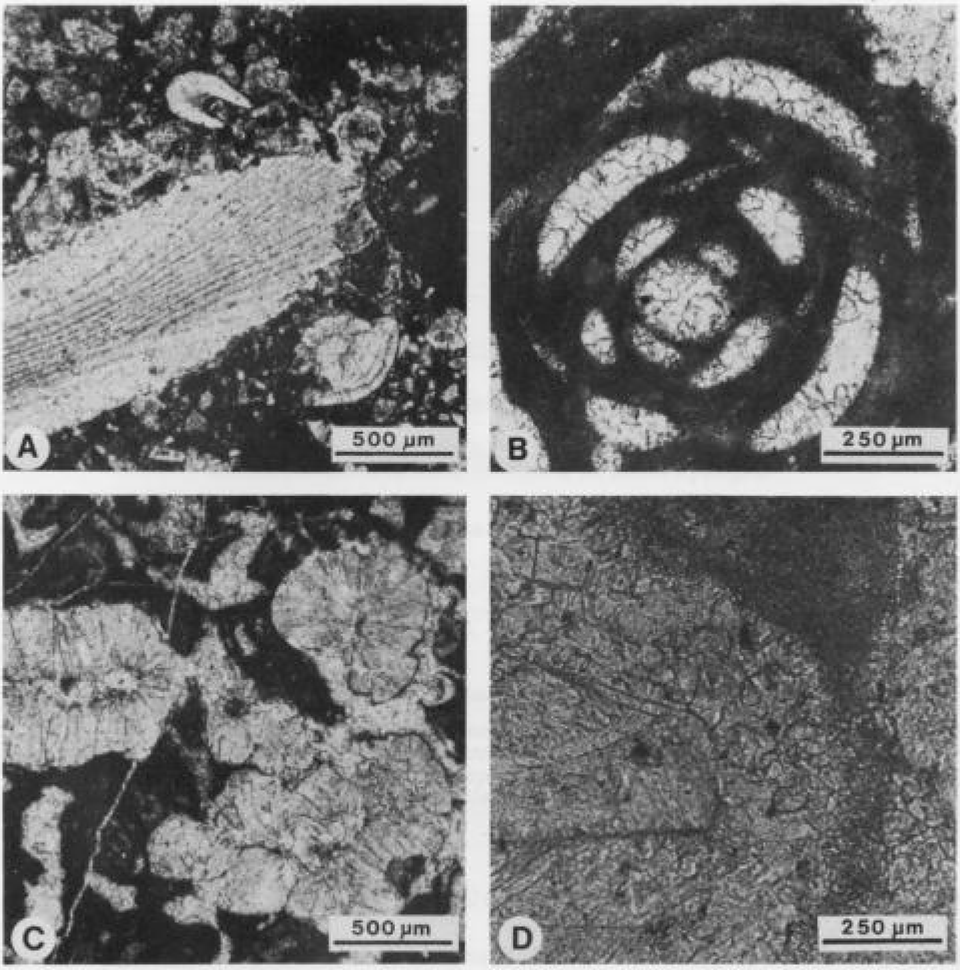

Plate 3

Diagenetic features of Late Paleocene limestones (Miliolid limestone)

(A) Echinoid spine with only very thin syntaxial overgrowth

(B) Miliolid with only very weak recrystallization. The intraparticle pores within the miliolid show fine to medium crystalline calcite cements which reveal an orientation perpendicular and subperpendicular to the substrate. These cements are interpreted to be former Mg-calcite rim cements which were altered by a freshwater diagenesis

(C) Limestone rich in Microcodium

(D) Transition zone between Microcodium and surrounding micritic matrix. The micrite is first altered to microsparite and pseudosparite. Subsequently the recrystallization to the very large crystals characteristic for Microcodium occurs

Plate 3

Diagenetic features of Late Palaeocene limestones (Miliolid limestone)

(1) Sediment fabric with wide [illegible] syntaxial overgrowth

(2) Miliolid, with [illegible]. The [illegible] in [illegible] crystalline [illegible] which [illegible] and [illegible] perpendicular to the substrate. These cements are interpreted to be formed [illegible] environment which were altered in a freshwater diagenetic [illegible].

(3) Limestone rich in Microcodium

(4) Transition zone between Microcodium and surrounding micritic matrix. The micrite is [illegible] altered to [illegible] and [illegible]. Subsequently the [illegible] in the [illegible], large crystals characteristic for Microcodium occur.