An Early Cretaceous radiolarian assemblage: palaeoenvironmental and palaeoecological implications for the Northern Calcareous Alps (Barremian, Lunz Nappe, Lower Austria)

By Alexander LUKENEDER & Miroslava SMREČKOVÁ

Abstract

Detailed palaeontological and lithological studies of Lower Cretaceous sediments from Lower Austria uncovered spectra of Lower Barremian microfaunal elements, among them radiolarians. Lower Barremian radiolarians are figured for the first time from the Northern Calcareous Alps. The radiolarian assemblage from Sparbach was obtained from marly limestone beds of the Karsteniceras Level. The Early Barremian level is dominated by the ammonoid Karsteniceras ternbergense (Coronites darsi Zone). The geochemical results (TOC, S, and CaCO₃), combined with preservational features (e.g. different pyritization stages) of the radiolarian fauna, indicate that the Karsteniceras Level was deposited under oxygen-depleted conditions. These conditions, show eutrophic peaks and produce mass occurrences of pyritized radiolarians in laminated, dark sediments.

Key words: Radiolarians – Early Cretaceous (Early Barremian) – Northern Calcareous Alps

Zusammenfassung


Schlüsselworte: Radiolarien – Unterkreide (Unter-Barremium) – Nördliche Kalkalpen

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Introduction

Lower Cretaceous pelagic sediments cover wide areas within the Northern Calcareous Alps and form a major element of this alpine part the northernmost tectonic units (e.g. Frankenfels, Lunz, Ternberg, and Reichraming Nappes). They are mostly exposed within synclines as represented from east to west by the Flössel, Losenstein, Schneeberg, Anzenbach, Ebenforst and Rossfeld Synclines. The most recent publications by FAUPL et al. (1994), ISMEL (1987), LUKENEDER (1998, 1999, 2001, 2003a, b; 2004a, b, c, d, 2005a, b), LUKENEDER & HARZHAUSER (2003) and VAŠÍČEK & FAUPL (1998) deal with the stratigraphy of the latter synclines in the Reichraming, Frankenfels and Lunz Nappes.

The Early Cretaceous of the Flössel Syncline is considered to range from the Late Valanginian to the Early Barremian (LUKENEDER 2005b). The discovery of a Lower Cretaceous ammonoid mass-occurrence in the Flössel Syncline (Lunz Nappe, Northern Calcareous Alps, Lower Austria), of Early Barremian age, was recently published by LUKENEDER (2005b). The latter occurrence (Karsteniceras Level) is dominated by the heteromorph ancyloceratid Karsteniceras. An invasion of an opportunistic (r-strategist) Karsteniceras biocoenosis during unfavourable conditions over the sea-bed during the Early Barremian was proposed for the Sparbach section. As noted by LUKENEDER (2003b), the limestone deposition during this interval occurred in an unstable environment and was controlled by short- and long-term fluctuations in oxygen levels.

This paper focuses on a detailed description and stratigraphy of the known ammonoid zonation (LUKENEDER 2005b) correlated with new microfossil data. Radiolarian preservation and abundance reflect primary environmental conditions, and the described radiolarian fauna is therefore also investigated with respect to environmental patterns. Note, however, that radiolarian abundance and preservation depend on many factors, e.g. nutritional status of the sea-water surface and the amount of dissolution during sinking to the sea floor and in the sediment.

In dealing with the systematics and stratigraphy of Lower Cretaceous radiolarian faunas (mostly Europe) we refer to the extensive and accurate papers of BAK (1999), BAUMGARTNER (1984), BAUMGARTNER et al. (1995), GORICAN (1994), JUD (1994), O’DOHGERTY (1994), SCHAAF (1984) and DE WEVER et al. (2000). Most of these papers also deal with biological, ecological and taphonomic issues. The most detailed compendium of the Jurassic and Lower Cretaceous radiolarian systematic framework was published by BAUMGARTNER et al. (1995), and their book remains state of the art even today.

Specific investigations on microfacies and changing environmental conditions during the Upper Jurassic and Lower Cretaceous within the Northern Calcareous Alps and adjacent areas in the Carpathians were undertaken by BOOVOVA et al. (1999), ONDREJKOVÁ et al. (1993), OZVOLDOVÁ (1990), OZVOLDOVÁ & PETERČÁKOVÁ (1992), PETERČÁKOVÁ (1990), REHÁKOVÁ (2000), REHÁKOVÁ et al. (1996), and VAŠÍČEK et al. (1994).

Study area and tectonic position

The outcrop is situated in the Frankenfels-Lunz Nappe System (Höllenstein Unit) in Lower Austria, about 1.5 km north of Sparbach (350 m, ÖK 1:50 000, sheet 58 Baden;...
The distinct-laminated appearance of the rock is a result of wispy, discontinuous, flaker-like laminae of dark (organic) material and some sorting of radiolarian tests into the layers. Many of these tests have been partly to completely replaced by pyrite (secondarily limonitic) in a micritic carbonate matrix. Pyritized radiolarians seem to be predominantly preserved around ammonoid tests. This could be due to the altered 'micro-environment', specifically the higher organic content (soft-body). The laminae range in thickness from 0.07–0.1 mm to 0.7–2.4 mm. Contacts between them are gradational to sharp. Phosphatic debris is abundant and consists mainly of fish scales, bones and teeth. Laminated brown-black mudstone is rich in organic carbon. Dark material is wispy, amorphous organic matter. Pale areas are laminae of flattened radiolarians now replaced by microcrystalline chalcedony.

Thin sections: 0 not laminated mudstone; 1a distinct laminated mudstone; 1b laminated mudstone; 2a–2c distinct laminated mudstone; 3a slightly bioturbated mudstone.

Constituent parts of marly limestones are: predominantly calcified radiolarians impregnated by Fe minerals, calcified sponge spicules, ostracods, rare bivalve fragments, rare roveacrinids, crinoid ossicles, fragments of fish (scales, teeth and bones, ichthyoliths), planktonic foraminifers (Favosella sp.) and benthiic foraminifers (Patellina sp.). Small disintegrated floral fragments are also distributed in the matrix, along with frambooidal pyrite, organic matter accumulated in the nests and very rare glauconite grains. Carefully disintegrated floral fragments are also distributed in the matrix, along with framboidal pyrite, organic matter accumulated in the nests and very rare glauconite grains. Carefully disintegrated floral fragments are also distributed in the matrix, along with framboidal pyrite, organic matter accumulated in the nests and very rare glauconite grains.

The limestone carbonate contents within the radiolarian beds (K1 and K2) (CaCO3 equivalents calculated from total inorganic carbon) vary between 73 and 83 %. The weight % TOC (Total Organic Carbon) values vary between 0.03 and 0.52 %. Sulphur ranges from 0.27 to 0.57 mg/g (Fig. 4).

Material and radiolarian fauna

Bed-by-bed collecting and a systematic-taxonomic approach provided the basic data for statistical analysis of the radiolarian faunas. Palaeontological and palaeoecological investigations, combined with studies of lithofacies in thin sections, peels from polished rock surfaces and geochemical investigations, yielded information about the environmental conditions in the area of deposition.

Radiolarian assemblages were extracted from the marly limestone by dissolution in the 12 % acetic acid (5 days). After sieving through a 40 µm screen and drying, the residue was prepared for removal of specimens under a binocular microscope. Species were determined using SEM.

The most abundant assemblage, obtained from sample 1a, comprises 10 species of radiolarians belonging to the order Nassellaria and 7 species to the Spumellaria (Fig. 2). The assemblage is dominated by the species Holocryptocanium barbui DUMITRICA, a representative of spherical cryptothoracic and cryptocephalic Nassellaria from the family Williriedellidae. The assemblage also includes the nassellarians Crolanium puga (SCHAÄF), Cryptamphorella clivosa (ALIEN), Dibolachras tytthopora FOREMAN, Dictyomitra pseudoscalaris (TAN), Hiscocapsa asseni (TAN), Pseudodicyomitra illyae (TAN), Sewhoscapsa doryphaeidae (NEVIANI), Sewhoscapsa orca FOREMAN, Thanarla

Biostratigraphy

The ammonoid association indicates that the cephalopod-bearing beds in the Schrambach Formation belong to the latest Early Barremian (probably to the Moutoniceras moutoniam ammonoid Zone; according to the results of the Vienna meeting of the Lower Cretaceous Ammonite Working Group of the IUGS; HOEDEMAEKER & RAWSON 2000). The M. moutoniam Zone was recently replaced (based on the Lyon meeting of the Lower Cretaceous Ammonite Working Group of the IUGS) by the Coronites darsi Zone (HOEDEMAEKER et al. 2003) (Fig. 3). Although Moutoniceras moutoniam and Coronites darsi are missing, the typical association hints at the latest Early Barremian. The radiolarian fauna of the Schrambach Formation belongs to the Coronites darsi ammonite Zone of the latest Early Barremian (HOEDEMAEKER et al. 2003; LUKENEDER 2001). The biostratigraphic evaluation of radiolarian assemblages was based on the biocenosis of BAUMGARTNER et al. (1995). The composition of the association represents the longer stratigraphic range Early Hauterivian–earliest Late Aptian (sensu BAUMGARTNER et al. 1995).
Discussion and conclusions

The microfauna of the Lower Cretaceous beds in the Sparbach succession (Flössel Syncline) is represented especially by radiolarians. The abundance of pyritized radiolarian tests is restricted to the distinctly laminated beds. The radiolarian assemblage encompasses a stratigraphic range from Early Hauterivian - earliest Late Aptian. The stratigraphic investigation of the accompanying ammonoid fauna constricts the range and reveals that the investigated part of the Sparbach section comprises Lower Barremian sediments.

The geochemical results indicate that the assemblage was deposited under conditions of intermittent oxygen-depletion associated with stable water masses. The process was controlled by short- and long-term fluctuations in oxygen content, coupled with a poor circulation of bottom-water currents within an isolated, basin-like region. The brighter colour of the sediment and the lower content of TOC and sulphur at the Sparbach section indicate a less dysoxic environment than in comparable, darker beds elsewhere in the Northern Calcareous Alps (e.g. KB1-B, Upper Austria). No evidence for condensation can be found.

Nassellarians dominate the radiolarian assemblage, whereby the genera *Holocryptocanium*, *Sethocapsa*, *Thanarla*, *Dictyomitra* and *Xitus* are the most important taxa. The assemblage is characterized by little diversification but specimen richness. *Holocryptocanium barbui* DUMITRICA is the dominant species. *Holocryptocanium barbui* DUMITRICA is a cryptocephalic and cryptothoracic representative of the family *Williriedellidae*; along with the thick-walled forms of the genus *Praeconosphaera*, they hint to a deep-water fauna. The latter forms predominate over the spumellarians, which show spiny tests (e.g. *Acaeniotyle umbilicata*, *Pantanellium squinaboli*) and indicate shallower levels in the water column.

*BARTOLINI* et al. (1999) showed that the reproductive rate of deep-water populations is much higher when mixed water layers containing a high nutrient supply prevail. Such conditions are proposed for the investigated radiolarian mass occurrence at Sparbach. We therefore assume that the radiolarian association at Sparbach indicates eutrophic conditions and a high flux of organic matter towards the sea-bottom. This is supported by the geochemical and faunal data given by *LUKENEDER* (2005b) for the same beds.

The spumellarian/nassellarian ratio of the Sparbach assemblage shows that nassellarians markedly dominate in specimen numbers and species occurrence versus spumellarians.

From HAECKEL’S time (1873–1887) up to the present, the opinion has been maintained that spumellarians are more abundant in shallow waters and nassellarians prefer deeper water and/or oceanic conditions. *BARTOLINI* et al. (1999), however, pointed out that the spumellarian/nassellarian ratio is a more complex issue in which many factors such as nutrient quantity, temperature and salinity gradients play a role.

Based on the described features from the Sparbach section, radiolarians show abundance peaks during times of oxygen depletion at the sea floor. We conclude that “plankton blooms” (e.g. radiolarian blooms) at the sea-water surface induced a drop in the oxygen content of deeper water layers at the sea floor. The increasing content of biogenic particles at the sea floor leads to oxygen depletion in such phases. Note that the abundance peaks of radiolarians and their increasing pyritization are associated with strong lamination and peaks in TOC (Fig. 4).

Dark, laminated deposits are preferentially enriched in radiolarians. We therefore suggest that phases of high nutrient availability and primary productivity are a motor for the formation of such radiolarian-rich, dark, laminated sediments. A distal, deeper environmental position of the accumulation site is assumed, and the facies point to eutrophication of the overlying water mass. *BAK & SAWLOWICZ* (2000) discussed the significance and the preservation of pyritized radiolarians. The pyritization of radiolarians described herein is too weak to presume formation while floating within the anoic water column. This pyritization most probably took place on the sea floor and/or in the sediment. This...
supports the results of Lukeneder (2005b), who proposed – in his recent investigations on the laminated sediments of the same locality – a low-oxygen environment combined with decreasing bottom-current activity.

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References


Plate 1

All specimens figured on plate 1 are Spumellaria from bed 1a, except Fig. 9 which belongs to Nasselaria.

Fig. 1: Paronaella cf. trifoliacea OZVOLDOVÁ – × 120

Figs. 2, 3: Praeconosphaera sp. – × 180

Fig. 4: Pantanellium squinaboli TAN – × 100

Fig. 5: Archaeospongoprunum patricki JUD – × 120

Fig. 6: Suna hybum (FOREMAN) – × 120

Fig. 7: Acaeniotyle umbilicata (RÜST) – × 125

Fig. 8: Acaeniotyle diaphorogona FOREMAN – × 130

Fig. 9: Dibolachras tythopora FOREMAN – × 120

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 2

All specimens figured on plate 2 are Nasselaria from bed 1a.

Fig. 1: *Pseudodictyomitra lilyae* (TAN) – × 130

Fig. 2: *Dictyomitra pseudoscalaris* (TAN) – × 120

Fig. 3: *Xitus clava* (PARONA) – × 110

Fig. 4: *Crolanium puga* (SCHAAF) – × 110

Fig. 5: *Thanarla brouweri* (TAN) – × 130

Fig. 6: *Sethocapsa orca* FOREMAN – × 110

Fig. 7: *Cryptamphorella clivosa* (ALIEV) – × 125

Fig. 8: *Sethocapsa dorysphaeroides* (NEVIANI) – × 125

Fig. 9: *Hiscocapsa asseni* (TAN) – × 160

Fig. 10, 11: *Holocryptocanium barbui* DUMITRICA – × 160

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 3

**Fig. 1**: enlarged part of pl.1, fig.1, *Paronaella cf. trifoliacea OŽVOLDOVÁ*

**Figs. 2, 4, 5, 7**: enlarged details of pl.1, figs 2 and 3, *Praeconosphaera* sp.

**Fig. 3**: broken specimen of *Praeconosphaera* sp., note pyritized areas in the inner area and the pyrite framboids in the lower part

**Fig. 6**: wall structures on a broken surface pl. 2, fig. 3, *Praeconosphaera* sp.

**Fig. 8**: enlarged part of on spine of pl.1, fig. 7, *Acaeniotyle umbilicata* (RÜST)

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 4

Fig. 1: detail of the aperture of pl. 2, fig. 1, *Pseudodictyomitra lilyae* (TAN)

Fig. 2: detail of the outer surface of pl. 2, fig. 1, *Pseudodictyomitra lilyae* (TAN)

Fig. 3: detail of the aperture of pl. 2, fig. 2, *Dictyomitra pseudoscalaris* (TAN)

Fig. 4: detail of the outer surface of pl. 2, fig. 4, *Dictyomitra pseudoscalaris* (TAN)

Fig. 5: detail of the aperture of pl. 2, fig. 3, *Xitus clava* (PARONA)

Fig. 6: detail of the outer surface of pl. 2, fig. 3, *Xitus clava* (PARONA)

Fig. 7: detail of the outer surface of pl. 2, fig. 4, *Crolanium puga* (SCHAAF)

Fig. 8: detail of the outer surface of pl. 2, fig. 5 *Thanarla browerii* (TAN)

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 5

Figs. 1, 3, 4: details of the internal structure of *Thanarla brouweri* (TAN)

Fig. 2: enlarged apex area of pl. 5, fig. 1, *Thanarla brouweri* (TAN)

Fig. 5: detail of the aperture of pl. 2, fig. 5, *Thanarla brouweri* (TAN)

Figs. 6, 9: broken specimen of *Sethocapsa orca* FOREMAN. Note the black hole at the position of the spine in fig. 6

Fig. 7: enlarged area around the apex of pl. 5, fig. 9, *Sethocapsa orca* FOREMAN

Fig. 8: enlarged area around the inner apex of pl. 5, fig. 6, *Sethocapsa orca* FOREMAN

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 6

Figs. 1–4 and 7, 8: different preservational stages of the outer surface of *Holocryptocanium barbui* DUMITRICA. Fig 2 shows enlarged detail of pl. 2, fig. 10. Fig. 4 shows enlarged part of the broken specimen of pl. 6, fig. 3

Fig. 5: enlarged wall structure of pl. 6, fig. 5, *Holocryptocanium barbui* DUMITRICA

Fig. 6: small pyrite framboids in the pores of the inner surface of *Holocryptocanium barbui* DUMITRICA

All specimens were collected at the Sparbach section, coated with gold before photographing (REM) and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0001 (REM stub).
Plate 7
All figures on plate 7 are from thin sections from bed 1a.

Fig. 1: Paronaella cf. trifoliacea OZVOLDOVÁ

Fig. 2–6, 10: different preservational stages and sections of Praeconosphaera sp.

Fig. 7, 9, 12: different preservational stages and sections of Hiscocapsa asseni (TAN)

Fig. 8: ?Crolanium puga (SCHAAF)

Fig. 11: ?Dibolachras tythopora FOREMAN

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0002-4 (thin sections).
Plate 8

All figures on plate 8 are from thin sections from bed 1a.

Figs. 1, 3, 4, 6, 9: different preservational stages and sections of *Holocryptocanium barbii* DUMITRICA

Fig. 2: ?Thanarla brouweri (TAN)

Fig. 5: Cryptamphorella clivosa (ALIEV)

Fig. 8: Sethocapsa orca FOREMAN

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0002-4 (thin sections).
Plate 9

All figures on plate 9 are from thin sections from bed 1a.

**Fig. 1:** *Praeconosphaera* sp. right, fragments of *Holocryptocanium barbui* DUMITRICA and an indet radiolaria left

**Fig. 2:** *Holocryptocanium barbui* DUMITRICA right and *Praeconosphaera* sp. left

**Fig. 3:** Crushed and broken fragments of different radiolarians containing *Holocryptocanium barbui* DUMITRICA

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0002-4 (thin sections).
Plate 10

All figures on plate 10 are from thin sections from bed 1b.

Fig. 1: *Praeconosphaera* sp.

Figs. 2, 3, 5, 7: *Hiscocapsa asseni* (TAN) – × 160

Figs. 4, 6 and 11–13: different preservational stages and sections of *Holocryptocanium barbui* DUMITRICA. Note pyrite frambooids in Fig. 4, dark, round. Fig. 12 shows a crushed specimen of *Holocryptocanium barbui* DUMITRICA. Fig. 13 left is an indet. radiolaria.

Fig. 9: indet. radiolaria

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0005-6 (thin sections).
Plate 11

All figures on plate 11 are from thin sections from bed 2a.

Figs. 1, 2: Paronaella cf. trifoliacea ŽVOLDOVÁ

Fig. 3: Praeconosphaera sp.

Figs. 4–7: different preservational stages and sections of Hiscocapsa assemi (TAN). Fig. 6 shows an accumulation of different radiolarians. Three specimens of Holocryptocanium barbui DUMITRICA and the third specimen from the top is Hiscocapsa assemi (TAN). The dark material is a pyrite cloud.

Figs. 8–11: different preservational stages and sections of Holocryptocanium barbui DUMITRICA. Note pyrite frambooids in Fig. 9, dark, round. Fig. 8 shows in the upper left corner ?Pseudodictyomitra sp.

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0007 (thin section).
Plate 12

All figures on plate 12 are from thin sections from bed 3a. Note that the main difference between the specimens on this plate and plate 1–11 is the low pyritization factor in bed 3a. In most cases radiolarians are only calcitic (white) and only in few cases partly pyritized (black).

Figs. 1, 3, 4, 6: indet radiolaria

Figs. 2, 7, 9–11, 14, 15: different preservational stages and sections of *Holocryptocanium barbui* DUMITRICA

Figs. 5, 12, 16: different preservational stages and sections of *Hiscocapsa assei* (TAN)

Fig. 8: ?*Pseudodictyomitra* sp.

Fig. 13: ?*Thanarla* sp.

All specimens were collected at the Sparbach section and are stored at the Museum of Natural History Vienna (Burgring 7, A-1010, Vienna), 2005z0081/0008 (thin section).